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Light Truck Capabilities, Utility Requirements and Uses: Implications for Fuel Economy

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16. Abstract

This report covers the findings of a study performed for NHTSA by the Volpe National Transportation Systems Center that addresses two key questions:
1) What are the unique capabilities, utility requirements, and uses of light trucks?
2) Do these consumer requirements and other regulatory requirements constrain the ability to improve light truck fuel economy?

The capabilities of light trucks that are notably superior to those of passenger cars are referred to as enhanced capabilities of light trucks. Five enhanced capabilities are identified, qualified and quantified: load carrying (passengers), load carrying (weight), load carrying (volume), towing and off-road operation. Utility requirements are treated as the functions and capabilities that truck buyers need. Public domain survey data is used to identify utility requirements for both personal and commercial uses. Two major surveys, the 1992 Truck Inventory and Use Survey (TIUS) and the 1990 Nationwide Personal Transportation Survey (NPTS), are used to identify and quantify the actual uses of light trucks for both personal and commercial purposes.

Observations on the relationships between light truck capabilities and fuel economy are based on manufacturer specifications and EPA fuel economy ratings for a sample of model year 1994 light trucks. Existing fuel economy studies are referenced to identify potential fuel economy technologies for model years 1998 through 2006. The estimated fuel economy gain for implementation of each fuel economy technology is also presented. Potential conflicts between the application of each fuel economy technology and light truck enhanced capabilities, future emissions and safety standards, and consumer choice attributes are presented.

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PREFACE

The House Appropriations Committee has directed the National Highway Traffic Safety Administration (NHTSA) to prepare a report identifying the unique capabilities, utility requirements, and uses of light trucks. Congress has also asked NHTSA to analyze whether such requirements would result in design constraints that would limit fuel economy improvements. The language of this request, from the Committee's 1995 Report on the Department of Transportation, follows:

> "The committee notes that NHTSA issued on April 6, 1994, an advanced notice of proposed rulemaking that requests information to assist the agency in assessing the extent to which manufacturers can improve light truck fuel economy for model years 1998 through 2006. The committee is concerned that advanced notice of proposed rulemaking does not adequately address the wide diversity of uses of light duty trucks.
>
> "Accordingly, the committee directs NHTSA to conduct an evaluation of the unique capabilities, use and utility requirements of light trucks and to analyze whether such requirements result in design constraints which limit future fuel economy increases. This evaluation should include a review of relevant technologies and their impact on consumer choice, product size, and load-carrying capability, driveability, and customer needs. The latter should include consideration of how light trucks are used in commercial and agricultural applications, by the disabled and handicapped and other special uses such as vanpools, off-road environments, towings, and recreational uses, not just as alternatives to passenger vehicles.
>
> "In this study, NHTSA should recognize the full range of uses of these vehicles by individual consumers and that even when these vehicles are used as passenger vehicles they also are used for moving household items, furniture, athletic teams and equipment, yard supplies, and numerous homeowner purposes. Additional factors which should be addressed include the effect of other federal and state vehicle standards (for example, safety and emissions standards), voluntarily-added safety features, and the general impact of major changes in light truck fuel economy on employment, the nation's economy in general, and international trade and competitiveness."

In response to these directives and other related issues posed by Congress, the Volpe Center has prepared this report to NHTSA. The report presents the best publicly available data and information from the most current primary data sources and examines the interrelationships between the fuel economy of light trucks and their capabilities, utility requirements, and use.

EXECUTIVE SUMMARY

In April 1994, NHTSA issued an Advance Notice of Proposed Rule Making (ANPRM) requesting information regarding light truck fuel economy capabilities for model years 1998 through 2006. Subsequently, in the Department of Transportation Appropriations Act for FY 1995, Congress requested that NHTSA perform a study addressing two key questions:

1. What are the unique capabilities, utility requirements, and uses of light trucks?

2. Do these consumer requirements and other regulatory requirements constrain the ability to improve light truck fuel economy?

In order to address Congress' questions, key concerns and compile the appropriate information, it was important to establish clear definitions for the following terms:

Capabilities - those functions or tasks that light trucks perform with substantially greater ease than passenger cars.

Utility requirements - those functions or capabilities that consumers or businesses demand to satisfy specific needs.

Use - the actual use of the vehicles in terms of the extent to which particular capabilities are employed.

The principal findings of the study conducted for NHTSA by the Volpe Transportation Systems Center follow.

I. The CAFE System and Development of the Light Truck Market

The light duty vehicle market has undergone a major shift in consumer demand from passenger automobiles to light trucks, with light truck market share increasing from 20% of light duty vehicle sales in 1975, to roughly 40% of sales in 1994. The light truck market has also diversified over the years, with the advent of compact pickups, compact sport utility vehicles (SUVs), and minivans. The average weight, horsepower, and power-to-weight ratio of new light trucks have increased steadily over the past 7 years.

The CAFE standard for light trucks increased from 17.2 miles per gallon (mpg) in 1979 to 20.6 mpg in 1995, compared to the 1995 CAFE standard for passenger cars of 27.5 mpg. The increased market share of light trucks over the past two decades and the lower average fuel economy of light trucks relative to cars have contributed to a lowering of the average fuel economy for the entire light duty fleet.

II. Light Truck Capabilities, Utility Requirements and Use

For the purposes of this study, light trucks are grouped into four segments: passenger vans, cargo vans, pickups, and SUVs. Capabilities of light trucks that are notably superior to those of passenger cars are referred to as the *enhanced* capabilities of light trucks. Most light trucks subject to CAFE possess one or more of the following enhanced capabilities:

- Load carrying (passengers), which can be as high as fifteen passengers for passenger vans.
- Load carrying (weight), which can be up to 3200 pounds of payload for pickups and cargo vans.
- Load carrying (volume), which is as high as 300 cubic feet of capacity for cargo vans and over 40 square feet of open-top cargo space for pickups.
- Towing, which can be as high as 9100 pounds of towing capacity for pickups and 6500 pounds for SUVs.
- Off-road operation, which is a capability of all four-wheel drive SUVs and four-wheel drive pickups.

Conclusions regarding *utility requirements* for light trucks include:

- Individual consumers value the passenger capacity, roominess and versatility of small vans.
- Individual consumers value the availability of four-wheel drive for SUVs; they are less interested in their ability to operate off-road.
- Businesses have needs for the passenger-moving capabilities of vans, the hauling capabilities of pickups and vans, and the towing capabilities of light trucks in general.
- Rural businesses, such as farming, ranching, forestry, timber, petroleum and mining, have needs that require light truck off-road capability.

The three major use categories for light trucks identified and quantified by the 1992 TIUS report are:

- Personal transportation, which excludes all commercial uses, and accounted for 75.5% of light truck use.
- Commercial transportation, which accounted for 22.2% of light-truck use.
- Mixed personal and commercial, which accounted for only 2.3% of light truck use.

Conclusions regarding light trucks *use* include:

- Of the light trucks used for personal transportation, minivans, in particular, are used for family and social/recreational purposes and typically carry higher passenger loads than cars.
- Light trucks in business use are employed in services, agricultural use, contractor activities, and construction use. Pickups are most likely to be used in agriculture, large vans in contractor activity, and minivans in trade.
- The majority of light trucks in personal use, including SUVs, are never operated off-road.
- A very small proportion of light trucks, including pickups and SUVs, frequently tow trailers.
- Extremely high levels of towing, payload and passenger capacity generally require light trucks that have a Gross Vehicle Weight Rating (GVWR) above 8500 pounds, and which are therefore not subject to CAFE.

III. Tradeoffs Between Capabilities and Fuel Economy

The following observations apply to a limited sample of model year 1994 light trucks and are not necessarily comprehensive or universally applicable.:

- *Passenger vans*--There is a weak correlation between increased passenger capacity and decreased fuel economy.
- *Cargo vans*--There is a weak correlation between higher payload capacity and lower fuel economy ratings, and a strong correlation between increased volume carrying capacity and decreased fuel economy.
- *Pickups*--There is no correlation between payload capacity or volume carrying capacity (as quantified by cargo bed area) and fuel economy, but there is a moderate correlation between increased pickup towing capacity and reduced fuel economy.
- *SUVs*--There is a moderate correlation between increased towing capacity and reduced fuel economy. SUVs with four-wheel drive achieved lower fuel economy than two-wheel drive versions of the same vehicle.

There are a great number of technologies that have the potential to improve light truck fuel economy for model years of 1998 through 2006. The applicability and effectiveness of particular fuel economy technologies are assessed given the following considerations:

- Light truck enhanced capabilities
- Future safety and emissions regulations
- Consumer choice as affected by performance, driveability, durability and dependability

Some fuel economy technologies that may conflict with light truck capabilities include *multi-valve engines*, which may limit load-carrying and towing capacity; *aerodynamic enhancement* which may reduce passenger carrying capabilities and load volumes; *rolling resistance reduction*, which may impair load-carrying and off-road capability; *Continuously Variable Transmissions* (CVTs), which may limit load-carrying and towing capacities; and *front-wheel drive,* which may limit load-carrying capacity, towing capacity, and off-road capability.

Future safety measures may conflict with efforts to improve light truck fuel economy through *weight reduction.* Compliance with safety standards reduces the potential for weight savings through redesign or the use of lighter materials.

A number of fuel economy technologies may conflict with more stringent future emissions standards. Nitrogen oxygen compound (NO_X) emissions standards in particular pose an obstacle to implementation of *lean burn-fast burn combustion, increased compression ratios, turbocharging, supercharging,* and *diesel cycle engines. Diesel cycle* engines may also have high levels of particulate matter (PM) emissions, while *two-stroke cycle* engines can be prone to either high hydrocarbon (HC) or high NO_X emissions.

Conflicts between the fuel economy technologies considered and consumer choice attributes of performance and driveability are minor.

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1. Introduction

1.1 BACKGROUND

In April 1994, NHTSA requested information to set Corporate Average Fuel Economy (CAFE) standards for light trucks for model years 1998 through 2006. No changes are planned in the 27.5 mpg requirement for passenger cars. In response, various interest groups, industries, and individuals expressed concern that more stringent fuel economy standards would diminish the capabilities of light trucks. Therefore, in the fall of 1994, Congress requested NHTSA to perform a study addressing two key questions:

1. What are the unique capabilities, utility requirements, and uses of light trucks?

2. Do these consumer requirements and other regulatory requirements constrain the ability to improve light truck fuel economy?

An initial challenge was to clearly define and distinguish from one another the three terms: capabilities, utility requirements, and use. Clear definitions were necessary to identify data requirements and for quantitative comparisons between various light trucks and between light trucks and passenger cars. The study uses the following definitions:

- **Capabilities** - those functions or tasks that light trucks perform with substantially greater ease than passenger cars (e.g., the ability to carry a heavy or bulky payload without a significant reduction in vehicle performance).

- **Utility requirements** - those functions or capabilities that consumers or businesses demand to satisfy specific needs (e.g., carrying a great number of passengers).

- **Use** - the actual use of the vehicles in terms of the extent to which particular capabilities are employed (the extent to which private motorists make use of the capability of sport-utility vehicles (SUVs) to be driven off road).

1.2 SCOPE

Since 1979, light trucks have been subject to CAFE regulations under the Motor Vehicle Information and Cost Savings Act. CAFE applies to light trucks with a Gross Vehicle Weight Rating (GVWR) of 8,500 pounds or less. The GVWR is the combined vehicle and load weight limit as determined by the vehicle manufacturer. This report divides the market into three major light truck segments: pickups, vans, and sport utility vehicles (SUVs). The report contrasts the capabilities, utility requirements, and use of light trucks subject to CAFE with those of passenger cars, as well as light trucks with GVWRs over 8,500 pounds.

The limitation of CAFE to light trucks of 8500 pounds GVWR or less is intended to exclude the larger, more powerful models designed to perform various heavy hauling tasks, such as might be associated with business applications. However, the utility requirements of certain private consumers, particularly for heavy trailer-towing and for carrying the extra weight added by custom-fabricated bodies, require trucks with GVWRs above 8500 pounds. One study noted, "Industry normally considers all trucks to 10,000 pounds GVW as light trucks, and the requirement to meet CAFE regulations may have caused some shift to increased sales in the 8,500 to 10,000 pounds GVW category."[1] Unfortunately, all public historical sales data and sales forecasts for vehicles with GVWRs up to 10,000 pounds are reported on a calendar year basis while CAFE related sales data for vehicles with GVWRs below 8,500 pounds are reported on a model year basis. Hence, it is difficult to obtain a consistent estimate of sales in the 8,500 to 10,000 pounds category by calendar or model year.[2]

1.3 RESEARCH METHODOLOGY

Each light truck segment consists of many combinations of sizes and body styles aimed at specific requirements and preferences. Because this report obtained data from several sources, which did not use the same classification criteria for light truck segments, the data was not always comparable from segment to segment or year to year.

Because the reporting methods used by primary sources for this report vary, rigorous comparative analysis was not possible; however, the data, as a whole, tell a consistent story and address the major questions posed by Congress. Not all questions can be answered. For example, available survey data shed light on the frequency with which light truck capabilities are used (e.g., how often pickups are used to haul cargo), but not on the degree to which these capabilities are used (e.g., how much cargo is hauled, and, hence, what percent of the payload capacities of pickups is actually used).

In addition, studies could not be found that rigorously investigated the trade-offs between fuel economy and light truck capabilities. Because such an analysis was beyond the scope of this report, fuel economy and light truck capabilities (such as towing, payload capacity, number of passengers carried, cargo volume) were correlated on the basis of empirical observations derived from manufacturers' sales literature and automotive journals. Because of the many variables affecting capabilities and fuel economy, these relatively simple correlations do not prove cause-and-effect, but they do give insight into the relationships between capabilities and light truck fuel economy.

Whenever possible, primary source data have been reinforced by secondary sources including consumer buyers' surveys, journal articles, and publicly available market research. This report's major sources of information are presented in the following chart.

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[1] Energy and Environmental Analysis, Inc. *Domestic Manufacturers Light Duty Truck Fuel Economy Potential to 2005*, prepared for Martin Marietta Energy Systems, Oak Ridge, TN, January 1994, p. 2-1

[2] Ibid, p. 2-1.

Primary Data Sources

Data Source	Years	Vehicle Classifications
Energy Information Agency of the U.S. DOE, "Residential Transportation Energy Consumption Survey (RTECS)"	1988, 1991 vehicle fleets	• No distinction between light trucks subject to CAFE and heavier (greater than 8,500 GVWR) light trucks • Passenger cars • Pickups • Minivans • Full-size vans • Sport-utilities
EPA, "Light-Duty Automotive Technology and Fuel Economy Trends Through 1993"	1975 to 1993 model years	• Light trucks up to 8,500 lb. GVWR • Passenger cars (miscellaneous) • Small pickups, vans, and sport-utilities • Large pickups, vans, and sport-utilities
NHTSA, "CAFE database"	1984 to 1994 model years	• Light trucks up to 8,500 lb. GVWR • Passenger cars other than station wagons • Station wagons based on passenger cars • Small and large pickups • Small and large passenger vans • Small and large cargo vans • Small and large sport-utilities
U.S. Bureau of the Census, "Truck Inventory and Use Survey (TIUS)"	1982, 1987, 1992 vehicle fleets	• No distinction between light trucks subject to CAFE and heavier (greater than 8,500 GVWR) light trucks • Pickups • Minivans • Full-size vans • Sport-utilities
National Personal Transportation Survey	1990 vehicle fleet	• No distinction between light trucks subject to CAFE and heavier (greater than 8,500 GVWR) light trucks • Pickups • Minivans • Full-size vans • Sport-utilities
Ward's Automotive News/Yearbooks and other miscellaneous public domain sources	Primarily model year 1995, Forecasts for later years	• Model specific

1.4 REPORT ORGANIZATION

Chapter 2 provides background information on the forces which had the greatest impact on the development of the light truck market. Chapter 2 contains an explanation of the CAFE system. There is also a summary of the development of the light truck market and a discussion of light truck trends in three areas: sales, fuel economy, and capabilities. Chapter 2 also outlines the potential national macroeconomic and industrial impacts of increased light truck fuel economy standards. The chapter also addresses Congress's desire to consider the impact of light truck CAFE on the economy, jobs, and industry competitiveness.

Chapter 3 defines and identifies the capabilities of light trucks subject to CAFE and assesses the utility requirements of commercial and individual consumers, plus the form and extent of their use of these capabilities. This analysis also presents comparisons with automobiles and with light trucks of higher GVWR that are exempt from CAFE.

Chapter 4 examines the trade-offs between light truck capabilities and fuel economy improvements. In addition, Chapter 4 identifies the potential fuel economy impact of new automotive technologies, safety standards, and emissions standards.

2. The CAFE System and Development of the Light Truck Market

2.1 INTRODUCTION

Chapter 2 provides background information on the U.S. corporate average fuel economy (CAFE) program plus historical and trend data on the light truck market. This information is provided to understand the development and size of this market and put the report's data and analysis into proper context. This chapter also examines the impact of the auto industry and light truck sales on the national economy and addresses Congress's concern with the impact of increases in the light truck CAFE standard.

Five significant historical developments are examined:

1. Establishment of the CAFE system and the basis for the difference between the fuel economy standards set for light trucks and those set for passenger automobiles.

2. Development of the light truck market from the early 1970's through the present, highlighting the increased light truck penetration of consumer markets (in reaction to post-oil crisis downsizing of passenger cars), the advent of compact pickups and, later, compact SUVs and minivans, and the production of light trucks by the Big Three manufacturers at their capacity limits.

3. Changes in the sales volumes and market shares for light truck categories affected by CAFE program, such as the expansion of minivan and SUV sales at the expense of station wagons, and the decrease in small pickup sales compensated for by an increase in the sales of large, heavier models.

4. Fuel economy trends of light trucks subject to CAFE, characterized by early significant improvement followed by a decade of stagnation.

5. Trends in vehicle weight and performance of light trucks subject to CAFE, especially the general increase in horsepower since the early 1980's.

2.2 THE CAFE SYSTEM

In 1974, world oil prices tripled as the average fuel economy rating of the new U.S. passenger car fleet fell to a historic low of 14 miles per gallon (mpg). In order to improve the fuel economy of the passenger fleet, Congress enacted the Energy Policy and Conservation Act of 1975, which established passenger car CAFE standards for each automaker, starting at 18 mpg in 1978 and increasing to 27.5 mpg by 1985.

The legislation authorized the Secretary of Transportation to determine the standard for light trucks. Currently, the CAFE standard applies to vehicles classified as pickups, vans, and utility vehicles with a GVWR less than or equal to 8,500 pounds. The 8,500-pound maximum excludes certain light trucks from CAFE requirements, principally large models of full-size vans and pickups. Commercial or recreational vehicles built on vans whose bodies have been cut away in the rear or on pickups produced in cab-and-chassis form, also have GVWRs above the 8500 pound CAFE limit.

Table 2-1. Corporate Average Fuel Economy (CAFE) Standards and the Sales-Weighted Fuel Economy Estimates for Automobiles and Light Trucks, 1978-95[a] (mpg)

Model Year	Automobiles				Light Trucks[b]			
	CAFE[c] Standards	CAFE Estimates			CAFE Standards	Cafe Estimates		
		Domestic	Import	Combined		Domestic	Import	Combined
1978	18.0	18.7	27.3	19.9	d	d	d	d
1979	19.0	19.3	26.1	20.3	17.2	17.7	20.8	18.2
1980	20.0	22.6	29.6	24.3	e	16.8	24.3	18.5
1981	22.0	24.2	31.5	25.9	e	18.3	27.4	20.1
1982	24.0	25.0	31.1	26.6	17.5	19.2	27.0	20.5
1983	26.0	24.4	32.4	26.4	19.0	19.6	27.1	20.7
1984	27.0	25.5	32.0	26.9	20.0	19.3	26.7	20.6
1985	27.5	26.3	31.5	27.6	19.5	19.6	26.5	20.7
1986	26.0	26.9	31.6	28.2	20.0	19.9	25.9	21.5
1987	26.0	27.0	31.2	28.5	20.5	20.5	25.2	21.7
1988	26.0	27.4	31.5	28.8	20.5	20.6	24.6	21.3
1989	26.5	27.2	30.8	28.4	20.5	20.4	23.5	21.0
1990	27.5	26.9	29.9	28.0	20.0	20.3	23.0	20.8
1991	27.5	27.3	30.0	28.3	20.2	20.9	23.0	21.3
1992	27.5	27.0	29.1	27.8	20.2	20.5	22.7	20.8
1993	27.5	27.8	29.5	28.4	20.4	20.7	22.8	20.8
1994	27.5	27.3	29.6	28.2	20.5	20.4	22.0	20.6
1995	27.5	27.7	29.9	28.5	20.6	20.1	21.6	20.4
1996	27.5				20.7			

Source: Adapted from ORNL based on U.S. Department of Transportation, NHTSA, *Summary of Fuel Economy Performance*, Washington, D.C., September 1994.

a Only vehicles with at least 75 percent domestic content can be counted in the average domestic fuel economy for a manufacturer.
b Represents two- and four-wheel drive trucks combined. Gross vehicle weight of 0-6,000 lb. for model year 1979 and 0-8,500 lb. for subsequent years.
c All CAFE calculations are sales-weighted.
d Standards for light trucks were first set for model year 1979.
e Standards were set for two-wheel drive and four-wheel drive light trucks separately, but no combined standard was set for this year.

CAFE standards are based on city and highway driving test procedures administered by the Environmental Protection Agency (EPA). Fleet CAFE values are measured as the sales-weighted harmonic mean of the individual fuel economies of an automaker's models. Each automaker's domestically produced and imported vehicles must comply as separate fleets.

CAFE standards steadily increased from 1978 to 1984, but since then have remained fairly constant or even occasionally decreased (see Table 2-1). The standards for light trucks for model years 1994 and 1995 were 20.5 mpg and 20.6 mpg, respectively. The DOT established a standard of 20.7 for model years 1996 and 1997. The CAFE standard for passenger cars for model year 1995 remains at 27.5 mpg.

Center for Auto Safety director Clarence Ditlow called CAFE, "the most significant energy conservation program" in the country, pointing out that it had significantly cut both U.S. oil consumption and air pollution (Associated Press: 7/25/95). One study provides specific figures to demonstrate the savings:

> "In the nearly two decades since the first oil shock in 1973, both regulatory pressure (the Energy Policy and Conservation Act of 1975 and its new-car fuel economy standards) and market forces drove fuel economy of the U.S. new car fleet from 14 miles per gallon to 28 mpg, saving about 2 million barrels per day of oil that would have been used had fuel economy remained at 1975 levels ....Because demand for auto travel continues to grow, gasoline use must also increase if fleet efficiency stagnates."[1]

2.3 DEVELOPMENT OF THE LIGHT TRUCK MARKET

The significant increase in sales and changes in product offerings for the light truck market is a well-documented chapter in American automotive history. As passenger cars initially became smaller and less powerful in response to higher fuel prices after 1973, purchasers began to opt for the increased passenger room and the load-carrying and towing ability offered by the conventional-size vans, pickup trucks, and four-wheel drive SUVs.

Three distinct phases occurred in the development of the light truck market: the expansion of the 1970's, which was due in large part to increased sales of small, imported pickups; rapid sales growth of the 1980's, especially for compact SUVs and minivans; and the recession and recovery of the 1990's. This section of the report highlights the key events in development of the light truck market.

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[1] U.S. Congress, Office of Technology Assessment, *Improving Automobile Fuel Economy: New Standards, New Approaches*, OTA-E-504, Washington, D.C.: U.S. Government Printing Office, October 1991, p. 1.

Table 2-2 contains examples of popular light truck model nameplates, grouped by light truck segment.

Table 2-2. Examples of Nameplates by Light Truck Segment, 1990-1995

Small Passenger Vans/Minivans	**Large Passenger Vans**
Chrysler: Town & Country, Dodge Caravan, Plymouth Voyager **Ford:** Aerostar, Windstar **GM:** Chevy Lumina, Chevy Astro, GMC Safari, Oldsmobile Silhouette, Pontiac Trans Sport **Nissan:** Quest **Toyota:** Previa, Minivan	**Chrysler:** Dodge Ram Wagon **Ford:** Club Wagon **GM:** Chevy Sportvan, GMC Rally
Small Cargo Vans	**Large Cargo Vans**
Chrysler: Dodge Caravan Cargo, Plymouth Voyager Cargo **Ford:** Aerostar Cargo **GM:** Chevy Astro Cargo, GMC Safari Cargo **Toyota:** Minivan Cargo	**Chrysler:** Dodge Ram Van 1500/2500/3500 **Ford:** Econoline E150/250/350 **GM:** Chevy Van G10/20/30, GMC Vandura
Small Pickups	**Large Pickups**
Chrysler: Dodge Dakota **Ford:** Ford Ranger **GM:** Chevy Sonoma, Chevy S10/T10 **Nissan:** All Nissan pickups **Toyota:** All Toyota pickups except T100 **Isuzu:** All Isuzu pickups	**Chrysler:** Dodge D 150/250/350, Dodge Ram 1500/2500/3500 **Ford:** F150/250/350 **GM:** Chevy C/K 1500/2500/3500, GMC Sierra **Toyota:** T100
Small SUVs	**Large SUVs**
Chrysler: Jeep Cherokee, Jeep CJ/Wrangler **Ford:** Ford Explorer **GM:** Chevy S10/T10 Blazer, GMC S15/T15 Jimmy, Geo Tracker, Oldsmobile Bravada **Nissan:** Pathfinder **Toyota:** 4Runner **Isuzu:** Rodeo **Suzuki:** Sidekick, Samurai	**Chrysler:** Dodge Ramcharger **Ford:** Bronco **GM:** Chevy Suburban, GMC Suburban, GMC Yukon

2.3.1 1970's Expansion of the U.S. Light Truck Market: Importation of Small Pickups

The following developments marked the light truck market of the 1970's:

- After 1973, purchasers begin to opt for conventional-sized vans, pickup trucks and four-wheel-drive SUVs as alternatives to small, less powerful passenger cars.

- By the end of the 1970's, domestic manufacturers shift capacity toward van, pickup and utility vehicle production.

- A significant U.S. market develops for small pickup trucks produced by Japanese manufacturers.

- (At the end of the 1970's,) various safety equipment standards previously applied only to passenger cars are imposed on light trucks.

- Emissions standards are applied to class 2 (6,001-10,000-pound GVWR) trucks as well as class 1 (6,000 pounds and under). These new standards ended a market advantage of the former since they could no longer avoid catalytic converters and required more expensive unleaded fuel.

- Retail sales of light trucks peak in calendar year 1978, but fall off rapidly with the sharply higher gasoline prices and shortages of 1979, and continue to fall through 1981.

2.3.2 The Growth Market of the 1980's: Advent of Compact SUVs and Minivans

The following developments marked the light truck market of the 1980's:

- During 1980-82, the U.S. experiences periods of economic recession and historical peaks in interest rates.

- Sales of vans and SUVs suffer. However, sales of the new small pickups actually continue to increase. In 1981 two small U.S.-built pickups are introduced: the Ford Ranger and the GMC S-series.

- With the beginning of the long cycle of U.S. economic growth in the early 1980's and the decline in interest rates, light truck sales recover, surpassing the previous peak sales level of 1978 by 1984.

- Japan agrees to limit the total number of vehicles exported annually to the U.S. through the Voluntary Restraint Agreement (VRA), which goes into effect on April 1st, 1981. The agreement is amended in 1984 to allow unlimited exports of light trucks to the U.S., but subjecting them to a 25% import tariff.

- The Japanese manufacturers continue to export significant volumes of small pickups. By 1985, retail sales of imported vans, pickup trucks, and SUVs are more than twice what they had been in 1978.

- In model year 1983, Ford, General Motors, and American Motors introduce new compact versions of their Bronco, Chevrolet Blazer/GMC Jimmy, and Jeep Cherokee/Wagoneer four-wheel drive SUVs, respectively. Toyota and Isuzu introduce imported compact SUVs for model year 1984.

- At the beginning of the 1984 model year, Chrysler introduces the first downsized van or minivan, which has become a significant feature of the U.S. personal automobile market in recent years. The first minivans are adapted from Chrysler's successful front-wheel drive compact car line. At the same time Toyota starts to import a rear-wheel drive minivan. The market for these vehicles is extremely strong, and selling prices of both vehicles rise to above-sticker or premium levels. *Ward's Automotive Yearbook* for 1985 comments that this phenomenon "had not been seen since the van and four-wheel drive boom of the mid-to-late 1970's." Both minivans are also offered in cargo versions.

- Ford and General Motors bring out rear-wheel drive minivans for model year 1985.

2.3.3 1990 Recession and Recovery: Expansion of the SUV Market

The following developments marked the light truck market of the 1990's:

- In 1990, both Ford and General Motors expand their sport-utility lines with four-door models, competing for the first time in that sector with Jeep and certain imported models.

- Ford redesigns and re-names its line of compact sport-utilities "Ford Explorer." The Explorer soon becomes the largest-selling SUV in the U.S. and one of the top 10 selling nameplates in the country.

- Declining sales of sub-compact passenger automobiles, plus the final Treasury ruling that two-door truck type vehicles are subject to the 25% U.S. Customs duty on fully-assembled trucks, stimulates interest of Japanese manufacturers in four-door versions of compact SUVs. By 1990, Toyota, Nissan, and Mitsubishi introduce four-door models.

- In model year 1990, General Motors introduces a front-wheel drive van even smaller than its previous minivan, in order to compete with Chrysler.

- U.S. retail sales of light trucks peak in calendar year 1988 and decline throughout the short recession of 1990-91, paralleling passenger car sales. Sales of small pickups imported from Japan begin to fall even before 1988 as the yen appreciates against the dollar, driving up sticker prices.

- Overall U.S. light truck sales decline in the 1990-91 recession, but recover after 1991. By calendar year 1993 sales are ahead of the previous peak in 1988 and continue to rise through 1994.

- In the van and SUV segments, recovery is driven by increased sales of compact models. In the pickup segment, declines in sales of compact versions are more than made up for by increases in the sales of large pickups, such as extended-cab versions of two-door models.

- Large pickups prove to be highly profitable sales lines for the domestic Big Three manufacturers. Until model year 1993, when Toyota introduces a large pickup for the U.S. market, U.S. companies have the large pickup market to themselves.

- By 1994, the capacity of all the Big Three manufacturers is strained to accommodate light truck demand. By contrast, automotive imports from Japan are running below the levels set by Japanese voluntary export restraints (VERs).

2.4 LIGHT TRUCK SALES TRENDS

In this section, historic sales data are presented for light trucks subject to CAFE standards, which limits coverage to trucks with GVWRs of 8,500 pounds and under. As noted in section 1.3, it is difficult to obtain sales data for 8,500- to 10,000-pound GVWR trucks which is consistent with sales data for vehicles subject to CAFE standards.

Figure 2-1 shows truck sales in the U.S., from 1975 to 1984 for 5 vehicle categories subject to CAFE standards: pickups, vans, SUVs, station wagons, and other passenger cars. Figure 2-2 provides similar information for model years 1984 to 1994.

