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16. Abstract

AIM '85 reports on the fiscal year 1985 findings of the Auto-In-Michigan Project, established by Michigan state government to explore likely developments in the automotive sector in Michigan in the 1985-92 period and to recommend public policies to address those developments. AIM '85 identifies approximately 30 developments which, according to the nearly 100 respondents to portions of the Project's 200-question survey, will have significant impact on automotive establishments in the state. These include possible assembly and axle plant closings due to the phase-out of most rear-drive cars; the shift toward far greater use of aluminum in major engine and drive-train castings; the emerging dominance of electrogalvanized steel in outer body skins; increasing plans for space frame/plastic panel light vehicles; decreasing OEM vertical integration and the emergence of a supply chain tiered under firms delivering finished modules or subassemblies; new trends in collective bargaining over investment and job security; and the effects of flexible automation on minimum efficient volumes and the resulting siting possibilities for new engine, transmission, and body panel operations. Twenty recommendations for State action are presented.

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AIM '85

The Auto-In-Michigan Project

1985 Report

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October, 1985

1985 REPORT
AUTO-IN-MICHIGAN PROJECT

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ACKNOWLEDGEMENTS

The AIM Project has been, from the beginning, an experiment. The proponent and the sponsors in State government wished to assemble a team that could probe the future of the auto industry in Michigan. I hoped this effort might inform the State's relations with the industry, especially on the economic development front. During the past year, this experimental probe has matured into an exceptional partnership between the public and private sectors. As the participants in the AIM Project offer the findings and recommendations in this 1985 Report, I wish to acknowledge, on their behalf, the many organizations and individuals that have aided our work, and to note the contributions of each member of the AIM Project team.

Our most important debt is to the AIM Advisory Board. This body of leaders from all segments of Michigan's automotive industry has been generous with their time and counsel. Each of them gave an exceptionally frank interview to the Project and provided access to key members of their organizations. Through the Advisory Board, we also thank the scores of experts in the industry who have given us interviews over the past months.

The AIM Project would not have been possible without the commitment of Ralph Gerson and Doug Ross, the former and present Directors of the Michigan Department of Commerce. They have understood AIM as a worthy public investment. Special appreciation is offered to Deputy Director Lou Glazer, for reasons he will understand. Peter Plastrik, Executive Director of the Governor's Cabinet Council, has been a tolerant host of AIM's Lansing operations and has given its Director sage counsel from the beginning.

The ambitious database development work conducted within the AIM Project would have been impossible without the extraordinary contribution of fourteen local economic development agencies that administered and processed our initial survey of automotive establishments. The dedication of their leaders and staff was exceptional. We are also indebted to the Board of the Independent Business Research Office of Michigan (IBROM) and to IBROM's Director, Sue Wolfram, for a generous grant that greatly facilitated AIM Project survey work with the local agencies.

The Industrial Technology Institute has offered consistent support to the Project. Dr. Lou Tornatzky, Director of ITI's Center for Social and Economic Issues, made Drs. Flynn and Luria available to the Project pro bono, and offered his own counsel at several crucial junctures.

The core of the AIM Project has been the work of our Central Research Team: Dr. David Cole, Director of the Office for the Study of Automotive Transportation, University of Michigan; Drs. Michael Flynn and Daniel Luria of the Industrial Technology Institute; Donald Smith, Director of the Industrial Development Division, University of Michigan; and Richard Hervey, President of Sigma Associates. These five individuals represent, collectively, over a century of experience in analysis of the auto industry. Each of them gave many more hours to the AIM project than their modest compensation required. Their generous commitment to our work is the foundation of whatever is excellent in the pages that follow.

The work of the Central Research Team was inherently collective. The individual chapters of this Report do, however, have principal authors. The chapters on the "Siting of Vehicle Programs" and "Input Sourcing" are by Daniel Luria, who is also the principal author of "Labor Relations." Michael Flynn wrote the chapter on "Manufacturer-Supplier Relations." David Cole contributed the chapter on "Emerging Product Developments." Richard Hervey, with research assistance from Donald Smith, is the author of "Automotive Materials." Donald Smith wrote the body of "Production Technologies"; I contributed the introductory section of that chapter. Alan Baum was the principal author of "AIM Database Development." "The Contribution of LEDAs" was written by J. Downs Herold.

