EPA-460/3-73-006a

PASSENGER CAR WEIGHT TREND ANALYSIS VOLUME I

EXECUTIVE SUMMARY

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

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PASSENGER CAR WEIGHT TREND ANALYSIS VOLUME I EXECUTIVE SUMMARY

Prepared by

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Contract No. 68-01-0417

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Prepared for

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Office of Air and Water Programs
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Emission Control Technology Division
Ann Arbor, Michigan 48105

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FOREWORD

This report, prepared by The Aerospace Corporation for the Environmental Protection Agency, Division of Emission Control Technology, presents the results of an analysis of the historical weight trends of passenger cars sold in the United States over a 16-year period, 1958 through 1973.

The results of this study are presented in two volumes. Volume I, Executive Summary, presents a brief, concise review of important findings and conclusions in the Highlights and Executive Summary sections. Volume II, Technical Discussion, provides a detailed discussion of each study topic and is of interest primarily to the technical specialist. In Volume II, the general analysis technique, parameters examined, and data sources used are delineated in Section 2. Section 3 presents a graphical display of study results, together with brief discussions of noted trends. It illustrates trends for sales distribution, curb weight, inertia test weight class, wheelbase and length, engine displacement, compression ratio, and accessory weights. An appendix of tables is included to summarize all parameters examined in terms of sales-weighted averages. These tables include breakdowns by market class and by nameplate.

ACKNOWLEDGMENTS

Appreciation is acknowledged for the guidance and assistance provided by Dr. Karl H. Hellman and Mr. F. Peter Hutchins of the Environmental Protection Agency, Division of Emission Control Technology, who served as EPA Technical and Contract Project Officers, respectively, for this study.

Mr. William Smalley was principally responsible for the acquisition and analysis of the data presented herein. The following additional personnel of The Aerospace Corporation also made valuable contributions to the analyses performed under this contract.

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HIGHLIGHTS

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Table 1. Domestic 1973 Models - By Market Class

STANDARD SIZE CLASS	AMC (Ambassador) Buick (LeSabre, Electra, Centurion) Cadillac (all except Eldorado) Chevrolet (Caprice, Impala, Biscayne, Bel Air) Chrysler (including Imperial) Dodge (Polara, Monaco) Ford (LTD, Galaxie, Custom) Lincoln (all except Mark IV) Mercury (Monterey, Marquis) Oldsmobile (Delta, 98) Plymouth (Fury, Gran Sedan) Pontiac (Catalina, Bonneville, Grand Ville)
INTERMEDIATE SIZE CLASS	AMC (Matador) Buick (Century) Chevrolet (Chevelle) Dodge (Coronet, Charger) Ford (Torino) Mercury (Montego) Oldsmobile (Cutlass) Plymouth (Satellite) Pontiac (Le Mans) (1.4% of imports are in this class)
COMPACT SIZE CLASS	AMC (Hornet) Buick (Apollo) Chevrolet (Nova) Dodge (Dart) Ford (Maverick) Mercury (Comet) Oldsmobile (Omega) Plymouth (Valiant) Pontiac (Ventura) (8.2% of imports are in this class)
SUBCOMPACT SIZE CLASS	AMC (Gremlin) Chevrolet (Vega) Ford (Pinto) (90.4% of imports are in this class)
SPECIALTY CAR CLASS	AMC (Javelin) Buick (Riviera) Cadillac (Eldorado) Chevrolet (Camaro, Corvette, Monte Carlo) Dodge (Challenger) Ford (Mustang, Thunderbird) Lincoln (Mark IV) Mercury (Cougar) Oldsmobile (Toronado) Plymouth (Barracuda) Pontiac (Firebird, Grand Prix)

HIGHLIGHTS

An analysis was made of the historical weight trends of passenger cars sold in the United States over a 16-year period, 1958 through 1973. Also examined were ancillary characteristics such as dimensional trends, displacement and compression ratio trends, and power and luxury item use trends.

Passenger cars have historically been divided by the industry into five basic market classes (see Table 1): standard size, intermediate size, compact size, subcompact size, and specialty cars. These market classes are closely, but not exclusively, related to wheelbase dimensions. The specialty class encompasses both large (e.g., Cadillac Eldorado) and small (e.g., Mustang) high-performance or sports models. Within each market class there are numerous corporations, domestic and foreign, producing cars for U.S. sale under various nameplates (Chevrolet Impala and Ford Galaxie 500 in the standard class, Chevrolet Nova and Plymouth Valiant in the compact class, Ford Pinto and Volkswagen Beetle in the subcompact class, etc.). The number of car models sold in any given year runs in the hundreds (304 domestic models in 1973). To determine an "average" weight value for the overall market in any given year, it is necessary to proportionally integrate the sales and weights of each car model or nameplate sold in that year to arrive at a sales-weighted average weight value.

The weight trend analysis and examination of ancillary characteristics resulted in the following findings.

A. Sales Trends

1. Total yearly sales of passenger cars in the U.S. have risen from about 3.15 million in 1947 to 11.34 million in 1973. Sales have been increasing at an average rate of approximately 315,000 units per year over this 26-year period after World War II. Sales in any given year, however, can vary considerably from the norm due to general economic conditions, strikes, etc.

2. Import car sales rose sharply from 1962 to 1970. Although sales volume continued to rise from 1970 to 1973, their percent of total sales remained relatively constant (approximately 15%).

3. In 1958, approximately 90% of all U.S. passenger cars were of the standard size class. From 1958 the share of the market occupied by the standard size car decreased dramatically, dropping to approximately 31% in 1973. This was occasioned by the introduction and public acceptance of the smaller size market classes during this period.

4. Subcompact sales more than doubled in the 1966-73 period. Subcompacts, in 1973, were the second-highest-selling market class (approximately 23% of total sales). The intermediate class was a close third in 1973, having approximately 20% of total sales.