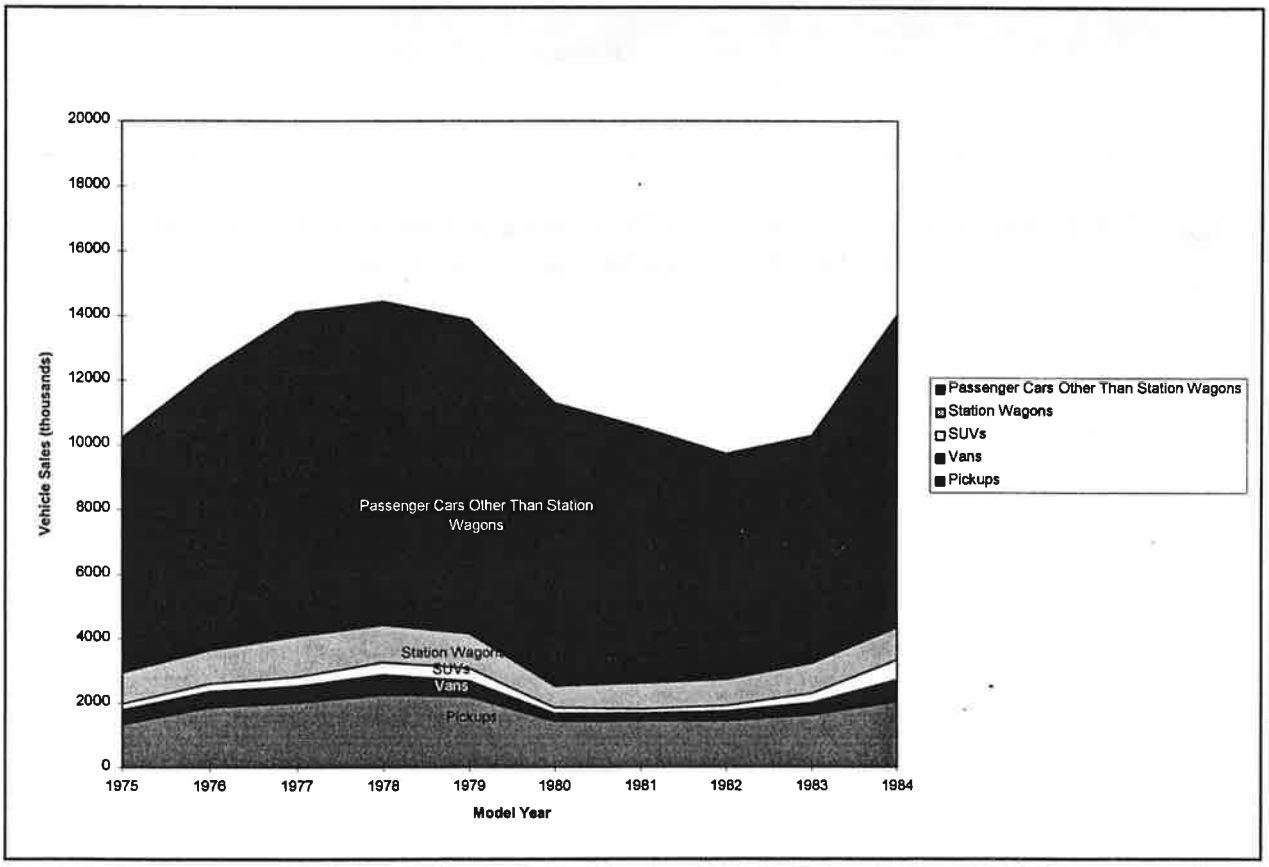

Figure 2-1. Estimated Sales Volumes: U.S. Produced and Imported Vehicles Subject to CAFE Standards, Model Years 1975 - 1984

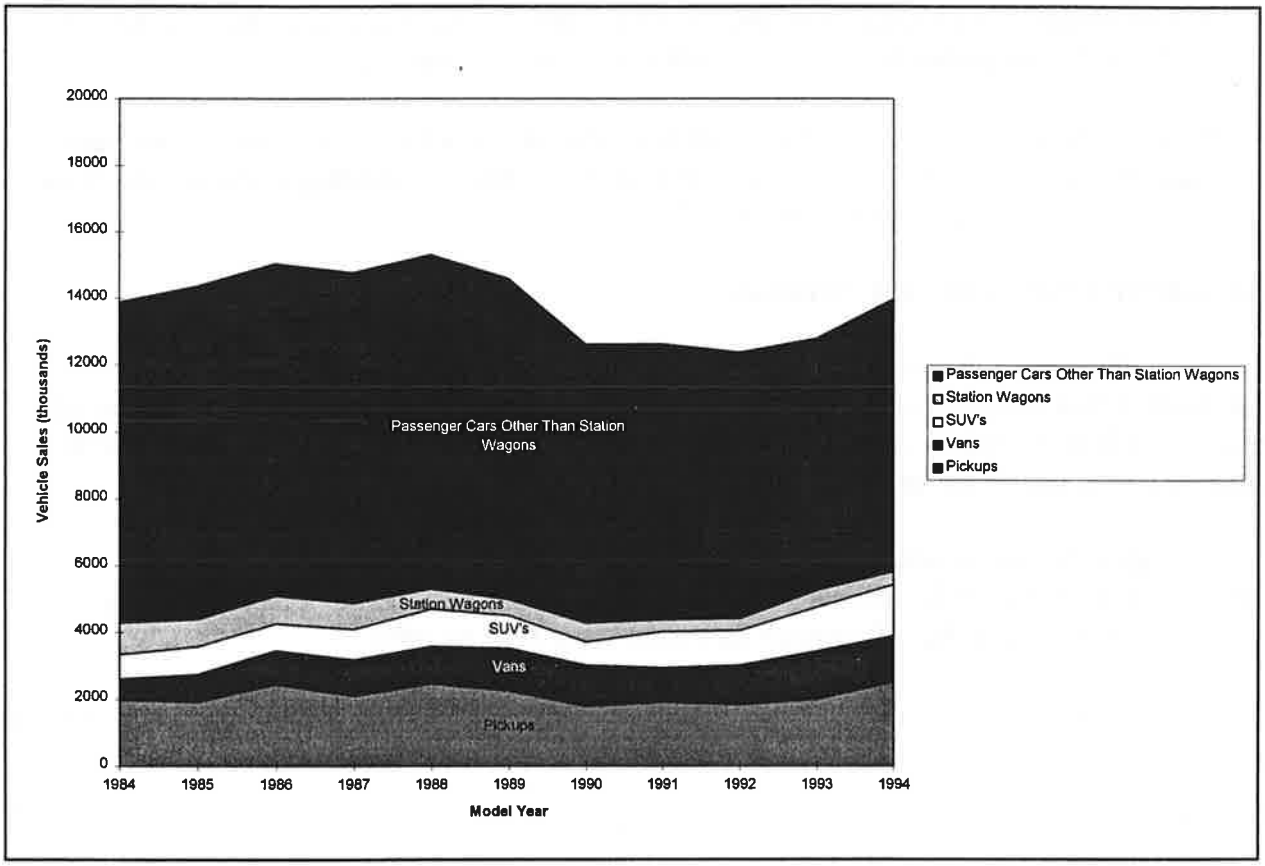

Figure 2-2. Estimated Sales Volumes: U.S. Produced and Imported Vehicles Subject to CAFE Standards, Model Years 1984 - 1994

Figure 2-3 displays the estimated market shares for each of the 5 vehicle categories subject to CAFE standards for model years 1984 to 1994. The evolution of the market as represented by the introduction of new product lines and the resulting sales cycles noted in the previous section can be clearly seen in Figure 2-3.

The growth in van sales after the introduction of minivans in the early 1980's, paralleled by the expansion of SUV sales and the associated decline of station wagon sales highlight the consumers' shift to light trucks as station wagon substitutes. By the mid-80's, two-wheel drive versions of General Motors' compact SUVs were reported as making a significant dent in sales of station wagons. In addition, *The U.S. Industrial Outlook* reported that by 1986, although there was widespread commercial use of minivans, personal use buyers were using them as substitutes for large station wagons. An editorial in *Ward's Automotive Yearbook* noted that industry analysts estimated one million first-time U.S. light truck purchasers in 1988 had switched from passenger cars to light trucks. During most of the 1984-94 period, stable fuel prices did not discourage the purchase of less fuel-efficient light trucks as alternatives to passenger cars.

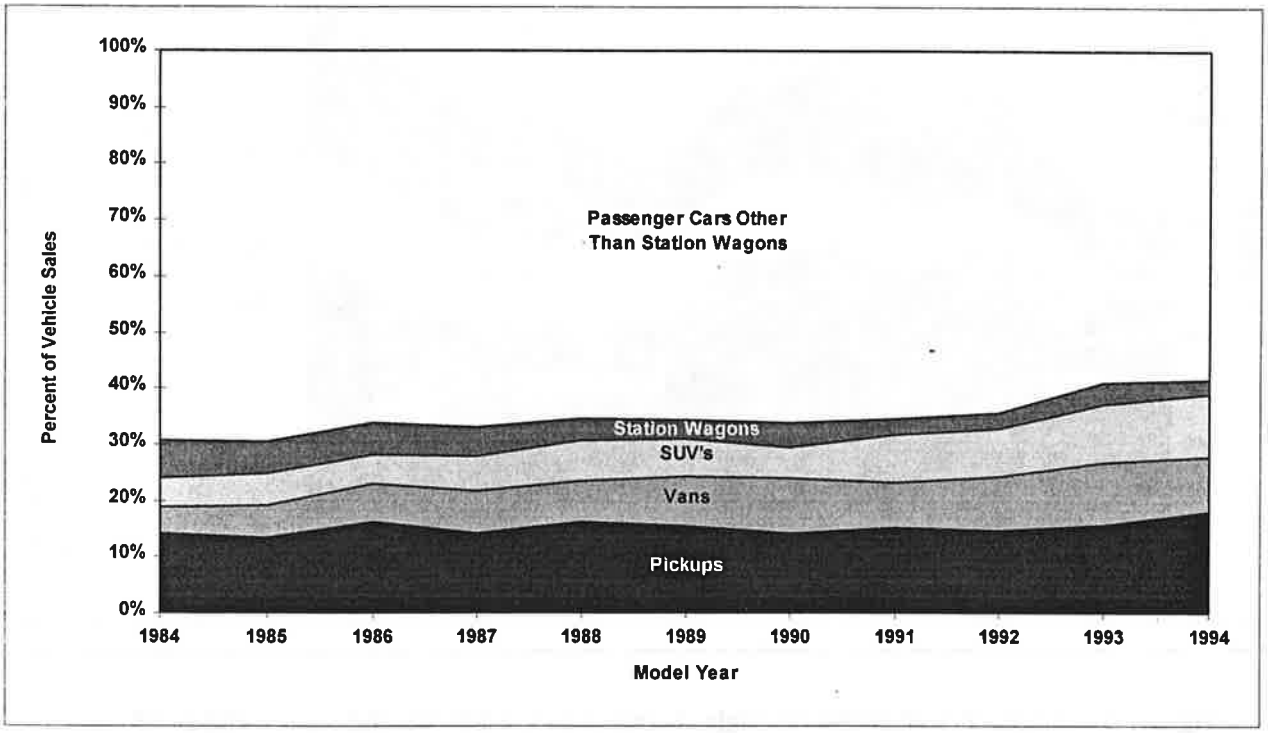

Figure 2-3. Share of Total Estimated Sales: Vehicles Subject to CAFE Standards, Model Years 1984 - 1994

Figure 2-4 and Table 2-2 present more detailed 1984-94 sales data for SUVs, vans, and pickups. Passenger versions of vans are distinguished from cargo versions (including those delivered by manufacturers in stripped-down form for conversion to special uses) and the traditional "full-size" models are distinguished from smaller models for vans, pickups and SUVs.

The 1990's upturn in pickup sales, led by the large models, is conspicuous, as is the long-term growth of small ("mini") passenger vans and small (including "compact") SUVs. These vehicles dominate the under-8,500-pound GVWR van and SUV segments, respectively. The sales volumes for large passenger vans subject to CAFE are very low as most of the large passenger vans sold had GVWRs above the 8500 pound CAFE limit.

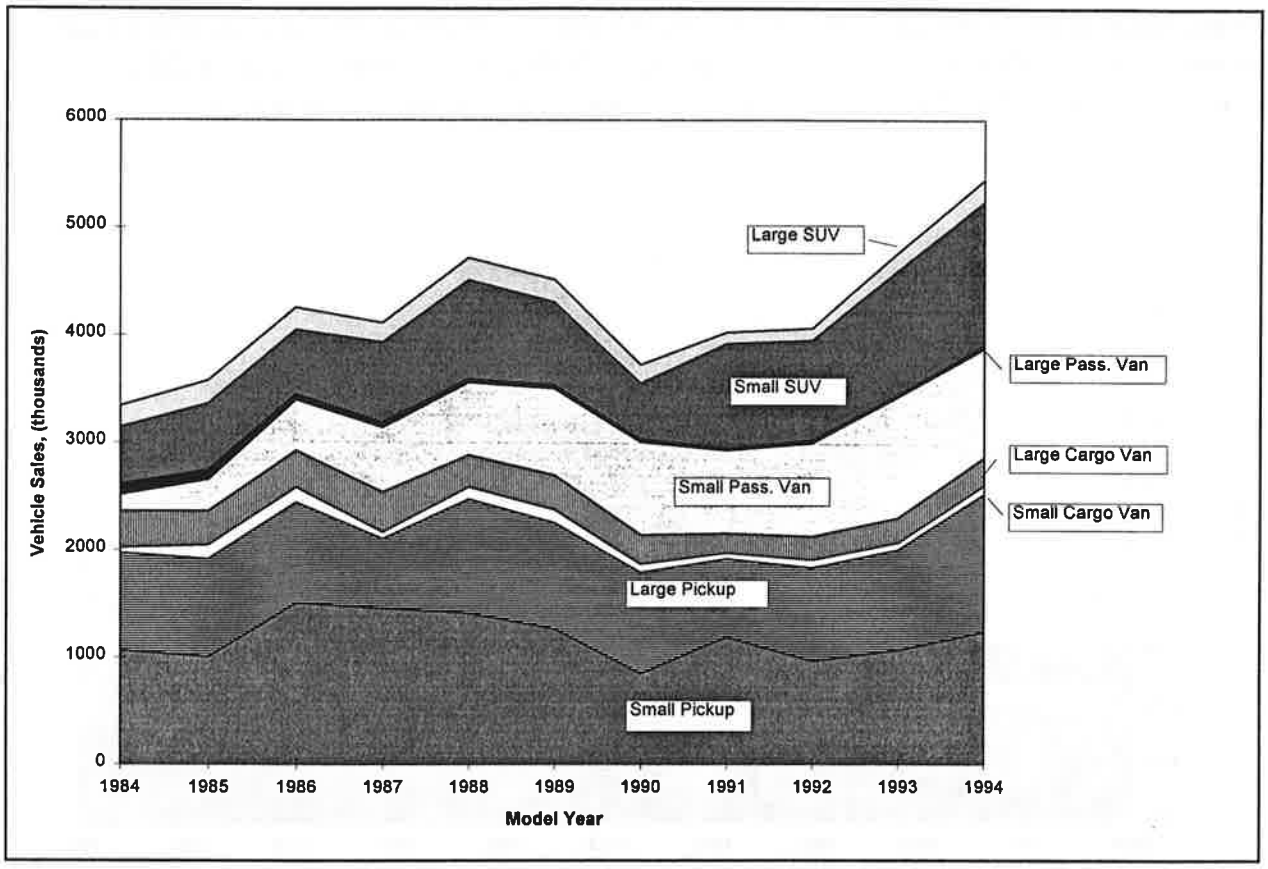

Figure 2-4. Light Truck Sales, Vehicles Subject to CAFE, Model Years 1984 - 1994

Table 2-3. Total Sales (000's): Light Trucks Subject to CAFE Standards, Model Years 1984 - 1994

CATEGORY	MY '84	MY'85	MY'86	MY'87	MY'88	MY'89	MY'90	MY'91	MY'92	MY'93	MY'94
Passenger Vans (Small)	152.5	299.1	476.1	603.3	680.0	807.8	867.7	773.5	872.5	1131.8	1019.2
	(4.5%)	*(8.3%)*	*(11.1%)*	*(14.6%)*	*(14.3%)*	*(17.8%)*	*(23.2%)*	*(19.0%)*	*(21.4%)*	*(23.6%)*	*(18.6%)*
Passenger Vans (Large)	98.8	86.8	52.1	45.7	30.6	31.9	23.9	16.1	25.0	16.8	29.1
	(2.9%)	*(2.4%)*	*(1.2%)*	*(1.1%)*	*(0.6%)*	*(0.7%)*	*(0.6%)*	*(0.4%)*	*(0.6%)*	*(0.4%)*	*(0.5%)*
Cargo Vans (Small)	46.9	129.4	141.5	124.6	110.8	121.2	81.0	55.5	70.0	65.5	81.0
	(1.4%)	*(3.6%)*	*(3.3%)*	*(3.0%)*	*(2.3%)*	*(2.7%)*	*(2.2%)*	*(1.4%)*	*(1.7%)*	*(1.4%)*	*(1.5%)*
Cargo Vans (Large)	339.9	316.4	341.3	311.8	297.8	322.1	268.2	180.0	218.5	227.7	257.9
	(10.1%)	*(8.8%)*	*(8.0%)*	*(7.6%)*	*(6.3%)*	*(7.1%)*	*(7.2%)*	*(4.4%)*	*(5.3%)*	*(4.8%)*	*(4.7%)*
Total Vans	638.1	831.7	1011.0	1085.4	1119.2	1283.0	1240.8	1025.1	1186.0	1441.8	1387.2
	(19.0%)	*(23.1%)*	*(23.6%)*	*(26.3%)*	*(23.6%)*	*(28.2%)*	*(33.1%)*	*(25.2%)*	*(29.0%)*	*(30.1%)*	*(25.4%)*
Pickups (Small)	1064.4	1004.8	1522.6	1460.6	1412.2	1265.9	850.3	1189.8	967.3	1069.8	1239.6
	(31.7%)	*(28.0%)*	*(35.6%)*	*(35.4%)*	*(29.8%)*	*(27.8%)*	*(22.7%)*	*(29.3%)*	*(23.7%)*	*(22.3%)*	*(22.7%)*
Pickups (Large)	912.1	910.9	921.0	643.3	1063.7	987.2	940.9	730.2	870.9	934.4	1281.8
	(27.2%)	*(25.3%)*	*(21.5%)*	*(15.6%)*	*(22.4%)*	*(21.7%)*	*(25.1%)*	*(18.0%)*	*(21.3%)*	*(19.5%)*	*(23.4%)*
Total Pickups	1976.5	1915.7	2443.6	2103.9	2475.9	2253.1	1791.2	1920.0	1838.2	2004.2	2521.4
	(58.9%)	*(53.3%)*	*(57.1%)*	*(51.0%)*	*(52.2%)*	*(49.5%)*	*(47.8%)*	*(47.3%)*	*(45.0%)*	*(41.9%)*	*(46.1%)*
SUV's (Small)	528.2	620.3	599.3	750.1	916.7	767.0	522.6	977.0	931.1	1154.0	1330.3
	(15.7%)	*(17.3%)*	*(14.0%)*	*(18.2%)*	*(19.3%)*	*(16.9%)*	*(14.0%)*	*(24.1%)*	*(22.8%)*	*(24.1%)*	*(24.3%)*
SUV's (Large)	200.9	214.9	204.8	173.8	203.6	215.2	172.8	102.2	107.4	167.5	206.9
	(6.0%)	*(6.0%)*	*(4.8%)*	*(4.2%)*	*(4.3%)*	*(4.7%)*	*(4.6%)*	*(2.5%)*	*(2.6%)*	*(3.5%)*	*(3.8%)*
Total SUV's	729.1	835.2	804.1	923.9	1120.3	982.2	695.4	1079.2	1038.5	1321.5	1537.2
	(21.7%)	*(23.2%)*	*(18.8%)*	*(22.4%)*	*(23.6%)*	*(21.6%)*	*(18.6%)*	*(26.6%)*	*(25.4%)*	*(27.6%)*	*(28.1%)*
Cab & Chassis Units	11.0	11.7	20.3	11.6	26.4	29.5	16.9	36.4	23.9	20.9	25.0
	(0.3%)	*(0.3%)*	*(0.5%)*	*(0.3%)*	*(0.6%)*	*(0.6%)*	*(0.5%)*	*(0.9%)*	*(0.6%)*	*(0.4%)*	*(0.5%)*
Total Light Truck Sales	3354.7	3594.3	4279.0	4124.8	4741.8	4547.8	3744.3	4060.7	4086.6	4788.4	5470.8

2.5 LIGHT TRUCK FUEL ECONOMY TRENDS

The fuel economy of new passenger cars and light trucks improved significantly in the decade following the 1973-74 oil crisis. A 1994 study by Oak Ridge National Laboratory (ORNL) noted that "from 15.3 mpg in 1975, the fuel economy of new light-duty vehicles increased to a peak of 25.9 mpg in 1987 and stood at 25.0 mpg in 1993. Neither passenger car

nor light truck fuel economy has improved significantly for more than a decade." [2] (See Figure 2-5)

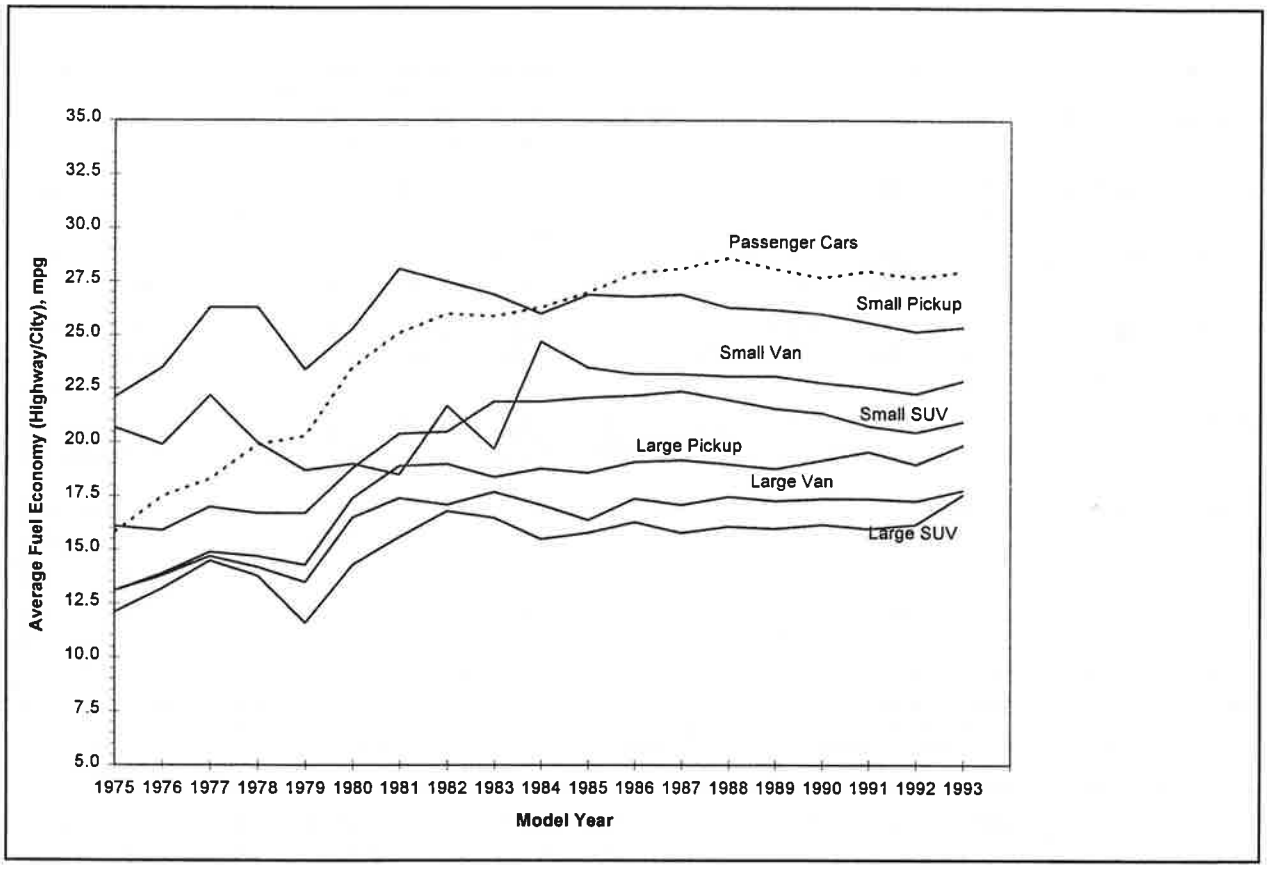

Figure 2-5. Light Truck Fuel Economy Trends

Most of the gains in domestic and import light truck fuel economy were made between 1980 and 1982. Essentially all of the 60% fuel economy gain between 1975 and 1993 was achieved by 1982. As shown in Table 2-1, domestic light truck fuel economy increased from 19.2 mpg in 1982 to 20.4 mpg in 1994, a gain of only 6% in 12 years. Import light truck fuel economy declined significantly from its peak in 1981 of 27.4 mpg to 22.0 mpg in 1994. A 1988 study by the Energy and Environmental Analysis (EEA) observed, "virtually all of the gain in fuel economy achieved since 1982 was due to the introduction of new compact-size pickups, vans, and utilities."[3]

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[2] Oak Ridge National Laboratory, *Transportation Energy Efficiency Trends 1972-92*, prepared for the U.S. Dept. of Energy, Washington, D.C., Dec. 1994.

[3] Energy and Environmental Analysis, Inc., *Light Duty Truck Fuel Economy: Review and Projections 1980-1995*, prepared for U.S. Department of Energy, Washington, D.C., November 1988

The 1988 EEA study also noted that there had been no major technological changes in standard-size light trucks since 1982, "other than the incorporation of four-speed automatic transmissions in trucks by Ford and GM."[4] Between 1982 and 1988, changes in engine calibrations and the use of improved lubricants and tires contributed to "modest" fuel efficiency gains. However, these gains were offset by fuel economy reductions associated with more stringent emission standards and useful life requirements implemented in 1984, as well as consumer demand for increased performance.

Although light-truck fuel efficiency has improved markedly since 1974, light trucks are still substantially less fuel efficient than automobiles. Whereas the average 1990 EPA-rated fuel economy for new automobiles was roughly 28 mpg, the average for new light trucks was closer to 21 mpg. In recent years, light truck fuel economy has averaged about 75% of passenger car mpg (see Figure 2-6). For model year 1993, light-truck fuel consumption ratings pulled the overall new light-duty vehicle average down to about 25.0 mpg.

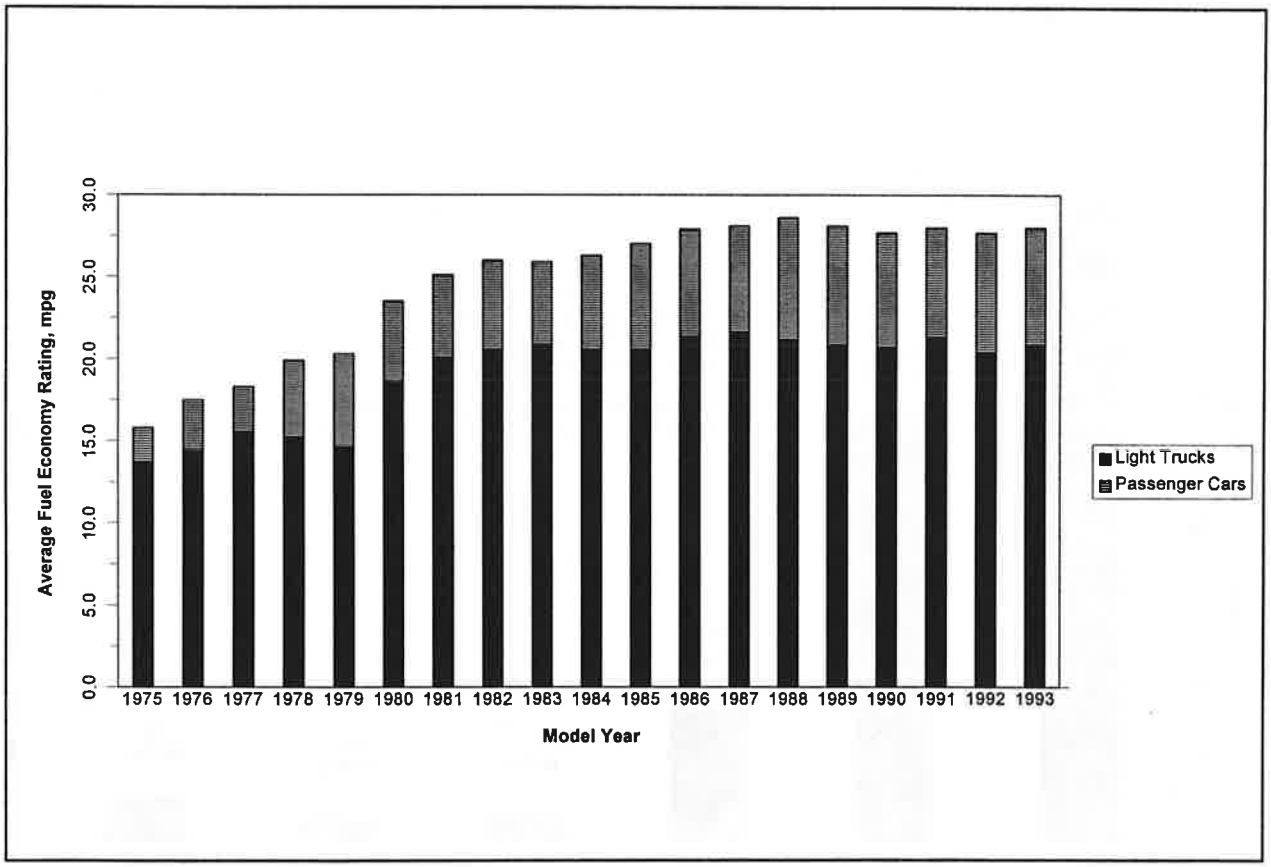


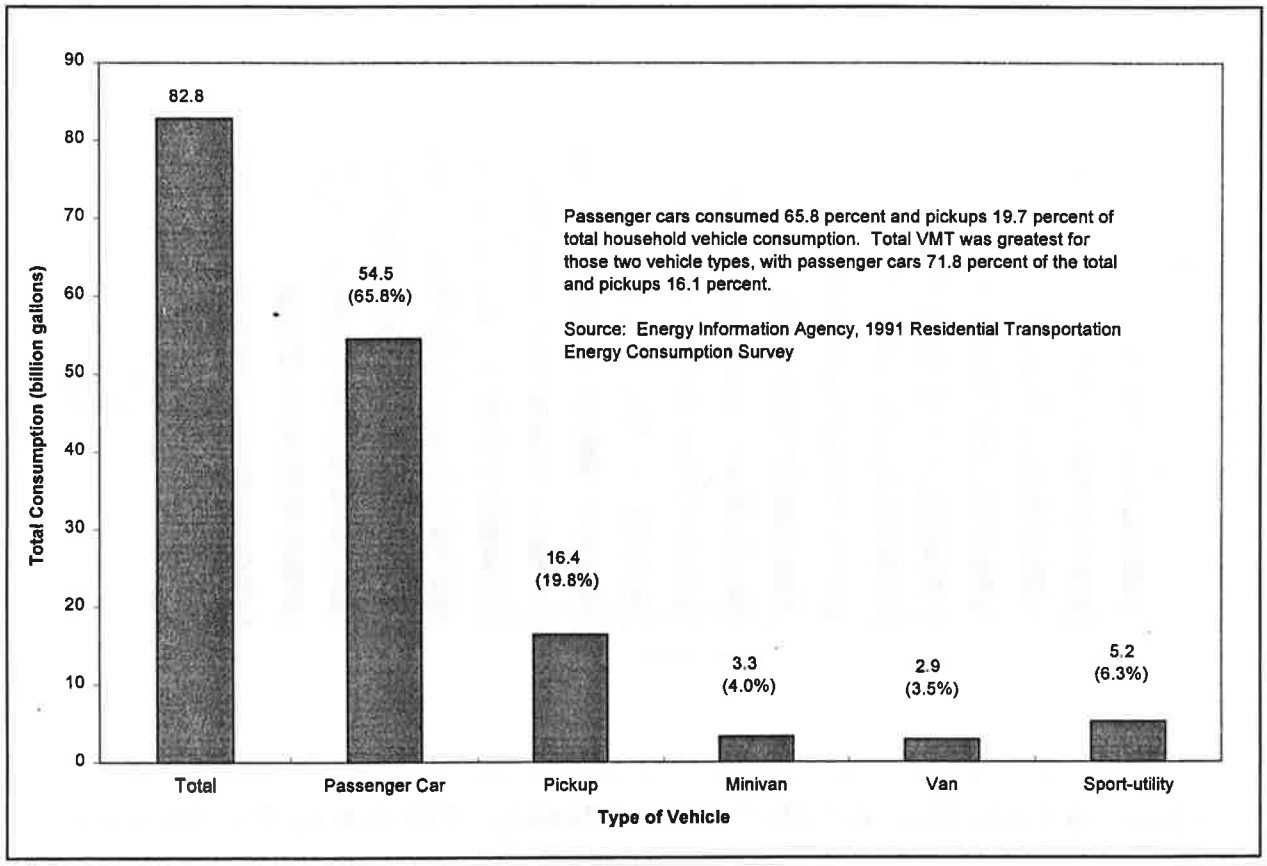
Figure 2-6. Comparison of Light Truck and Passenger Car Average Fuel Economy

As light trucks constitute a larger share of new vehicle sales and the on-road fleet, concern has been raised about the impact of this phenomenon on fuel consumption. The U.S. Census' 1992 *Truck Inventory and Use Survey* estimated the total number of registered private

[4] Ibid.

and commercial light trucks in the U.S. at 53.3 million: 33.0 million pickups, 8.5 million sport-utility vehicles (SUVs), 6.1 million minivans, and 5.7 million full-size vans. The FHWA's *Highway Statistics* estimated private and commercial automobile registration for that year at 143.0 million; based on these figures, therefore, the 1992 light truck share of combined car and light truck registration was 27%. In 1994, light trucks accounted for over 40% of the combined U.S. sales of new light trucks and cars, up from less than 33% in 1990.[5]

However, ORNL estimates that the 1975-1993 increase in fuel economy for new light vehicles would have been only about 10% higher if light trucks had not increased their market share of overall car and truck sales during that period.[6] ORNL estimates that the increased market share of light trucks reduced overall fuel economy by less than 1 mpg. This can be explained by the significant increase in both passenger car and light truck fuel economy during the last twenty years. In addition, the shift in light truck sales from larger to smaller trucks had a positive effect on average fuel economy.