The Preface and Executive Summary were coauthored by Daniel Luria and myself.

The AIM Project might have foundered in logistical problems; every week for months some aspect of AIM work was conducted at no less that nineteen different locations throughout Michigan. AIM remained coherent because a dedicated staff invested long hours in pushing the Project forward and solving problems before they disrupted research or were compounded by the Director.

David Andrea was an invaluable administrator, and more. His thoughtful and precise interview summaries contributed substantially to the analysis embodied in our Report. Downs Herold provided essential coordination between AIM and the participating local agencies, and served as an effective advocate for their interests. My colleague Alan Baum has devoted most of the past half-year to leadership of AIM's database development efforts. His work, assisted by Mark Everett and Lauren Hammett, constitutes the most detailed description yet achieved of auto in Michigan. During the most intense period of AIM interviews, we were joined by Jerry Jurek, whose wisdom and long experience as a manufacturing manager in the industry were a catalytic tonic.

Throughout this first year of the Project, and in the demanding weeks of preparing the text of this Report, Lisa Hart and Susan Postema of the Office for the Study of Automotive Transportation have contributed a resolute commitment to precision. From the very beginning of the AIM effort, Sharon Woollard, my colleague at the Department of Commerce, has taken on the often vexing task of managing the Project contract; her diligence has shielded others from the burdens of bureaucratic conformance; her thoughtful participation in AIM meetings has been stimulating.

Finally, I wish to acknowledge the singular contribution that Daniel Luria has made to the first year of the AIM Project. His hand has touched many sections of this Report. His commitment to analytical precision has been the conscience of the Project. I am able to pass the duties of Director to him with complete confidence.

Those acknowledged above have worked together to make the AIM Project a success. The limitations imposed on their best efforts by the original design and initial direction of the Project must be my responsibility.

Jack Russell

AIM CENTRAL RESEARCH TEAM

Dr. Jack Russell served as director of the Auto-In-Michigan Project in fiscal year 1985. He is the Director of the new Michigan Technology Deployment Service, Michigan Department of Commerce.

Dr. David E. Cole serves as the director of the Office for the Study of Automotive Transportation (OSAT) at the University of Michigan Transportation Research Institute. OSAT sponsors a variety of activities including annual automotive management seminars and detailed industry forecasts. Dr. Cole is also a professor of mechanical engineering.

Dr. Michael S. Flynn is a researcher with the Center for Social and Economic Issues at the Industrial Technology Institute. Before joining ITI in 1984, Dr. Flynn did extensive research with the Joint U.S.-Japan Auto Study on manufacturer-supplier relationships and on relative auto production costs.

Richard P. Hervey is the president of Sigma Associates. Sigma Associates is a consulting firm specializing in strategic and tactical planning, technology and market assessment, and market development for small- and medium-sized clients in automotive and related industries.

Dr. Daniel Luria, senior researcher in the Center for Social and Economic Issues of the Industrial Technology Institute, serves as AIM coordinator in fiscal year 1986. Prior to joining ITI in 1984, he spent eight years as a research associate and chief automotive analyst for the UAW Research Department in Detroit.

Donald N. Smith serves as the director of the Industrial Development Division of the Institute of Science and Technology at the University of Michigan. IDD serves as the central contact at the University through which industrial firms can develop relationships with faculty and research groups.

Associated AIM Project Personnel

David J. Andrea is a graduate student in business administration at the University of Michigan. Mr. Andrea served as AIM administrative/research assistant in fiscal year 1985.

Alan Baum is data resources coordinator for the Michigan Technology Deployment Service, Michigan Department of Commerce. Mr. Baum is responsible for database development efforts within the AIM Project.

J. Downs Herold serves as the Director for Liaison of the Industrial Development Division of the Institute of Science and Technology at the University of Michigan. Mr. Herold is the AIM Project LEDA Expediter.

Others

Mark Everett, a senior at Michigan State University, has been responsible for editing and organizing the LEDA response forms.

Lauren Hammett, also a senior at Michigan State University, has been responsible for summarizing articles from the popular and trade press on the Confer system.