5. The four major domestic corporations had 84.5% of the total U.S. passenger car sales in 1973. Adding Volkswagen, Datsun, and Toyota to this group accounts for 93.3% of the total sales. The four domestics plus the top ten imports account for 98.0% of the total passenger car sales.

6. The percent sales distribution between the domestic corporations has been relatively constant for the last 10 years. In 1973, General Motors had 44% of total U.S. passenger car sales; Ford had 24%; Chrysler had 14%; and American Motors had 3%.

B. Weight Trends

1. Passenger cars in all market classes have shown a marked and steady increase in curb weight with time. This curb weight increase trend is independent of manufacturer. For example, Chevrolet and Ford standard size cars increased approximately 1100 lb (33%) and 980 lb (29%), respectively, between 1956 and 1974. In the intermediate class, the Fairlane/Torino series increased curb weight by approximately 1100 lb (36%) from 1962 to 1974; the Chevelle increased curb weight 900 lb (28%) from 1966 to 1974. In the compact class, from 1962 to 1974 the Chevy II/Nova series increased curb weight by 940 lb (36%), while the Valiant increased by 620 lb (24%).

2. The intermediate class car of 1974 weighs about the same as the standard size car of 1970 (approximately 4200 lb curb weight). Similarly, the compact car of 1974 has about the same curb weight as the intermediate car of 1966 to 1970 (approximately 3300-3600 lb).

3. The overall sales-weighted curb weights of U.S. passenger cars dropped sharply from the 1958 level (approximately 3700 lb) to approximately 3450 lb in the 1960-64 period. This was due to the introduction of compacts in 1960 and high sales of both compacts and intermediates in that period. Since 1964, sales-weighted curb weights have risen steadily, reaching approximately 3650 lb in 1973.

4. The overall U.S. sales-weighted inertia test weight average (including domestic and foreign cars) has the same general pattern as curb weight variation with time. It dropped sharply from the 1958 level (3967 lb) to its lowest value of 3712 lb in 1961. Since 1961 there has been a steadily rising sales-weighted inertia test weight trend, reaching a new high value of 3968 lb in 1973.

5. Curb and inertia test weight values for domestic passenger cars surpassed their 1958 levels in 1970 and appear to be on a still-rising trend. For example, the sales-weighted inertia test weight average, for domestic cars only, was 4223 lb in 1973, compared with 4096 lb in 1958.

C. Dimensional Trends

1. Standard size Fords and Chevrolets have increased wheelbase approximately 6 in. (5%) and overall length from 15 to 22 in. (7 to 11%) in the period 1957 to 1974. All market classes show a sharp increase in overall length in 1973 and 1974, presumably due to safety bumper provisions.

2. Domestic intermediate and compact models also have increased wheelbase and overall length with time. Some domestic intermediates are now using a shorter wheelbase for the 2-door model than for the 4-door model. The 1974 intermediates are as long (206 to 215 in.) as some 1957-70 standard size cars (200 to 216 in.). The 1974 compact models (~197 in.) are as long as 1962-66 intermediates (197 in.).

D. Displacement and Compression Ratio Trends

1. In 1973, the U.S. total sales-weighted engine displacement was slightly lower than in 1958. The average displacement of domestic passenger cars was approximately 20 cu in. (7%) higher in 1973 than in 1958, even though the sales of less-than-standard-size cars increased from 10% to 69% of total sales during this period. The sales-weighted displacement of the standard size class increased nearly 67 cu in. (22%) to a value of 371.4 cu in. in this same period.

2. The sales-weighted engine displacement of import models rose approximately 32 cu in. (43%) in the period 1958 to 1973.

3. The 1973 U.S. total sales-weighted compression ratio was the lowest since 1962 (approximately 8.2). The import compression ratio rose to 8.15 in 1973 from 7.0 in 1958. The impact of anticipated use of lower octane unleaded gasoline has been forcing the trend of domestic and U.S. total sales-weighted compression ratio values.

E. Accessory Equipment Trends

1. Air conditioning was installed on 73% of all domestic cars in 1973, up from 8% in 1960. It accounted for 73 lb of weight per car in 1973 on a sales-weighted basis, or approximately 1.85% of the average curb weight in 1973.

2. The other optional power and luxury items are also increasing in popularity, accounting for 47 lb per car in 1970, or approximately 1.25% of the average curb weight in 1970. More and more of these items (power brakes, power steering, power windows, radios, bucket seats, etc.) are being made standard equipment and thus are no longer accounted for as optional power equipment.

3. Air conditioning plus all other optional power and luxury items represented approximately 2.9% of the passenger car curb weight in 1970. This value dropped to 2.6% in 1972 because some items that were optional in 1970 became standard equipment in 1972.

4. Based on trends from 1966 to 1970, the combined value for air conditioning plus all other power and luxury items (standard plus optional) is estimated to be approximately 3.2% of the curb weight in 1973.

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EXECUTIVE SUMMARY

1. INTRODUCTION

This report presents the results of an analysis of the historical weight trends of passenger cars sold in the United States over a 16-year period, 1958 through 1973.

Passenger cars are divided by the industry into five basic market classes: standard size, intermediate size, compact size, subcompact size, and specialty cars. The first four classes are segregated by wheelbase characteristics. The specialty class encompasses both large (e.g., Cadillac Eldorado) and small (e.g., Mustang) high-performance or sports models. Within each market class there are numerous corporations, domestic and foreign, producing cars for U.S. sale under various nameplates (Chevrolet Impala and Ford Galaxie 500 in the standard class, Chevrolet Nova and Plymouth Valiant in the compact class, American Motors Gremlin and the Volkswagen Beetle in the subcompact class, etc.). The number of car models sold in any given year runs in the hundreds (304 domestic models in 1973). To determine an "average" weight value for the overall market in any given year, it is necessary to proportionally integrate the sales and weights of each car model or nameplate sold in that year to arrive at a sales-weighted average weight value.

The principal topic covered is passenger car weight trends, but also included is a review of sales trends and ancillary car characteristics such as dimensional trends, displacement and compression ratio trends, and accessory equipment trends.