[5] *Ward's Automotive Yearbook, 1990* and *1995*. The light truck sales figures include some vehicles with GVWRs above 8500 pounds that are not subject to CAFE but exclude any vehicles that are not vans, pickups, or SUVs.
[6] Oak Ridge National Laboratory, op. cit.

Figure 2-7. Total Annual Vehicle Fuel Consumption, by Vehicle Type for 1991

Figures 2-7 through 2-9 reproduce bar charts prepared by the Energy Information Agency of the Department of Energy that illustrate the differences between the total fuel consumption and fuel economy of all passenger cars, pickups, SUVs, vans, and minivans being operated in 1991 by households. These fuel economy figures are, of course, lower than those previously cited for new vehicles alone since they are derived from the entire fleet of old and new vehicles on the road.

In summary, both passenger car and light truck fuel economy have improved since the fuel conservation issue first arose in the early 1970's, although most of the improvement in the average economy of new cars and light trucks occurred in the early 1980's. The improvement in light truck fuel economy has somewhat mitigated the negative effect of the increasing share of light trucks overall light vehicle sales. New light trucks still, on average, have both lower fuel economy ratings and higher annual per-vehicle consumption of fuel in household use than passenger cars.

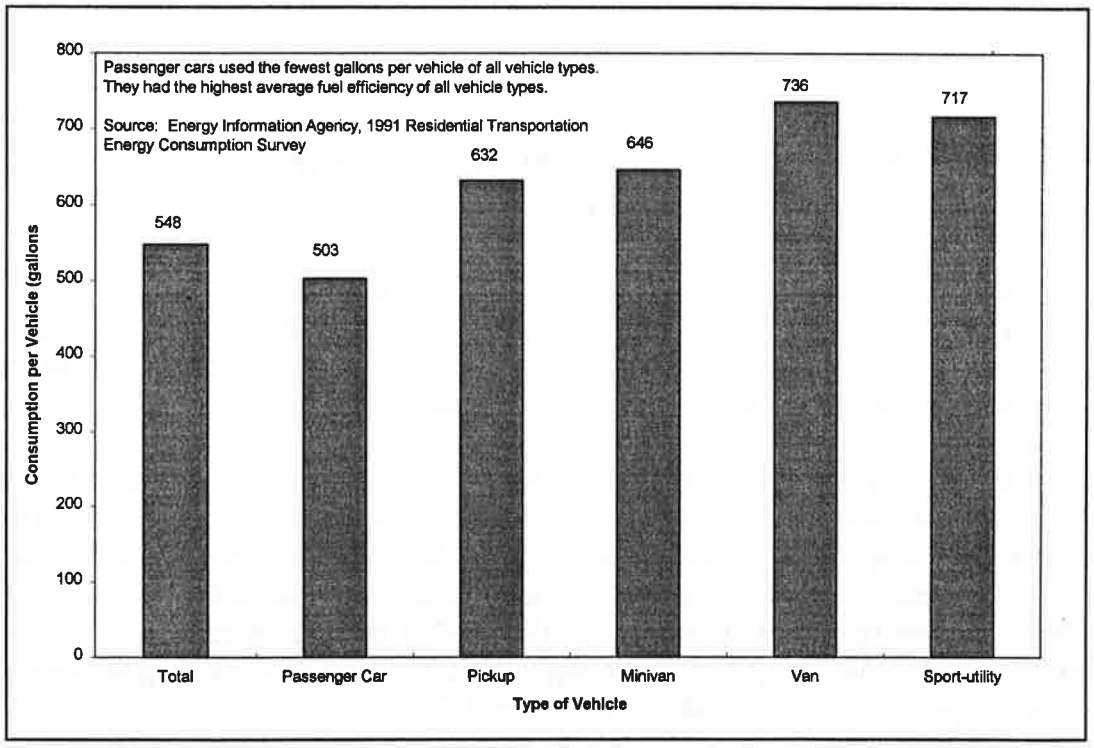


Figure 2-8. Average Annual Vehicle Fuel Consumption, by Vehicle Type for 1991

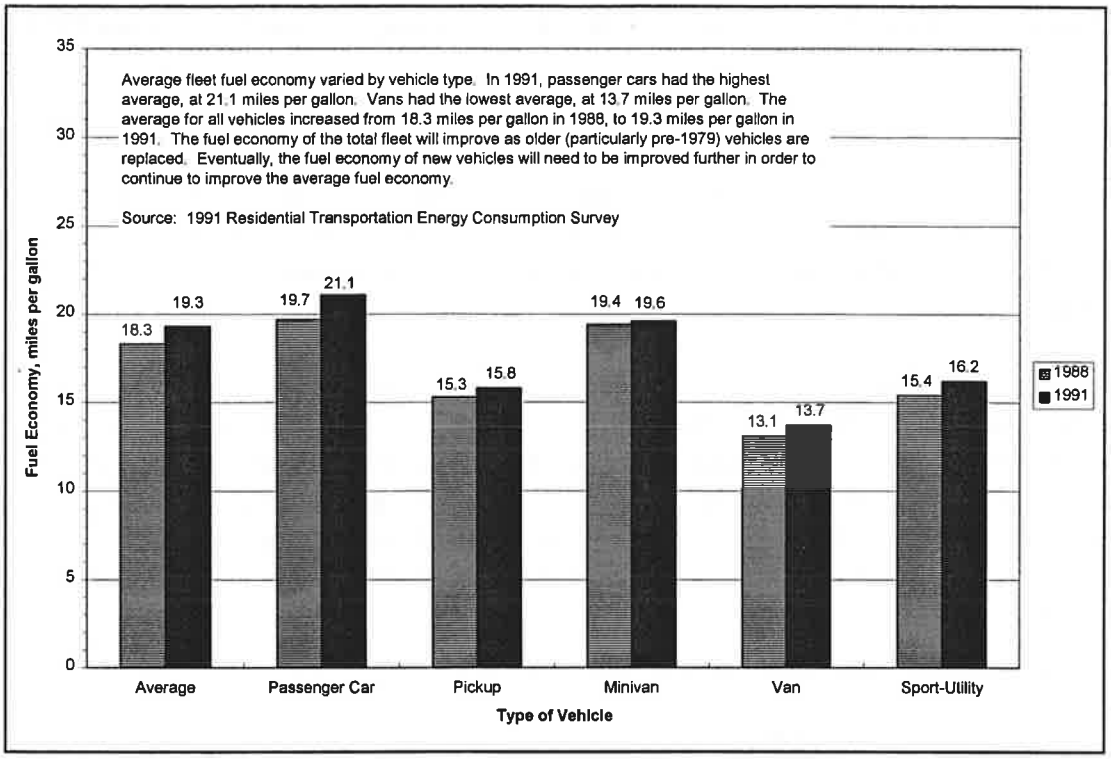


Figure 2-9. Average Fuel Economy, by Vehicle Type, 1991 Fleet

2.6 TRENDS IN LIGHT TRUCK ATTRIBUTES

Vehicle performance is often quantified by a vehicle's power to weight ratio. Using this metric, light truck performance increased dramatically during the 1980's, although fuel economy remained nearly constant. Both average light truck weight and average light truck power have varied over a substantial range during the past twenty years.

In its advanced notice of proposed rulemaking on the establishment of CAFE standards for model years 1998-2006, NHTSA stated that CAFE standards had not "had any measurable effect on light truck weight or size, and, hence, safety."[7] In support, NHTSA noted that the average equivalent test weight of light trucks increased from 3,805 pounds in model year 1984 to 4,200 pounds in model year 1993. However, the 1994 ORNL study, comparing weights over a longer period, reported that "weight has had a negligible effect on light truck mpg because light trucks today weigh almost exactly what they did in 1975."[8]

Figure 2-10 is taken from the ORNL study and contrasts changes in average car and light truck weight during the period between 1975 and 1993. A sharp reduction in average light truck weight occurred after 1979, but this bottomed out in 1987, and average truck weight has slowly crept upwards to a level near the late-70's peak.

[7] Federal Register 16327, 4-6-94.
[8] Oak Ridge National Laboratory, op. cit.

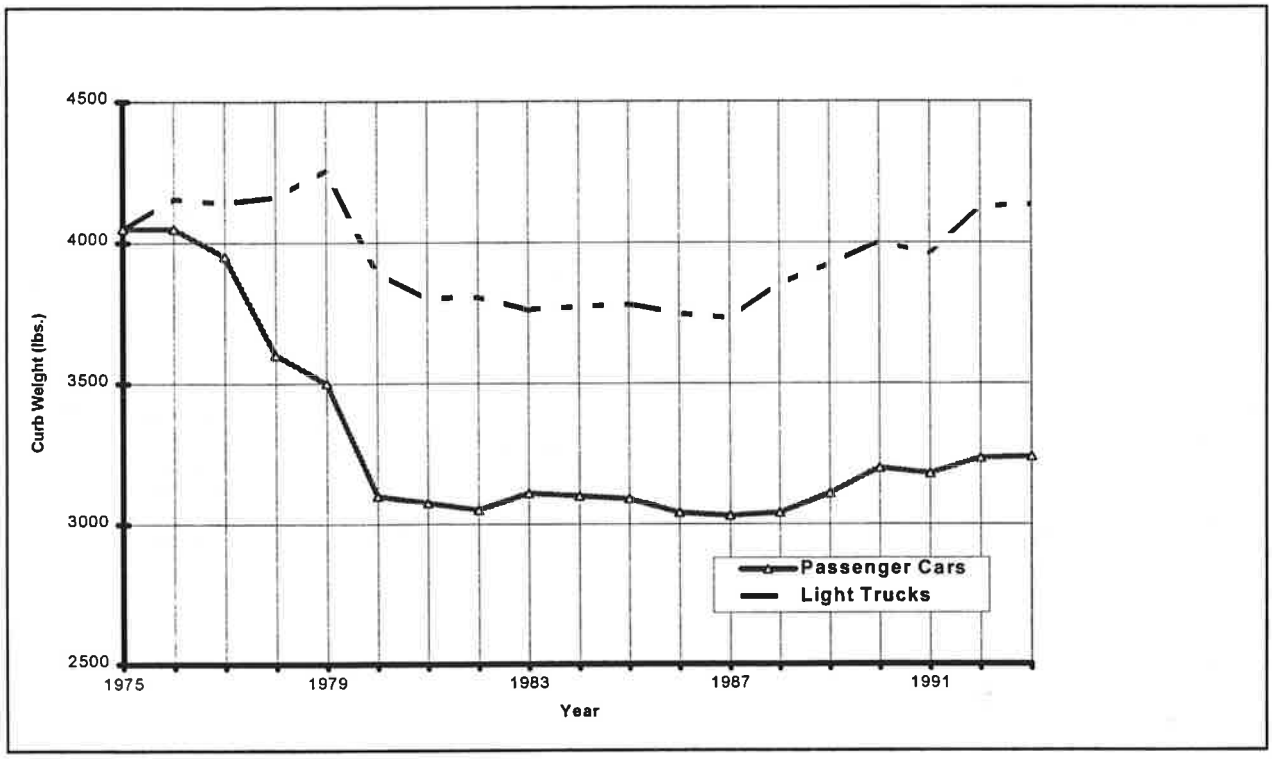


Figure 2-10. Passenger Car and Light Truck Weight, 1975-1993

Figure 2-11 is a more detailed breakdown of light truck test weight trends between 1975 and 1995.

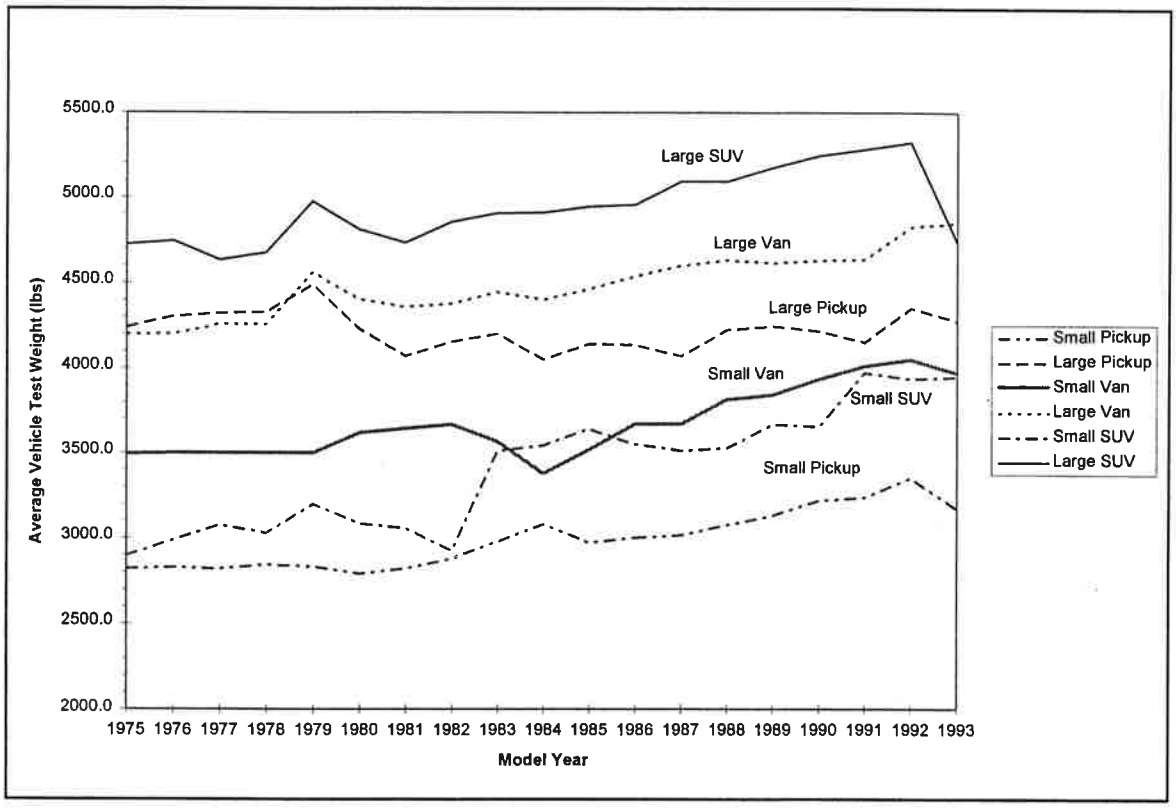


Figure 2-11. Light Truck Test Weight Trends

The average horsepower of light trucks has increased in every year since 1982. Figure 2-12 shows horsepower trends for 1975-93. In order to represent technological progress in fuel economy, the ORNL study estimated what the average fuel economy of both cars and light trucks would have been in each year had their weighted horsepower-to-weight ratios been unchanged over the 1975-93 period. According to the ORNL study, "the effect of increased horsepower (from 1975 to 1993) has led to a reduction in light truck fuel economy by only 1 mpg."[9]

[9] Ibid.

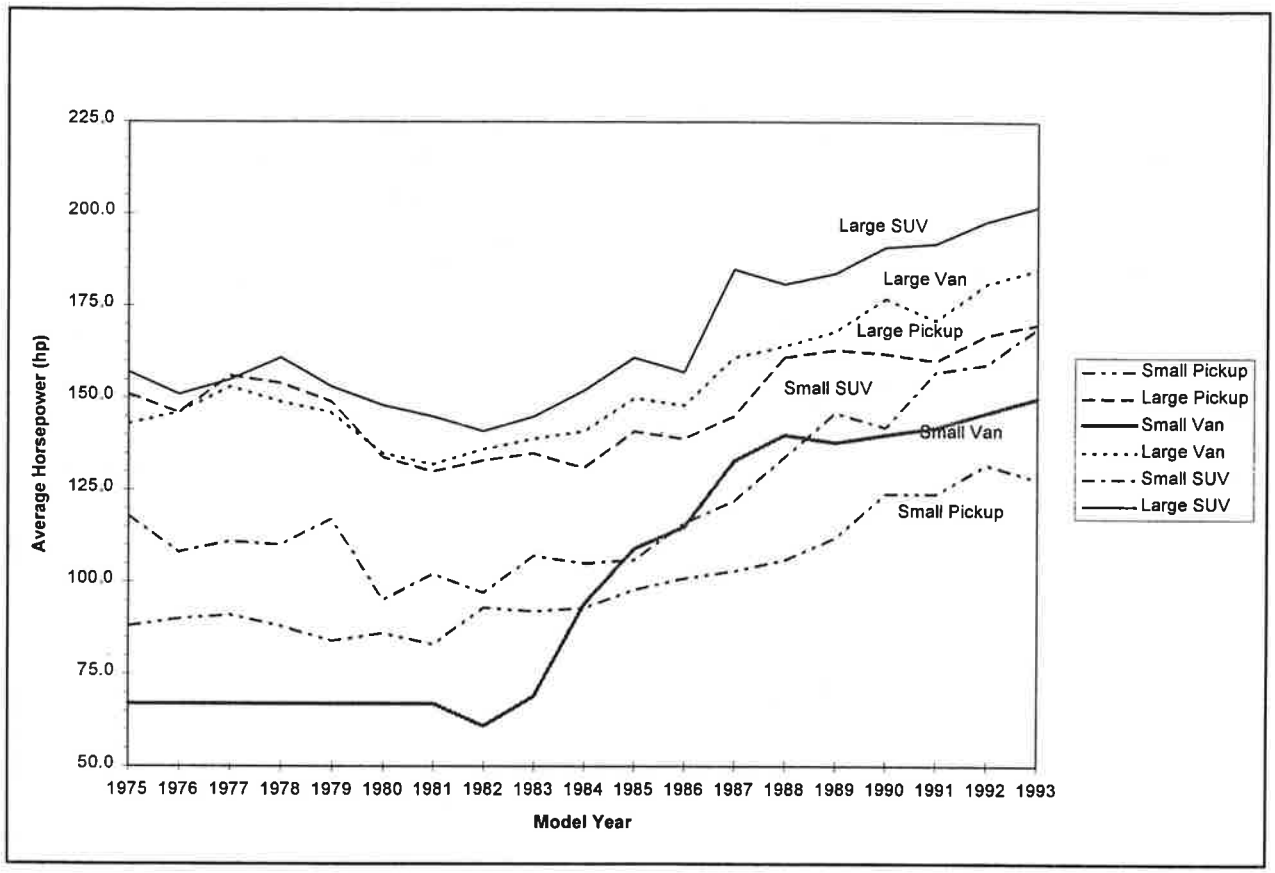


Figure 2-12. Light Truck Horsepower Trends

ORNL's comparison between passenger car and light truck fuel economy and horsepower trends suggests that "fuel economy technology has been applied in a very different manner in the light truck market."[10] A 1994 ORNL study reports that "vehicle technology has been improved to the extent that the same size and weight vehicle that attained 15 mpg in 1975 would attain 25 mpg using today's technology."[11]

Figure 2-13 shows trends for sales weighted average power-to-weight ratio for light trucks between 1973 and 1993. Power-to-weight ratio is often used as a measure of a vehicle's acceleartion potential, or driveability. Power-to-weight ratio decreased during the late 70s and early 80s, but then steadily increased from 1984 on. The huge jump in power-weight-ratio for small vans after 1983 represents the expansion of the segment from a single model, the Volkswagen Microbus/Vanagon, to a full range of vehicles popularly referred to as "minivans".

[10] Ibid.
[11] Ibid.

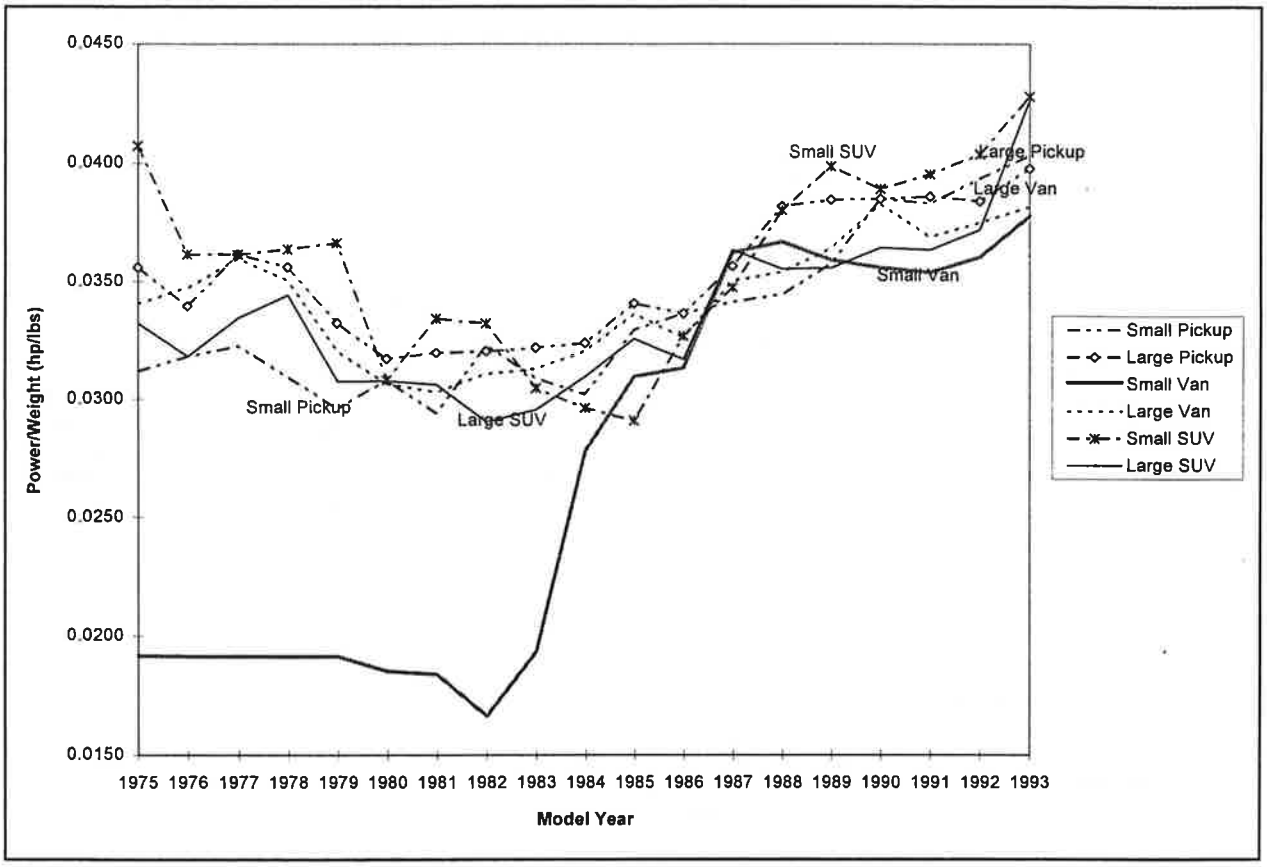


Figure 2-13. Light Truck Power-to-Weight Ratio Trends

2.7 THE AUTO INDUSTRY AND THE ECONOMY: IMPLICATIONS OF HIGHER LIGHT TRUCK CAFE

Congress asked NHTSA to consider the impact of increases in light truck CAFE standards on employment, the nation's economy in general, and international trade and competitiveness. However, given the scope of this report, the nature and limitations of the data, and the report's findings, it was not feasible to "estimate" the impact of increases in light truck CAFE standards on the nation's employment, economy, and competitiveness.

Instead, this section presents data that provide perspective on the importance of the auto industry and the light truck market to the nation's economy. Data are presented to illustrate the growth and change within the domestic auto industry that has been driven by the light truck market. This section also summarizes the findings of the 1992 National Research Council study on the relationship of higher auto fuel economy standards to vehicle sales, the economy, employment and international competitiveness.

2.7.1 The Auto Industry, the Light Truck Market, and the Economy

The motor vehicle and equipment manufacturing industries are the largest in America. In 1994, the U.S. auto industry employed 2.3 million Americans at more than 4,000 facilities and dealerships. The Big Three manufacturers alone employed nearly 700,000 employees with a total payroll of $31 billion (in 1993). Chrysler, Ford and General Motors are responsible for 19 out of every 20 jobs related to the production of cars and trucks in the U.S.

Since 1990, the auto industry has spent $58.3 billion on new plants and equipment, making a major contribution to our nation's economic growth. The industry contributed nearly 11% to the growth in the U.S. Gross Domestic Product (GDP) in 1994. Car and truck sales by the Big Three have averaged 4.4% of the GDP during the past three decades.[12]

2.7.2 Growth of Light Truck Production and Assembly Capacity

Table 2-4 presents data on the growth in light truck production capacity for model years 1980 and 1996. The Big Three manufacturers currently dominate the light truck market, accounting for over 93% of light truck production capacity. Light truck production capacity in North America more than doubled from 1980 to 1996, and the number of light truck plants increased by 56%.

Since the introduction of transplant facilities to the domestic market in 1980, transplant light truck capacity has increased by a factor of ten. The Big Three manufacturers' light truck capacity has also increased, although to a smaller degree: 240% for Chrysler, 185% for Ford, and 180% for General Motors.

Table 2-4. Comparison of Light Truck Production Capacity and Number of Plants for Model Years 1980 and 1996

Plant Name	Annual Capacity[13]		Number of Plants	
	1980*	1996	1980	1996
Chrysler	500,000	1,700,000	6	8
Ford	1,300,000	2,400,000	9	13
General Motors	1,400,000	2,500,000	9	14
Transplants	50,000	500,000[14]	1	4
Total	**3,250,000**	**7,100,000**	25	39

- Note: Capacity in 1980 could include light trucks up to 10,000 GVWR.

[12] *Key Facts About America's Car Companies,* American Automobile Manufacturers Association
[13] *Ward's Automotive Yearbook, 1995.*
[14] Transplant models include: Izusu Rodeo and Pickup, Honda Passport, Nissan Quest and Pickup, Toyota Tacoma, and Mazda Pickup

2.7.3 Impact of Higher CAFE Standards: Selected Findings of the National Research Council

The National Research Council (NRC) issued a 1992 report--*Automotive Fuel Economy: How Far Should We Go?*--which examines the potential of attaining higher CAFE for cars and light trucks.[15] The NRC report also addresses the impact of increased fuel economy on overall vehicle sales, auto industry and overall employment, and international competitiveness.

Sales

Higher fuel economy standards, the NRC report concluded, could decrease sales in two ways: through consumer reaction to higher sticker prices, and through negative consumer reaction to design changes implemented by manufacturers to increase vehicle fuel economy. "In the extreme, both of these effects would tend to reduce vehicle sales, reduce manufacturer profits, and reduce employment in the automotive industry and sectors connected to the industry."[16] The NRC feels that a worst case scenario would result in a one-to-one elasticity between price and consumer demand: that is, for every one percent increase in price, unit sales would drop one percent. Changes in employment and possible economies-of-scale effects led to the conclusion that, "This would represent a significant impact on the automotive industry even though sales revenue would remain unaffected."[17]

Employment

The NRC report recognized, "the impact of higher fuel economy on employment in automotive and related industries is difficult to assess."[18] If the assumption is made that unit sales have a one-to-one elasticity with price changes, and automotive worker productivity is unaffected by fuel economy standards, then a one-percent increase in price should lead to approximately a one-percent decrease in auto production employment. However, the NRC report also pointed out "some portion of the price increase, however, arises from the wages paid to the workers who manufacture and install the new fuel economy technologies that generate the price increase. So, while there might be a loss of jobs due to shrinkage in unit sales, the loss would be offset to some extent by the growth of jobs in producing the fuel economy technologies."[19]

Competitiveness

The NRC report declared:

> "more stringent fuel economy standards may have a greater impact on who manufactures cars for the U.S. market and where they are manufactured than on aggregate sales or employment. That is, higher fuel economy standards may affect the competitive position

[15] National Research Council, *Automotive Fuel Economy: How Far Should We Go?* National Academy Press, 1992.
[16] Ibid., p. 160.
[17] Ibid., p. 161.
[18] Ibid.
[19] Ibid,. p. 162.

> of U.S. manufacturers vis-à-vis the rest of the world more than they would affect the industry as a whole. The importance of the competitive effect depends heavily on the form of the regulation, perhaps more so than its level. For example, a fuel economy standard that averages corporate fuel economy across all (vehicle) classes--the current approach--has important differential effects among manufacturers.... Imported light trucks already achieve significantly higher fuel economy than domestic trucks in the same size classes. If fuel economy standards for light trucks were set above levels characteristic of current domestic trucks, but at or below those of the imports, the domestic manufacturers would be at a serious disadvantage."[20]

Import manufacturers would have the option of increasing the size, weight and power of their trucks to satisfy consumer desires, while domestic manufacturers would be severely constrained.[21]

2.8 SUMMARY

The U.S. light vehicle market over the past 20 years has been marked by:

- A major shift in consumer demand from passenger automobiles to light trucks.
- A trend, on both the demand and supply sides, toward more powerful trucks despite the introduction of smaller versions of vans and SUVs.
- A lower fleet average fuel economy and higher fuel consumption as a result of the increased market share of light trucks and the lower fuel economy standards for light trucks relative to cars.
- The growth of the light truck manufacturing into a major portion of the overall U.S. auto industry, and a major force in the US economy, in terms of employment and contribution to national GNP.

[20] Ibid.
[21] Ibid.

3. Light Truck Capabilities, Utility Requirements, and Use

3.1 INTRODUCTION

This chapter defines and addresses qualitatively and quantitatively the unique capabilities, utility requirements, and uses of light trucks. Chapter 3 also responds to the following specific concerns posed by Congress:

> "The [evaluation] should include consideration of how light trucks are used in commercial and agricultural applications, by the disabled and handicapped and other special uses such as vanpools, off-road environments, towing, and recreational uses.
>
> "NHTSA should recognize the full range of uses of these vehicles by individual consumers and that even when these vehicles are used as passenger vehicles they also are used for moving household items, furniture, athletic teams and equipment, yard supplies, and numerous other home owner purposes."

Chapter 3 has the following objectives:

1. Identify the capabilities of light trucks and compare them to other vehicles, such as passenger cars, station wagons, and larger (non-CAFE regulated) trucks. Capabilities refer to the supply side: those functions that light trucks are capable of performing well.