ADVISORY BOARD

The Advisory Board to the Auto-in-Michigan Project played an integral part in the success of the Project's first year. The twenty-two members of the Board represent a cross-section of the industry, and include representatives of the vehicle manufacturers, large and small suppliers, the United Auto Workers union, trade associations, and local economic development agencies. The following table presents the industry leaders who have agreed to support and advise the Project.

The initial objective of the Advisory Board was to guide the Project in its areas of exploration and methods of execution. Though the first formal gathering of the complete Board took place on May 21, 1985, many of the future members had already made themselves available for informal consultations with the Central Research Team (CRT). Valuable contributions were made by the Board in reviewing areas of inquiry and the questions to be asked, identifying persons to contact for interviews, and giving moral support to the Project's research activities.

Research activities were also greatly enhanced by the entire Board's willingness to participate in personal interviews. Allowing anywhere from one- to three-hour interviews, Board members provided the CRT with a tremendous amount of information on each of the eight areas (input sourcing, labor relations, materials, OEM/supplier relations, product developments, production technology, siting of vehicle programs, and universal-industry) of investigation. The knowledge gained in these interviews has provided a substantial foundation for the material presented in this report, and for the investigations that will continue into year two of the Project.

The formal presentation of the first year AIM Project findings to the Board will take place on October 2, 1985 at the University of Michigan. Each member of the Board will be presented an executive summary of the final report and will be briefed by the members of the CRT on the major findings. Areas of investigation for year two and potential state and local policy and program initiatives will also be discussed.

AIM ADVISORY BOARD MEMBERS

Name	Title	Organization
Donald W. Abelson	Plant Manager Pontiac Assembly Plant	CPC Group General Motors Corp.
Fred Bolling	Director Manufacturing Processes Laboratory	Ford Motor Company
Robert W. Carlton	President	Greater Jackson Chamber of Commerce
Conrad T. Coen	Director Worldwide Procurement and Planning	Chrysler Corp.
Robert Costello	Executive Director of Purchasing	General Motors Corp.
Michael Doherty	Vice President Sales/Engineering	R. J. Tower Corp.
Robert Eaton	Vice President Advanced Product and Manufacturing Staff	General Motors Corp.
Norman Ehlers	Executive Director Purchasing and Transportation Services	Ford Motor Company
John Green	Executive Vice President	Sackner Products
David Greeneisen	Senior Director Research & Development	Sheller-Globe Corp.
Robert King	President	UAW Local 600
James Knister	Vice President	Donnelly Corp.
Odessa Komer	Vice President	United Auto Workers Union
John Konkal	Vice President	Cross Company
Ralph Mandarino	President and Chief Executive Officer	Four Star Corp.
Ralph Miller	President	Modern Engineering
William Risk	Development Manager Automotive Materials Center	General Electric Company
James Roth	President Stamping and Frame Division	The Budd Company

AIM ADVISORY BOARD MEMBERS

Name	Title	Organization
Robert M. Sinclair	Vice President Engineering	Chrysler Corp.
Douglas J. Smith	Director	Office for Economic Expansion, Grand Valley State College
Rick Steinhelper	Assistant Managing Director	Detroit Tooling Association
Howard Young	Special Consultant to the President	United Auto Workers Union

A PREFACE
THE PUBLIC INTEREST IN AUTOMOTIVE RESTRUCTURING

The AIM Project is based on a belief that an aware, activist State role can make a difference in our economic future. That view is not shared equally by all players in the state's automotive economy. Some skepticism toward public sector initiatives, it should be said, has a basis in historical experience. The private sector has certain expertise that government cannot challenge or hope to match. On the other hand, to the extent that opposition to activist policy is justified by claims that the State lacks industry-level knowledge and intelligence, we hope the AIM effort will give State efforts increased credibility as it pursues the public's interest in the future health of its dominant manufacturing sector.

Of the nearly four million Michigan residents that work for wages and salaries, nearly one in six is directly involved in manufacturing cars, trucks, and their parts. They and many of their neighbors live by automotive payrolls. Whole communities live and die with particular automotive facilities.

Many of the decisions that determine our communities' fates are made by a handful of individuals in Michigan's companies. Many of the agreements that determine, either directly or by tradition, the living standards of Michiganians are crafted by similarly small groups of management and labor representatives.

