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IDENTIFYING AUTOMOTIVE CHANGES IN FACILITIES AND CAPITAL EQUIPMENT AND ASSESSING COMMUNITY AND EMPLOYMENT IMPACTS

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16. Abstract

This paper summarizes the research methodologies and several of the findings of the motor vehicle industrial research and analysis at the Transportation Systems Center in Cambridge, MA. The paper presents a brief overview of the many forces impacting the automotive and related industries, and the resultant implications of these forces on facilities, employment and communities. It focuses on the facility planning and capital investment impacts of the ongoing automotive design changes by the domestic manufacturers and suppliers. The required auto redesign efforts and the associated materials, parts and equipment sourcing patterns have significant implications on plant utilization which directly impacts the employment levels and economic viability of certain communities and regions of the country.

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PREFACE

The energy shock which hit the United States in 1979 has had a profound effect on many aspects of American life, but, perhaps, none more so than the domestic automobile industry. The shock resulted in a change in product, technology, manufacturing and employment patterns within the industry which is likely to be a permanent legacy.

To meet the public's demand for quality, fuel-efficient autos, the domestic auto industry is undertaking the greatest retooling effort in history. It has been estimated that over the next five years, the automakers will spend approximately $80 billion for redesigning and downsizing the auto fleet to achieve improved fuel efficiency and quality, with the supplier industries investing at a comparable level.

This paper attempts to put into a clearer perspective the facilities planning, capital cost and regional employment impacts of this unprecedented retooling effort. The paper focuses on:

- o The basic issues involved in redesigning an automobile to meet new marketplace demand;
- o The ongoing and planned auto redesign efforts by the domestic auto manufacturers and the resulting impacts on the vehicle and facilities;
- o How these forces could impact plants and employment levels in the future.

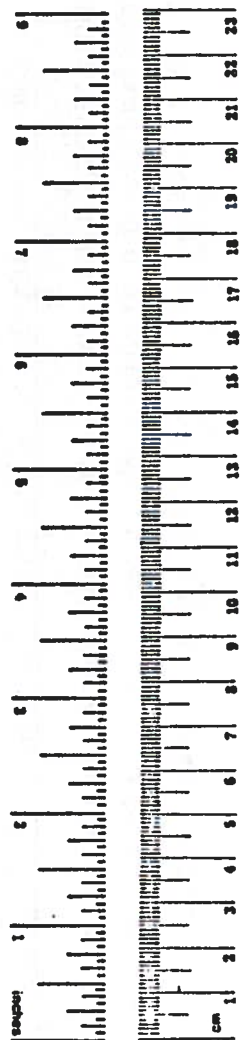
In addition, the paper also presents an overview of a program implemented by the TSC to measure the impacts of present and future automotive design changes.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

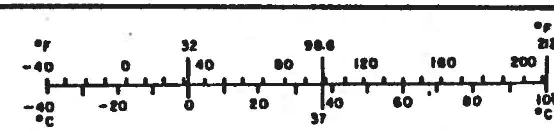
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

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



Approximate Conversions from Metric Measures

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



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1. TECHNICAL DISCUSSION

1.1 THE ISSUES

To understand fully this retooling program and the implications it has on costs and leadtimes, one must first understand:

- The overall implications of redesigning a motor vehicle
- The process of manufacturing a motor vehicle.

1.1.1 The Implications of Automotive Redesign

Figure 1 is a simplified illustration of the impact chain as the industry redesigns the auto fleet. This chain forms the basis for understanding the magnitude of the impacts on the auto manufacturers and suppliers and eventually workers and communities. As shown in the diagram, as fuel prices increase and supply interruptions become more frequent, the consumer places increasing demands on the automaker to develop a fuel-efficient vehicle. In reaction to this change in demand, automakers have responded in several ways.

- They went back to the drawing boards and identified ways of reducing vehicle weight. (This is indicated in the upper right hand corner of Figure 1.)
- They have also identified ways to "repackage" (i.e., redesign) the auto so as to reduce its weight while preserving its traditional qualities of comfort, performance and ride. (This is depicted in the lower left hand corner of Figure 1.)

The net effect of these weight reduction efforts by the manufacturers has been an increase in vehicle fuel economy. As the automakers strive to reduce vehicle weight and thus to increase vehicle fuel economy, this inevitably leads to the manufacture of new vehicle parts and components. This in turn leads to changes in manufacturing plants. The result, as shown in the lower right hand corner of Figure 1, may be the expansion in capacity of some plants or the closing of others.

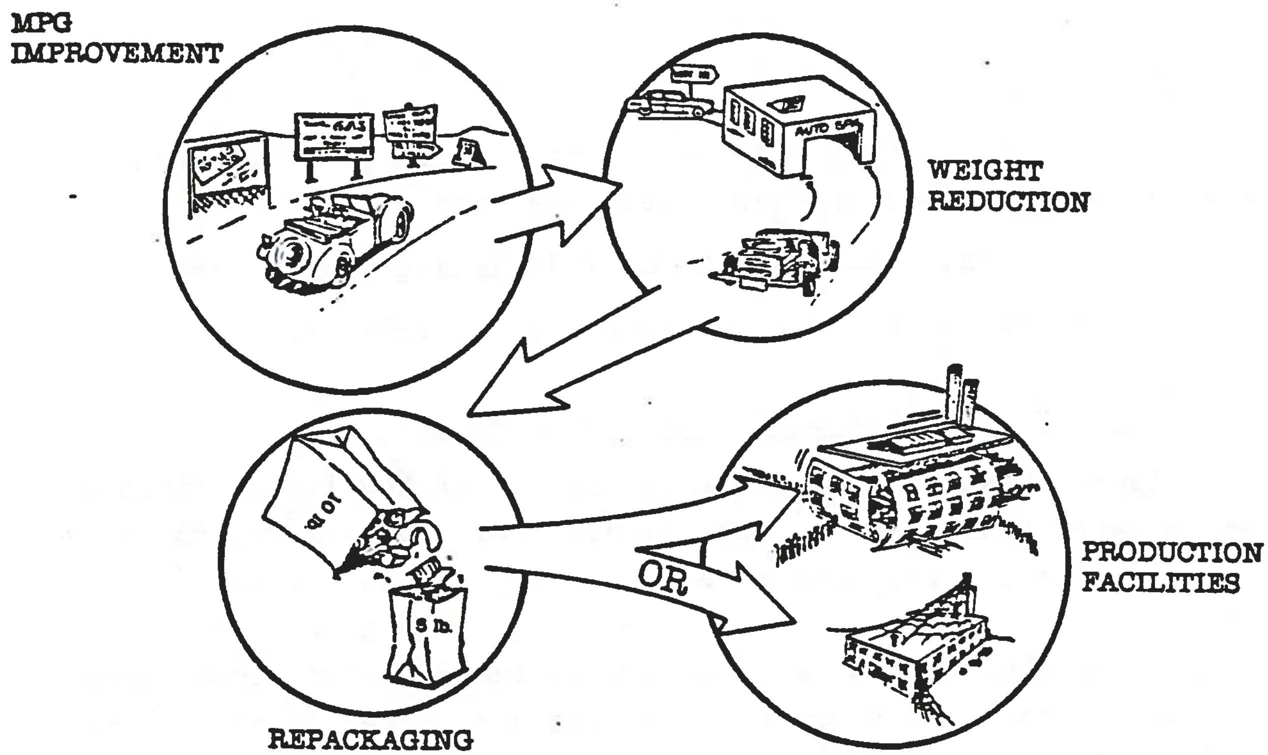


FIGURE 1. THE IMPACT CHAIN

The domestic manufacturers clearly recognize that failure to keep up with the market demand for increasingly fuel-efficient vehicles would inevitably lead to long-term shutdowns of production facilities as competitors meet the new demand. Responding to the marketplace is costly. For example, the change of a product line from rear-wheel drive to front-wheel drive has cost the auto manufacturers upwards of a billion dollars and has taken four to five years to implement.

1.1.2 The Manufacturing Process

The automobile is the most complex consumer product devised. Each of the over 10,000 parts is created from raw materials, which must be mined, processed, and manufactured. These parts are combined into components, auto sub-assemblies, and vehicle systems. Finally, major systems are assembled to produce an automobile.

As shown in Figure 2, the manufacture of an automobile involves many types of manufacturing plants, all making highly specialized parts. These funnel through the system and arrive at the final assembly plant. Figure 2 illustrates a few of the major types of manufacturing facilities required to build an automobile. In reality, there are thousands of manufacturing facilities involved in the manufacturing process, with at least 80 different generic plant types.

The process of manufacturing a vehicle has evolved over 70 years, as has the design of the automobile. This industry structure is the result of years of massive capital investment. This system is the fundamental reason why a mass produced car can still be purchased for about $5000 while an individually produced car can cost five to ten times more.

There is a major inflexibility in the system which has evolved. Minor changes can be accommodated without major capital investment. However, the complex system is very costly to change, because each significant design change in a single automobile part impacts two to four plants in the system.

As the complexity of the change increases, the manufacturing facility impacts grow from minor retooling, to major retooling, to new equipment, to all new plants, and, possibly, to plant relocation. All plants and companies in the complex industry are constantly faced with a strategic choice:

- o Should I invest and make the part myself? or
- o Should I buy the part from somebody else who will invest in new facilities?

On balance, when the significant design change occurs, somebody somewhere must invest capital to build and/or modify a manufacturing plant. It is the magnitude of this investment, and the time

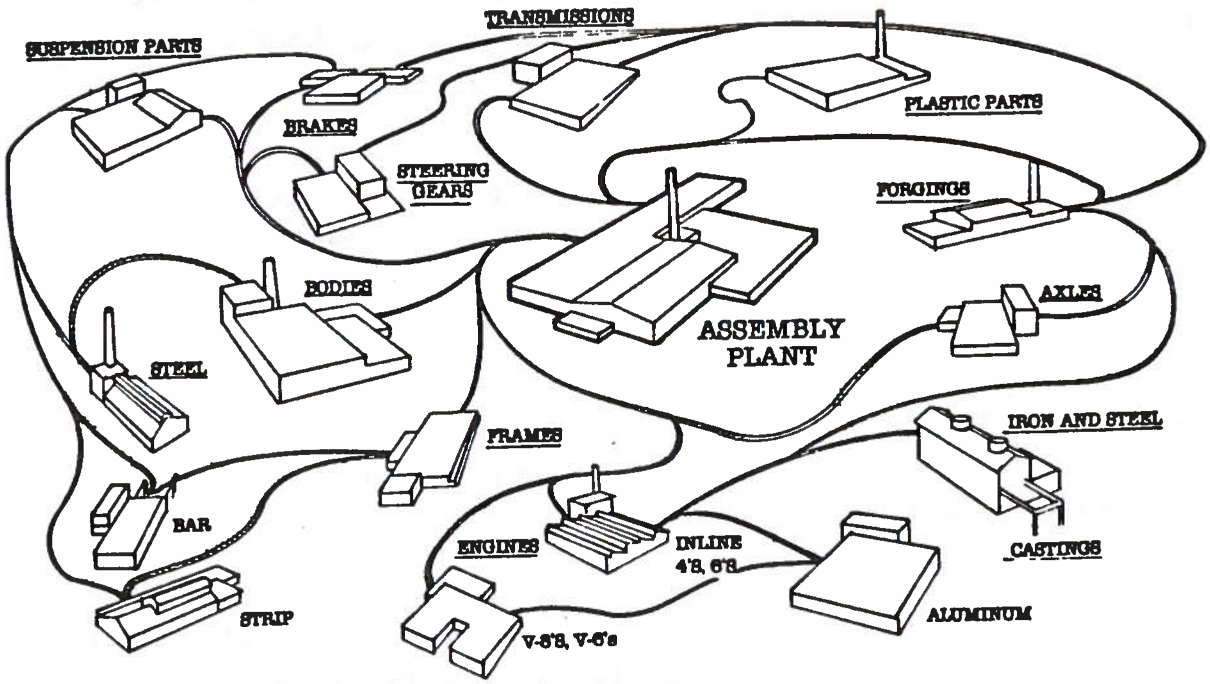


FIGURE 2. THE MANUFACTURING PROCESS

it takes to build a new or modify an existing plant that is the subject of the following section of the paper.