This volume (Volume I) summarizes the more pertinent information from the analyses. Further details are given in the main body of the report (Volume II).

2. SALES TRENDS

As shown in Figure 1, the total yearly sales of passenger cars in the U.S. have risen from about 3.15 million in 1947 to 11.34 million in 1973. Sales have been increasing at an average rate of approximately 315,000 units per year over this 26-year period after World War II. Sales in any given year, however, can vary considerably from the norm due to general economic conditions, strikes, etc. The share of the market captured by the domestic auto corporations and by all foreign imports is illustrated in Figure 2 in terms of percent of total sales. Although import car sales rose sharply from 1962 to 1970, their percent of total sales remained relatively constant (approximately 15%) from 1970 to 1973.

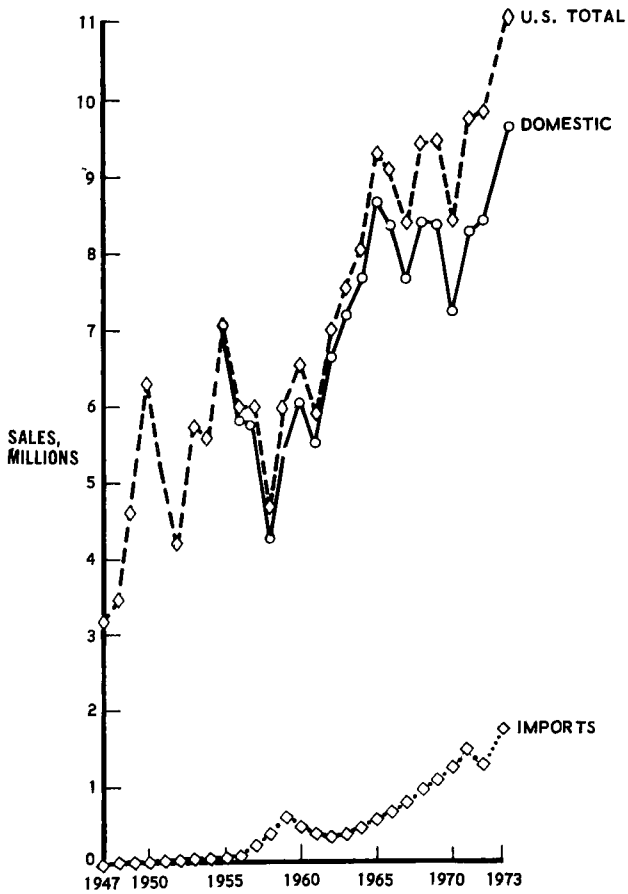

Figure 1. U.S. Total Passenger Car Sales

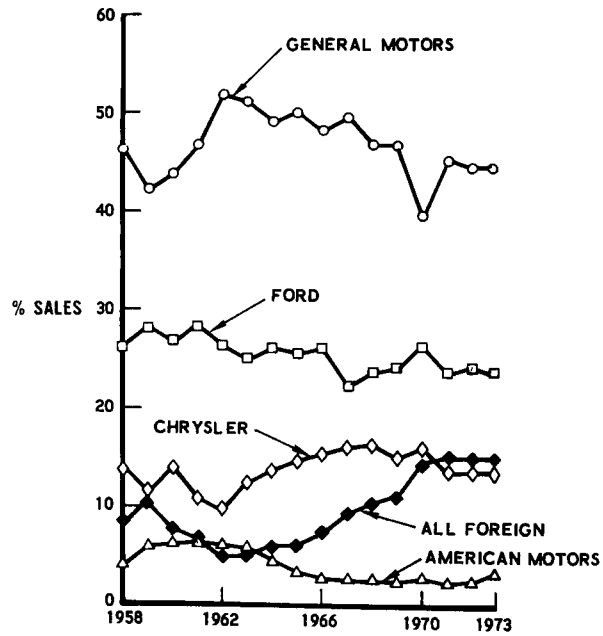

Figure 2. Passenger Car Sales by Corporation

Figure 3 provides a breakdown of 1972 sales by nameplate. The larger producers are counted first, and the cumulative U.S. total sales percentage developed accordingly, as shown. The four domestic corporations had 85.4% of the total U.S. passenger car sales. Adding Volkswagen, Datsun, and Toyota to this group accounts for 94.3% of the total sales. The four domestics plus the top ten imports account for 97.95% of the total 1972 sales.

The percent sales distribution between the domestic corporations has been relatively constant for the last 10 years. In 1973, General Motors had 44% of total U.S. passenger car sales, Ford had 24%, Chrysler had 14%, and American Motors had 3%.