2. Define and document the utility requirements of light truck users. Utility requirements are those functions or capabilities that consumers or businesses demand to satisfy specific needs. Utility requirements refer to the demand side: those functions that consumers or businesses demand to satisfy specific needs.

3. Document the major consumer and commercial applications and uses of light trucks. Use refers to the actual use of the vehicle, regardless of what it is capable of or why it was purchased, and especially in terms of the extent to which particular capabilities are employed. Identify who uses light trucks as another aspect of use.

3.2 RESEARCH PROCEDURE AND METHODOLOGY

Five enhanced capabilities of light trucks were identified. Each of these capabilities was evaluated for each light truck segment and contrasted to light trucks with GVWRs above the 8500 pound CAFE limit and with passenger cars. Utility requirements of light truck consumers were identified for each light truck segment. To maintain consistency with the historical production statistics presented in Chapter 2, each of the light truck segments was divided into "large" and "small" subsegments. The major applications and uses of light trucks were then

extracted from survey data. The uses of light trucks were also contrasted with the uses of passenger cars and light trucks with GVWRs above the 8500 pounds CAFE limit.

Information for Chapter 3 was gathered from government surveys, public domain surveys administered by private marketing firms, vehicle manufacturer sales literature, special interest group publications, and a variety of other sources. Much of the information required for evaluating light truck capabilities was extracted from vehicle sales literature (e.g., pickup payload capacity). Public domain data for determining light truck utility requirements were scarce. The best data are from the vehicle manufacturers and are proprietary. Some survey data from marketing firms were publicly available and were used to determine light truck utility requirements. Finally, conclusions regarding light truck usage were based heavily on two extensive surveys: the 1992 Truck Inventory and Use Survey (TIUS) and the 1990 Nationwide Personal Transportation Survey (NPTS).

Chapter 3 is constrained by the limitations in these publicly available data. Some of the surveys provided detailed information on some types of use and little or no information on other types. For example, the 1992 TIUS provided copious data on the various types of cargo carried by light trucks for commercial purposes but no information on the types of cargo that are towed by light trucks. Similarly, the 1990 NPTS provided elaborate data on the number of passengers for trips taken in light trucks for personal transportation but no information on whether the vehicle was hauling cargo or towing a load.

3.3 CAPABILITIES OF LIGHT TRUCKS

3.3.1 Definition of Enhanced Capabilities

Enhanced capabilities are those functions or tasks that light trucks can perform with significantly greater ease than passenger cars. The majority of light truck and passenger car capabilities are similar. For example, light trucks on average are more capable of towing a load, yet some cars have a higher towing capability than some light trucks. Indeed, there are no capabilities that are truly unique to all light trucks. For this reason, the report identifies five enhanced capabilities of light trucks.

- Passenger-Carrying Capability: The ability to carry more than four persons with reasonable ease and comfort. Also, the ability to accommodate handicapped or disabled passengers or drivers.

- Load-Carrying Capability (weight): The ability to carry heavy payloads without a significant reduction in vehicle performance (acceleration, hill-climbing, etc.), and the ability to load and unload heavy cargo with ease.

- Load-Carrying Capability (volume): The ability to carry bulky, voluminous payloads during normal operation of the vehicle, and the ability to load and unload these cargoes with ease.

- Towing Capability: The ability to tow trailers without a significant reduction in performance (acceleration, hill-climbing, etc.).

- Off-Road Capability: The ability to reliably operate the vehicle over rough or unpaved terrain or paved roads under inclement weather conditions.

Figure 3.1 illustrates enhanced capabilities for each of the four different light truck segments. Primary capabilities are those that the vehicle is particularly well-suited to perform vis-à-vis passenger cars. Secondary capabilities are those that the vehicle is less well-suited to perform.

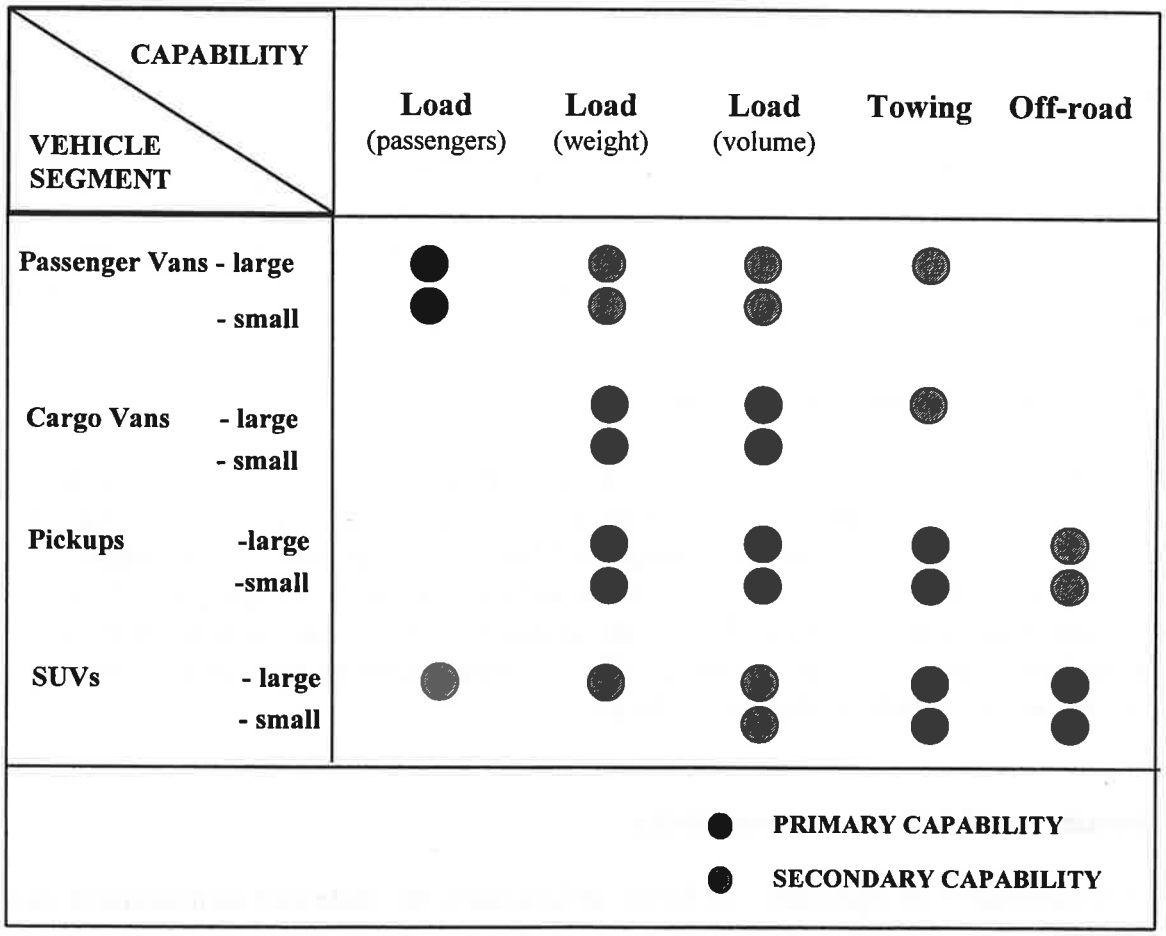


Figure 3- 1. Light Truck Enhanced Capabilities by Segment

Passenger Van Enhanced Capabilities

Passenger vans are those which offer seating capability beyond the driver and one passenger. While passenger vans often have at least some removable seats, their primary enhanced capability was judged to be the carrying of passengers. Load capability in terms of volume and weight were judged to be secondary enhanced capabilities for passenger vans. Towing is also a secondary enhanced capability of large passenger vans but not for small passenger vans.

Cargo Van Enhanced Capabilities

Cargo vans offer seating only for a driver and one passenger. Cargo vans are built for carrying loads of cargo, which can be bulky and/or heavy. As with passenger vans, towing is a secondary capability, but only for large cargo vans.

Pickup Enhanced Capabilities

All pickups possess large open cargo beds, which give them enhanced volume carrying capability. Most pickups also have enhanced load carrying capability in terms of weight. Both small and large pickups have enhanced towing capabilities relative to passenger cars. Off-road capability was judged to be a secondary enhanced capability because many pickups are available with four-wheel drive and high ground clearances, but most are sold as two-wheel drive vehicles.

Sport Utility Vehicle Enhanced Capabilities

Off-road capability is a primary enhanced capability of SUVs, as most are designed specifically for off-road capability, with high ground clearances and four-wheel drive. All but the smallest SUVs also have substantial towing capabilities. Many SUVs also have larger interior spaces than current passenger cars, so volume carrying capacity was judged to be a secondary enhanced capability. Large SUVs have passenger and payload capacities beyond those of most passenger cars, so passenger carrying and weight carrying were judged to be secondary enhanced capabilities for these vehicles.

3.3.2 Summary of Light Truck Capabilities

The capabilities of light trucks are better understood in the context of their intended uses. Table 3.1 summarizes the general capabilities of vans, pickups, and sport-utility vehicles (SUVs) as related to typical uses. Passenger vans and cargo vans are combined as a result of the data structure in the source material from which the table was derived. Given the tremendous diversity and number of light truck models and options, it is not possible to show every light truck capability. The table also identifies those particular capabilities that would likely require light trucks over the 8,500 pounds GVWR CAFE limit. This information was principally derived from material prepared by the vehicle manufacturers for marketing purposes.

Table 3-1. Primary and Secondary Capabilities of Light Truck Segments

Primary Capabilities	Secondary Capabilities	Typical Uses: Personal	Typical Uses: Business/Institutional
Small Vans			
• Passenger-carrying: 3-row seating • Load-carrying: high cargo volume (CM)	• Driveability (traction): front or all-wheel drive (when offered) • Towing: moderate loads (CM)	• Station-wagon substitute: household errands, including moving furniture & other items; recreational travel	• Light retail delivery • Transportation of utility or service personnel
Large Vans			
• Passenger-carrying: 4-row & 5-row seating • Load-carrying incl. special-use conversion: extremely high cargo volume; over 1-ton payload; over 2-ton payload (85)	• Towing: 7,600-10,000-lb. loads	• Custom travel conversions • "Class B" camper conversions • Wheelchair-driving conversions	• Commuter vanpools • School/religious/social group excursions • Short-distance customer transportation (hotel, etc.) • Transportation of utility or service personnel, supplies and equipment for repairs/installations • Retail, wholesale, & for-hire package delivery • Wheelchair-van conversions • "Type 2" ambulance conversions

Table 3-1. Primary and Secondary Capabilities of Light Truck Segments (continued)

Primary Capabilities	Secondary Capabilities	Typical Uses: Personal	Typical Uses: Business/Institutional
Small Pickups			
• Load-carrying: open-top accessibility; over 1-ton payload (Dodge Dakota V8 only) • Towing: moderate loads; 7,100-lb. loads (Dodge Dakota V8 only)	• Driveability (traction): 4-wheel drive available • Off-road operation: relatively high axle clearance (CM)	• Inexpensive personal car substitute • Household utility or second car: household errands, including moving bulky furniture & "dirty" yard loads; carrying bulky recreational equipment in truck bed; carrying slide-in campers; recreational trailer towing • Substitute for sport-utility vehicle in occasional recreational use off-road	• Limited substitute for large pickup, with less capacity

Table 3.1 Primary and Secondary Capabilities of Light Truck Segments (continued)

Primary Capabilities	Secondary Capabilities	Typical Uses: Personal	Typical Uses: Business/Institutional
Large Pickups			
• Load-carrying: open-top accessibility; over 1-ton payload; over 2-ton payload (85) • Towing: 8,200-9,100-lb. loads with V8 engines; 12,500-13,300-lb. loads (85)	• Driveability (traction): 4-wheel drive available • Off-road operation: relatively high axle clearance (CM)	• Same as utility/second car roles of small pickups, but with greater capacity	(Examples) • In agriculture: carrying farm supplies, towing farm equipment, limited towing of livestock trailers, occasional off-road operation on farm • In construction & related trades: carrying building materials, towing wheeled or trailered equipment, occasional off-road operation at building sites • Maintenance vehicle for rugged-terrain sites (4-wheel drive models)
Small Sport-Utilities			
• Enhanced Traction: 4-wheel drive available • Off-road operation: relatively high axle clearance (CM) • Towing: moderate loads ("compact" models); 6,500-lb. loads (Jeep Grand Cherokee V8 only)		• Small car or inexpensive sports car-substitute (smallest models) • Station-wagon substitute ("compact" models): household errands, including moving furniture & other items; recreational trailer towing • Occasional recreational off-road use	• Law enforcement agency patrol vehicle in rugged-terrain areas ("compact" models)

Table 3.1 Primary and Secondary Capabilities of Light Truck Segments (continued)

Primary Capabilities	Secondary Capabilities	Typical Uses: Personal	Typical Uses: Business/Institutional
Large Sport-Utilities			
• Enhanced Traction: 4-wheel or all-wheel drive available • Off-road operation: relatively high axle clearance (CM) • Towing: rear-wheel drive; 6,500-7,000-lb. loads; 10,000-lb. loads (85-Chevrolet/GMC Suburban only)	• Passenger-carrying: 3-row seating (Chevrolet/GMC Suburban & Toyota Land Cruiser only) • Load-carrying: over 1-ton payload (Chevrolet/GMC Suburban only); over 1.5-ton payload (85-Chevrolet/GMC Suburban only)	• "Prestige" or luxury car-substitute • Station-wagon substitute, with greater capacity than smaller sport-utility models • Occasional recreational off-road use	• Utility/maintenance vehicle for forest reservation-type parks & other rugged-terrain sites

Key:
85 - Generally requires a model rated at over 8500 lbs. GVWR
CM - Certain Models only

3.3.3 Light Truck Off-Road Capability

A substantial proportion of light trucks, approximately 28.6% of the 1992 stock according to the 1992 TIUS, was equipped with four-wheel drive. SUVs had the greatest proportion of four-wheel drive equipped vehicles, followed by pickups, full-size vans, and minivans (see Figure 3-2). It should be noted that there is difference between the proportion of compact SUVs equipped with four-wheel drive and the proportion of full-size SUVs equipped with four-wheel drive. Almost all compact SUVs have four-wheel drive (99.1%) compared with about half of the full-size SUVs (49.9%).

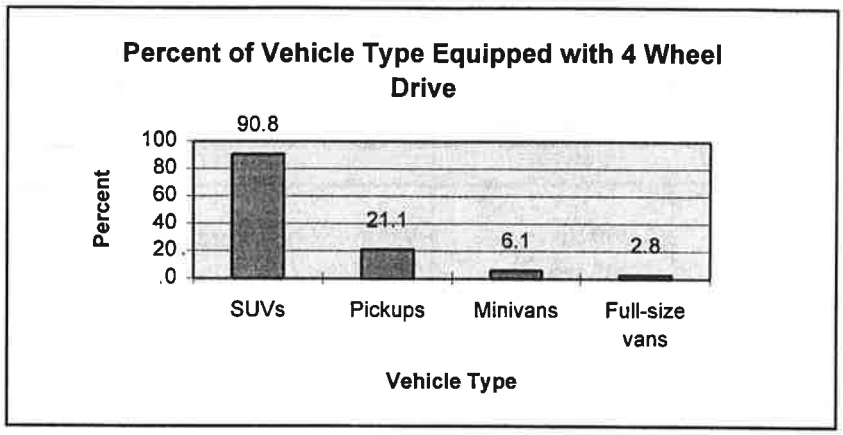


Figure 3- 2. Percent of Vehicle Type Equipped with Four Wheel Drive.

Optional four-wheel drive gives pickups off-road capability for work on farms, construction sites, etc. Medium-duty trucks are not generally available with four-wheel drive, except on a special-conversion basis. A third of large Ford, General Motors, and Chrysler pickups was sold with four-wheel drive in calendar 1994.

For purposes of this report, "off-road capability" was defined in Section 3.3.1 to include the ability to operate reliably on paved roads that would be relatively impassable to a typical passenger car in inclement weather. It must be pointed out that improved traction on snow-covered or other slippery roads can be obtained with all-wheel drive minivans and passenger cars. However, these vehicles are not designed with the high axle clearances, high ratios of body height to wheelbase and front/rear overhang, and special low gear ranges that give four-wheel drive pickups and SUVs extensive off-road capabilities, even over soft or uneven terrain.

3.3.4 Capabilities of Light Trucks with GVWRs above 8500 Pounds

Table 3.2 shows the additional load-carrying and towing weight capabilities of 1995 model year light trucks of over-8,500-pound GVWR relative to their CAFE-subject counterparts.

Table 3.2 Additional Capabilities of Over-8,500 Pounds Maximum GVWR Models (Model Year 1995)

VEHICLE TYPE	INCREASE IN MAXIMUM RATING OFFERED		ADDITIONAL ENGINES OFFERED
	From (8,500 GVWR & under)	To (over 8,500 GVWR)	
Large Vans			
Dodge Ram • towing • payload	 9,000 lbs 3,295 lbs	 9,000 lbs (no increase) 4,420 lbs	none
Ford Econoline • towing • payload	 7,600 lbs 2,140 lbs	 10,000 lbs 4,185 lbs	7.3L V-8 Turbo diesel and 7.5L V-8
Chevrolet G Series (inc. GMC) • towing • payload	 10,000 lbs 2,791 lbs	 10,000 lbs (no increase) 4,311 lbs	none, except slightly higher-power version of 6.5L V-8 Diesel
Large SUVs			
Chevrolet Suburban (inc. GMC) • towing • payload	 6,500 lbs 2,394 lbs	 10,000 lbs 3,362 lbs	7.4L V-8
Large Pickups			
Dodge Ram • towing • payload	 9,100 lbs 2,900 lbs	 13,600 lbs 5,340 lbs	5.9L Turbo Diesel I-6 and 8.0L V-10
Ford F Series • towing • payload	 8,200 lbs 2,425 lbs	 12,500 lbs 5,105 lbs	7.3L Turbo Diesel and 7.5L V-8
Chevrolet C/K (inc. GMC) • towing • payload	 8,500 lbs 3,202 lbs	 13,000 lbs 5,459 lbs	7.4L V-8

3.3.5 Comparison of Light Truck and Passenger Cars Capabilities

The capabilities of passenger cars and light trucks can be evaluated and compared. For example, most cars, because of their smaller interior room, usually cannot provide the passenger-carrying capacity and comfort of vans, even minivans. Reduction of towing capabilities of passenger cars has been cited as one of the key factors that stimulated the large switch to light trucks for personal use. As of model year 1995, only a dwindling number of large, U.S.-built rear-wheel drive passenger cars and station wagons had significant towing capability.

- The only full-size, rear-wheel drive station wagon offered in the U.S., as of model year 1995, was in the Chevrolet Caprice (Buick Roadmaster) model line. This line, available only with V-8 engines, had a manufacturer's rated towing capacity of 5,000 pounds; it is expected to be discontinued by General Motors.

- The popular mid-size, front-wheel drive Ford Taurus, Toyota Camry and Oldsmobile Ciera lines, which included station wagons, offered V-6's as the largest engine option and were rated at only 2,000-pound towing capacity. Mid-size, rear-wheel drive Volvos offered in the U.S., including station wagons, had I-6's as the largest engine option and were rated at 3,300-pound towing capacity.

- For recreational trailer towing with a sedan, *Trailer Life* magazine's 1995 annual tow-rating guide described the rear-wheel drive Mercury Marquis as a "popular full-size tow car." With its V-8 engine, it was capable of towing 5,000 pounds.

3.4 UTILITY REQUIREMENTS

3.4.1 Utility Requirement Definition

"Utility requirements" refer to those functions that consumers or businesses desire vehicles to perform. As noted in Chapter 2, 1994 sales of light trucks accounted for 40% of the total light vehicle market (the combined market for cars and light trucks). One reason that light trucks have become very popular is because they are perceived to possess the capabilities required to perform a great array of functions for consumers and businesses.

Private and household consumer utility requirements include:

- Moving passengers: visiting friends or relatives, transporting children for Little League, etc.

- Hauling: moving furniture or gathering garden or building supplies for home projects and household errands.

- Towing: campers, horse trailers, recreational equipment (snowmobiles, jetskis, etc.) and boats.

- Off-road travel: recreational trips, such as camping trips, skiing trips, hiking trips that involve negotiating rough terrain or paved roads subject to inclement weather conditions.

Business and institution utility requirements include:

- Moving passengers: vanpooling employees to and from work or shuttling employees between various work locations.

- Hauling: delivering packages and miscellaneous cargo between several business locations, carrying tools and supplies.

- Towing: cargo, livestock, equipment (such as landscaping equipment or construction equipment).

- Off-road travel: rural businesses such as farming, ranching, forestry, timber, petroleum, and mining.

3.4.2 Passenger-Carrying Utility Requirement

The buyers of minivans are attracted to their passenger-carrying capabilities. Recent minivan buyers were asked to select the top three reasons for buying a minivan over any other type of vehicle from a list of 15 options. Sixty percent of minivan buyers selected "passenger room," which was the most popular of the 15 options; 46% selected "overall room," which was the second most common option; and 25% selected "seating flexibility," which tied with "cargo room" as the fourth most popular option.[1] In a recent market survey, 92.8% of minivan buyers selected "roominess" as either an "important" or "very important" factor in their decision to purchase a minivan, compared with only 75.5% of buyers of any vehicle.[2]

3.4.3 Load-Carrying (Weight and Volume) Utility Requirement

Minivan, SUV, and compact pickup buyers are all attracted to these vehicles' cargo-carrying capability. Twenty-five percent of minivan buyers selected "cargo room" as one of the top three reasons for buying a minivan (tied for fourth most popular of the 15 options), while twenty percent of minivan buyers selected "ease of loading/unloading" as one of the top three reasons for buying a minivan (seventh most popular of the 15 options).[3] Fifty-seven percent of SUV buyers selected "cargo space" as one of the reasons for buying a SUV (fourth most popular

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[1] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[2] R.L. Polk & Co., *Minivan Buyer Profile Survey, 1994.* This difference in percentages is significant at the 95% confidence level.
[3] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.

of 9 options). Forty-four percent of compact pickup buyers selected "payload / cargo space" as a very important factor in their decision to buy a pickup over any other type of vehicle.[4]

3.4.4 Towing Utility Requirement

No reliable data could be found on the proportion of consumers who purchase light trucks to satisfy a towing requirement. However, the data on capability confirm that many light trucks demonstrate superior towing capacity. Given the utility requirement of some consumers to tow boats, camping trailers, horse trailers, snowmobiles, farm equipment, etc., it is reasonable to infer that some light trucks are purchased with towing capacity as a primary utility requirement.

3.4.5 Off-Road Travel Utility Requirement

Many drivers are also attracted to the ability of light trucks to perform off-road; however, the definition of "off-road" driving can vary markedly among buyers. Some define off-road driving as negotiating treacherous, unpaved terrain. Others define off-road driving as crossing a median strip. Furthermore, a number of buyers of SUVs and pickups equipped with four-wheel drive say that they do not use the enhanced off-road capability of these vehicles, but they feel better knowing that the capability is there if needed. This is manifest in one survey where 64% of the respondents specifically chose "four-wheel drive capability" as a reason for their purchase, and only 35% chose "off-road ability."[5]

It is worth noting that since 1982 the proportion of light trucks equipped with four-wheel drive has been rising in each of the individual light truck segments. For example, the proportion of SUVs equipped with four-wheel drive rose 34% in the 1982-1992 time period. The proportion of pickups equipped with four-wheel drive rose 25% over the same period.

3.4.6 Consumer Choice

Consumers are also attracted to light trucks for many reasons beyond the enhanced capabilities of a particular vehicle. Some attributes which shape the consumers purchase decision are vehicle performance, dependability, durability, and versatility. These are referred to as consumer choice attributes. Some surveys identified vehicle safety as a consumer choice attribute which was relevant to light trucks. Interestingly, fuel economy did not seem to be an important consumer choice attribute in any of the sources used for this study.

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[4] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992.
[5] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Sport Utility Vehicles*, 1992.

Performance and Driveability

Performance can describe the responsiveness of the engine and transmission to changes in power demand. Driveability can be thought of as a vehicle's acceleration potential, which is often quantified by power-to-weight ratio or 0-60 mph acceleration time.

Dependability and Durability

Consumers place major emphasis on the perceived dependability and durability of light trucks. Dependability is a measure of the long-term vehicle reliability, and durability is a measure of the overall vehicle toughness and the ability to function under heavy usage or abusive operating conditions. In recent market surveys, buyers of minivans,[6] SUVs,[7] and compact pickups[8] were asked to select those factors that were "very important" in their decision to buy a particular make and model, from lists of 37, 33, and 31 factors, respectively. For all three of these light truck segments, dependability was the most popular factor selected and durability was second. More than 90% of buyers of all three vehicle segments selected dependability and durability as the most important factors influencing the purchase decision.

This finding is corroborated by anecdotal evidence: some consumers say they bought a truck because they wanted a "tough" vehicle that wouldn't spend excessive time in the repair shop. Other consumers claim that the best thing about owning a truck is that you can treat it like a truck and worry less about the vehicle being dented or scratched. Light trucks have a more rugged appeal than cars, and this utility requirement seems to have captured the buying attention of the public.[9]

Versatility

Some consumers are attracted to the versatility of light trucks, that is, the ability of a single vehicle to perform several different tasks, such as hauling cargo and carrying passengers, simultaneously or separately. In a recent survey, buyers of compact pickups were asked to indicate how important each factor within a list was in the decision to buy a pickup truck rather than any other type of vehicle (e.g., car, station wagon, van, etc.).[10] Seventy-three percent of the consumers chose functionality/versatility as a very important factor in buying a compact pickup truck. SUV buyers also were attracted to the perceived rugged versatility of SUVs. Versatility was cited by another survey as the most popular reason (among eight reasons listed) for purchasing an SUV, with 70% of the respondents selecting this reason.[11]

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[6] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[7] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Sport Utility Vehicles*, 1992.
[8] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992.
[9] Wall Street Journal, July 24th, 1995, *Riding High: Pickup Trucks Enjoy a Boom*
[10] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992.
[11] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Sport Utility Vehicles*, 1992.

SUV buyers are more likely to engage in a number of recreational activities where the enhanced capabilities of an SUV are valuable as compared to buyers of any other vehicle type. A recent market survey indicated that SUV buyers are 18.3% more likely to engage in skiing (snow & water) than all other vehicle buyers; 14.3% more likely to engage in camping & hiking than all other vehicle buyers; and 13.4% more likely to engage in boating & sailing than all other vehicle buyers.[12]

Minivan buyers are also attracted to the suitability of minivans for vacation and recreation purposes. In one survey, recent minivan buyers were asked to select the top three reasons for buying a minivan rather than any other type of vehicle.[13] Recreation and vacation use was the third most popular reason, with 36% of the respondents selecting it as one of their top reasons for buying a minivan over any other type of vehicle.

Other Consumer Choice Attributes

Consumers are attracted to the greater (actual or perceived) safety of light trucks over cars. According to the Hachette New Car Buyer Surveys, 79.5% of minivan buyers[14] and 61% of compact pickup buyers[15] considered safety to be a very important factor in their vehicle purchase decision. There is also an abundance of anecdotal evidence for why consumers purchase light trucks. Many drivers say that they enjoy the feeling of sitting high off the road.[16] The improved visibility and the ability to look down onto surrounding traffic gives them a feeling of greater control.[17]

It also worth noting the trend toward more upscale light trucks in all segments, which may be partially responsible for the increasing market share of light trucks. Light trucks are now offered with options such as leather interiors and compact disk players -- features that may be luring car buyers away. According to the trade and general press, luxury SUVs now compete with luxury passenger cars for sales, and ownership has come to connote social prestige, which may legitimize their relatively high prices in the minds of potential buyers. With luxury automakers such as Mercedes Benz and Lexus entering the SUV market, one can expect this trend to continue.

Fuel Economy

Fuel economy ranked low on the list of "very important" factors used in making a purchase consideration in three light truck buyer surveys. Fuel economy ranked 26th for

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[12] R.L. Polk & Co., *Sport Utility Vehicle Buyer Profile Survey, 1994.*
[13] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[14] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[15] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992.
[16] New York Times, June 25th, 1995, *As Trucks and Vans Roam the Suburbs, Gas Prices Rise*
[17] Wall Street Journal, July 24th, 1995, *Riding High: Pickup Trucks Enjoy a Boom*

minivans[18] , 27th for SUVs[19], 12th for compact pickups[20], out of lists of 37, 33, and 31 factors, respectively. In general, fuel economy apparently is not a major consideration in vehicle purchases. A survey by Allison-Fisher Inc. , "asked car buyers to rank 20 factors in their buying decisions. Dependability was first. Fuel economy was last."[21]

3.4.7 Who Buys Light Trucks

Data on who buys light trucks were obtained from several surveys. Information was compiled based upon household size, household income, and education level.

Household Size

Minivan buyers have more children than buyers of any vehicle--1.5 children versus 0.9 children--according to a recent market survey. This finding is supported by the 1991 Residential Transportation Energy Consumption Survey (RTECS), which found that "vehicle preferences reflect the household's state of life (single with no children, households with young children, households with teenagers or older parents, etc.)." For example, households with children owned 76 percent of the minivans and 58 percent of the SUVs. Note that the minivan segment had the highest levels of vehicle miles and passenger-miles traveled per vehicle, followed by the SUV segment, according to the 1990 NPTS.

Household Income and Education Level

The 1990 NPTS data indicate that SUV and minivan buyers have higher household incomes than car users. Pickup users have slightly lower household incomes than car users. Buyers of pickups and full-size vans have lower levels of education than buyers of cars, minivans, and SUVs.

3.5 USE OF LIGHT TRUCKS

3.5.1 Definition of Use

Use refers to the particular applications of light trucks by consumers, businesses, and institutions; i.e., how light trucks are *actually* used. The Truck (TIUS) employs the following major categories of light truck use:

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[18] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[19] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Sport Utility Vehicles*, 1992.
[20] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992.
[21] New York Times, *As Rugged Vehicles Take to the Streets, Gas Prices Take Off,* June 25th, 1995.

- **Personal Transportation:** Operated as a personal-use vehicle in place of an automobile for pleasure driving, travel to work, etc., *with no commercial use.*

- **Commercial Transportation:** Operated by a private business (including self-employers); used in related activities of that business. Subsegments include:

  - Agricultural: Used for hauling or towing farm products, live animals, animal feed, farm machinery and equipment, etc., often on private farm roads or off-road terrain.

  - Contractor Activities and Special Trades: Used by painters, plumbers, carpenters, electricians, etc., to haul tools and trade supplies.

  - General Services: Used to assist in such activities as lodging operations, landscaping, repair, laundry, advertising, entertainment, etc.

  - Construction: Used to assist in hauling materials and tools in the construction of homes, buildings, roads, structures, etc.

- **Mixed Personal and Commercial:** Operated for both personal transportation and commercial transportation.

3.5.2 Overview: Personal vs. Commercial Use

The 1992 TIUS indicates that the majority of light truck users operate their vehicles for personal transportation only, as opposed to commercial use only or mixed personal and commercial use. The 1992 TIUS estimated that 75.5% of light trucks were used as personal-use vehicles for commuting to work, pleasure driving, etc. with no commercial use. The proportion of light trucks identified as personal-use only varied by segment: 82.6% of SUVs; 81.5% of minivans; 74.2% of pickups; and 65.8% of full-size vans.

This overall proportion of light trucks used exclusively for personal transportation has been rising. The proportion estimated by the TIUS rose from 66.2% in 1982 to 73.6% in 1987 to 75.5% in 1992. All light truck segments demonstrate a similar trend, with the exception of full-size SUVs. The proportion of full-size SUVs used for personal transportation declined from 82.6% in 1982 to 74.2% in 1992. However, the proportion of compact SUVs used for personal transportation rose from 78.2% in 1982 to 84.3% in 1992. Consequently, the proportion of all SUVs used for personal transportation rose from 79.7% in 1982 to 82.6% in 1992.