1.2 ONGOING AND PLANNED AUTO REDESIGN EFFORTS BY THE DOMESTIC AUTO MANUFACTURERS

After the brief look at the overall chain of events that result in facilities planning and capital investment impacts on manufacturing facilities, this section of the paper will focus on ongoing design changes taking place in domestically manufactured automobiles. Four phases of automotive redesign will be explored:

- Phase I - Downsizing
- Phase II - Component Change
- Phase III - Major Materials Substitution and Redesign

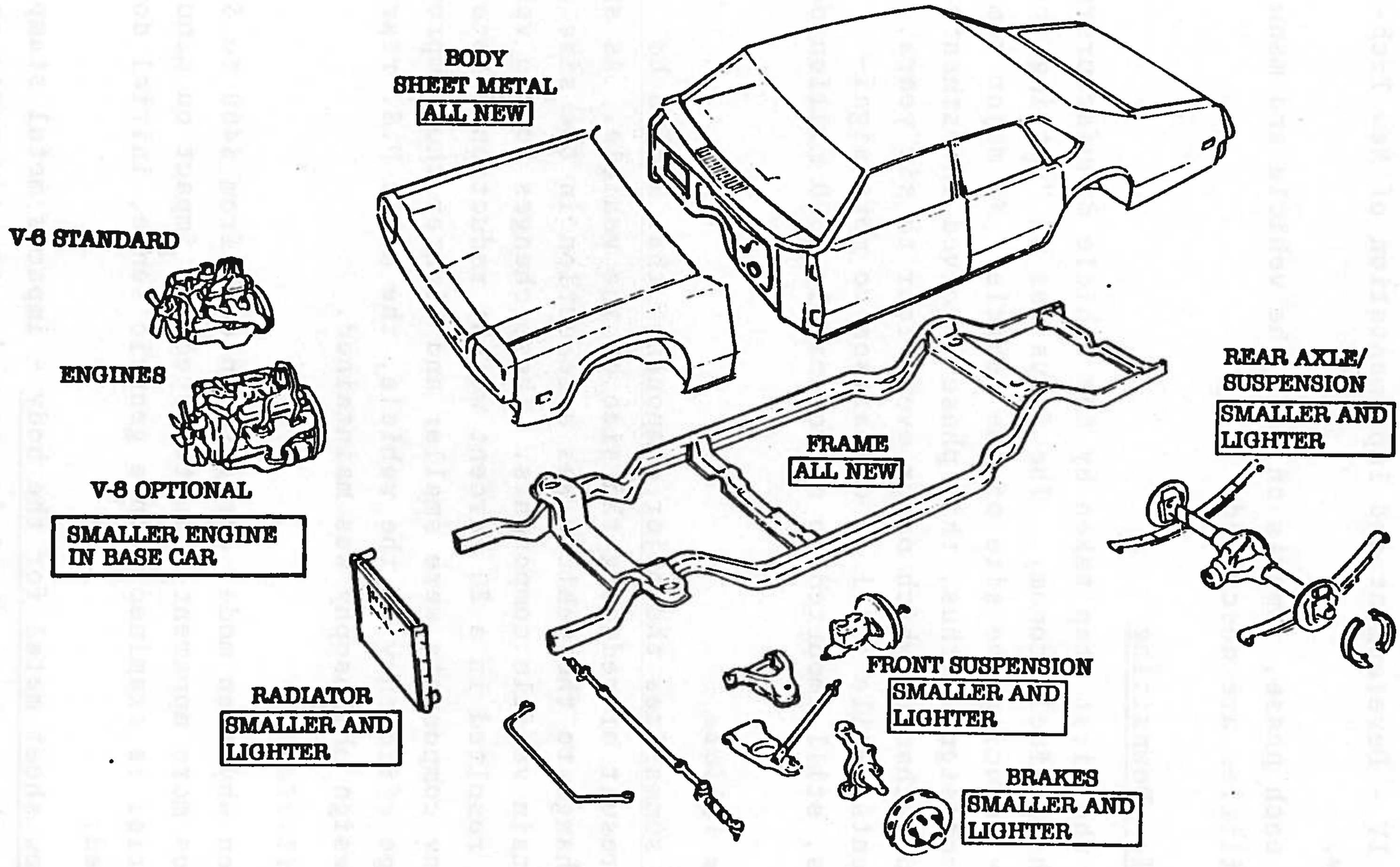


FIGURE 3. PHASE I CHANGES TO THE VEHICLE

- o Phase IV - Development and Implementation of New Technology.

In discussing each phase, impacts on both the vehicle and manufacturing facilities are described.

1.2.1 Phase I: Downsizing

This was the first step taken by the vehicle manufacturers to improve vehicle fuel economy. The focus was on "getting the weight out" by reducing the size of the vehicle. No major components were redesigned, thus, this phase involved investments typical of model changes which occur every four to six years. These investments, while small in comparison to more significant changes, still amounted to approximately $500 million per car line.

Changes to the Vehicle

Figure 3 summarizes the major components that had to be changed as a result of reducing the size of the vehicle. As shown, the primary change to the vehicle was a reduction in the size and weight of certain vehicle components. These changes to the vehicle typically resulted in a 20 percent weight reduction. Note that while many components were smaller and lighter thus improving the package efficiency of the vehicle, the basic U.S. rear-wheel drive design philosophy was maintained.

Impact on Facilities

The reason why even model changes can cost from $400 to $600 million becomes more apparent when the specific impact on manufacturing facilities is examined. In a generic sense, initial downsizing involved:

- o <u>All new sheet metal for the body</u> - impacts metal stamping plants where sheet steel is stamped into body parts on expensive tools and dies.
- o <u>The shift to a V-6 engine as standard with V-8 as optional</u> - shifts engine plant capacity and requires

changeover of engine lines. The equipment used to produce V-6 engines is not always the same as that for V-8 engines.

- <u>Smaller and lighter components such as rear axles, suspension parts, brakes and radiators</u> - requires substantial retooling at numerous plants.
- <u>All new frame</u> - requires substantial retooling.
- <u>Assembly plant</u> - requires new tooling and fixtures.

Each change has a direct impact on a specific plant or plants.

Figure 4 is a highly simplified presentation which illustrates the impact of initial downsizing of automobiles on manufacturing facilities. Remember that the 17 plants shown here represent thousands of manufacturing facilities. The complex web of product and in-process materials flow is represented only partially. The impact is primarily on plants owned and operated by the automobile manufacturer. The cross hatching represents significant impact on facilities.

1.2.2 Phase II: Component Change

Phase II represents a fundamental shift in the design philosophy of vehicles. Whereas in Phase I the vehicle was still driven by the rear wheels, the Phase II emphasis was on front-wheel drive. The primary goal of this shift was to reduce vehicle weight further while preserving and, if possible, enhancing basic vehicle features such as comfort, ride and interior space for passengers.

Changes to The Vehicle

A summary of the major component changes resulting from the switch to front-wheel drive in Phase II is shown in Figure 5. As shown in the diagram, the following major changes occur:

- New body sheet metal is used, and the body design is now unitized.
- The frame is eliminated, and replaced by new structure added to the body.

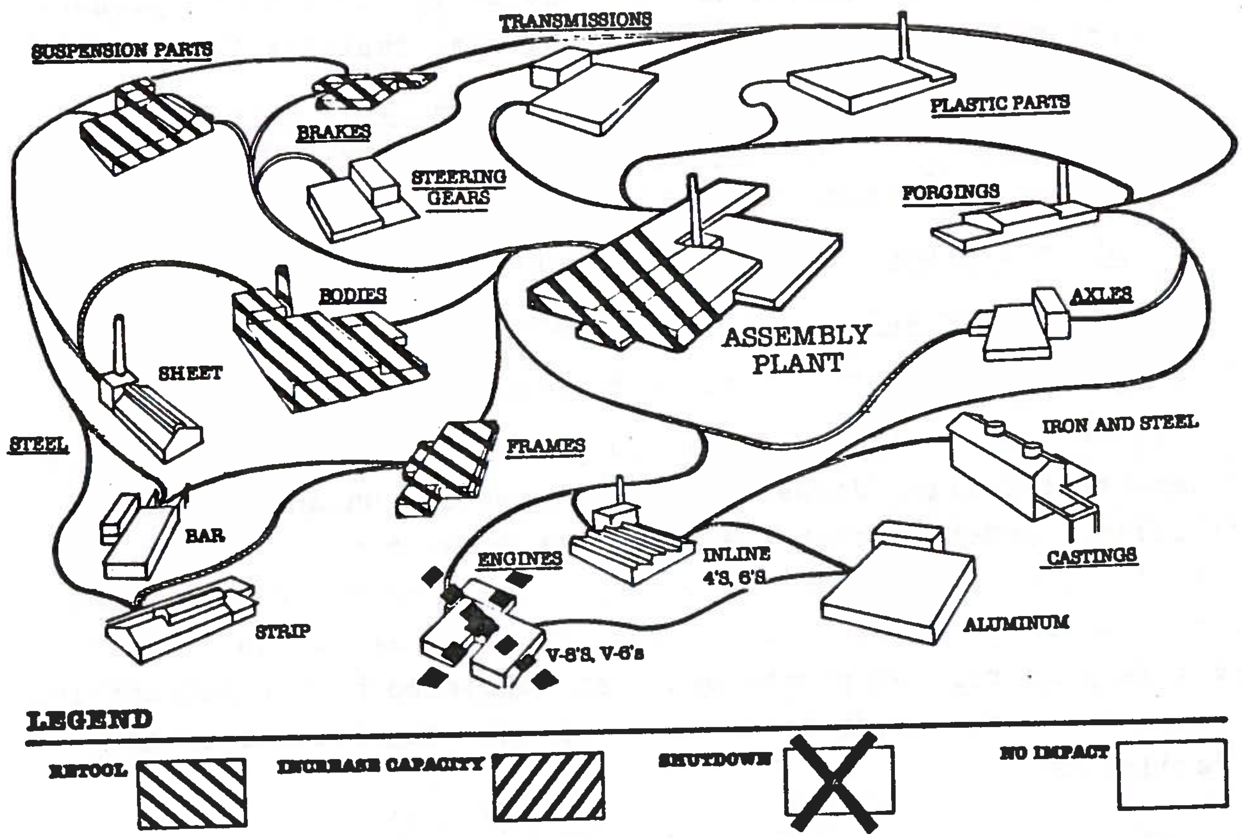


FIGURE 4. PHASE I IMPACTS ON FACILITIES

- The rear axle is eliminated and replaced with an all new rear suspension system.
- The V-8 engine is eliminated, and the V-6 and in-line 4 cylinder engines become standard.
- The drive shaft and transmission are eliminated and are replaced by an all new transmission called a transaxle, and new twin front-wheel drive shafts with constant velocity joints.
- Major chassis components are now mounted on an all new "subframe."