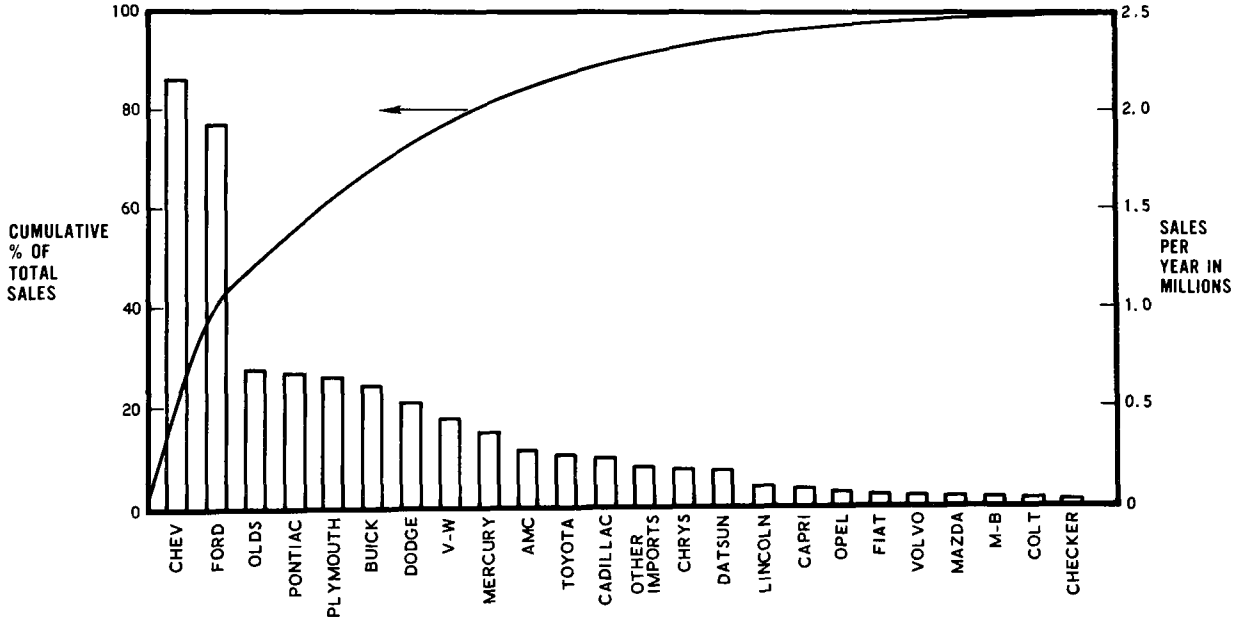

Figure 3. 1972 U.S. Sales by Nameplate

The distribution of sales by market class during the last 16 years is shown in Figure 4. Most striking is the decline of the standard size car, which represented approximately 90% of the entire market in 1958. The other market classes have risen proportionally, with the sub-compact class showing the most significant gains in recent years.

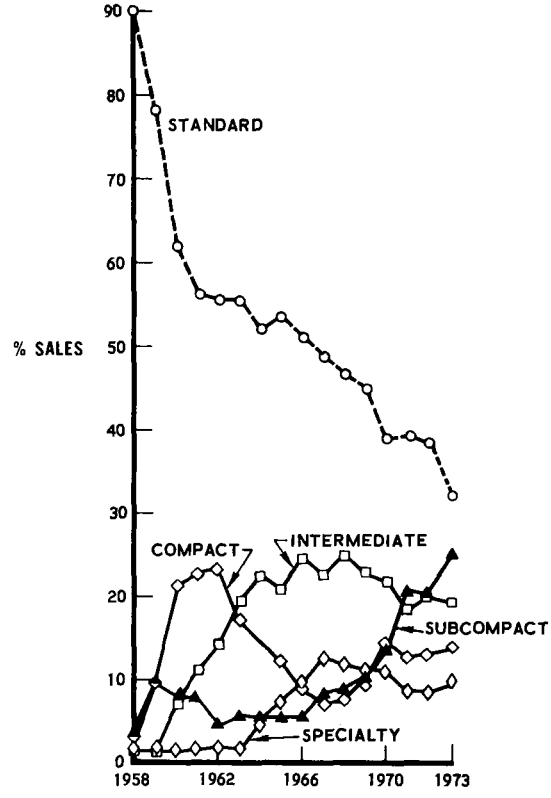

Figure 4. Passenger Car Sales by Market Class

Figure 5 illustrates the cumulative monthly sales variations by market class for calendar year 1973. As can be noted, the sales distribution by market class remained relatively constant throughout the year. The decline in sales of the standard size class was evident at the beginning of the year, as was the attendant general increase in percentage sales of the

subcompact, compact, and specialty car classes. The intermediate size class change from 1972 to 1973 (and throughout 1973) was quite small.

Subcompact sales more than doubled in the 1966-73 period, and in 1973 were the second highest selling market class (approximately 23% of total sales). Close behind is the intermediate class (at 20%), whose sales peaked in 1968 (25% of total sales), but have dropped slightly since then. Compact car sales peaked in 1962 (25% of total sales), but in 1973 represented only approximately 15% of total sales.

The specialty car class encompasses both large and small high-performance cars (Cadillac Eldorado, Lincoln Mark IV, Mustang, Camaro, Monte Carlo, etc.). The increased sales of this class in 1966 are due to the popularity of the smaller Mustang- and Camaro-type models.

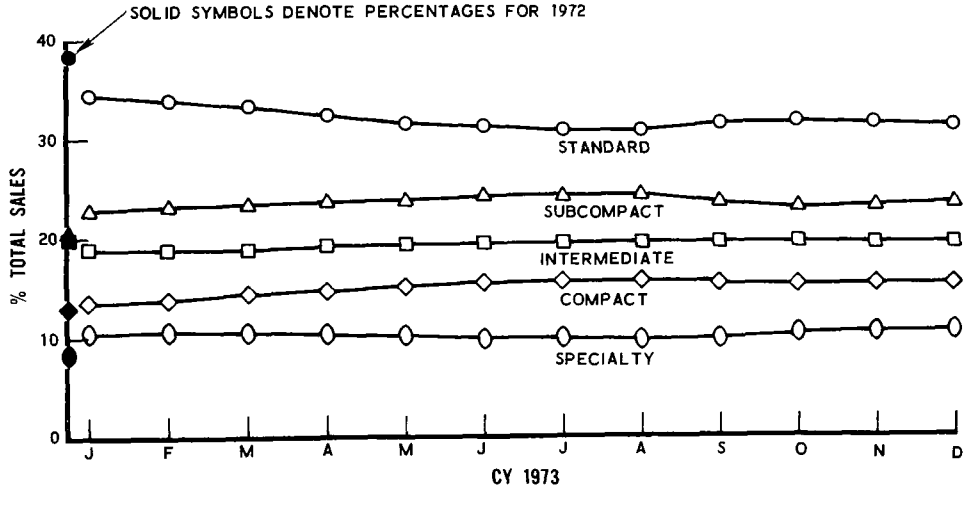

Figure 5. 1973 Sales by Market Class (Cumulative Total by Month)

3. WEIGHT TRENDS

Passenger cars in all market classes have shown a marked and steady increase in curb weight with time, independent of manufacturer. This trend is illustrated in Figure 6 for the standard size Chevrolet Impala and Ford Galaxie 500 (from 1956 to 1962 the values shown are those for the comparable model offered). Between 1956 and 1974 this increase in curb weight amounted to approximately 1100 lb (33%) and 980 lb (29%) for the Chevrolet and Ford models, respectively.