These "decisions at the top" are an inevitable, and generally accepted, instance of leadership in market economies. They do, however, generate costs as well as benefits, and some of those costs are borne more widely than by the workers and managers on whose behalf most private economic deals are concluded. That wider distribution of narrowly-originated economic outcomes presents the rationale for, and the first guide to application of, a public role in the state's automotive economy.

All stakeholders in that economy are investors, either directly or indirectly. Businesses allocate investible funds among projects, unions invest labor power after they bargain over the conditions of labor and the distribution of the value of sales between stockholders and wage-earners, and government provides infrastructure, services such as public education, and -- increasingly -- targeted subsidies in the tax and training fields.

Each investor seeks to maximize the return on their investment. Sometimes, joint maximization is possible, while at other times objective functions clash. Business seeks to maximize profit, labor to increase wage-earners' share of output, and government the net wealth created within its boundaries. When new Michigan investments are made that do not devalue existing ones, and which generate rising living standards for workers and shareholders alike, all stakeholders enjoy net benefits.

Unfortunately, a fortuitous coincidence of interests is not always the case. Business sometimes maximizes the earnings of its shareholders by disinvesting from Michigan facilities, imposing mighty costs on workers and those their incomes support. This is a dilemma posed by many outsourcing decisions that shift government's role from recipient of tax revenues to provider of social support for the unemployed. Likewise, a particularly large wage hike may raise a particular group's living standards, but impose costs on others by discouraging future investment. Finally, new investments may be made in Michigan but impose costs on existing businesses with which they compete; sometimes those costs can more than offset the gains from the new investment. (This last situation is alleged by some suppliers to apply to new Michigan investments by their foreign-based competitors.)

As an example of stakeholders' interests in tension, consider the oft-cited need to reduce domestic small car production costs by some $2,000 per unit. Clearly, the OEMs and their domestic suppliers want to see this goal met, since sales and shares hang in the balance. U.S. labor unions likewise want auto-producing jobs here rather than elsewhere. Finally, government at all levels wants the fiscal benefits of domestic rather than the foreign output portended by such a large cost gap.

Beyond this common ground, however, interests diverge. Labor wants the cost-reduction effort to succeed without big pay or benefit cuts, to keep existing small car facilities operating, and to maintain high UAW content. Domestic independent supplier shops want to sell what they produce without having to accept price cuts, so they'd rather see labor do more of the belt-tightening. The OEMs, for their part, want the cost-reduction goal met without sacrificing product quality. Moreover, unlike workers, unions, and smaller independent suppliers, the OEMs retain the option of delivering for their shareholders even if they don't meet the U.S. cost reduction goal, by purchasing vehicles from abroad.

The State, finally, wants production costs cut so the work can remain in Michigan. It is more willing than unions to countenance labor cost moderation as a tool, and less insistent that all of the Michigan content be unionized. It wants the social peace of a viable distribution of output and power, and thus would prefer that the costs of regaining competitiveness be shared more or less equitably among the private parties.

The State navigates these waters with two objectives. First, the State as an investor needs to look after the return it earns. Among other approaches, it can condition certain of its investments on particular behavior on the part of private parties. For example, it might conceivably seek promises of minimum Michigan content in vehicles built in State-subsidized plants as the quid pro quo for granting or continuing those subsidies. Second, the State has an interest in seeing to it that deals are struck between management and labor that anchor in, or return or attract to, Michigan new net wealth-creating activity. Such deals will tend to raise the State's direct return-on-investment and pay future fiscal dividends.

In the Report that follows, we present the AIM Project participants' major conclusions regarding the future status of the auto industry in our state and key recommendations for State action. In considering these, the reader is asked to try to think in terms of the individual and joint maximization metaphor we've been using. Think, if you will, of a four-sided table at which the state is joined by the auto makers, their suppliers, and the UAW. Imagine the parties discussing our findings, and seeking mutually satisfying courses of action to meet both the risks and the opportunities that will be generated by the automotive industry as its changes in this state over the next seven years.

No seat at that table is an easy chair. Perhaps the most demanding position, however, is occupied by the State, for it must pursue the general interest, considering the needs of each of the others, and of us all. To ask how the State can serve our general interests as Michigan passes through the continuing automotive transformation is to live with some very challenging questions:

- Can cost-justifiable public action influence which facilities are given new vehicle programs?