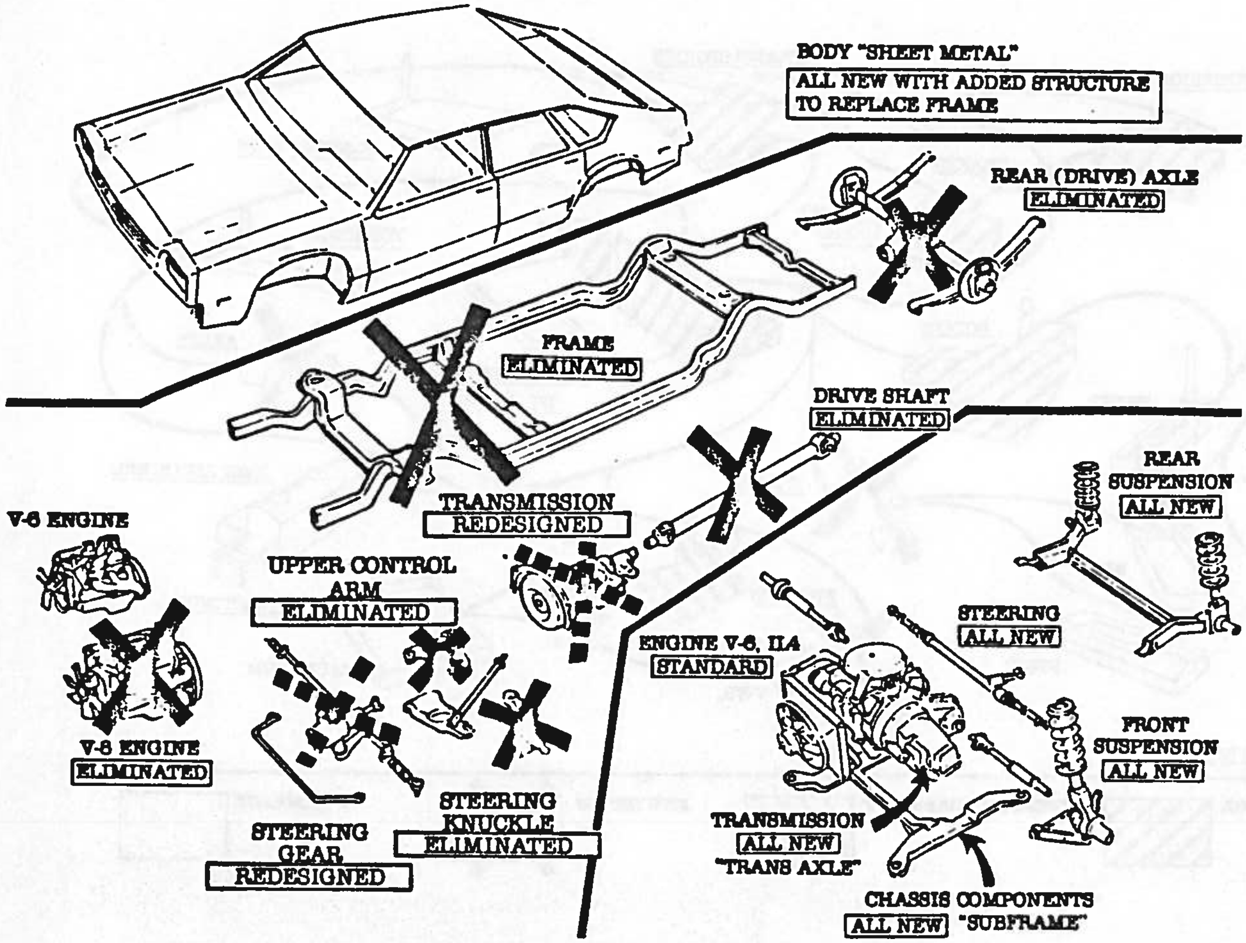


FIGURE 5. PHASE II CHANGES TO THE VEHICLE

o The front suspension is an all new McPherson Strut, and the steering system is an all new rack and pinion type.

In Phase II, most of the major vehicle component changes result in a further weight reduction of approximately 5 percent. Note that no significant material changes are made in Phase II. The traditional materials, iron and steel, are still being widely used.

Impact on Facilities

Figure 6 outlines the impact of the Phase II vehicle changes

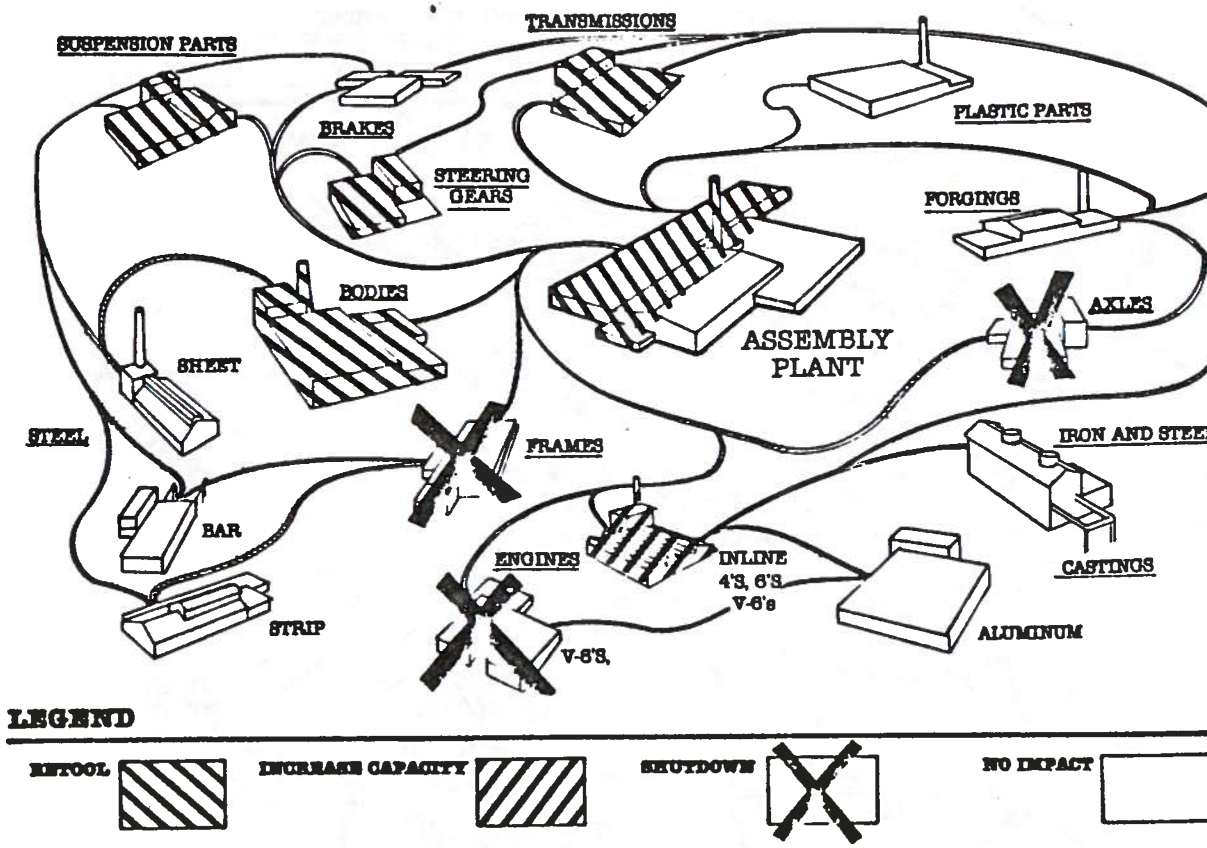


FIGURE 6. PHASE II IMPACTS ON FACILITIES

on manufacturing facilities. In comparison to the Figure on Phase 1, the facility impact of Phase II is much more widespread. Some plants are eliminated as shown by the large crosses (V-8 engines, axles). Major retooling and capacity dislocations occur at both auto manufacturer and supplier plants. Since materials remain essentially unchanged, there is little impact on material suppliers as represented by steel strip mills and rolling mills on the diagram.

1.2.3 Phase III: Major Materials Substitutions and Redesign

According to many experts, in order to truly achieve lightweight vehicles with exceptional fuel economy, the car of the

1980's will eventually require major material substitutions. Thus in Phase III, the focus will be on substituting lighterweight materials such as aluminum, plastic, composites, etc. for iron and steel throughout the entire vehicle. All parts of the vehicle will be candidates for material substitutions. This phase will require not only changes in technology but also changes in the "art of manufacturing." As a result, the costs in Phase III will be greater than in Phase II.

Changes to the Vehicle

As just mentioned, all parts of the vehicle are candidates for material substitution. Figure 7 shows some potential material substitutions in major chassis components. A key point to remember is the multiplier effect of weight changes in components. Changing the engine head and block from heavy cast iron to lighter aluminum will drop overall vehicle weight by more than the weight removed from the engine. A lighter engine allows for a lighter subframe and a lighter suspension system. If these components are then also made of new lightweight materials, the weight reduction effect can be substantial (theoretically).

Changes in material require capital to be invested at all points in the industry:

- o Material suppliers must invest in new alloys and material processing equipment to meet special "automotive" applications.
- o Component and vehicle manufacturers must develop and perfect techniques to use these materials and invest in new plants, equipment and tooling.

Material substitution is a revolutionary step in vehicle manufacturing involving many business risks.

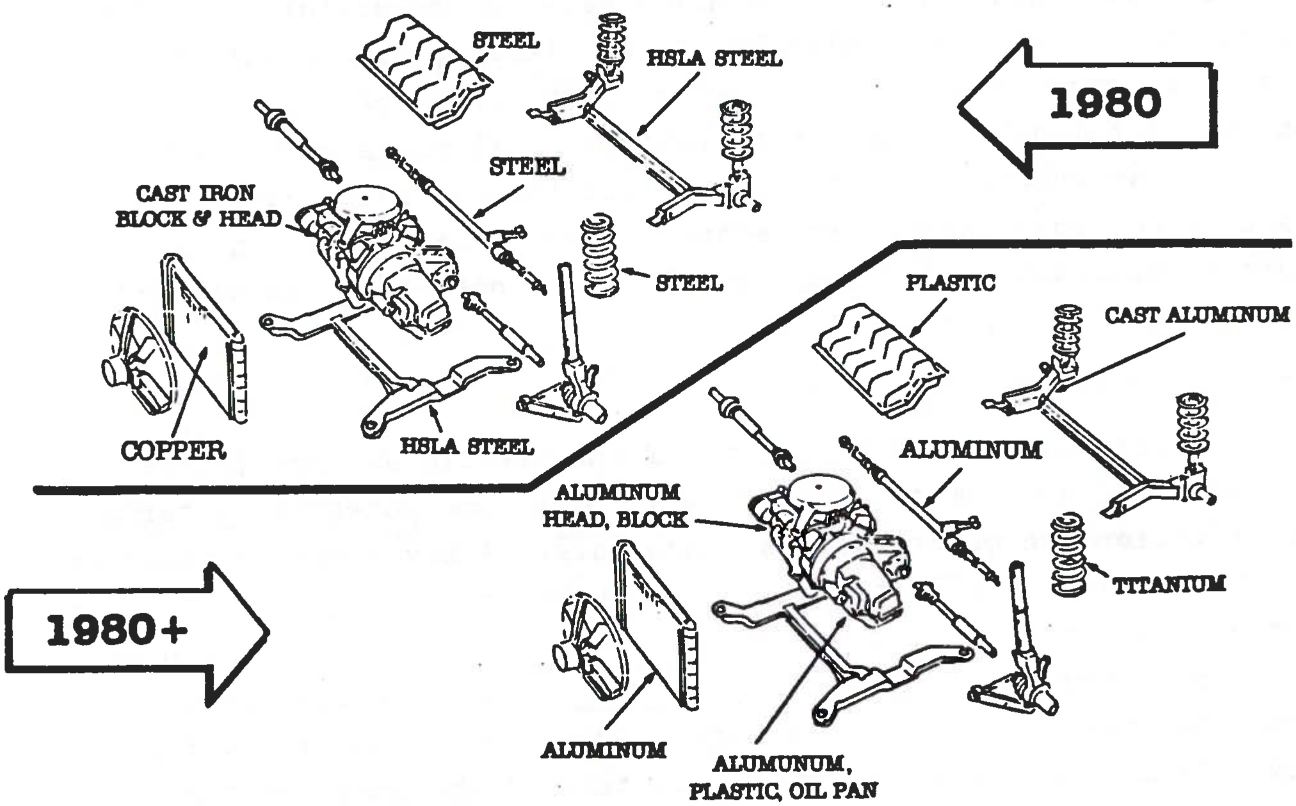


FIGURE 7. PHASE III CHANGES TO THE VEHICLE (CHASSIS)

Figure 8 illustrates major body parts which are candidates for material substitution. In an engineering design context, it is possible today to find two or three materials to replace stamped steel for almost any part. Material selection is a highly complex process of balancing weight, formability, corrosion resistance, strength, and a host of other factors involved in design with cost.

The years ahead will see new materials come and go in various applications as Detroit tests materials in various mass production body parts and as material supplies and prices fluctuate. Materials requiring large capital investments in specific facilities (plant, equipment, and tooling) will have to possess outstanding overall characteristics in order to become part of the future automobile.