Finally, a very low percentage of light trucks appear in the TIUS as being used for mixed personal and commercial use: only 2.3% of the 1992 stock. This proportion is stable across all the light truck segments.

3.5.3 Personal Transportation Use

Reliable data could not be found on the extent to which personal-use light trucks are used to perform household-related "work" (e.g., moving furniture, shuttling Little League teams, etc.). It is worth noting that a substantial number of households consider a light truck to be the principle household vehicle, that is, the vehicle driven most often. The percentage of households that considered their light truck to be the primary vehicle were, according to previously cited surveys: 82.3% of minivan buyers,[22] 65.2% of SUV buyers,[23] and 51.1% of compact pickup buyers.[24]

Commuting to Work

Of the light trucks used for personal transportation, the proportion of total trips taken for getting to or from work is about the same for SUVs and full-size vans as it is for cars. This proportion is substantially greater for pickups and substantially lower for minivans. Figure 3-3 shows the proportion of all trips taken for commuting-to-work segment, based on both person trips and vehicle trips.[25]

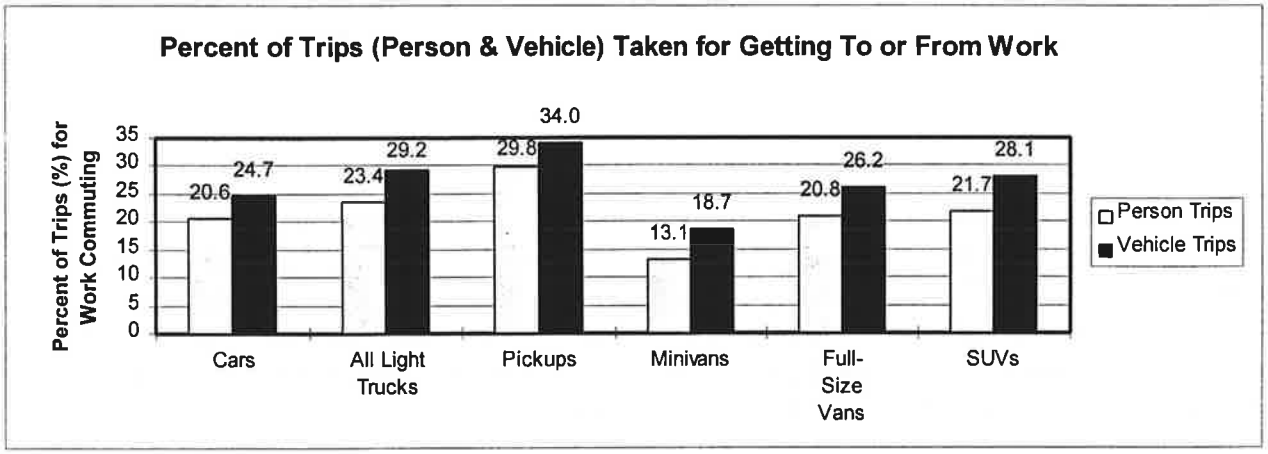

Figure 3- 3. Proportion of Commuting Trips by Segment

Other Trip Reasons

For personal transportation, the proportion of total trips taken for family or personal business, school/church, and other social or recreational purposes is higher for minivans than for cars or any other light truck segment.[26]

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[22] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Minivans*, 1993.
[23] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Sport Utility Vehicles*, 1992.
[24] Hachette Filipacchi Magazines, Inc., *New Car Buyer Survey for Compact Pickup Trucks,* 1992
[25] 1990 National Personal Transportation Survey
[26] Ibid

Average Trip Length

For personal transportation, light trucks are used to take longer trips, on average, than cars. Figure 3-4 shows that pickups and SUVs in particular are used to take longer trips than cars.[27]

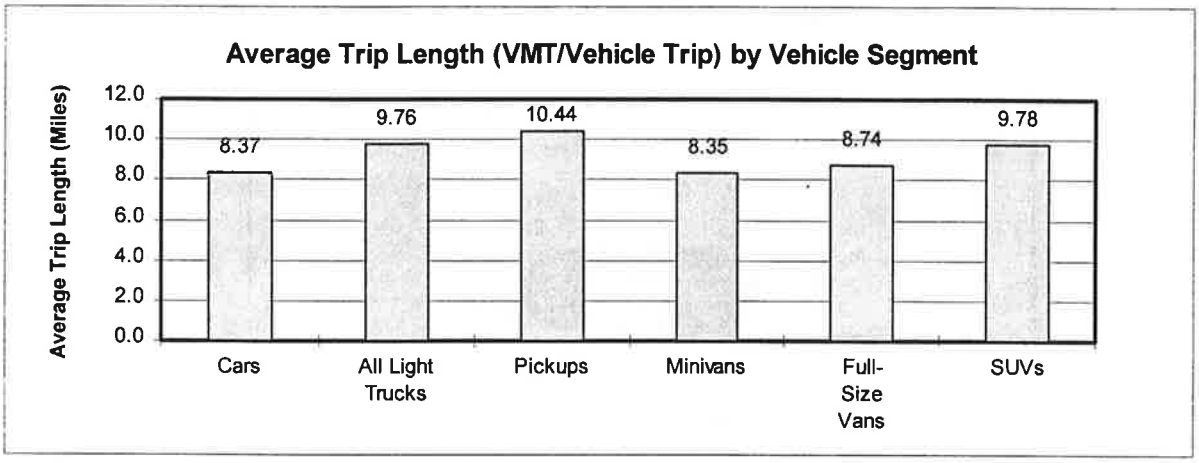

Figure 3- 4. Average Trip Length by Segment

Average Annual Vehicle Mileage

Minivans and SUVs are driven substantially more in a year than cars as shown in Figure 3-5. Pickups are driven about the same mileage as cars. Full-size vans are driven fewer miles than cars.[28]

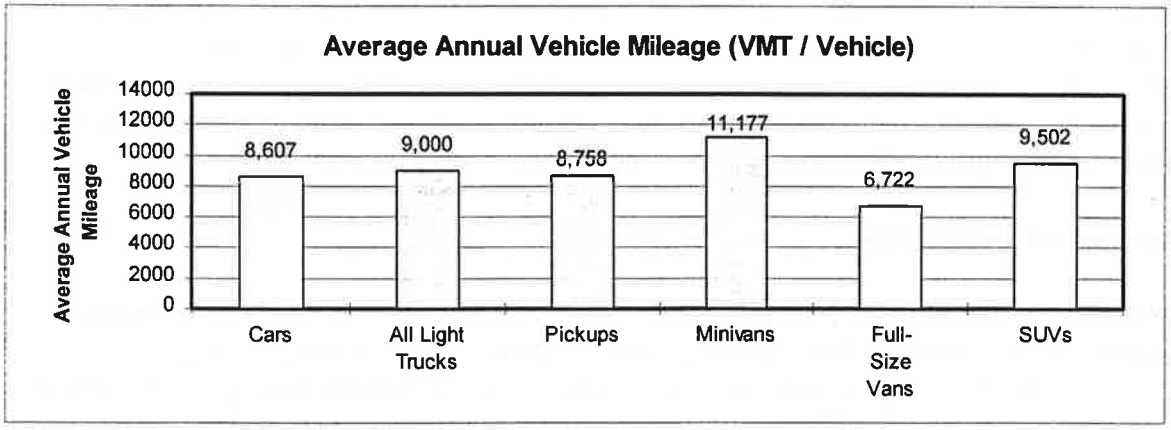

Figure 3- 5. Average Annual Vehicle Mileage by Segment

[27] Ibid
[28] Ibid

3.5.4 Commercial Use

Of those light trucks that are used for commercial and mixed (commercial and personal) purposes (24.5% of the 1992 stock), the most common business type identified in the 1992 TIUS was "general services" followed by agriculture, contractor activities, retail trade, construction, and wholesale trade. Figure 3.6 shows the breakdown of commercial use for all light trucks. Note that "other" includes use categories such as utilities, daily rental, forestry, and mining.[29]

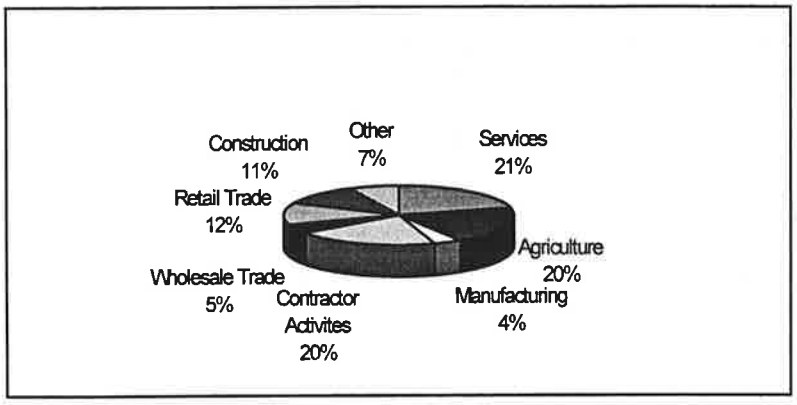

Figure 3- 6. Application of Commercial and Mixed Use Light Trucks (All Segments)

The type of business varies considerably by light truck segment. For example, a much greater proportion of commercial-use pickups were used for agriculture than the proportion of commercial-use trucks in any other segment. 28.0% of commercial-use pickups were used for agriculture, compared with 6.7% of SUVs, 3.5% of full-size vans, and 2.5% of minivans. The American Farm Bureau Federation stated in a submission to NHTSA that "nearly all US farms have a pickup, usually a full-sized model, used for a variety of hauling and towing needs. For farmers, pickups are truly tools of the trade...." Similarly, full-size vans were more likely than other light trucks to be used for contractor activities, and minivans were more likely than other light trucks to be used for wholesale and retail trade. Minivans, however, have been reported to be displacing at least the smaller models of full-size passenger vans in company fleets.[30]

3.5.5 Passenger-Carrying Use

On average, personal-use light trucks carry more passengers on each trip than do cars. Minivans carry the greatest number of passengers while pickups carry fewer passengers than cars. Figure 3.7 shows average vehicle occupancy rates (based on two commonly-used metrics) for cars and light truck segments.[31]

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[29] 1992 TIUS
[30] Ibid
[31] 1990 National Personal Transportation Survey

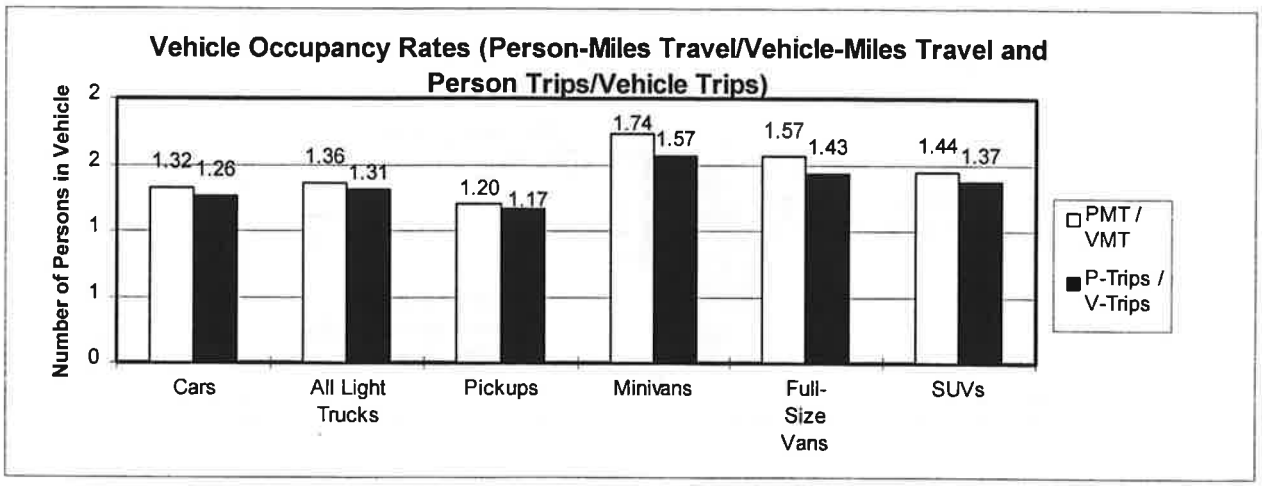

Figure 3- 7. Average Number of Persons per Trip by Light Truck Segment

Commercial usage of light trucks to carry passengers is not predominant, though full-size commercial vans are used to carry passengers more than other commercial use light trucks. The 1992 TIUS shows that the proportion of commercial-use vehicles that is used to carry passengers frequently (i.e., between 76% and 100% of annual mileage) is: 6.0% of full-size vans; 2.1% of minivans; 2.1% of compact SUVs; 1.4% of full-size SUVs; 0.3% of pickups.

3.5.6 Load Carrying Use (Weight and Volume)

Reliable data could not be found on the extent and type of cargo-carrying usage for personal-use light trucks. Nonetheless, there is an abundance of anecdotal information on the cargo-carrying use of personal-use light trucks. Pickups, for example, offer considerable versatility in purely personal use, providing the capacity to deliver a large item for a home-improvement project, even though the cargo bed may be empty during most of the time the truck is in use. Minivans are often used as "station wagon substitutes" and are ideal for performing the typical family tasks of carrying pets, recreation gear, vacation travel baggage, groups of children, and items that need protection from the outside environment. Finally, medium-sized and larger SUVs are particularly well-suited for recreational excursions, such as camping or skiing trips, which require a versatile vehicle capable of accommodating a large amount of bulky gear.

There is an abundance of information on the cargo-carrying use of commercial light trucks. The 1992 TIUS estimated that just under one fifth (19.1%) of commercial-use light trucks rarely carry cargo, while just over two fifths (43.4%) always carry cargo, as shown in Figure 3.8.

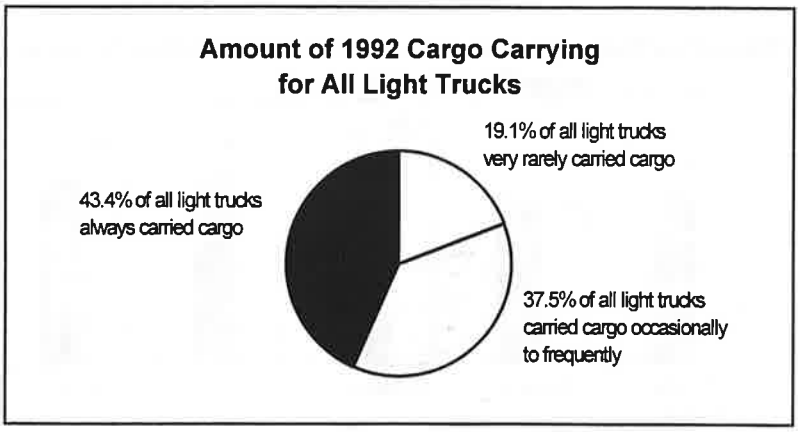

Figure 3- 8. Amount of Cargo Carried for All Commercial-Use Light Trucks during 1992

Commercial-use, full-size vans carry cargo more frequently than other light truck segments, followed by pickups, minivans, and SUVs. Figure 3.9 shows the proportions of each light truck segment carrying cargo always, very frequently, frequently, occasionally, or rarely. The frequency of cargo-carrying is based on annual vehicle mileage.[32]

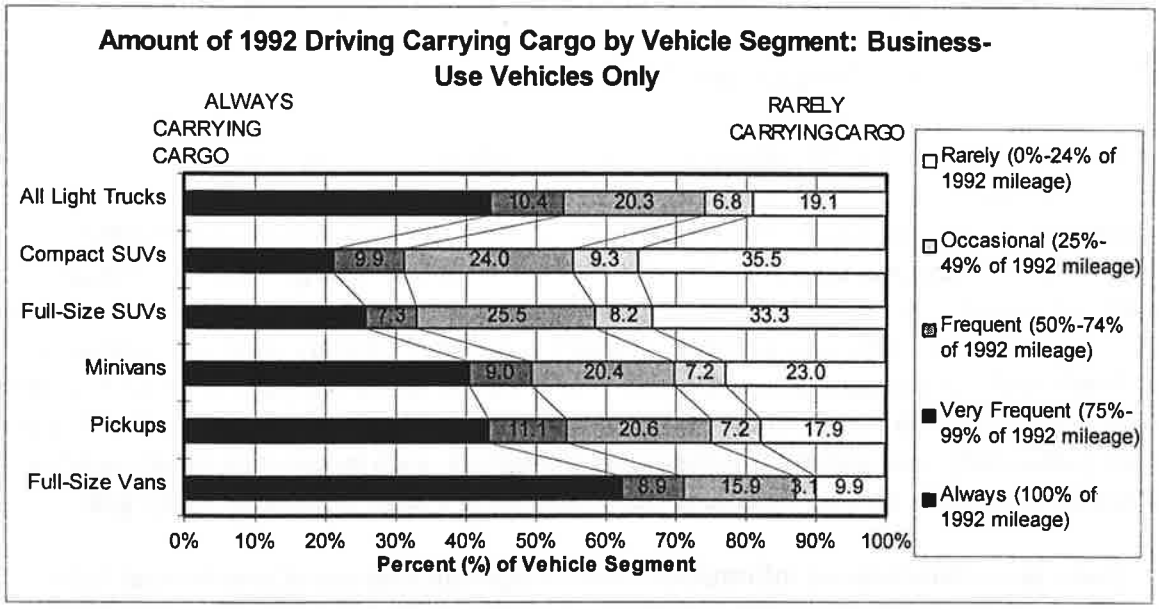

Figure 3- 9. Amount of Cargo-Carrying by Segment (Commercial-Use Trucks Only)

The most common cargo carried by commercial-use light trucks is miscellaneous tools and/or parts for specialized use (as in a craftsman's vehicle, traveling workshop for plumbers,

[32] 1992 TIUS

carpenters, road service crews, etc.), followed by farm products, building materials, and machinery.

The type of cargo carried by light trucks varies considerably by each light truck segment. In certain cases, the type of cargo clearly matches the type of commercial use: pickups are more likely to carry agricultural products; full-size vans are more likely to carry craftsman's equipment; and minivans are more likely to carry "retail and wholesale trade" cargo.[33]

3.5.7 Off-Road Use

Most light trucks are rarely driven in "off-road" conditions. That is, few light trucks utilize their enhanced off-road capability. SUVs are used for skiing, fishing, hiking, camping and other recreational travel that may at some point require the use of four-wheel drive because of poor on-road traction and/or the need to maneuver off-road. Light trucks used by farmers and ranchers may rely extensively on enhanced off-road capability.

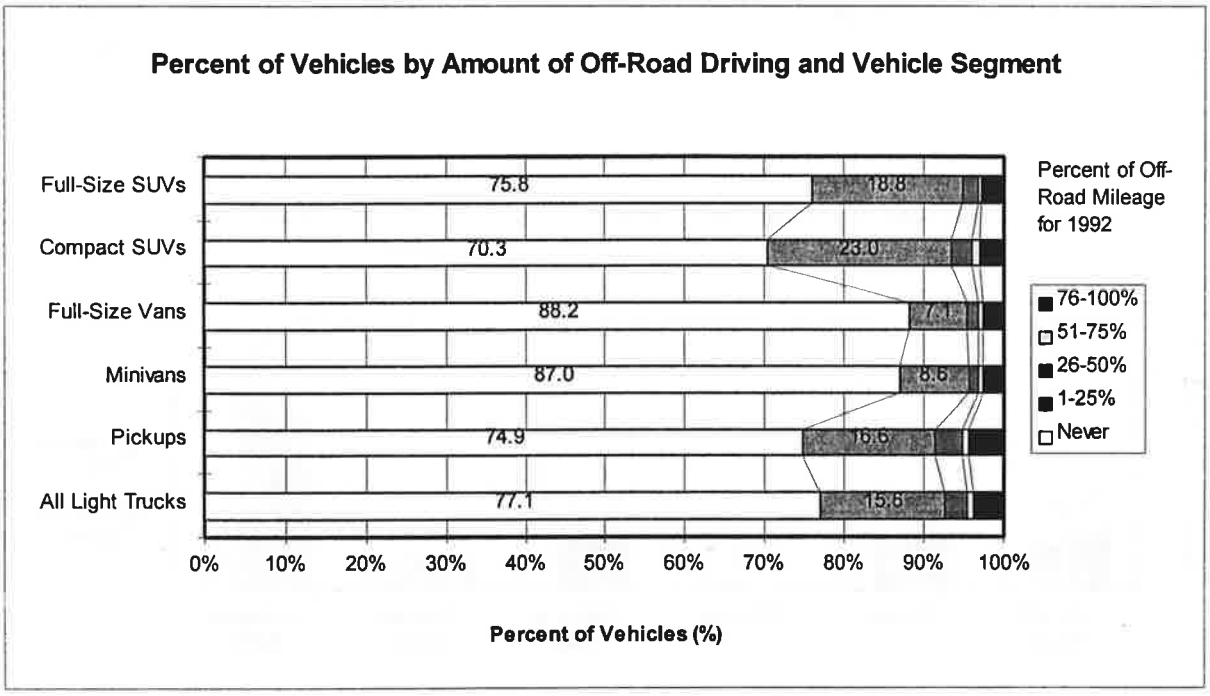

Figure 3- 10. Proportion of Light Trucks By Off-Road Driving and Vehicle Segment

The 1992 TIUS found that 77.1% of all light trucks never were used off-road. Even more interesting is that 70.3% of compact and 75.8% of full-size SUVs were never used off-road, even though 90.8% of the SUVs included in the TIUS were equipped with four-wheel drive (see Figure 3-2).

[33] Ibid

Other surveys corroborate the view that the majority of SUVs are never used off-road or are not purchased with the specific intent of using them off-road. According to the R. L. Polk SUV Buyer Profile Survey, 62.8% of household SUV buyers have not gone off-road and do not plan to. In a survey of the subscribers to "Open Road" magazine, a publication specifically for off-roading enthusiasts, 48% of the respondents claimed to use their light truck for "off-road driving," while 70% used their light truck as the "main means of household transportation."

Use of vans off-road is generally not practical because of lack of vehicle-to-ground clearance. None of the large vans currently sold in the U.S. are offered with four-wheel-drive. All-wheel-drive versions of several minivans are available, but as noted in Section 3.3.5, these vehicles are not designed for off-road use.

3.5.8 Towing Use

The 1992 TIUS shows that the proportion of vehicles frequently towing a trailer (for more than 50% of annual mileage) varies greatly by light truck segment and use segment (commercial, personal, all uses). Owners of personal-use full-size SUVs reported the highest proportion of frequent trailer-towing, followed by owners of commercial-use pickups (see Figure 3.11).

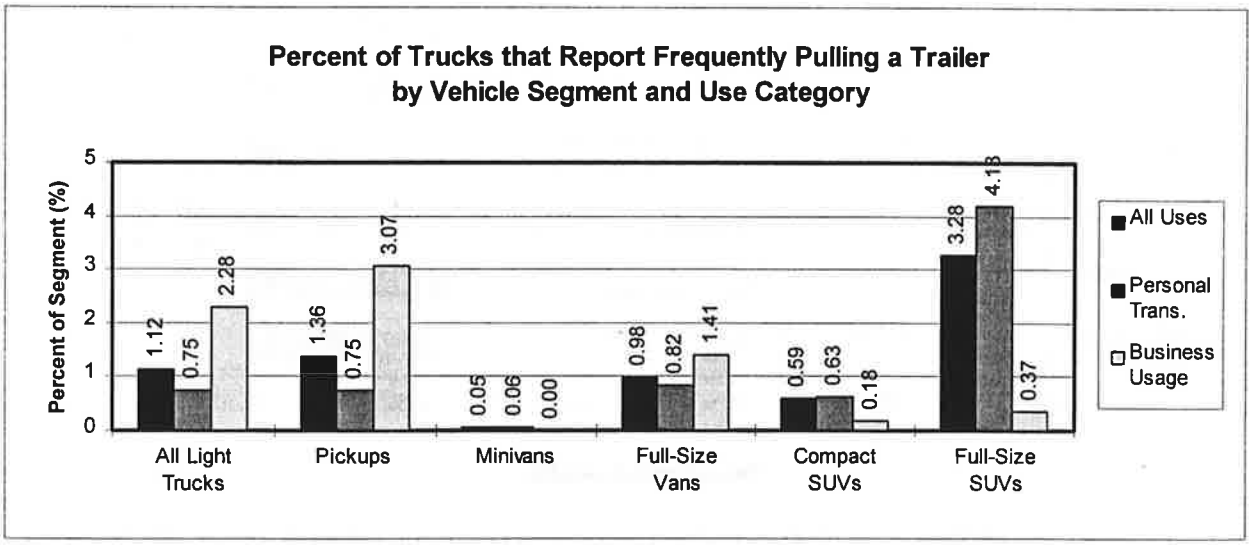

Figure 3- 11. Percent of Light Trucks by Vehicle Segment and Use Segment that Report Frequently Pulling a Trailer

Personal-use full-size SUVs might be used to haul boats, jetskis, campers, horse trailers, snowmobiles, and other miscellaneous recreational equipment. Commercial-use pickups might be used by construction, repair, and landscape tradespeople to tow, for example, small cement mixers, air compressors, or lawn-and-garden power equipment. Trailering of such loads could typically be handled by light trucks with GVWRs under 8500 pounds, although an operator

might prefer a larger pickup to be able to carry a heavier cargo-bed load or transport employees while towing. Large pickups also are used to tow large recreational travel trailers on ball or fifth-wheel hitches.

3.5.9 Handicapped/Disabled Use

Only a small percentage of light trucks have wheelchair lifts installed, with full-size vans having the highest proportion of all light truck segments. The 1992 TIUS estimated that 0.31% of the stock of all light trucks had a wheelchair lift installed, as compared with 1.73% of the full-size van segment, as illustrated by Figure 3.12.[34]

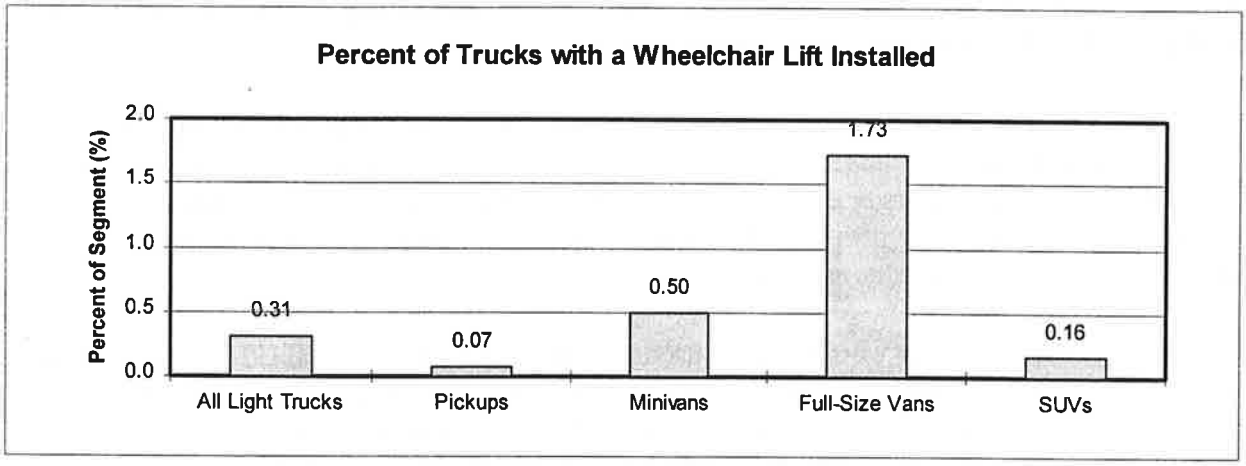

Figure 3- 12. Percentage of Light Trucks with a Wheelchair Lift Installed

Full-size vans can be equipped with heavy-duty suspensions to handle the unbalanced weight of wheelchair lifts. Some vans with wheelchair lifts are also modified by specialist converters so as to be driveable by handicapped persons. Ford Motor Company is reported to offer to these converters special versions of its current large van line, which are built with a separate frame to facilitate floor alterations. A few converters are reported to be installing wheelchair driving equipment in front-wheel drive minivans.

The percent of light trucks with vehicle control aids for the handicapped installed does not vary significantly by segment, with the exception of full-size vans. The 1992 TIUS estimated that 0.36% of all light trucks had vehicle control aids for the handicapped. By segment, 0.48% of full-size vans had vehicle control aids, followed by 0.35% of SUVs, 0.35% of pickups, and 0.34% of minivans.[35]

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[34] Ibid
[35] Ibid

3.5.10 Use of Light Trucks with GVWRs Above 8,500-Pounds

Vehicle sales data between model years 1992 and 1994 indicate that approximately 11.2% of the pickups and 8.3% of the full-size vans sold had GVWRs over the 8,500-pound CAFE limit. No minivans had GVWRs above the CAFE limit. Finally, only 0.9% of the SUVs sold had GVWRs above the CAFE limit (certain GMC and Chevy Suburban models).[36]

Pickups are available without their pickup boxes as "cab-and-chassis" units. Truck body fabricators install special-use equipment on these units. This includes high-cube bodies for small moving vans, tool and supply compartments for mobile repair/construction service units, lifting arms for tow trucks, flatbed or dump-truck bodies for transportation of small quantities of heavy cargo, and camper bodies. The cab-and-chassis units offered by the Big Three manufacturers for model year 1995 all had GVW ratings over 8,500 lbs.

"One-ton" or "three quarter-ton" models of over 8,500 pounds GVWR pickups are suitable for towing heavy construction equipment, such as compact loader/excavators and small rollers. Analogously, farmers occasionally use large pickups to haul heavy, multiple-axle livestock trailers attached by fifth-wheel devices on the truck's cargo bed. This can be a convenient and economical alternative to medium-duty trucks.

Large extended-body vans are often used as base vehicles by specialized converters who equip them with raised roofs and doors and wheelchair lifts to transport various combinations of wheelchair-bound and ambulatory disabled persons. Large vans are also sometimes converted to ambulances. The GVWR ratings of these vehicles are typically above the 8,500-lb. CAFE maximum. In addition, even heavier ambulances are built with special bodies installed on cut-away versions of large vans or cab-and-chassis versions of large pickups.

A substantial number of large vans are converted to luxury travel and recreation vehicles, typically for personal use. *Automotive News* recently reported that nearly half of General Motors large vans are converted in this manner. The annual survey of converters by the Recreation Vehicle Industries Association reports sales to dealers of 181,800 such vans during calendar 1994. Van conversions for personal travel do not necessarily have GVWRs above 8,500 pounds. Large vans that are expanded and equipped with toilets and kitchens to become "type B" motorhomes typically have GVWRs above 8,500 lbs. There are the even heavier "type C" motorhomes, which consist of special bodies installed on cut-away versions of large vans in the same manner as heavy ambulances and other special-body van conversions.

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[36] *Ward's Automotive Yearbook*, 1993, 1994, 1995

3.6 SUMMARY

- Capabilities of light trucks subject to CAFE that are notably superior to those of passenger cars include:

    - Towing capacity much greater than the typical 1-ton capacity of modern, front-wheel drive cars; up to 5 tons with large models.
    - Up to 1 1/2-ton payload capacity with large models.
    - 3- and 4-row seating in vans.
    - Extemely high internal cargo volume for large vans.
    - Ease of cargo accessibility in pickups.
    - Ability to operate off paved roads with SUVs and pickups equipped with four-wheel drive.

- Higher levels of light truck capabilities are generally available only with models with GVWRs above the 8,500-pound maximum subject to CAFE including:

    - Over 5-ton towing capacity
    - Over 1 1/2-ton payload capacity
    - 5-row seating in large vans

- Conversion of pickups and vans to carry specialized bodies for camping, motor home travel, ambulance and disabled-person transport and numerous business uses generally requires vehicles over the maximum GVWR subject to CAFE.

- Heavy towing of loader/excavators and livestock trailers, for example, generally requires vehicles over the maximum GVWR subject to CAFE.