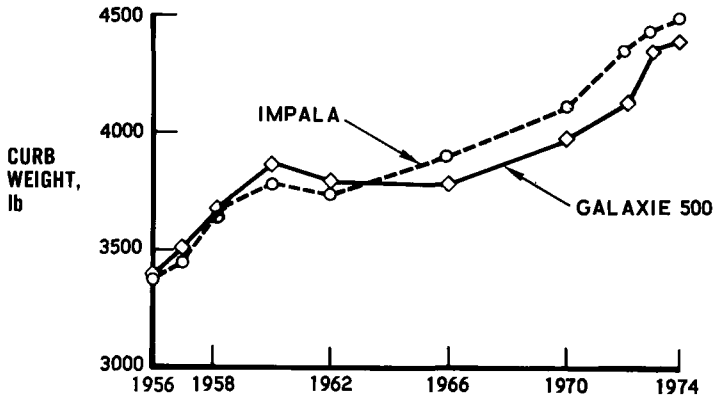

Figure 6. Passenger Car Curb-Weight Trends by Nameplate (Standard Class)

In the intermediate class, the Fairlane/Torino series increased curb weight by approximately 1100 lb (36%) from 1962 to 1974; the Chevelle increased curb weight 900 lb (28%) from 1966 to 1974. In the compact class, from 1962 to 1974 the Chevy II/Nova series increased curb weight by 940 lb (36%), while the Valiant increased by 620 lb (24%).

For the time period through 1974, the standard, intermediate, compact, and subcompact size models increased in curb weight approximately 2 to 3% per year on an average basis for the years and models examined. The major imports (Volkswagen, Datsun, Toyota) leveled off in curb weight increases in the 1970-72 period; Datsun, however, experienced a 400-lb (19%) increase from 1972 to 1974.

The intermediate class car of 1974 weighs about the same as the standard size car of 1970 (approximately 4200 lb curb weight). Similarly, the compact car of 1974 has about the same curb weight as the intermediate car of 1966 to 1970 (approximately 3300-3600 lb).

The overall sales-weighted values of U.S. passenger car curb and inertia test weights dropped sharply in the 1960-64 period from 1958 values (shown in Figure 7). This was due to the introduction of domestic compacts in 1960 and high sales of both compacts and intermediates during that period. There has been a steadily rising trend in sales-weighted weight values from 1962 to 1973. The overall sales-weighted inertia test weight average in 1973 (3968 lb) is slightly above the previous 1958 high of 3967 lb.

Curb and inertia test weight values for domestic passenger cars surpassed their 1958 levels in 1970 and appear to be on a still-rising trend. Import cars exhibit a steady rise in curb and inertia test weights from 1958 to 1973.

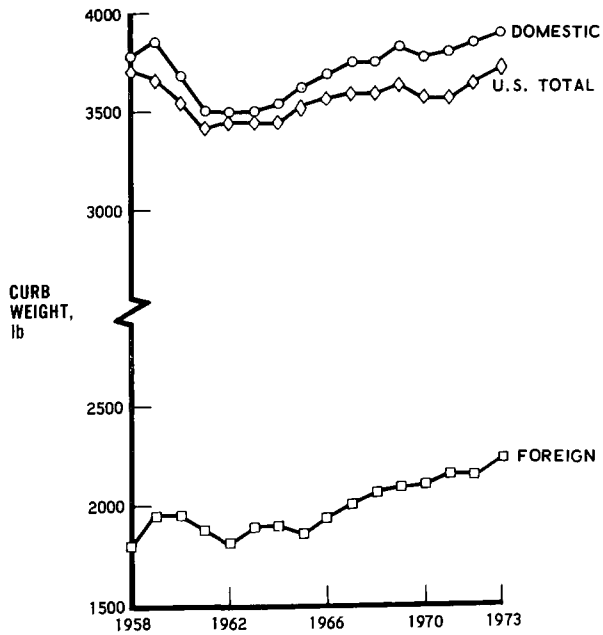

Figure 7. Overall Passenger Car Curb-Weight Trends (Sales Weighted)

Figure 8 illustrates sales-weighted curb weight trends for the five passenger car market classes. In general, they parallel the overall trends of Figure 7. Specialty car class weight trends are clouded because of the mix of both small and large vehicles. The introduction of new and popular models (e.g., the Mustang in 1966) can make large variations in weight for this particular class.

Figure 9 depicts curb weight variations as a function of domestic corporations and total imports. The sales-weighted average curb weights of General Motors cars are consistently about 300 lb higher than Ford and Chrysler values. This is due to the combined sales of standard-size cars in a plurality of nameplates (Chevrolet, Pontiac, Oldsmobile, Buick, Cadillac). On the other hand, the curb weights of American Motors cars average approximately 500 lb less than those of Ford and Chrysler. This is because American Motors cars have been exclusively oriented toward the smaller-car market until very recently.