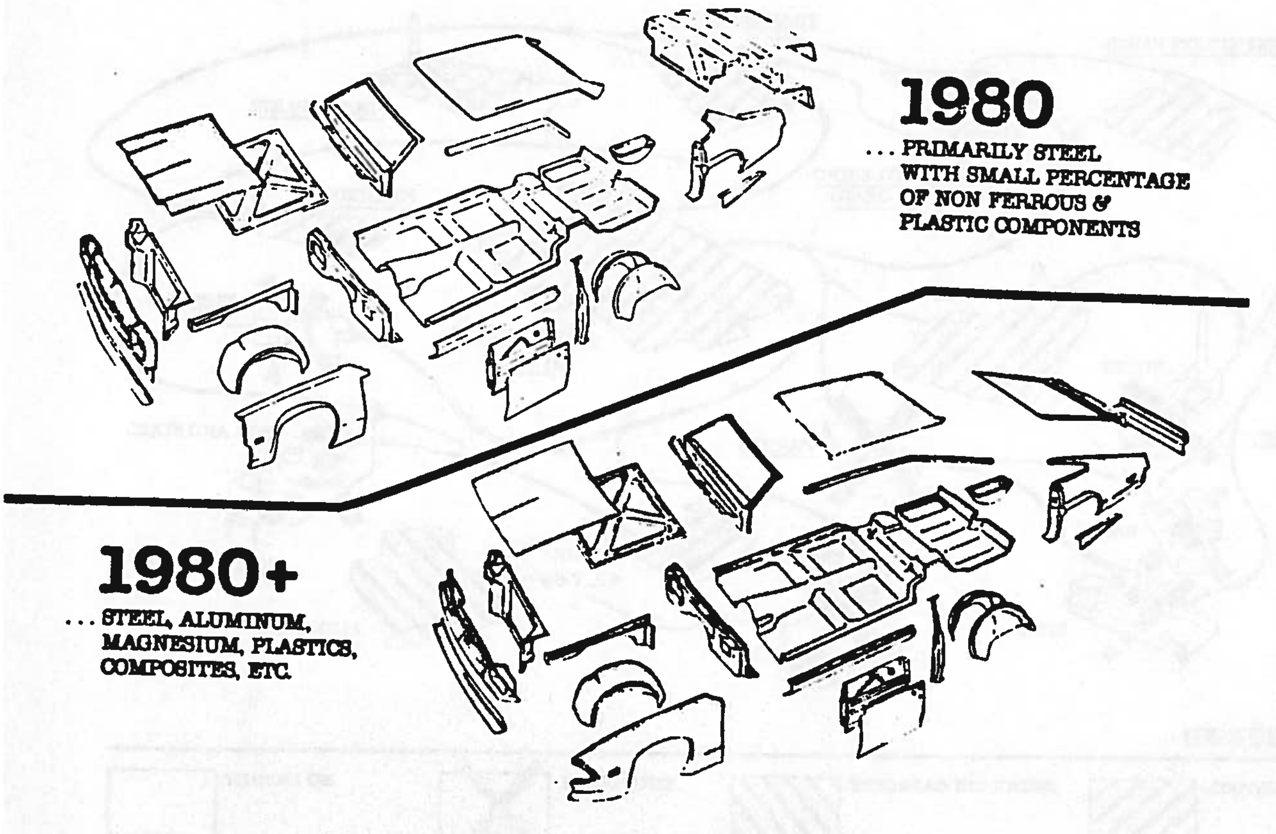


FIGURE 8. PHASE III CHANGES TO THE VEHICLE (BODY)

The top of the figure shows body parts in peripheral areas where materials substitution is now taking place. Design is not the inhibiting factor in material substitution. Manufacturing technology and capital investment costs are barriers which must be removed in order to usher in the new automotive materials revolution.

Impact on Facilities

Figure 9 outlines the major manufacturing impacts of the Phase III redesign effort. As shown in the figure, Phase III materials substitution and redesign impacts all manufacturing facilities. Many facilities, such as iron castings, will probably disappear. New facilities, such as certain types of plastic and composite material plants will appear. Material suppliers, machine tool suppliers, component suppliers, and all plants of the

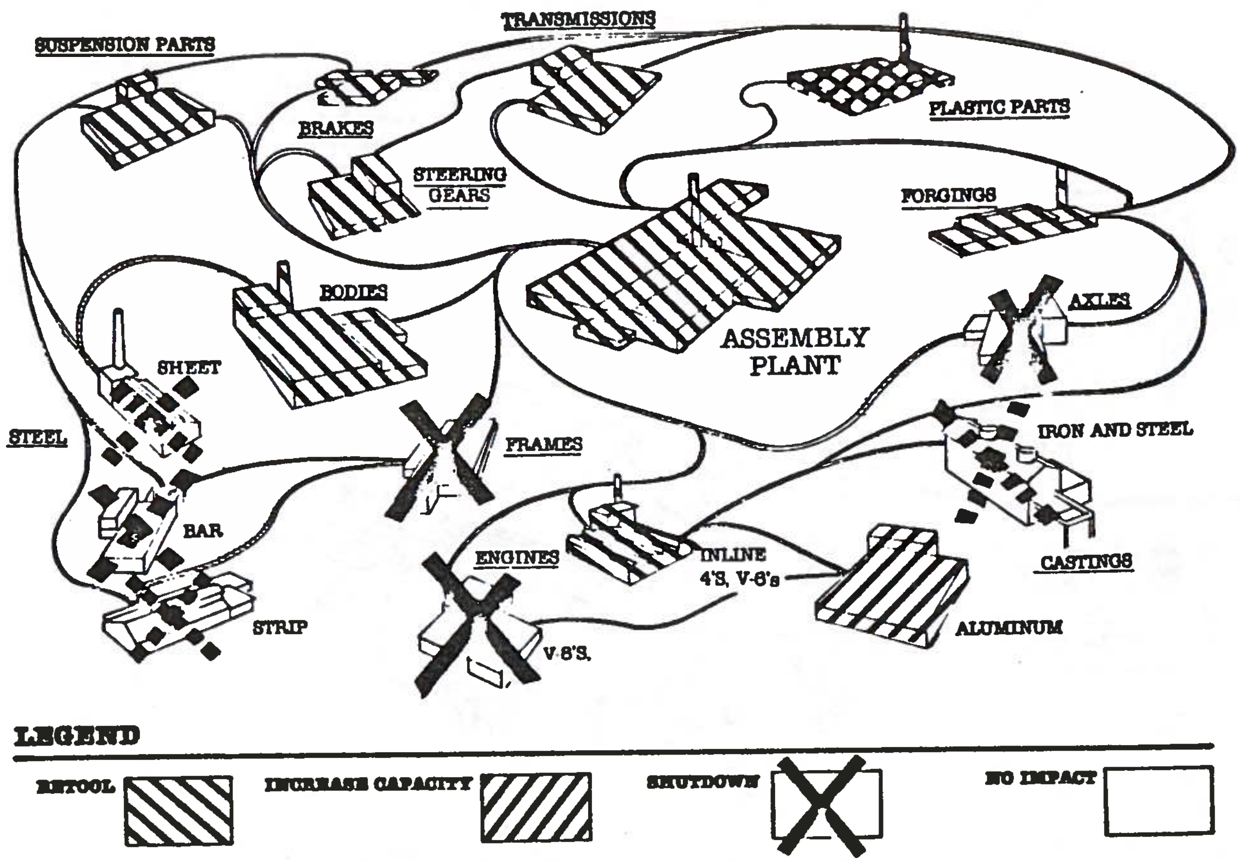


FIGURE 9. PHASE III IMPACTS ON FACILITIES

auto manufacturers will be affected. The revolutionary new car will result in massive capital needs and employment dislocations. Some of these could occur at a relatively rapid rate.

1.2.4 Phase IV: Develop and Implement New Technology

The fourth phase of auto redesign is the development and implementation of new technology. To realize 50 MPG fleets in the 1980's, new components processes, and materials must be developed and commercialized. This phase involves considerable lead times and risks, increasing uncertainty but creating potentially great benefits for the consumer.

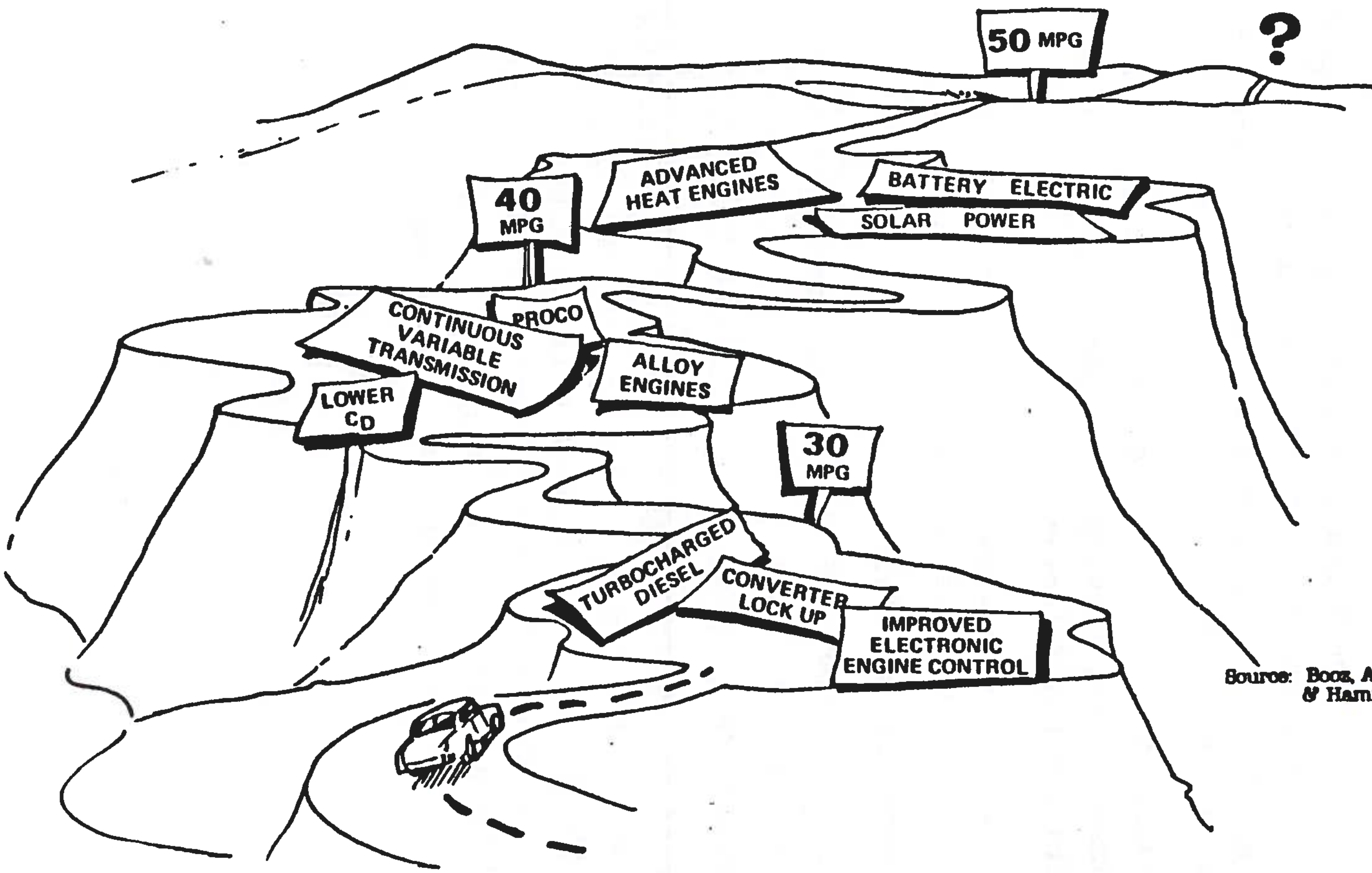
Changes to the Vehicle

As shown in Figure 10, the auto makers are considering many avenues to achieve the objective of greater fuel economy, and are spending millions of dollars on research and development. Among the new technologies being considered are:

- Advanced engine techniques such as programmed combustion, turbo charging, turbo compounding, stratified combustion, compression ignition, external combustion and rotary combustion
- Advanced transmissions such as continuously variable transmissions, flywheel transmission, and automatic overdrive transmissions
- Advanced fuel management including closed loop systems, multifuel capability and electronic fuel injection
- Advanced engine electronics
- Chassis and body refinements for improved aero-dynamics and weight reduction.

Impacts on Facilities

Because of the radical changes in vehicle design which will occur in Phase IV, the impact on facilities will be greatest during this phase. As shown in Figure 11, essentially every facility will be impacted, and new facilities will be required for advanced technologies. Investments will amount to billions of dollars, while lead times will be in the range of five or more years.