- Is it possible, and economically rational, for the State to understand fully the articulation of the establishment-specific chains of value added in the automotive economy, so that events at the finished vehicle level (such as the abandonment of import restraints) can be translated into detailed supplier plant impacts?

- To what extent can the State up its rate of return by conditioning its investments on particular private behaviors? Would requiring a minimum level of Michigan content in return for tax or training subsidies or for support of foreign trade zone status succeed in its goal, or make business less likely to invest here? Would this tradeoff be worth it, bringing fewer, but "deeper," investments contributing more net new activity?

- Can State action that is based on the sort of rigorous "social accounting" criteria we've described be defended in the political arena?

- How can Michigan, as a high-wage, highly-unionized state, maximize the advantages of proximity to OEM assembly and regional component operations? Are there public sector actions not now being taken that could provide cost-effective incentives to greater clustering of supplier facilities? What can the State do to increase the extent to which first-tier suppliers of modular subassemblies build up their modules from discrete parts produced in the state?

- Are there cost-effective State actions that could provide constructive new uses for automotive facilities that become vacant? Is it possible for the State to work with private business and with labor to co-plan the future of such apparently at-risk facilities?

This list of questions could, of course, be developed further. Each poses, in different ways, whether public interest can be advanced by informed public investment. The work of the AIM Project will find its best uses in an environment in which these questions are frankly addressed and resolved by industry, labor, and government. We look forward to a continuing discussion with the AIM Advisory Board and the automotive industry stakeholders its members represent.

AIM '85

EXECUTIVE SUMMARY AND RECOMMENDATIONS

For the past ten months, a unique endeavor has been sponsored by State government. Under the Auto-in-Michigan (AIM) Project, a team of researchers and policy leaders has been at work seeking to understand the forces affecting the state's leading industry and, based on that understanding, to suggest State government actions to prepare for likely developments in the 1986–1992 period.

This document is the Executive Summary of the 300-page 1985 Report of the AIM Project. It presents, in capsule form, our major findings and conclusions. (These also appear in simplified tabular form at the end of this Executive Summary.) Most important, we offer our recommendations for some key State actions that might flow from our findings.

During the past months, we have moved within an industry that is making an impressive effort to transform the ways in which it mobilizes resources to compete in the international marketplace. In Detroit and Grand Rapids, in Flint and Sterling Heights, and in Lansing we have seen leaders moving an industry forward.

Big ships turn slowly, however. During the rest of this decade, and well into the next, Michigan's auto industry leadership must navigate heavy seas. Continuing turbulence remains the only realistic forecast for auto in Michigan.

Most of Michigan's nineteen car and light truck assembly plants now or soon will host new or nearly new vehicle programs that are aimed at the markets of today and tomorrow. A few big plants are at peril, however, and more might be if our now-unrestrained Japanese competitors claim still larger shares of the U.S. market.

We have observed all auto makers fully committed to a fundamental change in their relations with suppliers, a process that will surely reduce the number of Michigan firms with which they directly conduct business. The direct suppliers that remain in the industry will enjoy stable, long-term relations with their customers, but they, and the smaller suppliers that serve them, will provide less employment than in the past. Aggressive State actions, however, can do much to preserve and create Michigan jobs throughout the entire chain of automotive production.

AIM finds an industry passing through the early stages of a revolution in its production technologies, and one in which the mix of materials in the typical product may change dramatically in the mid-term future.

The application of computer technology to the design, engineering, prototyping, production, testing, and marketing of the automotive product will increase rapidly during 1986–1992. The transformation, driven by digital technology, will be disruptive, but it can yield substantial benefits for Michigan if new efficiencies reduce costs and defend U.S. market share, and if Michigan grows as a center of initiative in computer-integrated manufacturing.

The cars of tomorrow will contain more aluminum and engineering plastics, a development that brings both risks and opportunities for our state. Iron foundries dedicated to engine and drivetrain components will face difficult times as aluminum casters and smelters that serve them claim new automotive business in engine blocks, cylinder heads, intake manifolds, transmission cases, and lesser components. Plastics will challenge stamped steel as the "skin" of choice in a widening range of U.S.-produced vehicles. This crucial contest should be watched with care in Michigan, for whatever its resolution, many jobs will be lost, and others created, in the industry's home state.