- Individual consumers are attracted to the image of light truck ruggedness and the perceived durability and dependability of light trucks.

- Individual consumers value the passenger capacity, roominess and versatility of small vans.

- Individual consumers value the availability of four-wheel drive for SUVs; they are less interested in their ability to operate off paved roads.

- At least three-quarters of light trucks are used for personal transportation. Minivans, in particular, are used for family and social/recreational purposes and typically carry higher passenger loads than cars.

- Light trucks in business use are employed in services, agriculture, contractor/construction activity, and trade. Pickups are most likely to be used in agriculture, large vans in contractor activity, minivans in trade.

- A majority of light trucks in personal use, including SUVs, are never operated off-road.
- Only a very small proportion of light trucks, including even pickups and large SUVs, pull trailers most of the time.
- A very small proportion of light trucks have wheelchair lifts installed.

4. Trade-Offs Between Capabilities And Fuel Economy

4.1 INTRODUCTION

Chapter 4 assesses how consumer requirements and other regulatory requirements might constrain the ability to improve light truck fuel economy for model years 1998 through 2006. Congress requested specifically that the following considerations be included in the preparation of this report:

> "...a review of relevant technologies and their impact on consumer choice, product size and load carrying ability, driveability, and customer needs. The latter should include...commercial, agricultural applications...."
>
> "...the effect of other federal and vehicle standards (for example, safety and emissions standards), voluntarily-added safety features..."

Given these considerations, Chapter 4 has the following objectives:

1. Examine the relationships between light truck capabilities and light truck fuel economy.

2. Review the potential improvements in light truck fuel economy through the use of various technologies and strategies.

3. To explore the potential conflicts between light truck fuel economy improvements and light truck capabilities, safety standards, emissions standards, and consumer choice.

4.2 RESEARCH PROCEDURE AND METHODOLOGY

4.2.1 Light Truck Capabilities and Fuel Economy

Research revealed that light truck fuel economy studies completed within the past fifteen years estimated potential fuel economy improvements on the basis of fixed light truck capabilities. The sensitivity of fuel economy to changes in the level of light truck capabilities has largely remained unexplored. Because available research was lacking, this study attempted to explore what correlations exist between fuel economy and light truck capabilities.

For the purpose of examining the relationships between fuel economy and light truck capabilities, the 1994 model year sales fleet is divided into four segments: passenger vans, cargo vans, pickups, and Sport Utility Vehicles (SUVs). For each light truck segment, a group of

on which light truck capabilities seem to be linked to fuel economy rating, and perhaps more importantly, which capabilities are not linked to fuel economy.

All the correlations for capability and fuel economy are based on the attributes and specifications of model year 1994 gasoline-powered, automatic transmission vehicles. These are the most recent comprehensive numbers available.

4.2.2 Potential of Technical Strategies for Improving Fuel Economy

To identify potential technical strategies for improving light truck fuel economy existing studies were reviewed. Projected fuel economy gains based on the implementation of a number of technologies are documented. The fuel economy improvement estimates reflect fixed light truck capabilities.

The fuel economy technologies can be grouped into three classes:

- Engine technologies
- Transmission technologies
- Chassis/body technologies

4.2.3 Potential Conflicts Between Light Truck Fuel Economy Improvements and Capabilities, Safety and Emissions Standards, and Consumer Choice

This study considers the applicability and effectiveness of fuel economy technologies and strategies given the following considerations:

- Light truck enhanced capabilities
- Future regulations: safety and emissions
- Consumer choice: performance, driveability, durability and dependability, and versatility

4.3 LIGHT TRUCK CAPABILITIES AND FUEL ECONOMY

Figure 4-1 displays the primary and secondary enhanced capabilities of each of the four light truck segments. This categorization is consistent with the light truck segments discussed in Chapter 3, except that no size distinctions are made (e.g. compact pickups versus full-size pickups). With respect to capabilities, examination of recent and current production vehicle specifications shows no obvious break points between large and small vans, pickups or SUVs. Vans were split between those with a passenger-carrying capability and those equipped exclusively for cargo carrying.

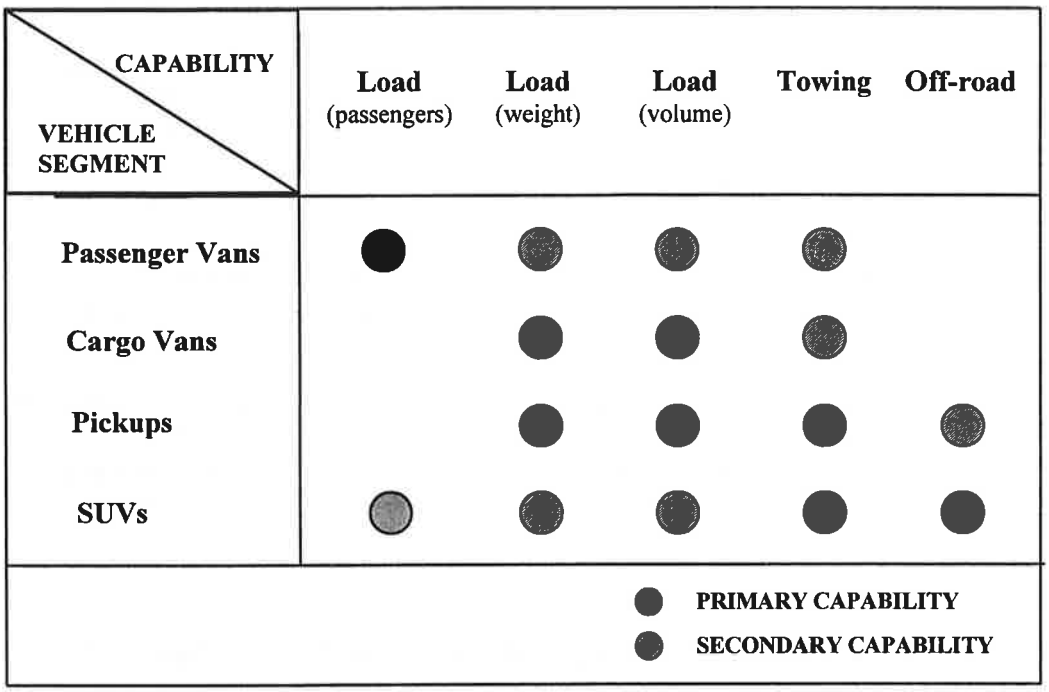

Figure 4-1. Light Duty Truck Enhanced Capabilities

4.3.1 Quantification of Light Truck Capabilities

Light truck enhanced capabilities were previously defined in Chapter 3. Each of the light truck primary enhanced capabilities must be quantified to allow plotting of light truck capabilities against fuel economy rating. With the exception of off-road capability, each capability is quantified by a numerical capacity, volume, or area. SUVs with four-wheel drive are assumed to possesses off-road capability (see Figure 4-2).

PASSENGER VANS		CARGO VANS	
CAPABILITY	ATTRIBUTE	CAPABILITY	ATTRIBUTE
LOAD (PASSENGERS)	NUMBER OF SEATS	LOAD (WEIGHT)	PAYLOAD CAPACITY (LBS)
		LOAD (VOLUME)	USABLE VOLUME (CU.FT.)
PICKUPS		**SPORT UTILITY VEHICLES**	
CAPABILITY	ATTRIBUTE	CAPABILITY	ATTRIBUTE
LOAD (WEIGHT)	PAYLOAD CAPACITY (LBS)	TOWING	TOWING CAPACITY (LBS)
LOAD (VOLUME)	CARGO BED AREA (SQ.FT.)	OFF-ROAD OPERATION	PRESENCE OF FOUR WHEEL DRIVE
TOWING	TOWING CAPACITY (LBS)		

Figure 4-2 Attributes for Quantifying Light Truck Primary Capabilities

4.3.2 Fuel Economy Ratings, Capabilities, And Vehicle Attributes For Recent Model Year Light Trucks

All the observations regarding light truck capabilities and fuel economy are based on the attributes and specifications of model year 1994 gasoline-powered, automatic transmission vehicles. Each light truck segment was represented by between 12 to 19 different 1994 models. The models were selected either because they were popular models with high sales numbers, or because they helped fill out the full range of a particular capability (i.e. passenger capacity) for that light truck segment.

The basis of this portion of the study is NHTSA's CAFE database, which contains EPA fuel economy ratings and production numbers for all model year 1994 light-duty vehicles sold in the United States. Vehicle capabilities are not included in NHTSA's database, so it was necessary to augment the database with information from a variety of sources. These included manufacturers' sales brochures, *Trailer Life* magazine and *Ward's Automotive Yearbook.*

4.3.3 Correlation Techniques In This Study

A correlation presents the change in one variable relative to the change in another variable. The variables are linked by an identifying parameter, which in the case of this study is the specific light truck model.

A strong correlation between two variables does not guarantee a causal relationship between the two variables. It is possible that a strong correlation is due to a functional relationship between two variables, or due to both of the variables being functions of a common third parameter, or due to coincidence.

To derive the relationships between light truck fuel economy and capabilities, a multivariate regression would be necessary. To be valid, such a regression would require the inclusion of all variables that could affect either fuel economy or truck capability. A multivariate regression requires a large sample size if it is to be valid. A multivariate regression was judged to be outside the time limitations and data availability of this study.

The square of the correlation coefficient, R^2, also known as the coefficient of determination, is used to measure the quality of a curve-fit versus the data. An R^2 of 1.0 indicates a curve-fit is perfect, while an R^2 value of 0 implies that the curve-fit has no explanatory value.[1] The following terminology is used to describe the findings for each light truck segment examined in this report:

- A strong correlation if $R^2 > 0.8$
- A moderate correlation if $0.8 > R^2 > 0.6$
- A weak correlation if $0.6 > R^2 > 0.4$
- Little or no correlation if $R^2 < 0.4$

The curve-fits for each of the scatter plots in this section of the report are exponential functions, of the form:

$$\mathbf{y = kx^a}$$

y = fuel economy rating in miles per gallon
x = numerical value that quantifies a capability (i.e. number of seats)
k,a = constants

The equation for each curve-fit and the corresponding R^2 value is included on each of the plots in Figure 4-3 through 4-14.

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[1] Wonnacott, Thomas H. & Wonnacott, Ronald J. ,*Introductory Statistics, 3rd Edition*, 1977

4.3.4 Findings by Light Truck Segment

Scatter plots of fuel economy versus capabilities and vehicle test weight are included for each of the four light truck segments. The sample size for each light truck segment is as follows:

- Passenger vans - 12 models
- Cargo vans - 14 models
- Pickups - 19 models
- Sport Utility Vehicles - 17 models, except for the comparison of two-wheel drive versus four-wheel drive SUVs, for which information could only be found on 10 models.

Each point is labeled with the corresponding vehicle model. The curve-fit is represented by a dashed line along with the equation for the curve-fit and the corresponding R^2 value.

Passenger Vans

There is a weak correlation between increased passenger van seating capacity, as quantified by number of seats, and decreased fuel economy ratings (see Figure 4-3).

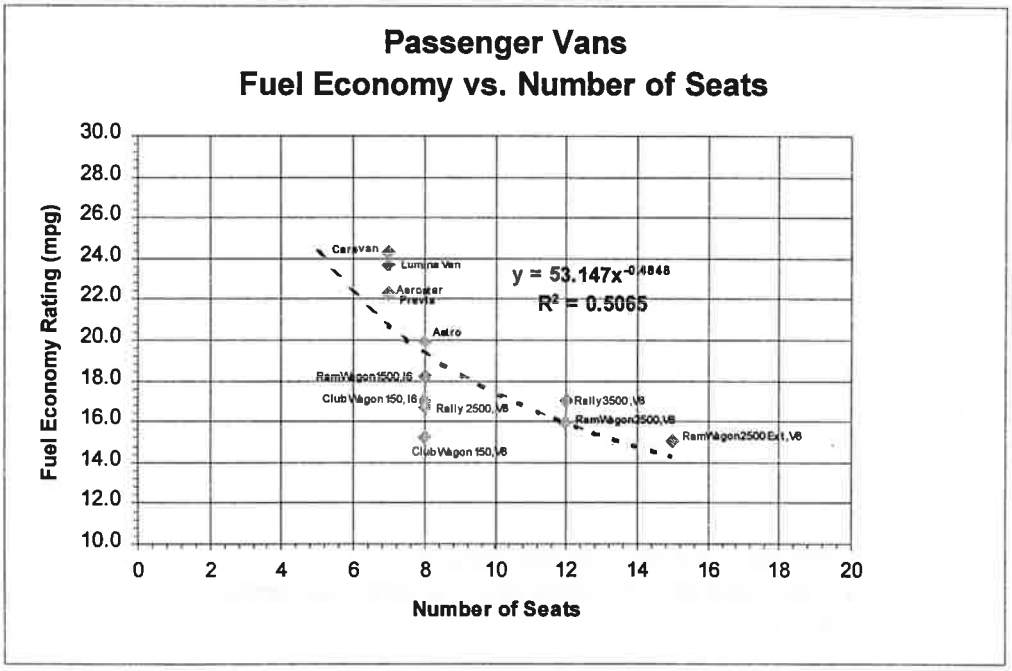

Figure 4-3. Passenger Vans: Fuel Economy vs. Number of Seats

Passenger vans exhibit a strong correlation between higher test weights and lower fuel economy ratings (Figure 4-4).

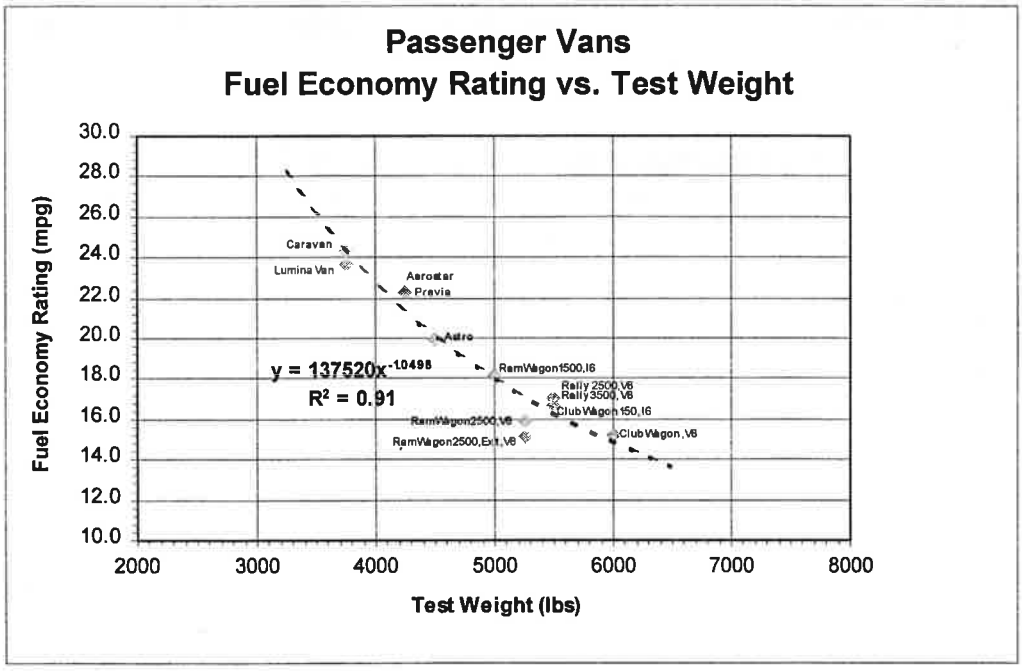

Figure 4-4. Passenger Vans: Fuel Economy vs. Test Weight

Cargo Vans

There is a weak correlation between higher cargo van payload capacity and lower fuel economy ratings (see Figure 4-5).

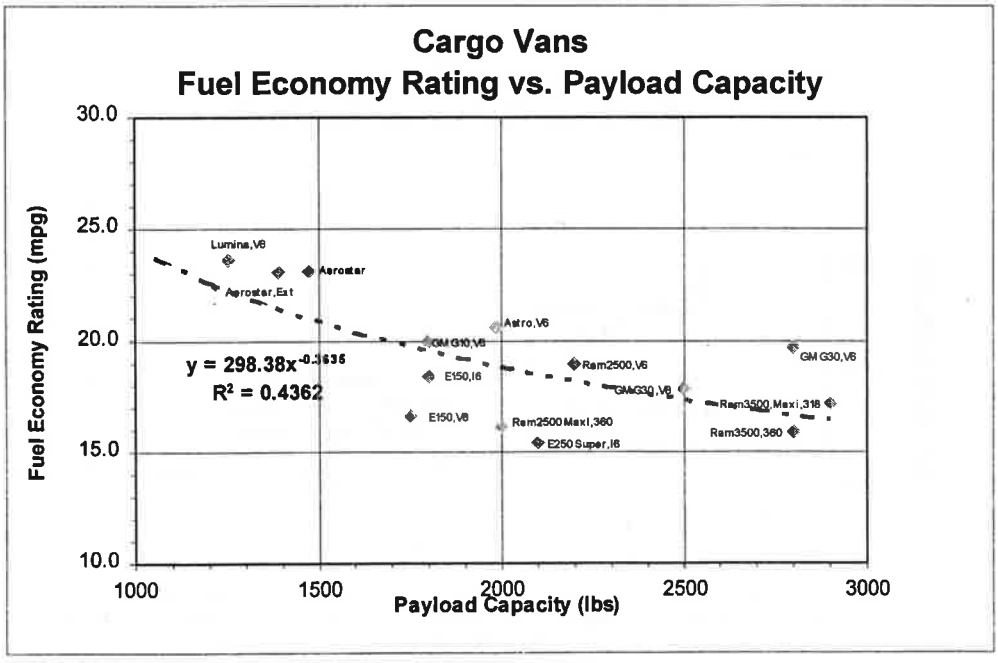

Figure 4-5. Cargo Vans: Fuel Economy Rating vs. Payload Capacity

There is a strong correlation between decreasing fuel economy and increasing cargo van volume-carrying capability, as quantified by usable volume (see Figure 4-6). The scatter in the plot of fuel economy versus usable volume is due in part to differences in engine displacement for similar models, with increased engine displacement causing decreased fuel economy.

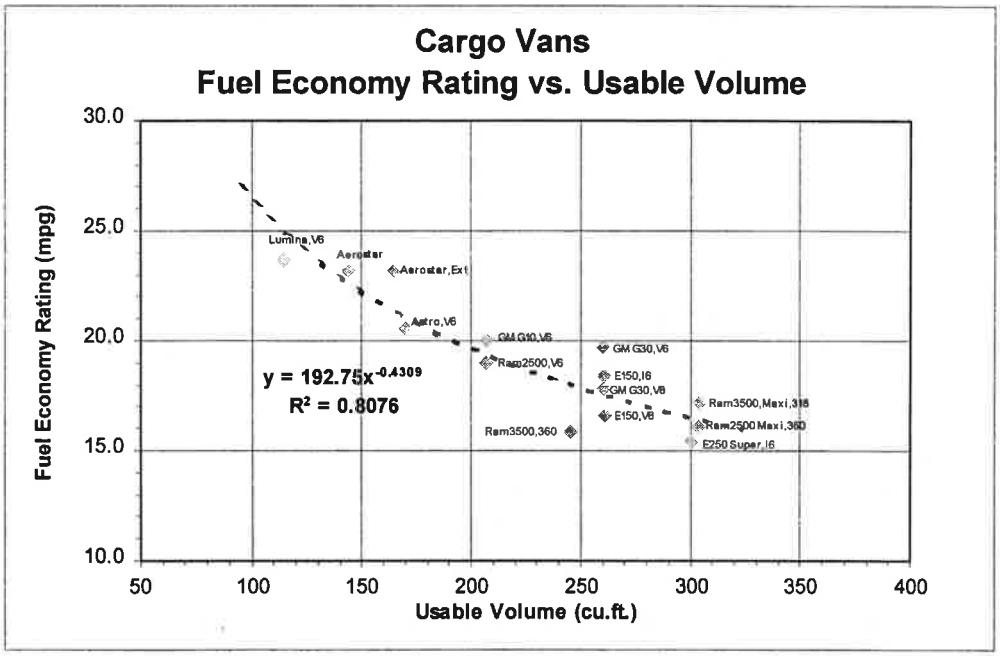

Figure 4-6. Cargo Vans: Fuel Economy Rating vs. Usable Volume

There is a strong correlation between decreasing fuel economy and increased cargo van test weight (see Figure 4-7).

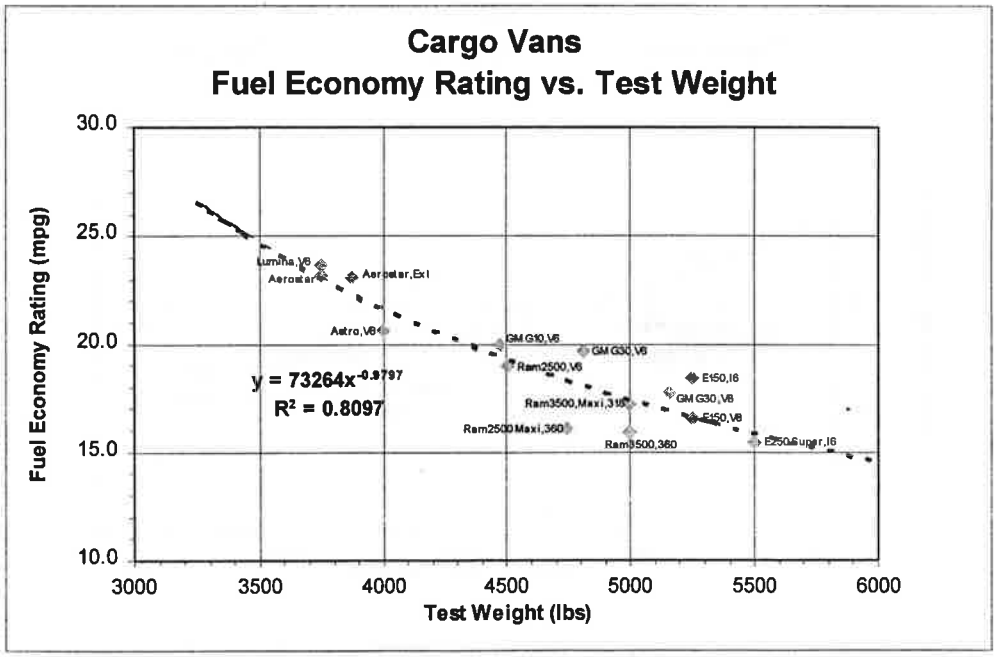

Figure 4-7. Cargo Vans: Fuel Economy Rating vs. Test Weight

Pickups

Fuel economy has little or no correlation with pickup payload-carrying capability (see Figure 4.8).

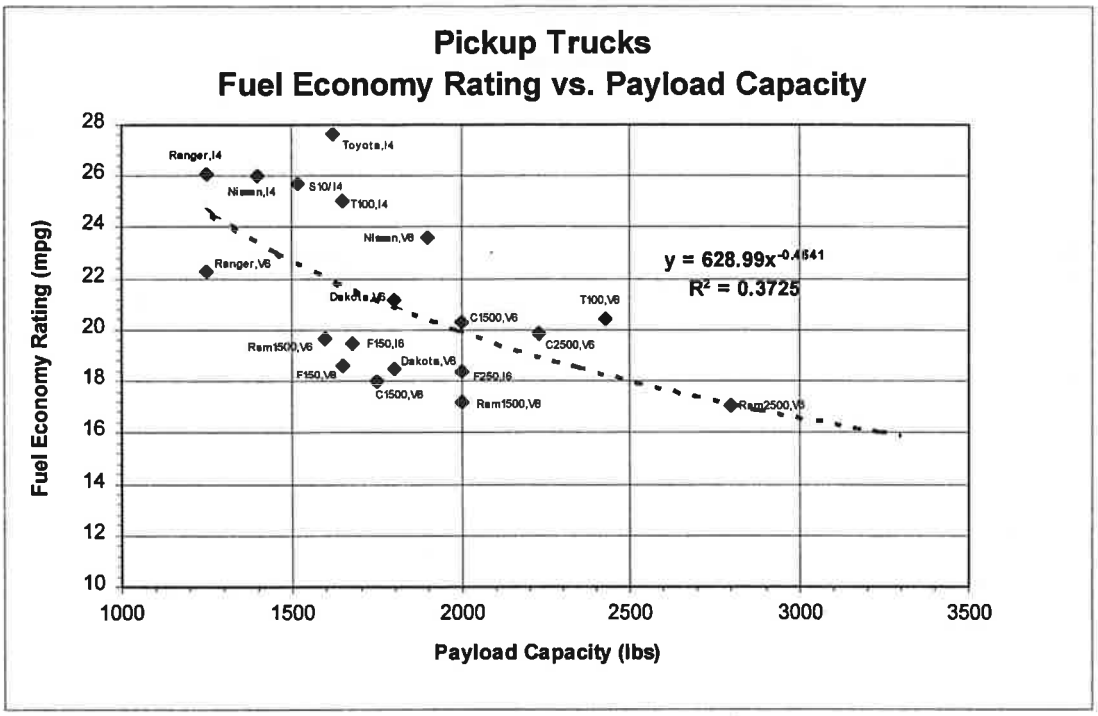

Figure 4-8. Pickup Trucks: Fuel Economy Rating vs. Payload Capacity

There is also little or no correlation between fuel economy and pickup truck volume-carrying capability, as quantified by cargo bed area in square feet (see Figure 4-9).

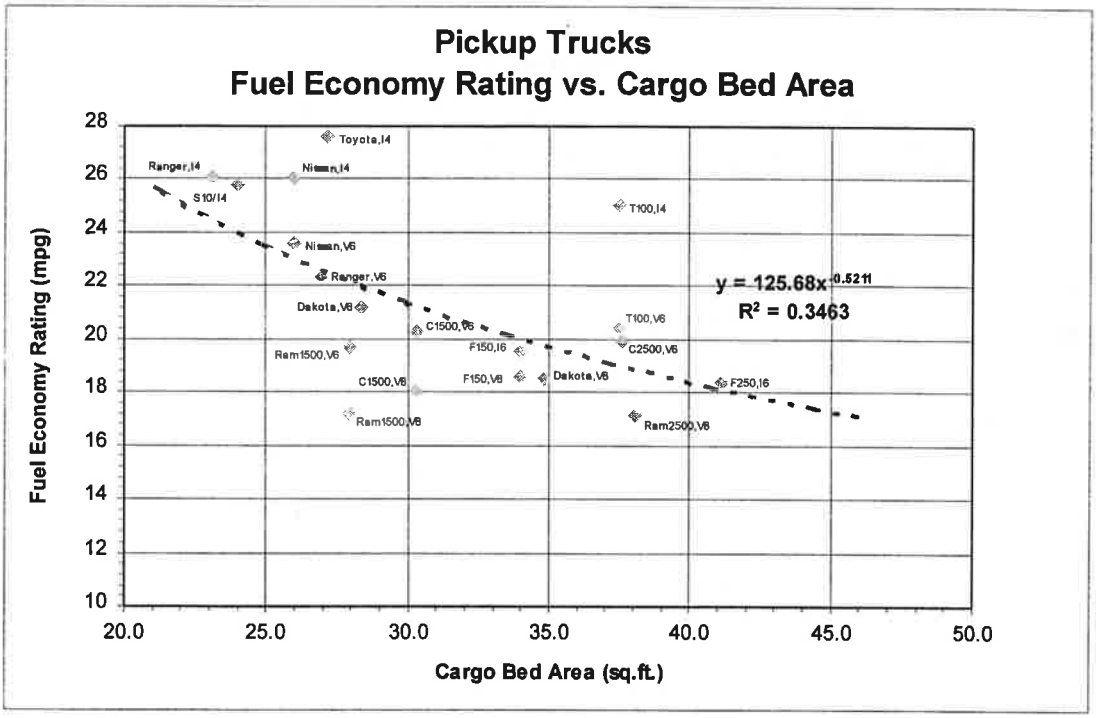

Figure 4-9. Pickup Trucks: Fuel Economy Rating vs. Cargo Bed Area

Decreasing fuel economy has a moderate correlation with increased towing capacity. There is more scatter in fuel economy ratings for towing capacities below 6000 pounds (see Figure 4-10).

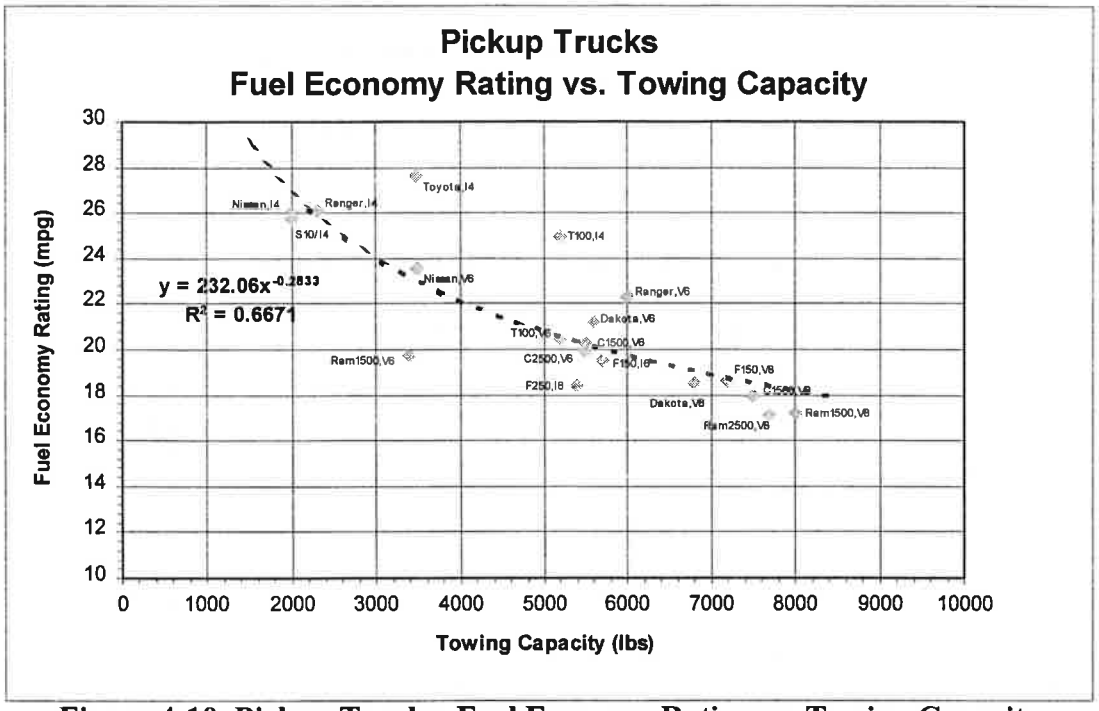

Figure 4-10. Pickup Trucks: Fuel Economy Rating vs. Towing Capacity

Fuel economy has a strong correlation with pickup test weight, with lower fuel economy ratings corresponding to higher test weights (see Figure 4-11).