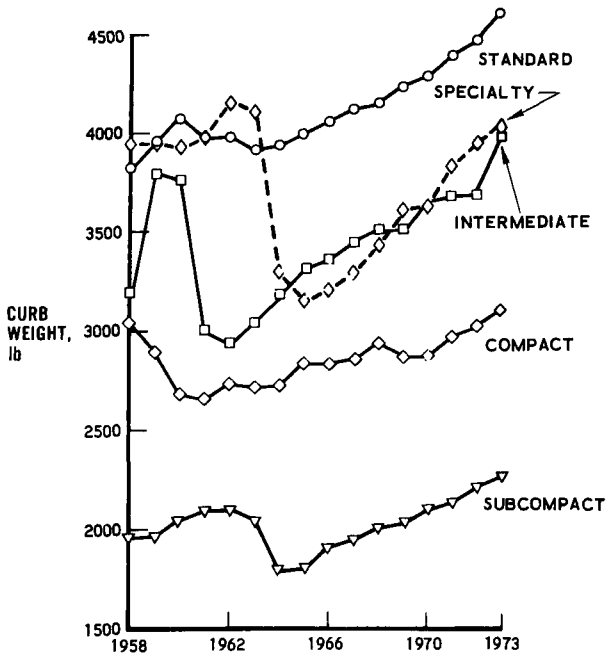

Figure 8. Curb Weight Trends by Market Class (Sales Weighted, U.S. Total)

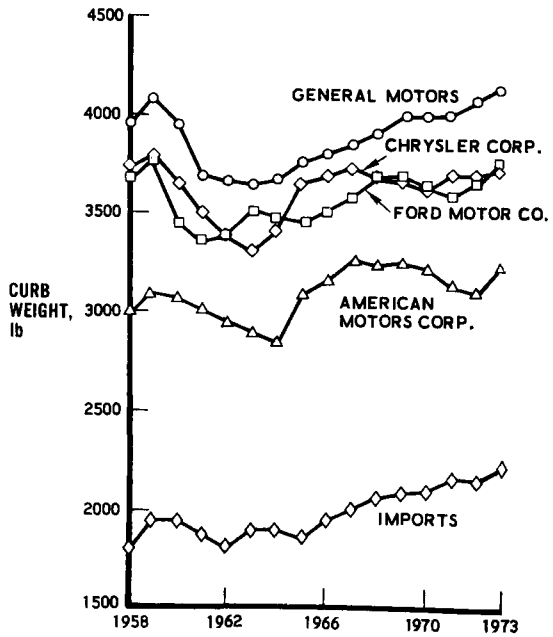

Figure 9. Curb Weight Trends by Corporation (Sales Weighted)

4. DIMENSIONAL TRENDS

Standard-size Fords and Chevrolets have increased wheelbase approximately 6 in. (5%) and overall length from 15 to 22 in. (7 to 11%) in the period 1957 to 1974, as illustrated in Figures 10 and 11. Domestic intermediates and compact models also have increased wheelbase and overall length with time. Some domestic intermediates are now using a shorter wheelbase for the 2-door model (4 in. less) than for the 4-door model. All market classes show a sharp increase in overall length in 1973 and 1974, presumably due to safety bumper provisions.

1974 intermediates are as long overall (206 to 215 in.) as some 1957-70 standard size cars (200 to 216 in.). 1974 compact models (~197 in.) are nearly as long overall as 1962-66 intermediates (197 in.).

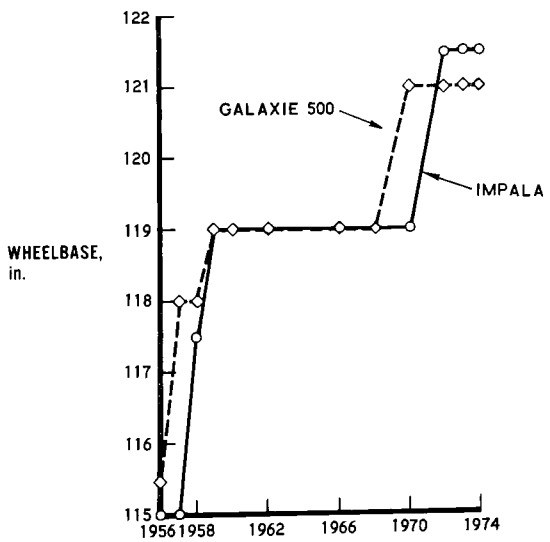

Figure 10. Passenger Car Wheelbase Trends (Standard Class)

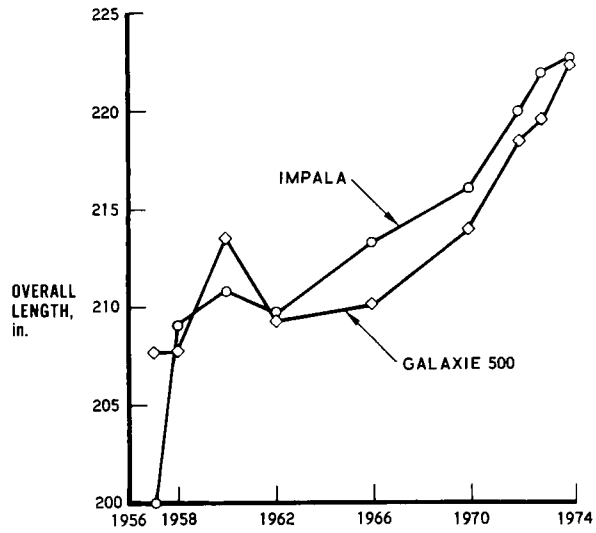

Figure 11. Passenger Car Overall-Length Trends (Standard Class)

Figures 12, 13, and 14 illustrate sales-weighted wheelbase, overall length, and total overhang (overall length minus wheelbase) trends for the total U.S. passenger car market, domestic cars only, and import cars only. The total U.S. sales-weighted wheelbase and overall length values have decreased from 1958 to 1973, despite the fact that all market classes have increased in these dimensions over the same period. This is the result of changes in market class sales distributions; the standard-size car was nearly the total market in 1958, but has been steadily decreasing in percent of total passenger car sales as the other market classes have made proportional increases in sales. The sharp rise in total overhang values in 1973 (to exceed 1958 values) may be related to safety bumper provisions.