These highlighted findings, and the many others that follow, convince us of the need to strengthen the special bonds between government and the auto industry in Michigan.

The AIM Project is an ambitious experiment in the education of government by industry. AIM is also a public effort to provide analysis that can be of direct, practical value to the managers and owners and workers who are the most important stakeholders in Michigan's automotive economy.

To understand the possible futures of the auto industry in this state, even to a 1992 horizon, is no small task. The Michigan automotive economy represents America's most complex industry, in its highest geographic concentration, in a period of unprecedented volatility. In a changing environment of risks and opportunities, informed analysis is essential. The State had three objectives in commissioning the AIM Project:

1) **To Make Government a Wise Investor of Public Resources**

Each year Michigan spends millions on auto industry needs and interests. The State must maximize the public return from these expenditures.

2) **To Develop Michigan Governments as Resourceful Suppliers**

Just as private, for-profit vendors are asked to contribute more to the industry, so state and local governments must become informed, innovating suppliers of the public services that support competitive production in Michigan.

3) **To Extend the Planning Horizons of Government**

In 1985, the industry is shaping the world of the early 1990s. More of government's economic development programs must anticipate needs that may emerge five or more years in the future as today's auto decisions are implemented.

Armed with this charter and modest state funding, the project has been hard at work during the past months. We have taken a bank of carefully crafted questions to a roster of experts and decision-makers from industry. These AIM Project interview questions were organized along seven fronts of change within the industry:

- Siting of OEM Vehicle Programs
- Input Sourcing
- Manufacturer-Supplier Relations
- Labor Relations
- Emerging Product Developments
- Automotive Materials
- Production Technologies

In each case, our purpose has been to assess how developments in the 1986–1992 period might influence the size, stability, and prospects of the auto industry in Michigan.

Section-by-Section Summaries

Siting of Vehicle Programs

The State's economic health depends on maintaining its share of vehicle assemblies. Action to replace the production that will be lost when current programs expire at Clark/Fleetwood, Pontiac Plant 8, Dearborn Assembly, and Wayne Assembly is thus a high priority.

Michigan is the core state of the U.S.-based assembly companies, for the past several decades accounting for approximately one-third of the nine to fourteen million cars and light trucks produced in North America. There is considerable basis for optimism that the state can retain and even increase its share of domestic builds. At the same time, there is every reason to expect that sharp increases in import share – already appearing in the wake of the non-extension of the VRA – will make it extremely difficult for the state to maintain its current unit production, especially as Japanese competition begins extending further into the intermediate segment.

Table 1 presents a summary of current and expected future assembly programs in Michigan.

Our work convinces us that five factors go a long way toward determining which of Michigan's nineteen current OEM assembly facilities have secure futures. These are the age of the current vehicle program, whether it is front or rear wheel drive, the configuration of the plant and the cost of changing it, the extent to which its market segment is or is likely to come in direct competition with imports, and the likely impact of fuel prices and government CAFE rules. Table 2 presents our effort at rating Michigan's assembly operations on these criteria.

TABLE 1

LIGHT VEHICLE ASSEMBLY PROGRAM SITING IN MICHIGAN, 1986-1992

FACILITY	CURRENT PROGRAM VEHICLES	ENDS	FUTURE PROGRAM VEHICLES	BEGINS
General Motors				
Clark/Fleetwood	B	89?		
	D	90?		
Pontiac #1	P			
Pontiac West #5	S10 trucks			
Pontiac East #6			GMT400	87
#8	G	87	GM 80	89
Willow Run			H(GM70)	86
Lansing	N			
(Buick City) Flint #4			H(GM70)	86
Orion	C			
Chevy Flint Truck	C/K trucks			
Poletown			E/K(GM30)	86
			V(GM35)	87
Lansing 2			GM33	87
Ford				
Wixom	LS, Panther			
Michigan (Wayne) Truck	Utilities			
Wayne (Car)	Erika:Escort	90?	?	
	Lynx,EXP	87		
Dearborn	Fox: Mustang	90?	?	
	Capri	87		
Chrysler				
Jefferson	K	87+	A?	88
	E	87?		
	CV	87?		
Sterling Heights	H	85	P (Added to H)	87
Warren (Dodge City)	D/W Pickups		N (added)	86+
	Utilities	85		
Mazda				
Flat Rock			727	87+

TABLE 2

CRT RISK RATINGS OF MICHIGAN
CAR AND LIGHT TRUCK ASSEMBLY PLANTS,
1986-1992

(Scale: 0=no risk,..., 9=grave risk; a plant risk score over 10—absent firm future plans—indicates signficant danger.)