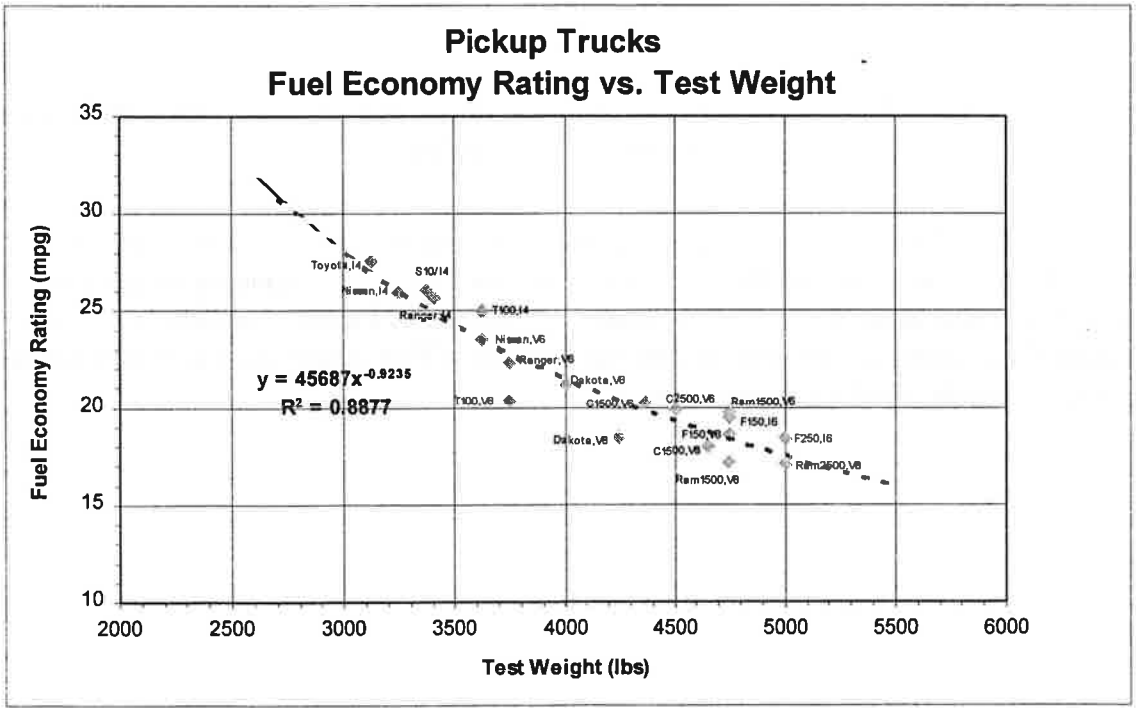

Figure 4-11. Pickup Trucks: Fuel Economy Rating vs. Test Weight

SUVs

The presence of four-wheel drive is assumed necessary for full off-road capability. Figure 4-12 contains the change in fuel economy rating between two-wheel drive and four-wheel drive versions of 10 different 1994 SUVs. Nameplate, transmission, engine displacement, and number of doors were held constant between two-wheel drive and four-wheel drive versions. There is a decrease in fuel economy of between 0% and 20% for equipping a given SUV model with four-wheel drive instead of two-wheel drive.

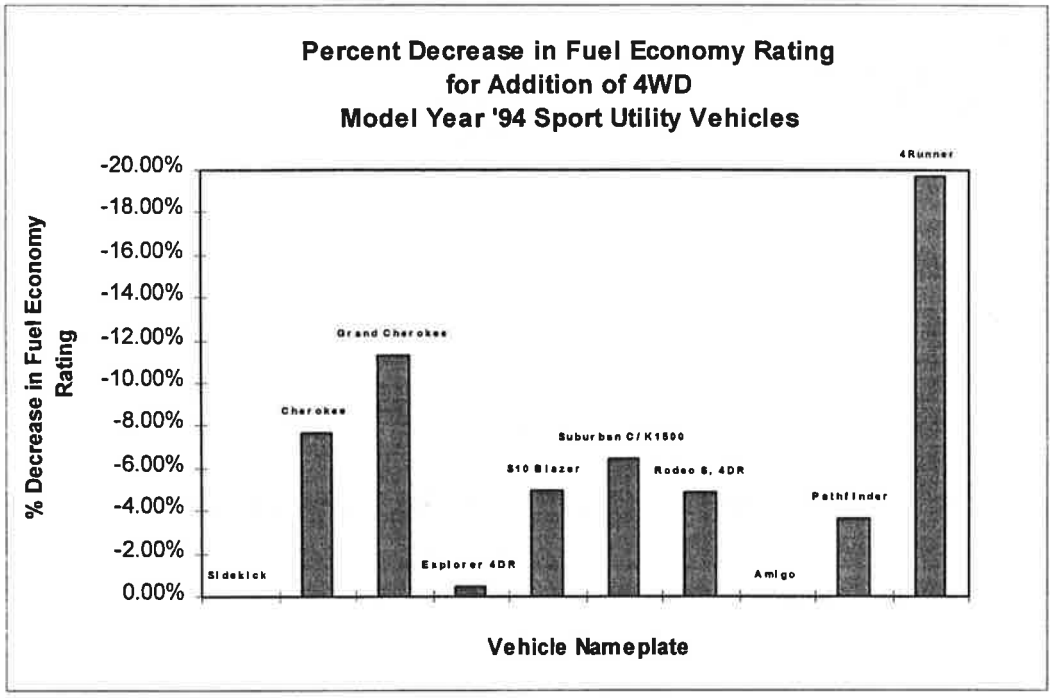

Figure 4-12. Percent Decrease in Fuel Economy Rating for Addition of 4WD Model Year '94 Sport Utility Vehicles

Figure 4-13 illustrates a strong correlation between increasing SUV test weight and decreasing fuel economy. Notice that there is no obvious shift in fuel economy versus test weight for two-wheel drive(2WD) SUVs compared to four-wheel drive (4WD) SUVs. This implies that the decrease in fuel economy for the addition of four-wheel drive is largely due to the associated vehicle weight increase.

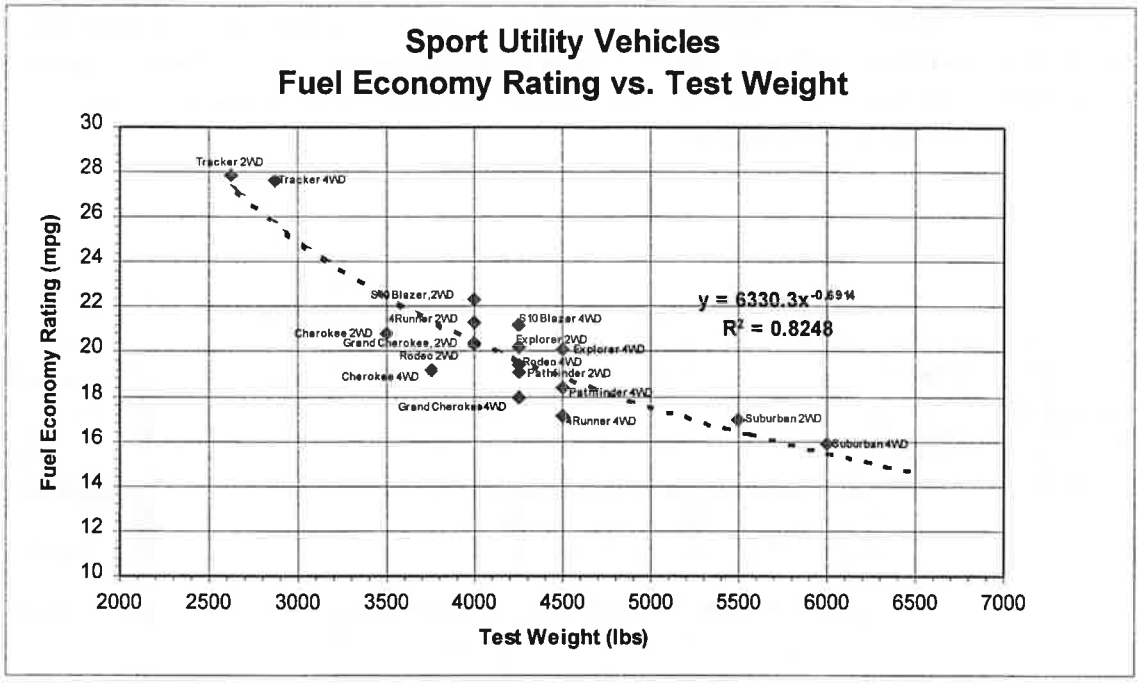

Figure 4-13. Sport Utility Vehicles: Fuel Economy Rating vs. Test Weight

There is a moderate correlation between decreasing fuel economy and increasing towing capacity (see Figure 4-14).

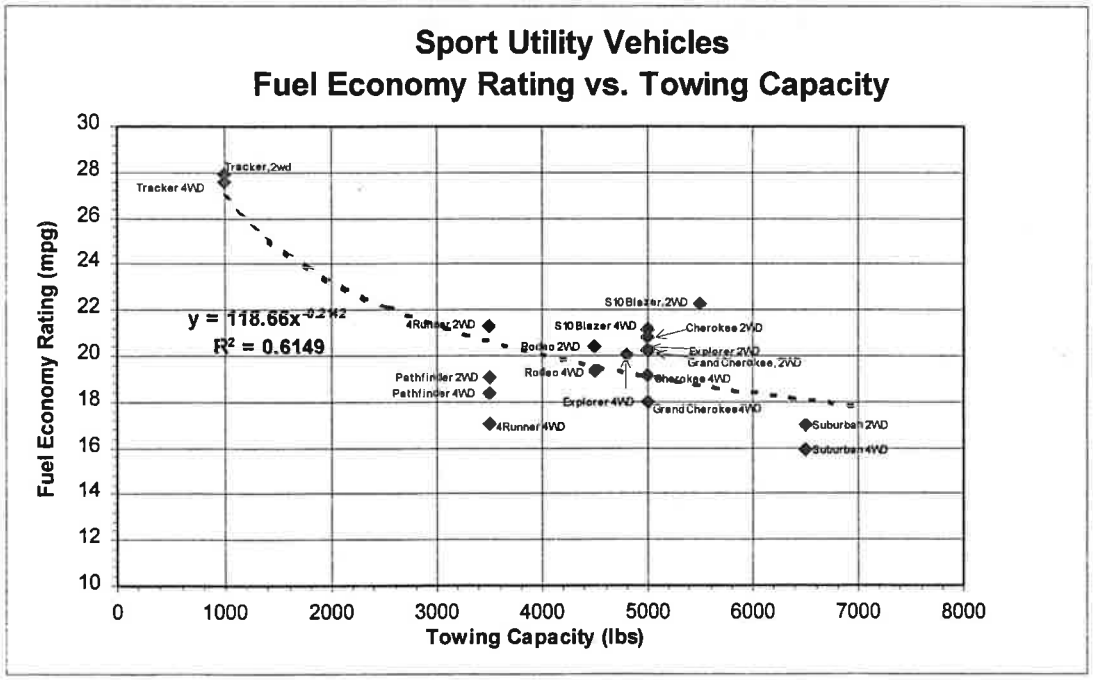

Figure 4-14. Sport Utility Vehicles: Fuel Economy Rating vs. Towing Capacity

Figure 4-15 summarizes the observations of fuel economy rating plotted against light truck capabilities and light truck test weight. These observations apply to the limited samples of model year 1994 light trucks included in this portion of the study, and are not necessarily comprehensive or universally applicable.

	LOAD (PASSENGERS)	LOAD (WEIGHT)	LOAD (VOLUME)	TOWING	OFF-ROAD	TEST WEIGHT
PASSENGER VAN	WEAK OBSERVED CORRELATION	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	STRONG OBSERVED CORRELATION
CARGO VAN	NOT A PRIMARY CAPABILITY	WEAK OBSERVED CORRELATION	STRONG OBSERVED CORRELATION	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	STRONG OBSERVED CORRELATION
PICKUPS	NOT A PRIMARY CAPABILITY	NO OBSERVED CORRELATION	NO OBSERVED CORRELATION	MODERATE OBSERVED CORRELATION	NOT A PRIMARY CAPABILITY	STRONG OBSERVED CORRELATION
SPORT UTILITY VEHICLES	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	NOT A PRIMARY CAPABILITY	MODERATE OBSERVED CORRELATION	ADDITION OF 4WD DECREASES FUEL ECONOMY	STRONG OBSERVED CORRELATION

Figure 4-15. Observations for Fuel Economy and Light Truck Capabilities and Test Weight

4.4 IMPACT OF TECHNICAL STRATEGIES ON FUEL ECONOMY

4.4.1 Sources

Four major studies[2] [3] [4] [5] that evaluate technological approaches to improving fuel economy for passenger cars and light trucks were identified. In several cases, the studies included fuel economy technologies that were relevant to both cars and light trucks. The fuel economy gains reported by each of the major studies were tabulated, with findings grouped by technology. Table 4-1 summarizes the relevant content of each report.

Table 4-1. Existing Fuel Economy Studies

Report	Fuel Economy Technology Issues	Safety and Emissions Standards Issues	Other
Automotive Fuel Economy *- How Far Should We Go? National Research Council, 1992 Prepared in response to request by NHTSA & FHWA*	• Description of automotive fuel economy technologies • Percent change in fuel economy for a given technology	• Vehicle test/curb weight impact of future LDT safety and emissions standards • Vehicle price impact of future LDT safety and emissions standards	• New technologies for improving vehicle fuel economy • Emerging technologies for improving fuel economy • Differences in applicable fuel economy technologies for trucks and cars
Improving Automobile Fuel Economy *Office of Technology Assessment, 1991 Prepared in response to request by US Congress*	• Description of automotive fuel economy technologies	• Relationship between new fuel economy standards and safety as related to vehicle weight, interior volume and exterior dimensions	• Substitutes diesel engines for gasoline engines • Methodology for predicting the combined effect of several fuel economy technologies
Domestic Manufacturers Light Duty Truck Fuel Economy Potential to 2005 *Energy and Environmental Analysis, Inc., 1994 Prepared for Martin Marietta, Oak Ridge National Lab*	• Description of automotive fuel economy technologies	• Weight and fuel economy impact of future safety & environmental standards	• Aerodynamic drag coefficients for a number of current production LDTs & estimates for the minimum aerodynamic drag coefficient for future pickups, vans & SUVs
Potential for Improved Fuel Economy in Passenger Cars and Light Trucks *SRI, International, 1991 Prepared for Motor Vehicle Manufacturer's Association*	• Description of automotive fuel economy technologies • Percent change in fuel economy for a given technology • Cost effectiveness of each fuel economy technology	• Weight increases relevant to 1990 baseline due to safety standards	• Technology fuel economy improvements

[2] National Research Council, *Automotive Fuel Economy: How Far Should We Go?*, National Academy Press, 1992
[3] Office of Technology Assessment, *Improving Automobile Fuel Economy*, OTA-E-504, October 1991
[4] Energy and Environmental Analysis, Inc., *Domestic Manufacturers Light Duty Truck Fuel Economy Potential to 2005*, prepared for Martin Marrietta Energy Systems, Oak Ridge, TN, January 1994
[5] SRI International, *Potential for Improved Fuel Economy in Passenger Cars and Light Trucks*, SRI Project 1955, prepared for Motor Vehicle Manufacturers Association, Detroit, MI, July 1991

4.4.2 Potential Fuel Economy Technologies

Viable light truck fuel economy technologies for the 1998 to 2006 model years were grouped into the three classes: engine technologies, transmission technologies and chassis technologies. These groups were compiled from the four fuel economy studies identified above and from automotive press sources.

Engine technologies improve the efficiency of power production by the engine. This can be accomplished by technologies that reduce losses, such as friction reduction, or through thermodynamic improvements, such improvements to combustion. Table 4.2 provides brief descriptions of the engine technologies considered in the preparation of this report.

Table 4-2. Engine Technologies for Fuel Economy Improvement

TECHNOLOGY	DESCRIPTION
Multi-valve engines	More than 2 valves per cylinder
Variable valve timing	Permits both valve timing and lift to change in response to operating load and speed
Increased engine compression ratio	Improvements in cylinder head redesign, charge flow control, use of knock sensors, coolant flow improvements, etc.
Advanced Electronic Control	Improved control of air-to-fuel ratio, ignition system and overall engine operation
Port fuel injection	More precise control of air-to-fuel ratio in each cyylinder over the operating range of an engine
Lean burn - fast burn combustion	Use of air/fuel mixtures containing excess air
Overhead cam engine	Reduces friction & weight by using fewer moving parts and less inertial mass
Engine friction reduction and lubricant improvement	Reduction of rubbing friction occurring among engine moving parts
Engine accessory load reduction	Reduced load on engine from alternator, air-conditioning and pumps
Turbocharging	Exhaust driven turbine used to power compressor which pre-compresses air that is fed into engine
Supercharging	Belt or gear driven compressor pre-compresses air that is fed into engine
Diesel cycle engine	Compression ignition, fuel injected engines operating on Diesel cycle rather than conventional Otto cycle
Two-stroke cycle engine	Engines operating on a two-stroke cycle consisting of a power/intake stroke and a compression/exhaust stroke

Chassis/body fuel economy technologies consist of changes to the vehicle structure that result in lower power requirements, which will usually lead to lower fuel consumption. For example, vehicle power requirements can be reduced through vehicle weight and aerodynamic drag reduction.

Transmission fuel economy technologies improve the conversion of engine power to tractive work or force. Transmission fuel economy technologies may increase overall vehicle efficiency through reduced transmission losses or through improved matching between engine and vehicle, so that the engine can operate more efficiently.

Table 4-3 contains brief descriptions of chassis/body and transmission fuel economy technologies.

Table 4-3. Chassis and Transmission Technologies for Fuel Economy Improvement

TECHNOLOGY	DESCRIPTION
Chassis/body	
Weight reduction through redesign	Optimizing the chassis design and layout to minimize weight.
Weight reduction through material substitution	Substitution of lighter materials for heavier ones in existing designs.
Aerodynamic Enhancement	Smoothing the vehicle exterior through the incorporation of flush windows, streamlined mirrors, flush headlamp covers, etc.
Rolling resistance reduction	Reduction of tire rolling resistance through use of alternative materials or tire production techniques.
Transmission	
Continuously variable transmission	Automatic transmission with a continuous range of gear ratios. This type of transmission usually consists of a belt which transfers power between two variable diameter pulleys.
Front wheel drive	Front wheels of vehicle are driven rather than rear wheels. This configuration is often combined with a transversely mounted engine.
Electronic transmission / torque converter controlled	Applied to automatic transmissions. Use of microprocessor based control systems to control transmission shifting and converter lockup.
Reduction of transmission losses	Reduction of frictional and viscous losses through improved transmission fluids and automatic transmission design. Also the reduction of losses in drivetrain components including differentials, bearings and constant velocity joints .
Torque converter lockup for upper gears (automatics)	Applied to automatic transmissions. Engaging a solid connection between the engine and transmission in the upper gears, rather than a viscous fluid coupling.
5+ Speed automatic transmissions	Automatic transmissions with five or more gear ratios.

Table 4-4 and Table 4-5 contain percentage improvements in light-truck fuel economy rating for the implementation of a particular fuel economy technology. These projections are not based on a particular baseline model year, but rather on the addition of a particular fuel economy technology. Variation in the baseline is one reason for the large range of benefits predicted for implementation of some of technologies (e.g. multi-valve engines).

Caution must be exercised in using the tabulated values to predict potential "shopping cart" fuel economy improvements through the combination of several fuel economy technologies. In general, the tabulated fuel economy improvements are not additive if more than one is implemented for a single vehicle. Some technologies are mutually exclusive, and the benefits cannot be combined, as in the case of diesel cycle engines and lean burn-fast burn combustion, which refers to a gasoline, spark-ignition engine technology.

Table 4-4. Fuel Economy Projections: Engine Technologies

FUEL ECONOMY TECHNOLOGIES	POTENTIAL FUEL ECONOMY IMPROVEMENT FOR FIXED CAPABILITIES				
	LEVEL OF USE IN 1994 LDTS	EEA, REF.1	OTA, REF.2	NRC, REF.3	SRI, REF.4
ENGINE TECHNOLOGIES (Constant Power)					
Multi-valve Engines	Less than 5%	2.5% - 4%	3% - 6%	5.2%	0.8% - 1.3%
Variable Valve Timing	None	6%	6%	14% - 16%	2.6%
Increased Engine Compression Ratio	NA-relative to 1994 baseline	NA	2% - 3%	1.3% - 2%	1.3% - 2.0%
Advanced Electronic Control	NA-relative to 1994 baseline	NA	NA	NA	NA
Port Fuel Injection (replacing TBI)	Approx. 6%	2% - 3%	3%	2% - 3%	1.5% - 2%
Lean Burn - Fast Burn Combustion	None	NA	10% - 12%	10%	6% - 10%
Overhead Cam Engine	Approx. 8%	3%	6%	1.1% - 3.5%	1.1% - 2.5%
Engine Friction and Lubricant Improvements (Includes roller cam)	Some in most '94 LDTs	2% - 4.5%	1.5% - 3%	2% - 6%	1.5% - 6.6%
Accessory Load Reduction ("smart" alternator, advanced air-conditioning)	NA-relative to 1994 baseline	0.5%	0.5% - 1.5%	1%	0.7% - 1.4%
Turbocharging	Less than 1%	5% - 10% (for diesel)	NA	NA	8%
Supercharging	None	NA	NA	NA	8%
Diesel Cycle Engine	Less than 1%	20%	15% - 18%	NA	NA
2-stroke Cycle Engine	None	NA	12% - 14%	NA	NA

NA - Not Addressed

Table 4-5. Fuel Economy Projections: Existing Studies

FUEL ECONOMY TECHNOLOGIES	POTENTIAL FUEL ECONOMY IMPROVEMENT FOR FIXED CAPABILITIES				
	LEVEL OF USE IN 1994 LDTS	EEA, REF.1	OTA, REF.2	NRC, REF.3	SRI, REF. 4
CHASSIS/BODY TECHNOLOGIES					
Weight Reduction through Redesign (-10%)	NA-relative to 1994 baseline	6.6%	6.6%	5% - 6.6%	5%
Weight Reduction through Material Substitution (-10%)	NA-relative to 1994 baseline	6.6%	6.6%	5% - 6.6%	5%
Aerodynamic Enhancement (-10% drag)	NA-relative to 1994 baseline	2.3% - 4.6%	2.3%	2%	2.4%
Rolling Resistance Reduction	NA-relative to 1994 baseline	1% - 2%	0.5%	1% - 2%	1%
TRANSMISSION TECHNOLOIGES					
Continuously Variable Transmission (CVT) -relative to 4-speed automatic	None	NA	6%	0.5% - 3.5%	1% - 2%
Front Wheel Drive	Approx. 13% (vans)	2%	5%	10% - 11%	0.3% - 0.5%
Electronic Transmission / Torque Converter Controlled	Approx. 27%	1%	0.5%	0.5% - 1.5%	0.5% - 2%
Reduction of transmission losses	NA-relative to 1994 baseline	NA	NA	NA	NA
Torque Converter Lockup for Upper Gears (automatics)	Approx. 75% (98% of automatics)	3%	3%	2% - 3%	1.7% - 2%
5+ Speed Automatic Transmissions - relative to 4-speed automatic	None	2.5%	2.5%	0.5% - 3%	0.5%

NA - Not Addressed

4.5 POTENTIAL CONFLICTS BETWEEN FUEL ECONOMY TECHNOLOGIES AND LIGHT TRUCK CAPABILITIES, SAFETY STANDARDS & EMISSIONS STANDARDS

4.5.1 Fuel Economy Technologies and Light Truck Capabilities

Some of the fuel economy technologies identified in this report may conflict with light truck capabilities as discussed below.

- Multi-Valve Engines - Multi-valve engines may impair light truck driveability by decreasing acceleration at low speeds, especially at high vehicle weights and/or high vehicle and trailer combined weights. Multi-valve engines may limit the payload capacity of cargo vans and pickups, and limit the towing capacity of pickups and SUVs.

- Aerodynamic Enhancement - Aerodynamic enhancement can be achieved by reducing a vehicle's drag coefficient and/or by reducing the vehicle's frontal area. Van passenger capacity may conflict with aerodynamic enhancement because of the large frontal area required to accommodate a large passenger compartment within a reasonable vehicle length.

Similarly, cargo van aerodynamic enhancement may conflict with the large frontal area required to accommodate a large cargo compartment. Aerodynamic enhancement of pickups may be limited by the shape constraints of a large cargo bed necessary for volume-carrying capability. Off-road capability for SUVs requires high ground clearance to enable operation over rough terrain and accessories such as wide tires and mud flaps, all of which increase aerodynamic drag.

- Rolling Resistance Reduction - Rolling resistance can be reduced through tire design changes, but these design changes may impair the load-carrying ability of the tire. High passenger capacity vans, high payload capacity cargo vans, and high payload capacity pickups may require heavy duty tires that do not offer the degree of rolling resistance reduction possible with standard tires. Off-road capability for SUVs usually requires tires that have traction-enhancing features, such as low inflation pressure and large tread design, which cause high rolling resistances.

- Continuously Variable Transmission (CVT) - CVTs have limited power and torque transmission capabilities that restrict the gross vehicle weight rating (GVWR) of a CVT equipped vehicle. Passenger capacity for vans and payload capacity for cargo vans and pickups may be limited by low GVWRs. Similarly, the maximum combined pickup and trailer weight that can be propelled using a CVT may be severely limited. Finally, the overall dimensions of the vehicles that can be propelled using a CVT may be constrained by low gross weight limits, which could in turn limit the volume-carrying capacity of cargo vans and pickups.

- Front-wheel Drive - Weight distribution of loaded light trucks usually shifts towards the rear wheels. If front-wheel drive is used, a weight shift towards the rear reduces traction at the drive wheels which may limit passenger capacity for vans, and payload capacity for cargo vans and pickups. A similar effect occurs when front-wheel drive vehicles are used for towing, and, as a result, the towing capacity of front-wheel drive pickups and SUVs may be limited. Finally, SUV off-road capability is defined as requiring four-wheel drive rather than front-wheel drive.

4.5.2 Potential Conflicts Between Fuel Economy Technologies and Light Truck Safety Standards

Future safety measures may conflict with fuel economy technologies that involve weight reduction. Compliance with safety standards may require additional equipment or design changes which could add weight to light trucks. Safety measures such as crash-worthiness requirements may lead to the need for additional crash-energy absorption or strengthening of non-structural components (i.e. windows or bumpers), which in turn may reduce the potential for weight savings through redesign or the use of lighter materials. It is projected that by the year 2006, safety standards could add approximately 80 to 100 pounds to the test weight of a light truck relative to a 1994 baseline.

Table 4-6 summarizes the predicted impact of future light truck safety standards on vehicle attributes and the fuel economy technologies that may be affected during the 1998 to 2006 time-frame.

Table 4-6. Effect of Future Safety Standards on Fuel Economy Technologies

Future Safety Measures	Primary Impact on Vehicle Attributes	Affected Fuel Economy Technologies
Automatic Restraints - driver (FMVSS-208)	weight increase (15 lbs.)	May limit weight reduction
Automotive Restraints - passenger (FMVSS-20x)	weight increase (20 lbs.)	May limit weight reduction
Side Impact Protection (FMVSS-214)	weight increase (40 lbs)	May limit weight reduction
Roof Crush Resistance (FMVSS-216)	slight weight increase possible (<10 lbs)	May limit weight reduction
Interior Head Impact Protection (FMVSS-201)	slight weight increase possible (<10 lbs)	May limit weight reduction and aerodynamic drag reduction
Rollover Protection	most current light trucks meet standard	May limit weight reduction
Anti-lock Braking System	slight weight increase (<10 lbs.)	May limit weight reduction
Door Latch Protection (FMVSS-206)	slight weight increase (<10 lbs)	May limit weight reduction
Glazing Materials Standards (FMVSS-205)	TBD	No fuel economy technologies directly affected
Fuel System Integrity (FMVSS-301)	TBD	No fuel economy technologies directly affected
Increased Side Impact Protection (FR 38749)	TBD	May limit weight reduction
Frontal Crashworthiness	TBD	May limit weight reduction

4.5.3 Potential Conflicts Between Fuel Economy Technologies and Future Emissions Standards

A number of fuel economy technologies may conflict with stricter future emissions standards. Vehicle emissions can increase due to both an increase in the production of a pollutant by an engine, and a decrease in the effectiveness of a catalytic converter in treating engine exhaust.

Table 4-7 summarizes the primary impact of future light truck emissions standards and the fuel economy technologies that may be affected during the 1998 to 2006 time-frame

Table 4-7. Effect of Future Emissions Standards on Fuel Economy Technologies

Emissions Standard	Primary Impact	Affected Fuel Economy Technologies
Tier 1 (1996) Emissions Standards		
Gasoline-fueled trucks with GVWR < 6000 pounds	60 to 66% reduction in HC emissions; 66% reduction in CO emissions; 60 to 66% reduction in NOx emissions; - relative to 1991 baseline	Lean Burn Combustion, Increased Compression Ratio, Turbocharging, Supercharging, 2-Stroke Cycle Engine
Gasoline-fueled trucks with 6000 pounds< GVWR < 8500 pounds	50 to 60% reduction in HC emissions; 35 to 60% reduction in NOx emissions; 50 to 66% reduction in CO emissions; - relative to 1991 baseline	Lean Burn Combustion, Increased Compression Ratio, Turbocharging, Supercharging, 2-Stroke Cycle Engine
Diesel-fueled trucks with GVWR < 6000 pounds.	60% reduction in particulate matter (PM) emissions; no change in NOx emissions - relative to 1991 baseline	May prevent use of Diesels without improved fuel injection, oxidation catalysts or particulate traps.
Tier 2 (2004) Emissions Standards		
Gasoline-fueled trucks with GVWR < 6000 pounds	84% reduction in HC emissions; 84% reduction in CO emissions; 84 to 88% reduction in NOx emissions; - relative to 1991 baseline	Lean Burn Combustion, Increased Compression Ratio, Turbocharging, Supercharging, 2-Stroke Cycle Engine
Diesel-fueled trucks with GVWR < 6000 pounds	60% reduction in particulate matter (PM) emissions; 80% reduction in NOx emissions - relative to 1991 baseline	Will prevent use of Diesels unless low temp/high-O_2 catalysts are developed to reduce NOx emissions, and particulate emissions can also be controlled
Evaporative Emissions Standards	Reduction of gasoline volatility	Reformulation of fuel may result in a general reduction of vehicle fuel economy due to lower energy content of fuel, but will not conflict with fuel economy technologies

Nitrogen oxygen compound (NO_X) emissions in particular pose an obstacle to implementation of several fuel economy technologies. Increased compression ratios, turbocharging, supercharging, diesel cycle and two-stroke cycles can all increase combustion temperatures, which increases production and emissions of NO_X. Lean burn - fast burn combustion, turbocharging, diesel cycle and two-stroke cycles can increase the oxygen content of exhaust gases, which will decrease catalyst effectiveness in treating NO_X, thereby also increasing NOx emissions.

High levels of particulate matter (PM) emissions may also prevent use of diesel cycle engines. Two-stroke engines can have high hydrocarbon (HC) production because of incomplete combustion, or high NO_X production if a lean burn design is used.

Stricter emission standards may also conflict with fuel economy improvements that rely on weight reductions. Stricter standards for all types of exhaust emissions may result in larger and heavier catalytic converter designs, which will add to overall vehicle weight.

4.5.4 Impact of Consumer Choice on Fuel Economy Technologies

Chapter 3 demonstrated that consumer choice can be affected by factors other than enhanced capabilities of a particular truck. Some other vehicle characteristics which affect consumer choice are:

- Performance and Driveability
- Durability and Dependability
- Versatility or Flexibility of Use

Performance and Driveability

Performance can describe the responsiveness of the engine and transmission to changes in power demand. Driveability can be thought of as a vehicle's acceleration potential, which is often quantified by power-to-weight ratio or 0-60 mph acceleration time. Fuel economy technologies which reduce power-to-weight ratio, either by reducing power or increasing weight, will reduce a vehicles driveability in terms of acceleration ability. Engine and transmission responsiveness is difficult to quantify, but may be reduced by fuel economy technologies such as continuously variable transmissions, and turbocharged or multi-valve engines.

Durability and Dependability

Light truck durability is often associated with the sturdiness of the vehicle chassis, which might be compromised by weight reductions achieved through redesign or the use of lighter materials. Dependability is the vehicle reliability over time. Fuel economy technologies such as variable valve timing or variable displacement engines add mechanical complexity, which may reduce vehicle reliability due to an increased number of failures. Newer engine, transmission, and chassis technologies may not be as durable or dependable during extended use as technologies which have been in production and in service for several years.

Versatility or Flexibility of Use

Versatility is the ability of a single vehicle to perform several different tasks, such as cargo and passenger hauling, either simultaneously or during separate trips. The versatility of light trucks was cited in Chapter 3 as a important factor in determining consumer choice. Consumer surveys noted that passenger van buyers valued both the passenger-carrying and volume-carrying capabilities of these vehicles. Pickup buyers valued both the weight-carrying and volume-carrying capabilities in making their purchase decisions. SUV buyers cited off-road capability and volume-carrying capability as important selling points.