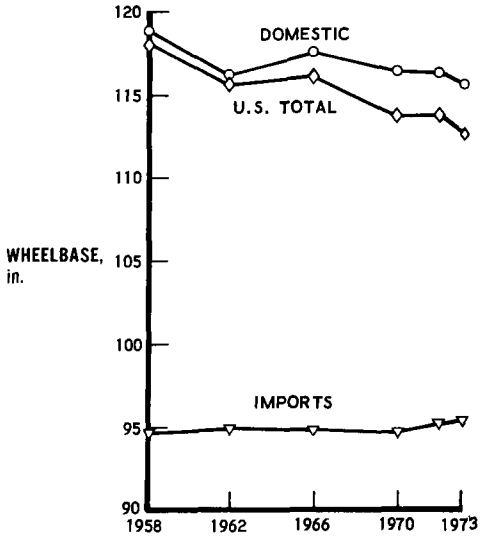

Figure 12. Passenger Car Wheelbase Trends (Sales Weighted)

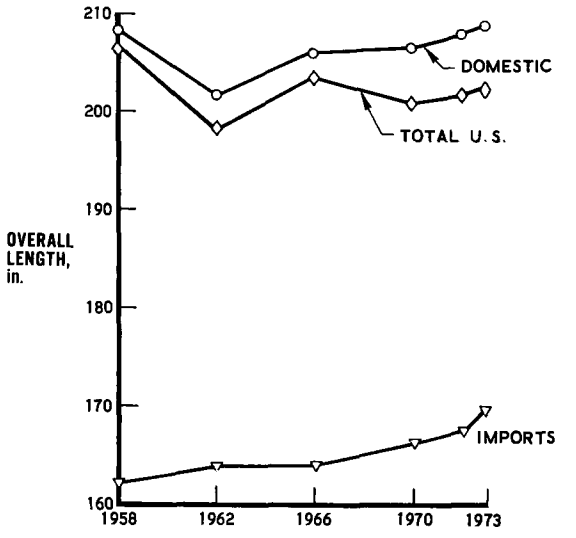

Figure 13. Passenger Car Overall-Length Trends (Sales Weighted)

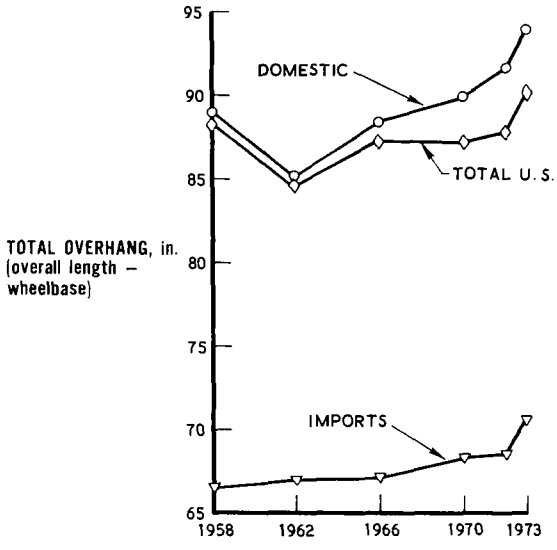

Figure 14. Passenger Car Total-Overhang Trends (Sales Weighted)

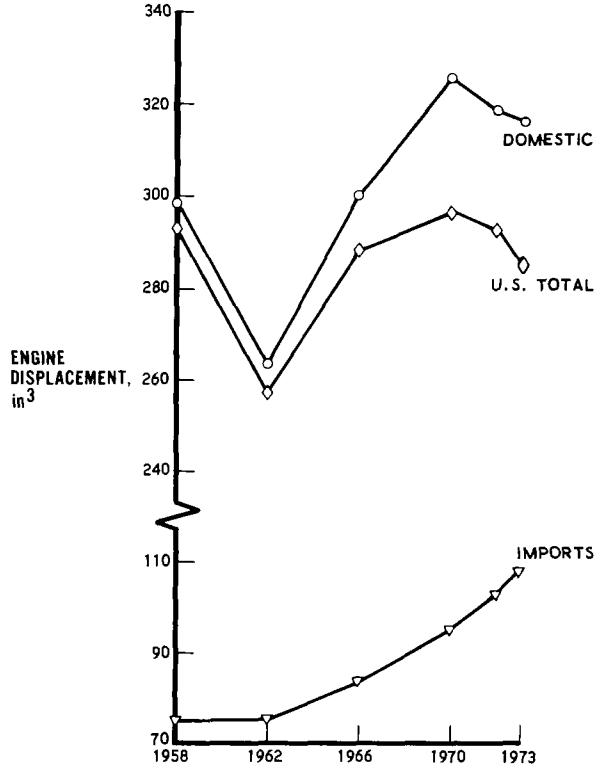

Figure 15. Engine Displacement Trends (Sales Weighted)

5. ENGINE DISPLACEMENT AND COMPRESSION RATIO TRENDS

The trend of sales-weighted engine displacement for passenger cars is shown in Figure 15 for the total U.S. market and for the domestic and import subdivisions. Clearly evident in 1962 is the impact of large-volume sales of domestic compacts (Falcon, Chevy II, Corvair, Valiant), which greatly reduced the sales-weighted cubic inch displacement (CID). From 1962 until 1970, the average CID increased steadily. From 1970 to 1973, the average value of domestic CID declined slightly, but the import CID continued to rise. In 1973, the U.S. total sales-weighted engine displacement (CID) was slightly lower than in 1958. The average displacement of domestically produced passenger cars was approximately 20 cu in. (7%) higher in 1973 than in 1958. The engine displacement of import models rose approximately 32 cu in. (43%) from 1958 to 1973.

Sales-weighted compression ratio trends are shown in Figure 16 for the total U.S. market, for domestic passenger cars, and for imports.