Source: Booz, Allen & Hamilton

FIGURE 10. PHASE IV CHANGES TO THE VEHICLE

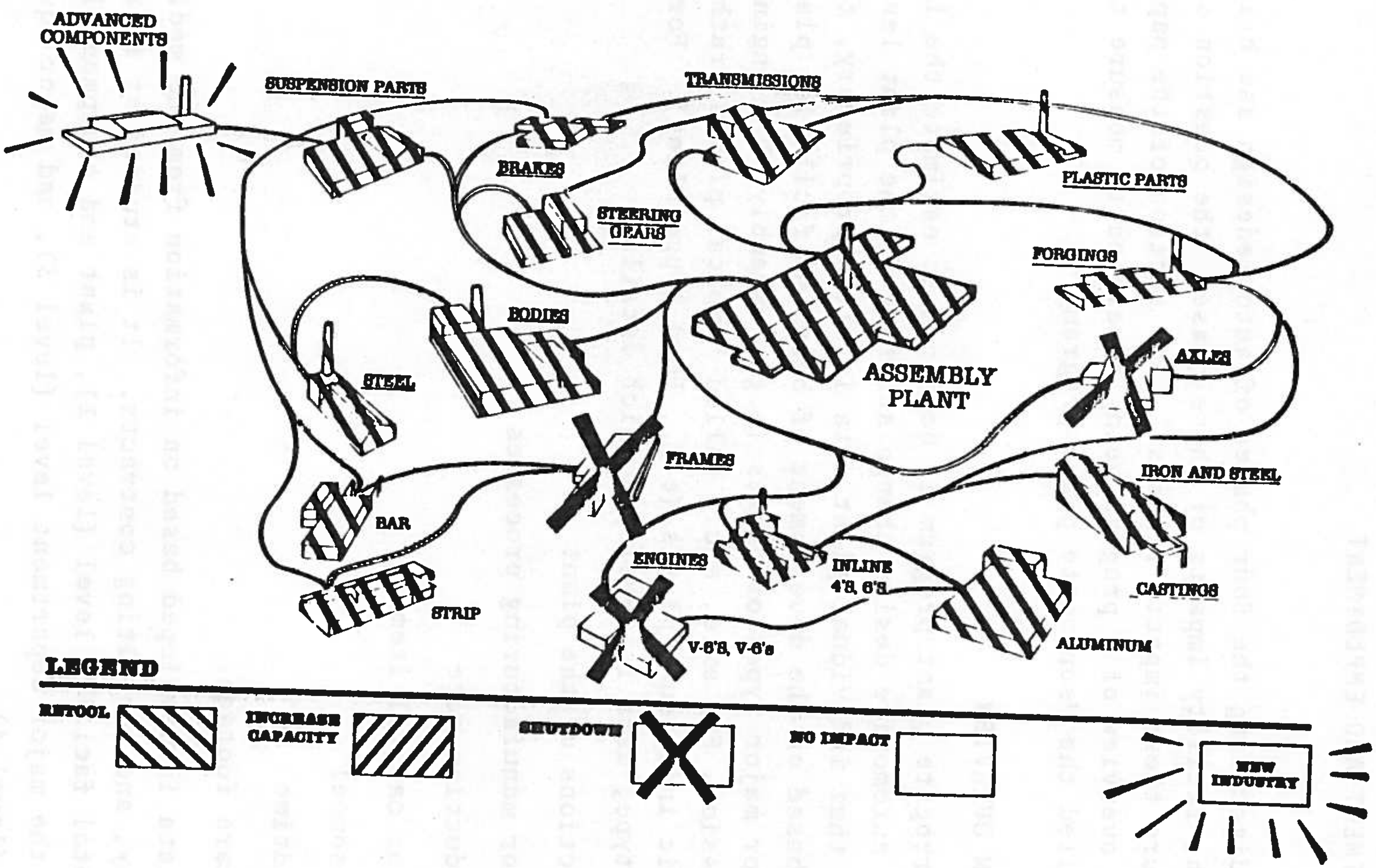


FIGURE 11. PHASE IV IMPACTS ON FACILITIES

2. PROGRAM FOR MEASURING THE IMPACT ON FACILITIES, CAPITAL INVESTMENT AND EMPLOYMENT

After discussing the four phases of auto redesign and briefly outlining the facility impacts of these phases, the question of how to measure these impacts remains. This section of the paper presents an overview of a program being developed to measure these impacts, called the "surrogate plant program."

2.1 PROGRAM OVERVIEW

The surrogate plant program is designed to estimate the impacts of an automotive design change starting at the plant level. Recognizing that individual plant data is often proprietary, the program is based on the development of baseline facilities planning data for major types of plants (e.g., assembly, V-6 engine, FWD transmission, FWD axle, etc.) called "typical plants" rather than specific individual plants (e.g., Ford Rouge Plant). For each plant type, data is developed which details:

- Functions of the plant
- Major manufacturing processes
- Production rate
- Major capital items
- Personnel
- Leadtime
- Square footage.

The above data is developed based on information from the media, the industry, and consulting contracts. It is studied at four levels: total facility level (level 1), plant and equipment level (level 2), the major department level (level 3), and major equipment level (level 4).

Using this data, combined with other data on the structure of the auto and supplier industry, the impacts of an automotive design change can be estimated as follows (see Figure 12):

- o First, the design change is assessed to determine the parts of the automobile affected.
- o Second, the parts affected are correlated with the plants or segments of the industry affected.
- o Third, the impact is measured at the appropriate level of detail in a "typical plant."
- o Finally, when typical plants are compared to actual plants and the impacts are summed across all plants of that type; the result is an accurate measurement of:
  - Capital investment, resultant facilities planning and regional employment impacts; (in total, by plant type, by specific plant and even by department within a plant).

To assist in the assessment of changes to auto and supplier ompany plant sites, this methodology categorizes auto and suplier facilities by the appropriate surrogate plant identification ode to enable the anticipation of which facilities may be impacted / changes in the parts and materials composition of the automobile. SC is currently compiling the plant locations of the major auto anufacturers and suppliers by the appropriate surrogate plant lentification, as shown in Figure 13. By using this approach, ocal economic development agencies, interested in determining e role of the auto sector in its industrial base, could identify cal companies and plants which may be affected by future auto dustry changes. An understanding of the manufacturing processes volved in the overall auto production system is the key element determining the role and future viability of small local firms .e., small tool and die shops, plating and machining shops, c.)

The following section is an overview of the auto industry in he U.S. and regional economy, and a discussion of the industry's rospects for change.

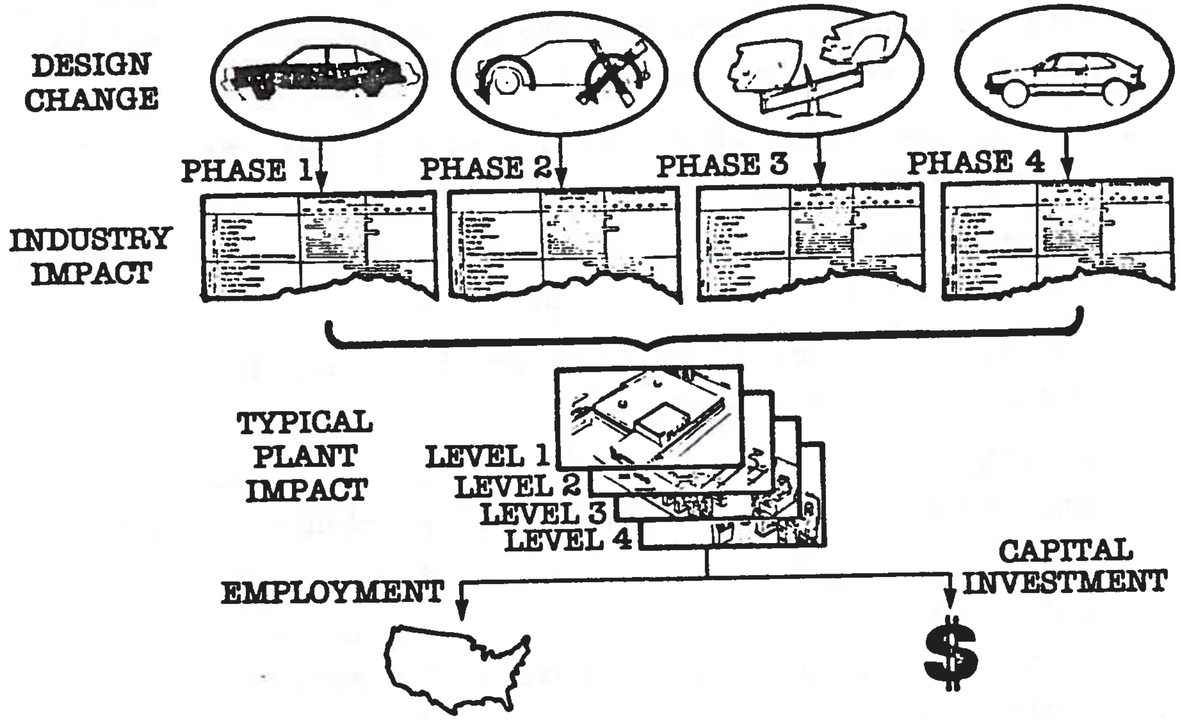


FIGURE 12. OVERALL PROGRAM FOR FACILITIES PLANNING/ CAPITAL COST/REGIONAL EMPLOYMENT ASSESSMENT

2.2 STRUCTURAL TRANSITIONS IN MOTOR VEHICLE AND RELATED EMPLOYMENT

2.2.1 Recent Employment History

The U.S. motor vehicle industry is the largest component of the manufacturing sector as measured by the U.S. Department of Commerce 1977 Census of Manufacturers. It accounts for 4.4 percent of all manufacturing employment and 8.2 percent of the value of shipments by all manufacturing industries. According to the most recent statistics compiled by the U.S. Department of Labor, Bureau of Labor Statistics, employment in the motor vehicle and parts sector reached a 20-year high of 982,000 in 1979, accounting for 4.7 percent of all manufacturing employment and 1.0 percent of all employment. Table 1 indicates that the sector's share of total employment and manufacturing employment has remained fairly constant over the last 10 years despite the highly cyclical nature of the industry.