Given time and data limitations, it was not possible in the course of this study to determine how fuel economy technologies might conflict differently with several simultaneous capabilities as opposed to individual capabilities.

Table 4-8 and Table 4-9 summarize the fuel economy technologies that might conflict with the consumer choice by decreasing light truck performance, durability and dependability.

Table 4-8. Fuel Economy Technologies and Consumer Choice

FUEL ECONOMY TECHNOLOGIES	ALL LIGHT TRUCKS	
	DRIVEABILITY & PERFORMANCE	DURABILITY & DEPENDABILITY
ENGINE TECHNOLOGIES (Constant Peak Power)		
Multi-valve Engines	Possible reduction in engine responsiveness	Increased mechanical complexity may reduce durability and/or dependability
Variable Valve Timing	Improved engine responsiveness possible	Increased mechanical complexity may reduce durability and/or dependability
Increased Engine Compression Ratio	No change	Higher engine pressures and temperatures may shorten engine life, reduce durability
Advanced Electronic Control	Improved engine responsiveness possible	No change
Port Fuel Injection (replacing TBI)	Minor improvement in engine responsiveness possible	Little or no change
Lean Burn - Fast Burn Combustion	Little or no change	Higher engine temperatures may shorten engine life, reduce durability
Overhead Cam Engine	Minor improvement in engine responsiveness possible	Little or no change
Engine Friction and Lubricant Improvement (Includes roller cam)	Possible increase in engine responsiveness	Should reduce engine wear and stresses, may increase engine life
Accessory Load Reduction ("smart" alternator, advanced air-conditioning)	Possible increase in engine responsiveness	Increased mechanical complexity may reduce durability and/or dependability
Turbocharging	Reduced engine responsiveness due to "turbo lag"	Increased mechanical complexity, and higher engine pressures and temperatures may reduce durability and/or dependability
Supercharging	Little or no change	Increased mechanical complexity, and higher engine pressures and temperatures may reduce durability and/or dependability

Table 4-9. Fuel Economy Technologies and Consumer Choice

FUEL ECONOMY TECHNOLOGIES	ALL LIGHT TRUCKS	
	DRIVEABILITY & PERFORMANCE	DURABILITY & DEPENDABILITY
CHASSIS/BODY TECHNOLOGIES		
Weight Reduction through Redesign (-10%)	No change, impact of weight reduction assumes constant power/weight ratio	May reduce durability of chassis
Weight Reduction through Material Substitution (-10%)	No change, impact of weight reduction assumes constant power/weight ratio	May reduce durability of chassis
Aerodynamic Enhancement (-10% drag)	Slight improvement in acceleration for constant power/weight ratio	Aerodynamic aids such as air dams and belly pans may be prone to damage
Rolling Resistance Reduction	Slight improvement in acceleration for constant power/weight ratio	No change
TRANSMISSION TECHNOLOIGES		
Continuously Variable Transmission (CVT) -relative to 4-speed automatic	Improved acceleration for constant power/weight ratio	Not known
Front Wheel Drive	Little or no change	No change
Electronic Transmission / Torque Converter Controlled	Improved transmission responsiveness compared to hydraulic transmission control	Not known
Torque Converter Lockup for Upper Gears (automatics)	Little or no change	Not known
5+ Speed Automatic Transmissions - relative to 4-speed automatic	Improved acceleration for constant power/weight ratio	Not known

4.6 SUMMARY

There are a great number of technologies that have the potential to improve light truck fuel economy for model years of 1998 through 2006. The applicability and effectiveness of particular fuel economy technologies can be assessed given the following considerations:

- Light truck capabilities
- Future light truck emissions and safety regulations
- Consumer choice in the purchase of light trucks

The following observations on the relationships between light truck capabilities and fuel economy apply to the limited samples of model year 1994 light trucks included in the study, and are not necessarily comprehensive or universally applicable:

- For passenger vans, there is a weak correlation between increasing passenger capacity and decreasing fuel economy.

- For cargo vans, there is a weak correlation between increasing payload capacity and decreasing fuel economy, but a strong correlation between increasing volume carrying capacity and decreasing fuel economy.

- For pickups, there is no correlation between payload capacity or volume capacity (as quantified by cargo bed area) and fuel economy. There is a moderate correlation between increased pickup towing capacity and reduced fuel economy.

- For SUVs, there is a moderate correlation between increased towing capacity and reduced fuel economy. Off-road capability for SUVs is equated with four wheel-drive capability. SUVs with four wheel-drive achieved lower fuel economy relative to two wheel-drive versions of the same vehicle.

- For all light trucks, there was a strong correlation between increased test weight and decreased fuel economy.

The applicability and effectiveness of some fuel economy technologies may conflict with light truck enhanced capabilities:

- Multi-valve engines may reduce engine torque at low engine speeds, which may limit the payload capacity of cargo vans and pickups, and the towing capacity of pickups and SUVs.

- Aerodynamic enhancement may conflict with passenger carrying capability for passenger vans, volume-carrying capacity for cargo vans and pickups, and off-road capability for SUVs.

- Rolling resistance reduction could conflict with the passenger carrying capability of vans, payload capacity of cargo vans and pickups, and off-road capability of SUVs.

- Continuously Variable Transmissions (CVTs) may conflict with the passenger carrying capability of vans, the payload capacity for cargo vans and pickups, and the towing capacity for all light-trucks. The limited power transmission capabilities may also constrain vehicle overall dimensions, which would limit the volume-carrying capacity of cargo vans and pickups.

- Front-wheel drive may limit the passenger carrying capability of passenger vans, the payload capacity of cargo vans and pickups, and the towing capacity of pickups and SUVs.

- Future safety measures may conflict with fuel economy technologies that involve weight reduction. Crash-worthiness requirements may also reduce the potential for weight savings through redesign or the use of lighter materials.

A number of fuel economy technologies may conflict with more stringent future emissions standards. Nitrogen oxygen compound (NO_X) emissions pose an obstacle to implementation of lean burn - fast burn combustion, increased compression ratios, turbocharging, supercharging, diesel cycle and two-stroke cycles. Diesel cycle engines may not be applicable because of high levels of particulate matter (PM) emissions, while two-stroke cycle engines can be prone to either high hydrocarbon (HC) or high NO_X emissions, depending on the design.

With respect to consumer choice attributes the predicted effects of fuel economy technologies on performance and driveability will be minor. Light truck durability is often associated with the sturdiness of the vehicle chassis, which might be compromised by weight reductions achieved through redesign or the use of lighter materials. Some newer engine and transmission technologies may not be as durable or dependable as technologies which have been in production and in service for several years.

Table 4-10 summarizes potential conflicts between light truck fuel economy improvements and light truck capabilities, future emissions and safety standards, and consumer choice.

Table 4-10 Potential Conflicts with Light Truck Fuel Economy Technologies

FUEL ECONOMY TECHNOLOGIES	PASSENGER VAN	CARGO VAN		PICKUP TRUCK			SPORT UTILITY VEHICLE		ALL LIGHT DUTY TRUCKS				
	PASSENGER CAPACITY	PAYLOAD CAPACITY	VOLUME CAPACITY	PAYLOAD CAPACITY	VOLUME CAPACITY (CARGO AREA)	TOWING CAPACITY	OFF-ROAD CAPABL.	TOWING CAPACITY	SAFETY STD.	TIER 1 EMIS. STD.(1996)	TIER 2 EMIS. STD.(2004	DRIVEABL & PERFORM.	DURABL. & DEPEND.
ENGINE TECHNOLOGIES (Constant Power)													
Multi-valve Engines	/	reduced payload cap.	/	reduced payload cap.	/	reduced towing cap.	/	reduced towing cap.	/	/	/	reduced responsvnss	reduced durability
Variable Valve Timing	/	/	/	/	/	/	/	/	/	/	/	/	reduced durability
Increased Engine Compression Ratio	/	/	/	/	/	/	/	/	/	increased NO_X	increased NO_X	/	reduced durability
Advanced Electronic Control	/	/	/	/	/	/	/	/	/	/	/	/	/
Port Fuel Injection (replacing TBI)	/	/	/	/	/	/	/	/	/	/	/	/	/
Lean Burn - Fast Burn Combustion	/	/	/	/	/	/	/	/	/	increased NO_X	increased NO_X	/	reduced durability
Overhead Cam Engine	/	/	/	/	/	/	/	/	/	/	/	/	/
Engine Friction and Lubricant Improvement (Includes roller cam)	/	/	/	/	/	/	/	/	/	/	/	/	/
Accessory Load Reduction ("smart" alternator, advanced air-conditioning)	/	/	/	/	/	/	/	/	/	/	/	/	reduced durability
Turbocharging	/	/	/	/	/	/	/	/	/	increased NO_X, HC & CO	increased NO_X, HC & CO	reduced responsvnes	reduced durability
Supercharging	/	/	/	/	/	/	/	/	/	increased NO_X	increased NO_X	/	reduced durability
Diesel Cycle Engine	/	/	/	/	/	/	/	/	/	increased PM	increased NO_X & PM	reduced responsvnss	reduced durability
2-stroke Cycle Engine	/	/	/	/	/	/	/	/	/	increased HCs & NO_X	increased HCs & NO_X	reduced responsvnss	Unknown

/ - No Conflict

Table 4-10 Potential Conflicts with Light Truck Fuel Economy Technologies (continued)

FUEL ECONOMY TECHNOLOGIES	PASSENGER VAN CAPABILITY	CARGO VAN CAPABILITY		PICKUP TRUCK CAPABILITY			SPORT UTILITY VEHICLE CAPABILITY		ALL LIGHT DUTY TRUCKS				
	PASSENGER CAP.	PAYLOAD CAP.	VOLUME CAP.	PAYLOAD CAP.	VOLUME CAP. (CARGO AREA)	TOWING CAP.	OFF-ROAD CAPABL.	TOWING CAP.	SAFETY STD.	TIER 1 EMIS. STD. (1996)	TIER 2 EMIS. STD. (2004)	PERFORM.	DURABL. & DEPEND.
CHASSIS/BODY TECHNOLOGIES													
Weight Reduction through Redesign (-10%)									conflict w/safety measures	may require heavier catalyst	may requir heavier catalyst		reduced durability
Weight Reduction through Material Substitution (-10%)									conflict w/safety measures	may require heavier catalyst	may requir heavier catalyst		reduced durability
Aerodynamic Enhancement (-10% drag)	limits volume passenger cap.		limits volume		limits cargo bed area		limits ground clearance						reduced durability
Rolling Resistance Reduction	limits passenger capacity	limits payload capacity		limits payload capacity			limits use of all terrain tires						
TRANSMISSION TECHNOLOGIES													
Continuously Variable Transmission (CVT) -relative to 4-speed automatic	NA - severely limits cap.	NA - severely limits cap.	limits size & volume capacity	NA - severely limits cap.	limits size & volume capacity	NA - severely limits cap.		NA - severely limits cap.					Unknown
Front Wheel Drive	limits passenger capacity	limits payload capacity		limits payload capacity		limits towing capacity	NA - 4 wheel drive required	limits towing capacity					
Electronic Transmission / Torque Converter Controlled													Unknown
Reduction of Transmission Losses													
Torque Converter Lockup for Upper Gears (automatics)													Unknown
5+ Speed Automatic Transmissions - relative to 4-speed automatic													Unknown

NA - Not Applicable

- No Conflict

A . OVERVIEW OF DATA SOURCES FOR LIGHT TRUCK STUDY

TRUCK INVENTORY AND USE SURVEY

Background:
The Truck Inventory and Use Survey is undertaken by the Census Bureau (US Department of Commerce) as part of the economic census, which has been administered every five years since 1967. The Truck Inventory and Use Survey provides data on the physical and operational characteristics of the nation's truck population, including both light and heavy duty trucks and both personal and commercial trucks. TIUS surveys have been conducted most recently in 1982, 1987, and 1992.

General Methodology:
The survey is based on a probability sample of private and commercial trucks registered (or licensed) in the United States. In the 1992 survey, the stratified, random sample consisted of 153,914 trucks drawn from an estimated universe of over 60 million trucks registered in all 50 states and the District of Columbia generally between July 1 and December 31, 1992. Report forms were mailed to the owners identified in each of the selected vehicle registration records, and approximately 90.2% of the questionnaires were returned with some response. The following types of vehicles were excluded from the survey: those owned by the federal government, state governments, and local governments; ambulances; buses; and motor homes.

NATIONWIDE PERSONAL TRANSPORTATION SURVEY

Background:
The focus of the NPTS is to obtain a profile of personal travel, as opposed to commercial travel (e.g., taxi driving, delivery truck driving, police patrol, etc.). The survey is sponsored by five agencies of the U.S. Department of Transportation, and administered by Research Triangle Institute. NPTS surveys have been conducted in 1969, 1977, 1983 and 1990.

General Methodology:
The 1990 survey used telephone interviews with households only (no businesses or other institutions). 26,172 households were contacted. 21,869 (unique) household interviews were obtained (84% response). The survey included all 50 states and the District of Columbia, with the sample stratified by geography and time. Data were collected between March 1, 1990 and February 28, 1991. For each household, each resident five years old or older was interviewed for the Travel Day section. The sample data are weighted to obtain estimated totals for the full US population.

HACHETTE SURVEYS

Background:
Hachette Filipacchi Magazines, Inc. publishes Road & Track, Car and Driver, and Open Road magazines. Hachette has conducted a number of "new car buyer surveys," and Open Road conducted its own survey of its readers.

New Car Buyers Survey: Minivans
500 recent buyers of each of 13 minivan models were surveyed by mail in the fall of 1993. Buyers were randomly selected across the country from the pool of June 1993 registrations. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 13 makes x 500 = 6500 surveys mailed x 51% net response = 3315

New Car Buyers Survey: Sport Utility Vehicles
500 recent buyers of each of 14 SUV makes were surveyed by mail in the fall of 1992. Buyers are randomly selected across the country from the pool of May/June 1992 registrations. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 14 makes x 500 = 7000 surveys mailed x 50% estimated net response = 3500

New Car Buyers Survey: Compact Pickup Trucks
500 recent buyers of each of 19 compact pickup makes (both 2WD and 4WD) were surveyed by mail in the fall of 1992 and in the spring of 1991. For 13 of the 19 vehicle makes, buyers were randomly selected across the country from the pool of November 1990 registrations. For 6 of the 19 vehicle makes, buyers were randomly selected across the country from the pool of the May/June 1992 registration period. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 19 makes x 500 = 9500 surveys mailed x 50% net response = 4750

Open Road Magazine Survey

Open Road magazine, a new biannual magazine written for owners of 4-wheel drive vehicles, also conducted a survey of its readers. This survey is unscientific: sample sizes are very low; selection bias is severe.

R. L. POLK SURVEYS

Background:
The Transportation Marketing Group of R. L. Polk & Co. has conducted a number of "buyer profile surveys" for various segments of the light truck market. R. L. Polk & Co. is a privately-held firm specializing in market research and services based in Detroit.

Sport Utility Vehicle Buyer Profile Survey
The survey compares the following two cohorts:

- recent new SUV buyers
- recent buyers of any new vehicle

A random sample of 250 vehicle buyers who purchased their vehicles between May and August of 1994 were interviewed by telephone for each cohort. Due to state or manufacturer restrictions on telephone interviewing, eleven states (including California) were excluded from the survey. These states accounted for 26.1% of 1993 light truck sales. R. L. Polk asserts that a sample size of 250 (for each cohort) corresponds to a sampling error of ± 6.2% at the 95% confidence level.

Minivan Buyer Profile Survey
The survey compares the following two cohorts:

- recent new minivan buyers
- recent buyers of any new vehicle

A random sample of 250 vehicle buyers who purchased their vehicles between May and August of 1994 were interviewed by telephone for each cohort. Due to state or manufacturer restrictions on telephone interviewing, eleven states (including California) were excluded from the survey. These states accounted

for 26.1% of 1993 light truck sales. R. L. Polk asserts that a sample size of 250 (for each cohort) corresponds to a sampling error of ± 6.2% at the 95% confidence level.

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A random sample of 250 vehicle buyers who purchased their vehicles between May and August of 1994 were interviewed by telephone for each cohort. Due to state or manufacturer restrictions on telephone interviewing, eleven states (including California) were excluded from the survey. These states accounted for 26.1% of 1993 light truck sales. R. L. Polk asserts that a sample size of 250 (for each cohort) corresponds to a sampling error of ± 6.2% at the 95% confidence level.

The following survey questions are relevant for the LDT study:

Have you, or do you plan to, use your SUV off road?

36.0%	Have/intend to go off road
62.8%	Have not gone off road and do not plan to
1.2%	Don't know

N = 250

Please rank how important each of the following vehicle attributes was in your decision to purchase an SUV, where 1 means "not at all important," ... 4 means "important," and 5 means "very important":

Attribute	SUV Buyers: % 4 or 5 rating	All Vehicle Buyers: % 4 or 5 rating
Ride or Handling *	82.4	88.3
Comfort of Vehicle *	79.2	85.6
Safety Features	77.2	82.5
Price *	71.6	82.1
Roominess	77.6	75.5
Styling	74.0	71.2
Power or Response	65.6	69.6
The Dealership	50.8	54.9
Ratings from Consumer Reports	45.2	42.4

* Indicates a significant difference between all vehicle buyers and SUV buyers at the 95% confidence level.

Please indicate your income category:

Income Category	% of SUV Buyers	% of all Vehicle Buyers
Under $30,000	9.6	13.2
$30,000 - $49,999 *	20.4	31.1
$50,000 - $69,999 *	28.4	20.2
$70,000 - $99,999	18.4	13.6
$100,000 or more	14.8	9.4
Don't know / refused	8.4	12.5

* Indicates a significant difference between all vehicle buyers and SUV buyers at the 95% confidence level.

Do you participate in the following physical activities and leisure activities? [The following lists only responses that indicated a significant difference between all vehicle buyers and SUV buyers at the 95% confidence level.]

Activity	% of SUV Buyers	% of all Vehicle Buyers
Camping / hiking	55.2	40.9
Bicycling	48.4	38.9
Golf	40.0	29.6
Skiing (snow & water)	42.4	24.1
Working out at gym	36.4	24.5
Running	2.8	0.4
Jogging	3.2	0.8
Boating / sailing	46.0	32.6
Sewing / needlework	17.2	25.6
Gourmet cooking	31.2	23.3

Minivan Buyer Profile Survey

The survey compares the following two cohorts:

- recent new minivan buyers
- recent buyers of any new vehicle

A random sample of 250 vehicle buyers who purchased their vehicles between May and August of 1994 were interviewed by telephone for each cohort. Due to state or manufacturer restrictions on telephone interviewing, eleven states (including California) were excluded from the survey. These states accounted for 26.1% of 1993 light truck sales. R. L. Polk asserts that a sample size of 250 (for each cohort) corresponds to a sampling error of ± 6.2% at the 95% confidence level.

The following survey questions are relevant for the LDT study:

Please rank how important each of the following vehicle attributes was in your decision to purchase a minivan, where 1 means "not at all important," ... 4 means "important," and 5 means "very important":

Attribute	Minivan buyers: % 4 or 5 rating	All vehicle buyers: % 4 or 5 rating
Ride or Handling	91.2	88.3
Comfort of Vehicle	90.4	85.6
Safety Features	88.0	82.5
Price	82.5	82.1
Roominess *	92.8	75.5
Styling	69.7	71.2
Power or Response	67.7	69.6
The Dealership	49.4	54.9
Ratings from Consumer Reports *	52.2	42.4

* Indicates a significant difference between all vehicle buyers and minivan buyers at the 95% confidence level.

Please indicate your income category:

Income Category	% of Minivan Buyers	% of all Vehicle Buyers
Under $30,000 *	7.6	13.2
$30,000 - $49,999	25.9	31.1
$50,000 - $69,999 *	30.7	20.2
$70,000 - $99,999	15.5	13.6
$100,000 or more	8.7	9.4
Don't know / refused	11.6	12.5

* Indicates a significant difference between all vehicle buyers and minivan buyers at the 95% confidence level.

How many children under the age of 19 are present in the household?

Number of Children	% of Minivan Buyers	% of all Vehicle Buyers
None *	27.9	52.5
One Child	17.5	17.5
Two Children *	34.3	21.0
Three Children *	15.9	6.6
Four or More Children *	4.4	2.4

* Indicates a significant difference between all vehicle buyers and minivan buyers at the 95% confidence level.

Do you participate in the following physical activities and leisure activities? [The following lists only responses that indicated a significant difference between all vehicle buyers and minivan buyers at the 95% confidence level.]

Activity	% of Minivan Buyers	% of all Vehicle Buyers
Camping/Hiking	48.6	40.9
Working out at gym	32.3	24.5
Dining out	91.6	85.6
Gardening	67.3	54.4
Home computers / video games	65.3	52.9
Fine art / antiques	41.4	30.4
Gourmet cooking	32.3	23.3

HACHETTE SURVEYS

Background:
Hachette Filipacchi Magazines, Inc. publishes Road & Track, Car and Driver, and Open Road magazines. Hachette has conducted a number of "new car buyer surveys," and Open Road conducted its own survey of its readers. The questions from each of these surveys that may be relevant for the LDT Study are listed below:

Open Road Magazine Survey

The following questions are from a survey enclosed in 98,800 issues of the fall/winter 1995 edition of Open Road magazine, a new biannual magazine written for owners of 4-wheel drive vehicles. The magazine went on sale Nov. 29, 1994, and the survey was closed for tabulation Jan. 24, 1995. A total of 517 usable returns were received.

If you currently own or lease a light truck, for what purposes is the light truck used?

79%	Any off-road/outdoor activities
73%	Outdoor activities (i.e., hunting, fishing, camping, skiing, etc.)
48%	Off-road driving
70%	Main means of household transportation
32%	Secondary household vehicle
2%	No answer

N = 456

If you use your truck for outdoor or leisure activities, about how often do you do so?

25%	Once a week
32%	2 or 3 times per month
20%	Once a month
9%	Once every two months
13%	Once every three months or less often
1%	No answer

N = 360

NOTE: This data is not representative of the general public due to selection bias. If we assume that an Open Road buyer who responds to the survey* is an "off-road enthusiast," then we can make the statement: "among off-road enthusiasts, 70% use their vehicles as the main means of household transportation."

* note the low response rate of 0.52%

New Car Buyers Survey: Minivans

500 recent buyers of each of 13 minivan models were surveyed by mail in the fall of 1993. Buyers were randomly selected across the country from the pool of June 1993 registrations. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 13 makes x 500 = 6500 surveys mailed x 51% net response = 3315

Please rank your top three reasons for buying a minivan rather than any other type of vehicle:

60%	Passenger room
46%	Overall room
36%	Recreation/vacation uses
25%	Seating flexibility
25%	Cargo room
22%	Just wanted a minivan
20%	Ease of loading/unloading
16%	Styling
16%	Handling/maneuverability
15%	Good visibility
11%	Safety
11%	Ability to walk front/rear
9%	Price
4%	Sliding door
3%	Child's safety seat

Do you consider the new minivan you recently purchased to be the principle vehicle in your household, i.e., the one driven most often?

Responses range from 77% for the Mazda MPV to 87% for the Dodge Caravan, averaging 82.3% for all the models weighted equally.

Please check how important each of the following factors was in your decision to buy the make and model that you did. Please indicate if it was "very important," "somewhat important," or "of little or no importance."

Rank	Factor	% considered "very important"
1	Dependability	96.2
2	Durability	93.2
3	Overall quality of workmanship	92.4
4	Overall comfort	88.4
5	Comfort of seats	84.5
6	Interior room	83.5
7	Safety	79.5
8	Handling	77.9
9	Riding on open road	76.8
10	Manufacturer's reputation	72.6
25	Pick up	49.9
26	Fuel economy	47.4
27	Future resale value	46.6
37	Keyless remote locks	10.8

New Car Buyers Survey: Sport Utility Vehicles

500 recent buyers of each of 14 SUV makes were surveyed by mail in the fall of 1992. Buyers are randomly selected across the country from the pool of May/June 1992 registrations. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 14 makes x 500 = 7000 surveys mailed x 50% estimated net response = 3500

Which of the following reasons best describe why you purchased a new SUV?

70%	Versatility
64%	4-Wheel Drive Capability
59%	Driveability in rain/snow
57%	Cargo space
51%	Tough/durable
42%	Just wanted an SUV*
40%	Safety
35%	Off-road ability
20%	Price

*** Among buyers who "just wanted an SUV": Was there any one reason in particular why you just wanted an SUV? [Averages across all models are given below.]**

19.4%	Appearance / Style / Looks
16.8%	Towing / Hauling Towboat Trailer
18.9%	Seating capacity / more passenger room
10.9%	Sport / hunting / fishing / camping, etc.
7.2%	Fun to drive
3.9%	Sits high / off ground

Do you consider the new vehicle you recently purchased to be the principle vehicle in your household, i.e., the one driven most often?

Responses ranged from 50% for the Jeep Wrangler to 75% for the Isuzu Rodeo, averaging 65.2% for all models weighted equally.

Was your most recent new vehicle purchased primarily for business use or primarily for personal use?

Responses ranged from 82% primarily personal use for the Isuzu Trooper to 96% primarily personal use for the Jeep Wrangler, averaging 87.7% for all models weighted equally.

If your vehicle was purchased primarily for business: Do you intend to use your new vehicle for personal use?

Responses ranged from 82% for the Toyota 4Runner to 100% for several models, averaging 92.6% for all models weighted equally. [Caution: bases are too small for reliability.]

Please check how important each of the following factors was in your decision to buy the make and model that you did. Please indicate if it was "very important," "somewhat important," or "of little or no importance."

Rank	Factor	% considered "very important"
1	Dependability	96
2	Durability	94
3	Overall quality of workmanship	91
4	Safety	76
5*	Overall comfort	75
6*	Comfort of seats	75
7	Handling	73
8	Overall feel of vehicle	71
9*	Manufacturer's reputation	67
10*	Warranty	67
26	Interest Rates	36
27*	Fuel economy	33
28*	Hauling / pulling power	33
29	Size of exterior dimensions	32
33	Air bags	17

Among buyers who seriously considered other makes: Please indicate the makes and models you seriously considered.

% of those who selected "any car" among "any car," "any light truck," "any pick-up truck," "any SUV," "any van" ranged from 16% for the Isuzu Trooper to 62% for the Geo Tracker, averaging 30.3% across all models.

* tied in ranking with another factor for percentage of respondents that considered it "very important"

New Car Buyers Survey: Compact Pick-up Trucks

500 recent buyers of each of 19 compact pick-up makes (both 2WD and 4WD) were surveyed by mail in the fall of 1992 and in the spring of 1991. For 13 of the 19 vehicle makes, buyers were randomly selected across the country from the pool of November 1990 registrations. For 6 of the 19 vehicle makes, buyers were randomly selected across the country from the pool of the May/June 1992 registration period. Only personal vehicle registrations are included in the sample -- vehicles registered to businesses, leasing companies, institutions, etc., are excluded.

Sample size estimate: 19 makes x 500 = 9500 surveys mailed x 50% net response = 4750

Please indicate how important each of the following factors was in your decision to buy a pickup truck rather than any other type of vehicle (i.e., car, station wagon, van, etc.) Factors considered "very important" in decision to buy pick-up truck rather than other type of vehicle.

73%	Functionality / versatility
69%	Tough / durable
69%	Price
65%	Good visibility
64%	Overall appearance / look
63%	Just wanted a pick-up truck
61%	Safety
58%	Driveability in rain/snow
44%	Payload / cargo space
44%	Cost of insurance
40%	Recreational use
38%	4-wheel drive capability
37%	Hauling / pulling power
33%	Uniqueness
26%	Off-road ability

Do you consider the new vehicle you recently purchased to be the principle vehicle in your household, i.e., the one driven most often?

Responses ranged from 41% for the Nissan Pick-up '92 to 59% for the Toyota Pick-up '90, averaging 51.1% for all models weighted equally.

Was your most recent new vehicle purchased primarily for business use or primarily for personal use?

Responses ranged from 76% primarily personal use for the Nissan Pick-up '92 to 89% primarily personal use for the Toyota Pick-up '90, averaging 83.5% for all models weighted equally.

If your vehicle was purchased primarily for business: Do you intend to use your new vehicle for personal use?

Responses ranged from 73% for GMC S-15 Sonoma 2WD to 95% for Toyota 2WD Pick-up '90, averaging 86.7% for all models weighted equally. [Caution: bases are too small for reliability.]

If your new vehicle has 4-wheel drive, have you or do you plan to drive the truck off-road (off paved roads)?

Responses ranged from 68% for the Chevy S-10 to 84% for the Toyota Pick-up '92, averaging 76.3% across all models weighted equally.

Please check how important each of the following factors was in your decision to buy the make and model that you did. Please indicate if it was "very important," "somewhat important," or "of little or no importance."

Rank	Factor	% considered "very important"
1	Dependability	93
2	Durability	91
3	Overall quality of workmanship	89
4	Manufacturer's reputation	78
5	Price	76
6	Warranty	71
7	Handling	71
8	Overall feel of vehicle	69
9	Comfort of seats	68
10	Safety	67
11	Pick up	67
12	Fuel economy	66
13	Overall comfort	65
31	Air bags	7

Among buyers who seriously considered other makes: Please indicate the makes and models you seriously considered.

% of those who selected "any car" among "any car," "any light truck," "any pick-up truck," "any SUV," and "any van" ranged from 8% for the Toyota 2WD Pick-up '92 to 35% for the Mitsubishi Pick-up, averaging 19.7% across all models.

Miscellaneous

Toyota Market Research Presentation for Tacoma pickup Introduction

Overview of Compact Pickup Truck Market:

48.8%	4x2 Regular Cab
7.9%	4x4 Regular Cab
28.6%	4x2 Xtracab
14.7%	4x4 Xtracab

Budget and Hertz to Rent Compact Pickups

USA Today article from 3/21/95 describes Budget and Hertz offering pickups for rent at airports in the South, Southwest and West.

Trailer Life Reader Survey

An independent researcher conducted a survey of Trailer Life subscribers in December 1992. Trailer Life is a magazine for RV enthusiasts with an average monthly paid circulation of 300,000. 2500 subscribers (selected randomly from the current subscription list) were mailed 16-page questionaiire packages. 1301 usable returns were received by M.O.R.-PACE, the independent research organization, representing an overall return rate of 52.0%.

87% of all readers own a pickup, van, or sport utility vehicle.
93% of all readers own camping gear.
24% of all readers own a motorboat.

Use car/truck to tow RV:

73%	Yes
27%	No

Types of trucks owned:

54%	Full-size pickup
13%	Midsize / mini pickup
18%	Van
11%	SUV
12%	Suburban-type vehicle

Average nights spent in private campground last year: 25.6
Average nights spent in public campground last year: 12.5
Median age: 61.5 years
Median Household Income: $41,490

Coalition for Vehicle Choice Survey

The Coalition for Vehicle Choice is an interest group that "represents more than 4700 agricultural, automotive, business, consumer, insurance and safety organizations throughout the U.S. committed to preserving America's right to choose safe and affordable transportation." CVC conducted an informal survey (i.e., not a random and stratified sample) of nearly 300 of its members to determine light truck usage.

Respondent's vehicle:

44%	Full-size pickup	6%	Minivan
22%	Full-size van	6%	Compact pickup
18%	Full-size SUV	4%	Compact SUV

Primary reason for buying the type of truck they chose:

25%	Hauling capacity	12%	4WD / Off-road capability
21%	Cargo space	10%	Power / performance
20%	Towing capacity	9%	Carrying passengers

How do you use your light truck?

41%	Mostly for work purposes
35%	Mixed -- both business and household

What do you carry or haul with your light truck?

44%	Large, heavy, bulky items
	Pulling a trailer
	Carrying people and light cargo
10%	Pulling a boat or camper

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