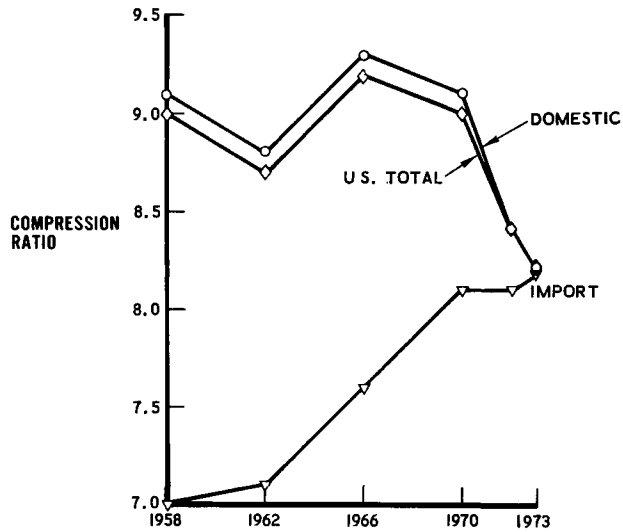

Figure 16. Engine Compression Ratio Trends (Sales Weighted)

Following the 1962 reduction in sales-weighted compression ratio occasioned by high-volume compact car sales, both the domestic and U.S. total averages rose sharply and then declined to new lows in 1973. The 1973 compression ratios reflect not only the increase in sales of smaller car models, but also the decision of the U.S. domestic auto industry to reduce compression ratio across the board in order to be able to operate with lower octane unleaded gasoline. Import compression ratios rose sharply and steadily from 1962 to 1972, but leveled off in the 1970-73 period, again because of anticipated use of unleaded gasoline. The 1973 U.S. total sales-weighted compression ratio is the lowest since 1962 (approximately 8.2). The import compression ratio rose to 8.15 in 1973 from 7.0 in 1958.

6. ACCESSORY EQUIPMENT TRENDS

Figure 17 summarizes available data concerning the percent of passenger cars that have been equipped with various power and luxury items over the past 16 years.

All items shown have risen sharply in the period 1962 to 1973. Both automatic transmissions and radios were used in over 90% of all domestically produced passenger cars in the 1970-73 period. The use of power steering was approaching the 90% level in 1973. Both air conditioning and power brakes, at approximately 75% in 1973, exhibit a slope that indicates that they also may approach the 90% level in 4 to 5 years. The vinyl top (at about 7 lb per car) was used in approximately 49% of all domestic cars in 1973.

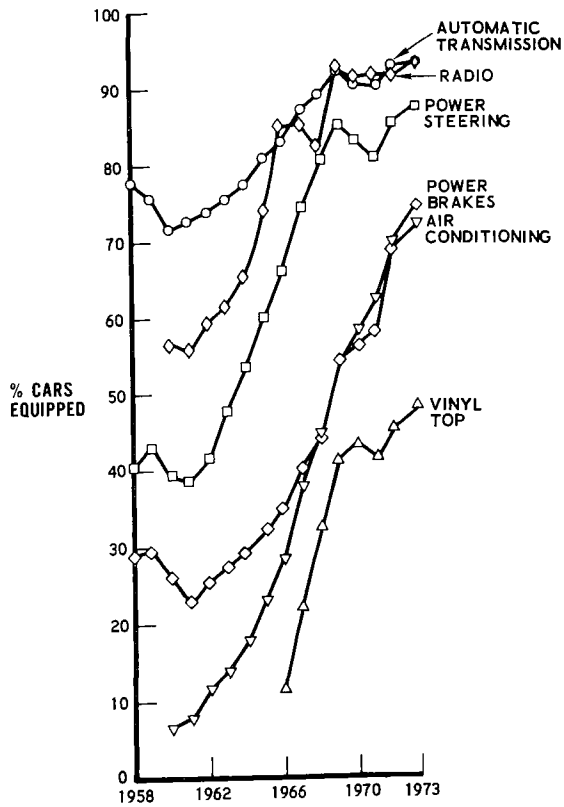

Figure 17. Power and Luxury Item Trends (Domestic Only)

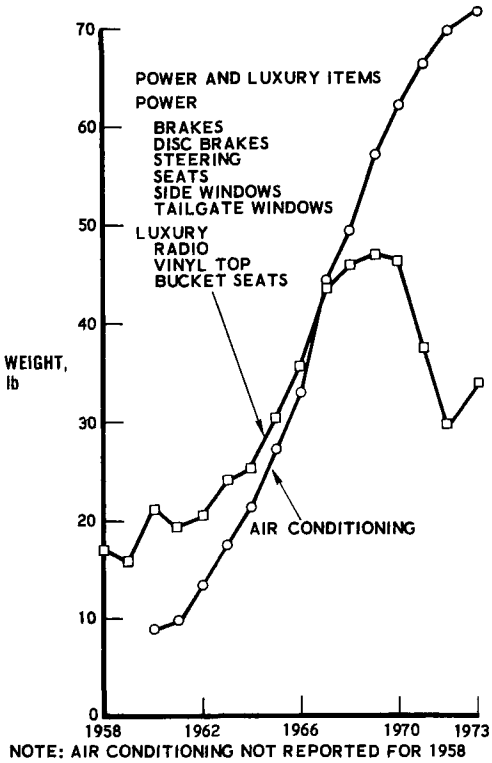

Figure 18. Optional Power and Luxury Item Trends (Sales Weighted, Domestic Only)

Figure 18 illustrates the sales-weighted average weight per car for optional air conditioning and other combined power and luxury items over the 1958 to 1973 period.

Air conditioning alone accounted for an average of 73 lb per car in 1973. The sharp drop in average weight for the combined power and luxury item curve from 1970 to 1972 is merely a reflection that a number of power and luxury items were made standard equipment on many car models in that period and are, therefore, not separately accountable as in the past. Thus, some items previously considered a luxury are now considered necessary.

At the slope existing between 1966 and 1970 for combined power and luxury items, their average weight in 1973 would represent approximately 52 lb per car, which, when added to the air conditioning weight of 73 lb, gives a total sales-weighted optional accessory weight average of 125 lb per car in 1973.

In 1973, air conditioning represented approximately 1.85% of the curb weight. Again using the extrapolated 1966 to 1970 characteristics for the other combined power and luxury items, their value in 1973 would be approximately 1.35% of the curb weight, for an overall total of approximately 3.2% of the curb weight (air conditioning plus power and luxury items).