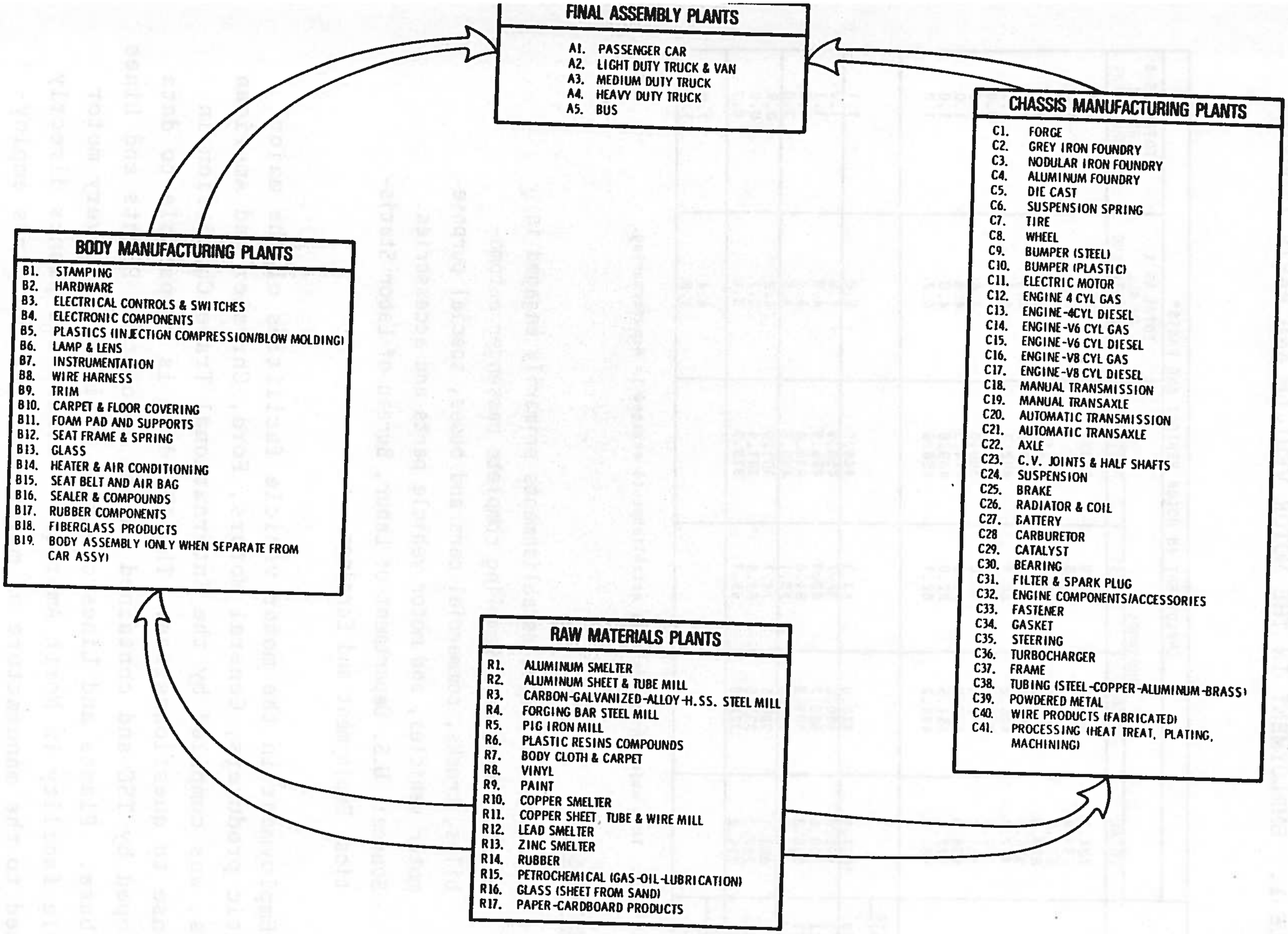


FIGURE 13. AUTOMOTIVE INDUSTRY SURROGATE PLANT IDENTIFICATION

TABLE 1. EMPLOYMENT IN THE MOTOR VEHICLE AND PARTS INDUSTRY

YEAR	EMPLOYMENT IN MOTOR VEHICLE AND PARTS*					
	THOUSANDS				TOTAL AS % OF ALL MANUFACTURING	TOTAL AS % OF ALL EMPLOYMENT
	TOTAL	AUTOS	TRUCKS	PARTS		
1960	724.1	361.2	30.9	313.0	4.3	1.1
1970	799.0	382.1	66.0	351.3	4.1	1.0
1971	848.5	420.2	67.7	361.3	4.6	1.1
1972	874.8	415.2	76.6	383.0	4.6	1.1
1973	976.5	461.6	85.0	429.9	4.9	1.2
1974	907.7	416.2	88.9	402.7	4.5	1.1
1975	792.4	375.3	64.7	352.5	4.3	0.9
1976	881.0	415.9	66.0	399.0	4.6	1.0
1977	938.0	439.8	73.9	424.3	4.8	1.0
1978	977.1	451.5	82.0	443.6	4.8	1.0
1979	982.8	444.2	82.1	456.5	4.7	1.0
1980						
YEAR QTR						
1978 IV	1031.9	475.0	83.3	466.9	5.0	1.1
1979 I	996.8	450.2	87.7	458.9	4.8	1.0
II	998.6	452.7	88.9	456.9	4.8	1.1
III	928.3	409.9	81.8	436.6	4.4	1.0
IV	936.2	426.6	79.1	430.5	4.5	1.0
1980 I	861.1	384.5	74.7	401.9	4.2	0.9
II	750.3	339.5	69.4	341.4	3.7	0.8
III	715.2	328.6	65.7	319.9	3.6	0.7
AVERAGE						
1960-76					4.4	1.0
1977-79					4.8	1.0

*By SIC Code. This major group includes establishments engaged in Manufacturing.

DEFINITIONS:

- Employment includes establishments primarily engaged in manufacturing or assembling complete passenger automobiles, trucks, commercial cars and buses, special purpose motor vehicles, and motor vehicle parts and accessories. Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings.

Employment in the motor vehicle facilities of the major domestic producers, General Motors, Ford, Chrysler and American Motors, was compiled by the International Trade Commission in response to questionnaires. The ITC data is comparable to data developed by TSC and contained in its automotive Plants and Lines data base. Plants and Lines contains a listing of every motor vehicle facility in North America -- almost 300 plants directly related to the manufacture of motor vehicles and parts employing over 950,000 production related workers. The figures in Table

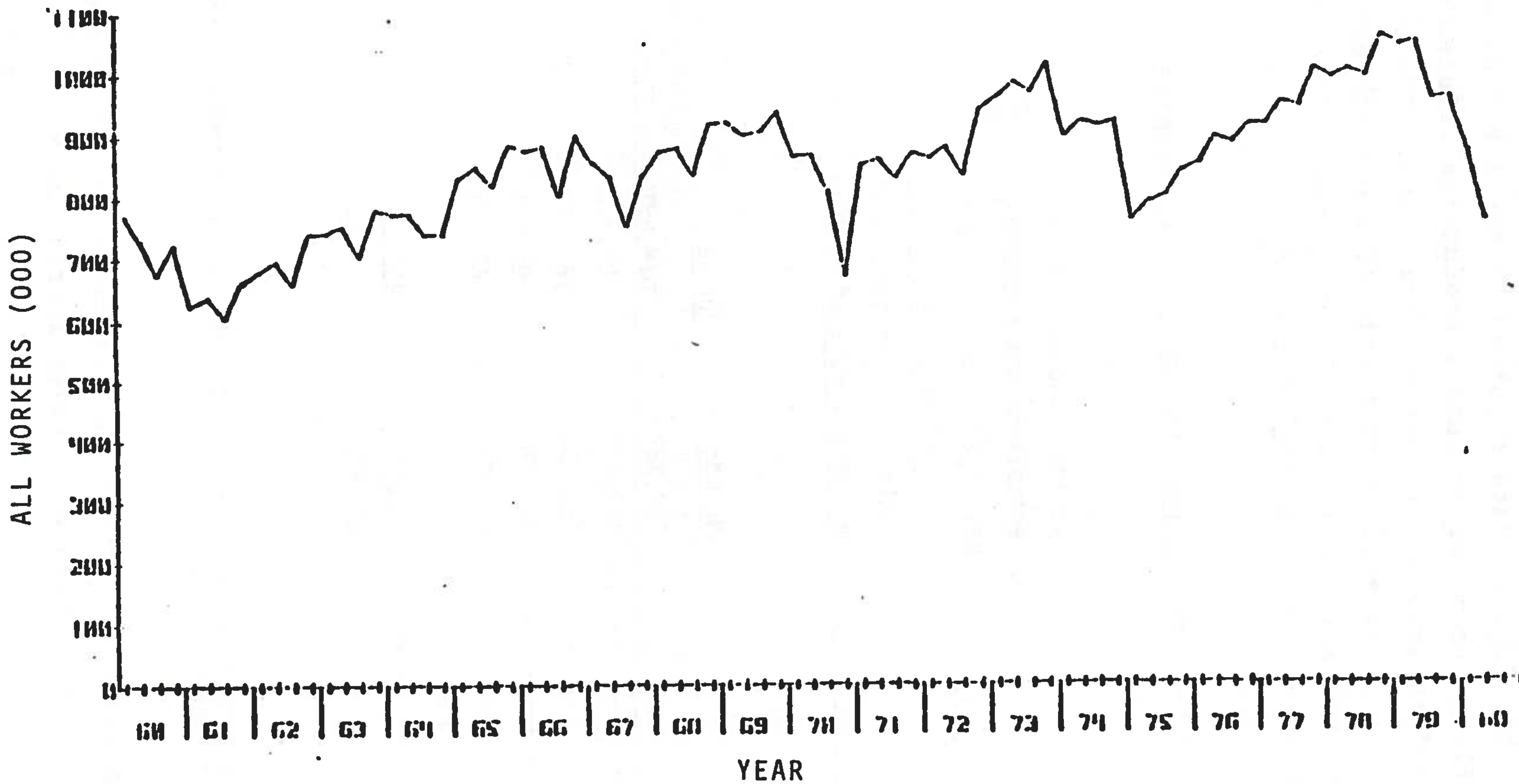
2 differ from the SIC code data compiled by the Labor Department since they reflect the major producers production related employment, hourly and salary, at production facilities. These figures more accurately reflect employment trends of the prime producers since they also reflect the non-SIC 371 employment of the manufacturers such as engine, stamping or electronics plants.

TABLE 2. AVERAGE EMPLOYMENT IN THE U.S. AUTOMOBILE INDUSTRY

Period	Average employment in U.S. establishments producing passenger automobiles and light trucks: All employees	Average employment in U.S. establishments producing passenger automobiles and light trucks: Production and related workers
	Number	Number
1975	793,381	614,691
1976	889,415	708,417
1977	953,304	761,428
1978	1,003,430	795,918
1979	971,929	766,003
January-June--		
1979	1,031,402	822,529
1980	803,873	612,650

SOURCE: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Periodic employment fluctuations are not uncommon in the motor vehicle industry. Figure 14 shows average quarterly employment from 1960 to mid-1980 based on U.S. Department of Labor data for motor vehicle and equipment manufacturers. The automotive



Source: Compiled from official statistics of the Department of Labor

FIGURE 14. AVERAGE NUMBER OF WORKERS EMPLOYED BY FIRMS MANUFACTURING MOTOR VEHICLES AND EQUIPMENT, QUARTERLY, 1960-1980

industry has been characterized by sporadic employment growth interrupted every two or three years by a sharp decline. Major employment declines have occurred in 1969-70 (27%), 1973-75 (25%) and 1979-80 (approximately 30%). While previous declines were primarily cyclical in nature (i.e. high interest rates and declining real GNP), the 1973-75 and 1979-80 periods were greatly impacted by external shocks resulting from questions concerning foreign oil availability. Employment dropped sharply over five quarters in 1974-1975 and then proceeded to steadily rise until 1979 when employment surpassed its previous 1973 peak. Over this period, consumers returned to historical patterns of buying large cars after a temporary shift to smaller vehicles. This resulted in increased production and the recall of workers. Thus, the 1973-75 downturn was cyclical in nature as oil supplies quickly returned to normal and the real price of gasoline stabilized and actually declined.

The most recent downturn is similar to the 1974-1975 period because there was an external shock to oil prices and availability followed by high interest rates and declining real GNP. Unlike the previous recession, the real price of gasoline continues to rise sharply, despite a brief slowdown, and foreign oil supplies continue to remain in jeopardy. The shift to smaller, more fuel-efficient vehicles has been more pronounced during this shock than during the last. Foreign manufacturers are enjoying record domestic sales while U.S. auto production has declined to a 20-year low. The impacts on labor, facilities, communities and suppliers have been more severe than in the past, and the future is quite unclear.

2.2.2 Current Auto and Supplier Dislocation

Unemployment in the motor vehicle sector as measured by the Department of Labor reached 25.9 percent in July 1980, and company layoffs (temporary and indefinite) peaked near the end of July at 313,500. Indefinite layoffs, which are more permanent in nature, reached 250,050 during the first week of August. This figure for indefinite layoffs was 44,700 higher than the highpoint reached in the previous 1974-1975 recession, and the 313,500 laid off workers represent over 40 percent of the companies domestic hourly automotive workforce. The company layoff figures shown in Table 3 reflect the highpoint in total indefinite layoffs over the last two years.

TABLE 3. LAYOFFS IN THE AUTOMOBILE INDUSTRY

Corporation	Total Hourly Workforce	Indefinite Lay-offs	Percent of Workforce
General Motors	471,000	137,000	29%
Ford	190,000	69,000	36%
Chrysler	101,500	41,300	41%
American Motors	16,000	2,750	17%
Total	778,500	250,050	32%

SOURCE: Ward's Automotive Reports, August 11, 1980.

Total indefinite layoffs declined for 14 straight weeks from August 4th to November 10th, 1980 as almost 68,000 workers were recalled for the new model year production runs. However, as of mid-November, indefinite layoffs had begun to edge up slightly in response to sluggish sales, and this trend continued through the end of 1980. Based upon a 1981 domestic production schedule of between 9.5 and 10 million units, approximately 150,000 workers could remain on indefinite layoff throughout the year. This production estimate may prove to be optimistic, which could result in a higher level of layoffs.

While high unemployment figures are a significant cause for alarm, they do not truly reflect the regional nature of the downturn nor the structural impacts of plant closings. Unemployment rates in states and metropolitan areas with significant levels of auto related employment have been consistently above the national average, as high as 20 percent in some areas. Table 4 lists the top five states and top ten metropolitan areas in terms of auto employment of the prime manufacturers. The five states listed

TABLE 4. AUTO RELATED EMPLOYMENT BY STATE AND AREA

STATES	Number of Plants	Auto Employment	Auto as % Manufacture	July 1980 Unemployment
Michigan	136	365,000	30	14.8%
Ohio	51	186,260	13	10.2%
Indiana	33	94,300	13	11.3%
New York	14	65,100	4	8.1%
Illinois	12	38,200	3	9.9%
METROPOLITAN AREAS				
Detroit	78	201,000	33	14.6%
Flint	16	60,800	69	22.2%
Buffalo	7	43,800	30	10.4%
Dayton	11	41,800	52	9.6%
Cleveland	9	35,900	13	9.2%
Ann Arbor	8	32,500	74	9.0%
Indianapolis	10	26,700	20	8.8%
Saginaw	11	24,400	65	16.8%
St. Louis	6	23,700	9	8.6%
Anderson	2	23,500	91	20.2%

represent approximately 80 percent and the ten metropolitan areas represent approximately 60 percent of total U.S. motor vehicle employment. The regional concentration of the motor vehicle industry in the Great Lakes states is one of the most dramatic elements of this and all previous auto-related recessions. The table clearly demonstrates the high correlation of high auto employment reflected in higher than average unemployment rates. Also, high unemployment costs the government a significant amount of money. The U.S. Department of Transportation, Transportation Systems Center has estimated that each unemployed auto worker costs the federal and state government almost $15,000 per year in lost tax revenue and transfer payments, while each supplier/worker represents approximately $8000 in federal outlays. In the 1980 fiscal year, a total of 462,207 auto workers received $1.2 bi[...] in Trade Readjustment Assistance, while, over the same time peri[...] many of the state unemployment insurance funds were depleted.

At the same time, a more permanent change has accompanied this most recent downturn than was the case in the previous cyclical recessions. Over the last 24 months, the domestic manufacturers have closed or announced the closing of over 20 facilities affecting over 50,000 workers. In some instances, these closings involve a permanent loss of jobs and a reduction in a community's economic base (i.e., Ford-Mahwah, New Jersey and Chrysler-Fostoria, Ohio). In other cases, the closing involved the transfer of productive assets from one location to another, (i.e., GM's moves in St. Louis, Missouri and Pontiac, Michigan). These closings reflect the permanent, more structural changes now taking place in the auto industry which, most likely, will result in future closings.

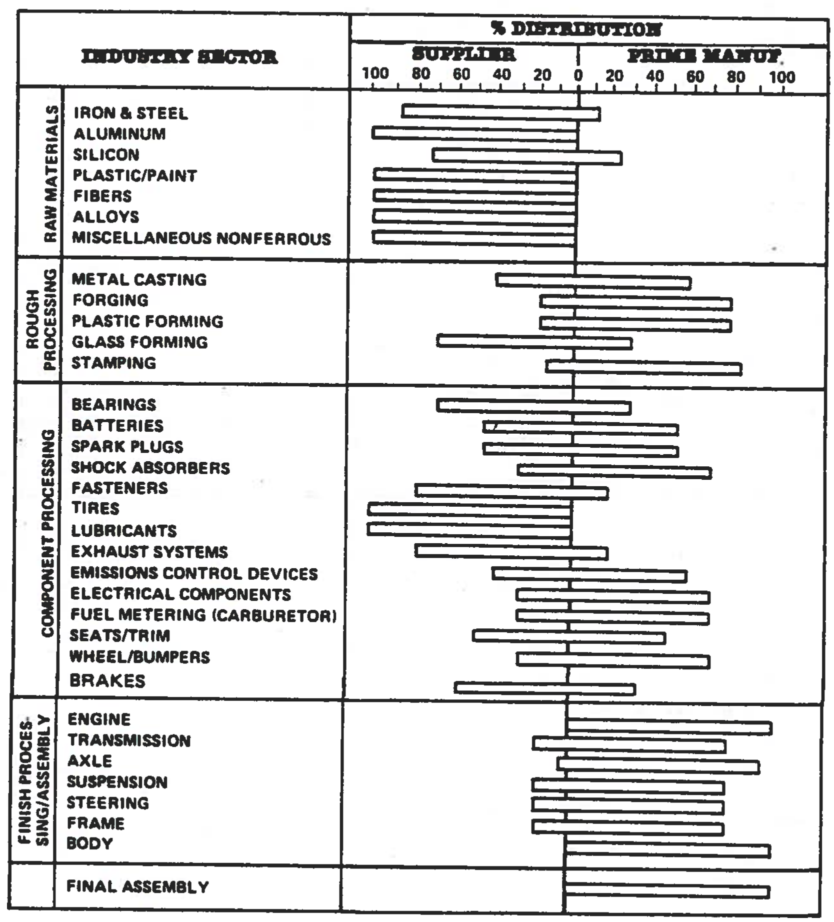
The downturn in production has not just affected employment and facilities in the auto sector. Motor vehicle manufacturers spent over $50 billion in the U.S. in 1979 for the purchase of goods and services, supporting in the range of 1,500,000 to 2,000,000 jobs in the supplier sector. These jobs are heavily concentrated in the geographic areas listed in Table 4. Auto company supplier expenditures and associated auto and supplier employment levels by state are shown in Table 5. An estimate of the number of workers affected by long term layoffs in 1980 is also given in the table. During the last two years, suppliers of materials, parts and componentry to the automotive industry have closed nearly 100 plants, eliminating over 80,000 workers. Estimates of unemployment in the supplier sectors as a result of the current downturn range from 350,000 as estimated by the Congressional Budget Office (July 1980) to a high of 650,000 as estimated by the AFL-CIO.

The link between the auto and supplier sectors is extremely strong. The automotive industry utilized approximately 22 percent of domestic steel production, 30 percent of ferrous castings, 20

TABLE 5. AUTO RELATED EMPLOYMENT IN THE PRIME MANUFACTURING STATES

	No. of Prime Auto Plants	Automotive Employment 1979	Number of Suppliers	Est. Supplier Expend. by Big Three 1979 (Billion)	Est. Supplier Employment 1979	Total Auto & Supplier Employment 1979	Total Employment as a % Total / % Mfg. Employment Jan. 1979	Est. No. Workers Affected by Layoff in 1980
Illinois	12	38,200	1,700	$5.6	168,000	206,200	4.3/16.2	120,000
Indiana	33	94,300	6,400	2.9	88,000	182,300	8.2/24.2	60,600
Michigan	136	365,000	26,400	21.4	650,000	1,015,000	28.1/84.7	310,000
Missouri	6	30,000	2,000	1.3	39,100	69,100	3.6/15.1	40,000
New Jersey	10	27,000	3,000	0.7	22,100	49,100	1.7/6.2	16,000
New York	14	65,100	7,000	4.3	131,000	196,100	2.8/13.4	65,000
Ohio	50	186,300	17,000	9.0	274,000	460,300	10.5/13.3	169,000
Pennsylvania	3	8,400	500	3.5	105,000	113,400	2.4/8.2	15,000
Wisconsin	10	22,000	2,500	1.2	36,000	58,000	3.1/10.2	6,000

Table Prepared by: U.S. Department of Transportation, Transportation Systems Center, Cambridge, MA percent of aluminum, 60 percent of synthetic rubber, 10 percent of glass, 10 percent of plastics and 20 percent of machine tools. Figure 15 shows a simplified diagram of the auto/supplier manufacturing infrastructure. Suppliers play significant roles in supplying raw materials and component processing, while the prime manufacturers are more dedicated to rough processing, finish processing



SOURCE: Facilities Planning and Capital Investment - G. Byron, TSC, August 1980.

FIGURE 15. AUTO/SUPPLIER MANUFACTURING INFRA STRUCTURE

and assembly. As in the case in the motor vehicle industry, the supplier industries are also heavily concentrated in the Great Lakes states. The nine states listed in Table 5 account for almost 90 percent of all purchases made by auto producers in the U.S. Also, many small communities in the Eastern half of the U.S. are largely supported by small supplier operations, which are not readily identified with the auto industry.

Many attempts have been made at quantifying the direct link between auto employment and/or production and supplier employment. The Department of Labor performed an analysis for the Congressional Budget Office's July 1980 report. This analysis concluded that for every 100 jobs in the auto industry, there are 105 jobs in the supplier sectors. Other studies indicate that every 250,000 units of production require approximately 21,000 labor years in the motor vehicle sector and about 44,000 labor years in the related supplier sector. Other multiplier studies estimate that for every auto worker there are between 1.4 and 2.0 associated supplier workers, depending upon the level of integration of the auto manufacturer. Recent analysis conducted at TSC utilizing the Automotive Industry Surrogate Plant program referenced in the previous section, indicates that for the production of every three million units of automobiles, approximately 600,000 jobs are generated in the auto and direct supplier industries. A summary of the number of plants required and associated employment levels is given in Table 6. Since auto production declined from 9.2 million units in 1978 to 6.6 million units in 1980, TSC estimates a decline of approximately 520,000 jobs in the auto and supplier sectors, utilizing the surrogate plant approach for employment estimation. The next section of this paper will focus on several of the forces which are impacting the industry which will assist in the determination of the prospects for recall of these workers, or which may lead to further auto and supplier worker layoffs.

TABLE 6. SUMMARY OF AUTO AND SUPPLIER PLANTS AND ASSOCIATED EMPLOYMENT LEVELS

Plant Type/Function	Number of Plants	Employment
Final Assembly	12	52,000
Body Manufacturing	43	68,000
Chassis Manufacturing	55	140,000
Raw Material Producers	19	50,000
Subtotal	129	310,000
Transportation		75,000
Plant Support		50,000
Machine Tools and Equipment, Perishable Tools		165,000
Subtotal		290,000
TOTAL		600,000

2.3 FUTURE INDUSTRY PROSPECTS

The next five to ten years will be a period of significant transition and upheaval for many of the domestic motor vehicle related communities and workers. Auto manufacturers are being forced to restructure their entire operations as they are thrust from an isolated North American market into the new realities of world competition and economic market forces. As the domestic producers plan for the new products of the future, they are being forced to evaluate all the traditional investment factors of the past -- land, labor, capital, innovation -- more closely than ever before to remove cost from the manufacturing system. Past relationships between industry, labor and all levels of government will continue to be affected as each group deals with the new realities of the marketplace while attempting to best represent their constituencies.

There are five primary areas of concern for the communities and workers which, while neither mutually exclusive nor all inclusive of the host of factors impacting the industry, can be considered as critically important to their future welfare over the next five years.

First, the on-going consolidation of the domestic manufacturing infrastructure, both auto and suppliers, coupled with the accelerating trend toward the world car with its dependency on an international parts sourcing network, will most likely result in dislocations of labor and facilities in some regions. Plant closings by the prime manufacturers in the auto and supplier sectors over the past 24 months have already resulted in serious dislocations in many of the older urban areas of the Great Lakes states, while new construction and expansion has continued in ex-urban areas, the southern states and outside U.S. borders. While it is true that emerging world-wide parts sourcing patterns will lead to new investment opportunities in the U.S. by foreign and domestic suppliers, it has become apparent that most foreign investors will demand greenfield locations away from the older industrial centers. These are likely to be suburban or southern locations (Honda, GKN, Michelin, Nissan). Chrysler's transition to front-wheel drive vehicles has already resulted in plant closings in Detroit, St. Louis, and Windsor, Ontario. Further plant closings are anticipated, with Detroit suffering the greatest number of closings. Ford, with excess large car and truck capacity, has announced the closing of several assembly operations, and future closings of assembly and stamping plants are likely. The future of Ford's Detroit casting and Cleveland engine plants is still very uncertain, as Ford scrambles to reduce its V-8 engine capacity and source four cylinder engines in Mexico and Japan. General Motors, while making major new investments in plant and facilities in the U.S., has been forced to close several older obsolete assembly operations in urban centers such as Detroit, St. Louis and Pontiac, Michigan. GM has replaced these plants with new greenfield operations in ex-urban areas, although they are currently negotiating for a site in the

Detroit area. At the same time, GM has announced major new sourcing arrangements on an international scale which will have further impacts on domestic employment opportunities.

A second area of concern for workers and communities is the demand being made upon the domestic producers to increase their productivity or manufacturing efficiency in order to compete with lower cost producers in other nations. Production cost advantages enjoyed by Japanese producers will have a significant impact on the ability of the domestic producers to compete for market share in the small car market. Domestic producers must utilize more efficiently all factors of the production process -- management techniques, inventory control, labor content, transportation systems, and supplier relationships -- while producing a high quality, cost-competitive vehicle.

Three major changes aimed at increasing productivity are of particular concern. First, as the manufacturers modernize and retool all of their facilities, efficiencies in labor utilization will be realized. For example, in the past, assembly plants assembled cars at the rate of 45-60 units per hour with an average plant employing approximately 5,400 workers. More modern plants producing the smaller cars of the future have line speeds of 70-75 units per hour requiring only 4500 workers. As a result of these changes, a product with a production volume of two million units would require three fewer assembly plants and 23,000 fewer workers. Efficiency gains such as this throughout the production base of the auto and supplier industries will result in a more efficient industrial base. However, the potential of plant dislocations may create hardships for certain communities and their workers.

A second aspect of productivity which will greatly impact labor utilization in the future is the increased use of robotics and other mechanically controlled labor saving equipment. The automakers are quickly moving into an era of versatile transfer lines with programmable work stations, more automated parts transfer and greater inspection capabilities. There are two schools of thought concerning the impact of increased robot utilization on the automotive workforce. Spokesmen for the auto producers and robot producers predict that increased utilization of programmable equipment will not have a significant impact on production line employment. They suggest that job displacements will occur primarily in the mundane, unhealthy simplistic tasks while creating job opportunities for inspectors and repair workers. Other industry analysts have estimated that over 100,000 production line jobs could be eliminated over the next 10 years as a result of increased work mechanization. The exact net employment impact is uncertain. What is certain is the industry's requirement to attain greater levels of productivity via more efficient utilization of all the production inputs.

A third area of importance is where the industry can increase its productivity to improve management control over in-process inventory and transportation costs. The ability of the domestic industry to reduce the increasing costs of carrying stockpiles of production parts and materials at the plants, as well as to reduce the costs of shipping parts across the U.S. from one plant to the next, will have a significant impact on its potential for competing against lower cost producers around the world. The adoption of the "just-in-time" production technique, which involves the daily delivery of parts from a geographically concentrated network of suppliers, will be a major step forward in increasing overall productivity and reducing manufacturing costs. This management technique would tend to favor suppliers, and thus workers and communities, in the industrial Midwest.

A third facet of the structural change now taking place in the industry is an increased reliance on an international network of suppliers and OEM facilities. The rapid transition to a "world-car" with a greater commonality of parts and componentry among car lines built throughout the world along with local content laws imposed by many of the developing nations has resulted in changes in traditional sourcing patterns which may result in labor and plant dislocations. All domestic producers are sourcing major parts and components from foreign suppliers for a variety of economic and political reasons. Local content laws, lower factor input costs and attractive investment climates have led to a rapid expansion of engine and assembly capacity in Mexico and South America by domestic producers. Lack of four cylinder engine capacity in the U.S. has resulted in foreign sourcing of engines by all the producers as well as the sourcing of many of the new parts and components for the new front-wheel drive cars of GM, Ford, and Chrysler. A continuation of these trends may result in a decrease in the employment base of the motor vehicle and supplier industries in the U.S. and further exacerbate pressures on labor and communities. As a result of this trend, many of the smaller supplier companies, which have supported the auto industry in the past, have been forced to permanently close operations, which has led to the erosion of our domestic manufacturing base. If domestic production returns to historic levels, many of these firms will not be available to support the auto manufacturing process.

The fourth area of concern is the level of future import market share. In 1980, importers captured a 26.7 percent share of the domestic market versus last year's 21.9 percent share. A 26.7 percent market share translates into 2.4 million units of non-U.S. produced vehicles. Based on production/employment factors generated by TSC, 2.4 million units of production translates into 450,000 auto and related supplier jobs in the U.S. The level of import penetration of the domestic market in the future will be a significant factor in the level of domestic auto employment sustained over time.

The final area of concern which will impact communities and workers is the on-going change in the vehicle which was outlined in the first section of the paper. The requirement to reduce the weight of the vehicle and adopt new technologies have already resulted in plant closings and permanent job losses in the auto and supplier sectors. Twenty iron foundries and two V-8 engine plants were closed during the past year resulting in the loss of over

20,000 jobs. Material shifts away from carbon steel and iron to aluminum, plastic and high strength steels could result in further plant and community dislocations. The transition from rear-wheel drive configurations to front-wheel drive has impacted axle, frame, and final assembly plants in the Midwest. Smaller engines use less iron, piston rings, bearings, spark plugs, etc. At the same time, as was mentioned in the first section of this paper, there are many new parts, materials and components which will be utilized in the vehicle of the future which are not currently being produced in large volumes in the U.S. today. These new products are prime candidates for future plant expansions or locations. All these trends have implications for the future utilization of many auto-related facilities in the Midwest and and, thus, workers and communities. Figure 16 demonstrates the recent trend in plant closings and openings over the past five years.

The precise quantification of future employment levels in the auto and supplier sectors over the next ten years is a difficult task. The forces impacting the industry can be quantified and demonstrated at certain points in time, given an agreed upon scenario of domestic production levels. However, the dynamics of the marketplace, industry decision making, economic fluctuation and even the forces outlined in this section make exact employment forecasts almost impossible. However, given our understanding of the industry and the forces impacting it, and our ability to estimate past, current and future employment levels, we forsee the elimination of over 500,000 jobs in the next 10 years from an auto and supplier base of over 3 million workers in 1979.

2.4 FUTURE ISSUES

Economic dislocations from plant closings, future declines in employment due to increased productivity, increases in import penetration, and shifting of corporate investments to suburban and international locations raise a host of issues for communities, workers, and levels of government. Because the automotive

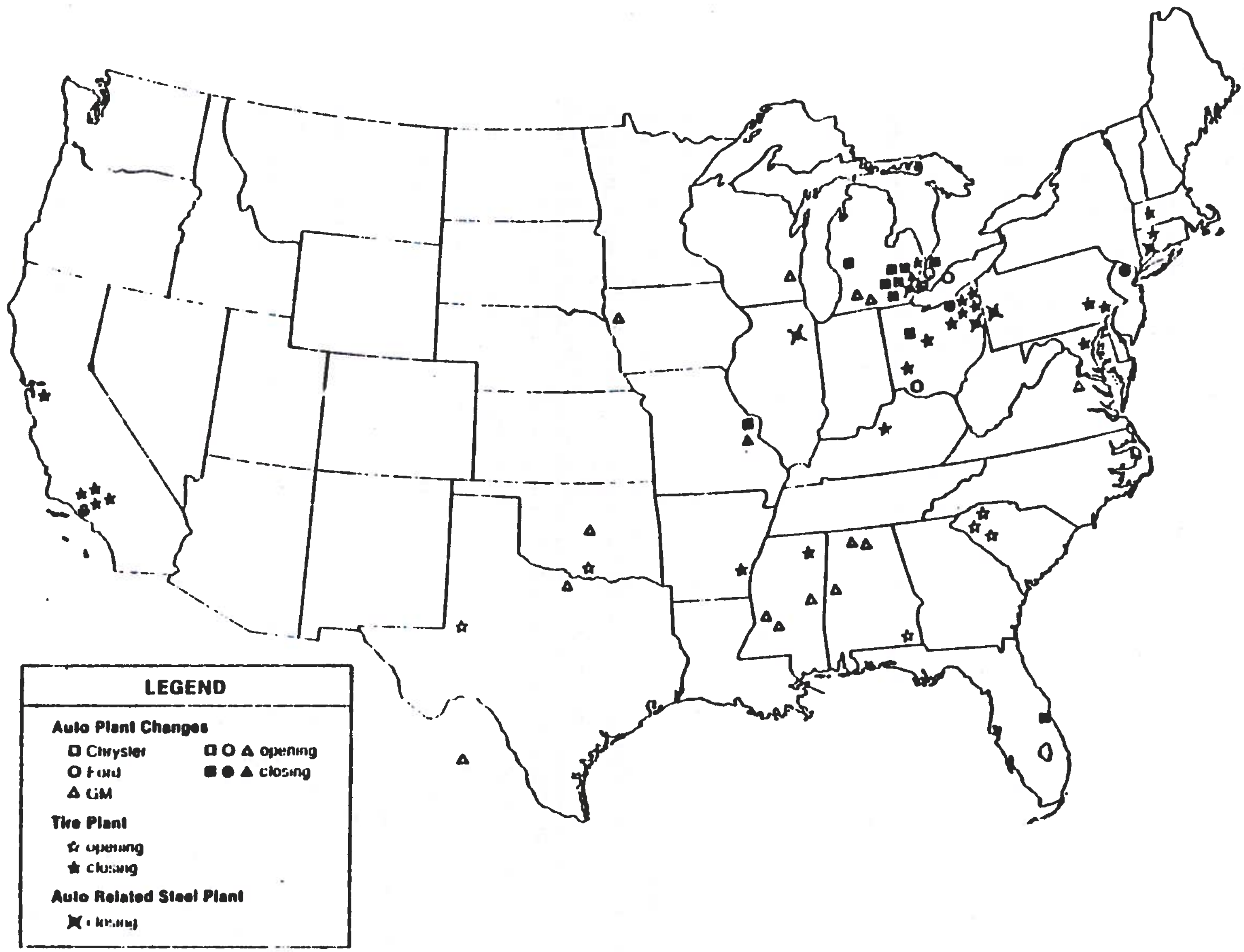


FIGURE 16. AUTO, STEEL, AND TIRE PLANT CHANGES 1975-1980

industry and its supplier sectors are so important to the U.S. economy, and are concentrated largely in the older industrial belt, the effects of corporate decisions and market forces will assume a more significant place in public debate than has occurred in the past.

While a wide range of issues emerges from these societal transformations, three major areas of concern can be identified that have the potential to raise fundamental questions about public policy, corporate responsibility, and economic development: 1) cities, 2) employment, and 3) the role of government.

1) Cities

Issues of dependency and regeneration are particularly important for older industrial cities such as Detroit and St. Louis. Dependent upon automotive and supplier industries for revenues and employment, cities such as these are placed in a double bind when their older plants close or relocate. Mayor Jim Conway of St. Louis characterizes the situation as a "plant closing treadmill". Forced to compete on a regional, and sometimes international level for new businesses by offering land sites, tax abatements, bond issues for public works, and other inducements, these cities are at a disadvantage because of dwindling revenues, an outmigration of skilled labor, a declining infrastructure, a lack of large industrial sites, and imperfect knowledge of the economic forces impacting its economic base. These factors contribute to the city's inability to compete for new private investment or adequately address issues of decline. In addition, increased dependency upon Federal funding places city governments in competitive positions for funds from the few programs that offer relief through guaranteed loans and planning grants. It is likely that the fiscal limits of these programs will soon be reached, raising further issues concerning the need for Federal investment in urban redevelopment. This may result in a thorough reorganization of present urban policy, possibly including closer business/community cooperation to aid in planning transitions or programs.

2) Employment

Employment issues center primarily around retraining and reemployment of a workforce that must make the transition from the automotive to other sectors. Income maintenance programs such as Unemployment Insurance (UI), Supplemental Unemployment Benefits (SUB), and Trade Readjustment Assistance (TRA) are designed to deal with dislocations which are cyclical and temporary in nature. Funding for these programs, whether from state, corporate, or Federal sources, is inadequate for dealing with structural unemployment. Recent depletions of TRA funds, SUB funds, and increased state borrowing to maintain UI funds point to these inadequacies. Income maintenance programs, while necessary, should not preclude a broader assessment of the factors contributing to job loss.

Current retaining programs such as CETA and TRA are either targeted to a special population or underfunded; both aspects make them ill equipped to handle the transition that auto and supplier workers must make. Before retraining programs can work well, several important questions must be answered. First, what are the disincentives which keep workers from transfering to another part of the country? (Age, loss of seniority, inability to sell homes, loss of pensions, may be some of the factors.) Second, should a retraining policy focus upon merely providing some employment regardless of the wage rate, or should it focus on developing employment in other manufacturing sectors in order to maintain wage levels? These questions must be addressed at the local level because of the unique nature of different urban and rural economics and societal characteristics.

3) The Role of Government

A third issue is one of the role of government as it reacts to the concerns of workers and communities which have been highlighted in the previous sections. This issue involves questions about the ability of all levels of government (as well as other affected parties) to work cooperatively to identify local, regional, and national problems and to structure comprehensive solutions. The inadequacies of social institutions such as corporations, unions, and government agencies to distinguish the effects of structural versus cyclical industrial change is apparent in the current response to the impending regional employment crisis. For example, government programs are geared toward coping with temporary dislocation problems such as short-term unemployment. They do not have the capacity to deal with permanent changes, such as the extended lead time necessary for facility rehabilitation and reuse in a timely and effective manner. Effective policies should anticipate, rather than react to, the effects of major industrial reorganization, such as the current changes occurring in the automotive industry. Detailed analysis of the impending changes in these sectors could be used to identify permanent employment loss, specific plant closings and relocations, and resultant implications for communities.

A fundamental question which must eventually be addressed is: How case-specific information on potential industrial dislocations or growth can best be disseminated and utilized in order to allow communities to formulate equitable and effective adjustment strategies.

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