			Risk Factor					
Co.	Plant	Current (1985) Program(s)	Age of Program(s)	Attributes of Plant	Cost of Change to FWD	Imports or Outsourcing	Fuel Prices or Rules	Plant Risk Score
GM	Clark/Fleetwood	B,D	9	7	8	0	3	27
	Pontiac 1	P	2	0	3	4	0	9
	Pontiac 8	G	9	5	6	0	2	22
	Pontiac 5	S10	3	2	0	2	0	7
	Willow Run	H	0	1	0	2	0	3
	Buick City	H	0	0	0	0	0	0
	Lansing	N	1	2	0	4	0	7
	Orion	C	1	1	0	2	2	6
	Flint Truck	C/K	4	2	0	0	4	10
Ford	Wixom	LS,Panther	4	1	6	0	3	14
	Wayne(Truck)	Bronco,F	3	0	0	0	4	7
	Wayne (Car)	Erika	5	0	0	9	4	18
	Dearborn	Fox	9	7	6	5	0	27
Chrysler	Jefferson	K,E,CV	6*	3	0	2	0	11
	Sterling	H	0	0	0	3	0	3
	Warren	D/W	0**	2	0	2	3	7

*Likely to decline to 0 due to siting of A's in 88.
**N truck (Dakota) coming in 1986+.

Based on the analysis underlying Table 2, it appears that four Michigan car assembly facilities are at risk in the 1986–92 period. Three of these are endangered by the shift toward front wheel drive: GM's Clark/Fleetwood operation and its Pontiac Plant 8, and Ford's Dearborn Assembly Plant. All three are old, multistory structures; none has on-site dedicated major panel stamping capacity or a fully modern new-style paint shop. By today's standards, all are lightly robotized and, with the exception of Plant 8, relatively labor-intensive. Perhaps most important, all produce rear wheel drive vehicles introduced more than a decade ago. The fourth at-risk assembly operation is Ford's Wayne car assembly line, due to increased small car imports.

We believe that two of the four endangered plants will be the site of future new vehicle programs. Pontiac Plant 8 is reportedly the future home of the plastic-skinned 1990 GM80 Camaro/Firebird successor. Wayne Assembly, because of its quality record and workforce reputation, will likely be chosen for a future Ford car or light truck program even if, as we fear, there is no domestic successor to the Escort/Lynx line. That leaves Clark/Fleetwood and Dearborn Assembly. The former, bolstered by the addition of remaining B-body volume in 1986, is likely to close in 1990 or 1991. Dearborn Assembly appears destined to close at about the same time, as Mach 1 (reskinned Mustang) production phases out. In the Recommendations subsection below, we outline some approaches the State might consider with regard to these two facilities.

Based on Table 2, it also appears that several other Michigan assembly plants are in some, albeit much less, risk. These include Chevy Flint Truck (scheduled to go from two lines to one in 1987), Ford Wixom (if conversion to front drive platforms is postponed), and Chrysler Jefferson (if the late-'87 A-body successor to the K-body is sited elsewhere).

Finally, there is the issue of foreign direct assembly investments: While the U.S. and Michigan gain when vehicles that otherwise would be shipped from abroad are instead assembled here, our work suggests that the typical Big Three Michigan assembly plant generates at least twice, and potentially as much as six times, as much Michigan manufacturing activity as the typical foreign-owned or joint venture assembly operation. This, of course, is due to the former's higher U.S. content (85–98% versus 25-50%) and its greater propensity to purchase major inputs from existing Michigan suppliers.

Input Sourcing

Major sales and job losses loom for Michigan's frame, stamping and axle plants. New aluminum engines, and perhaps manual transaxles, present future business opportunities. Efforts need to be made to increase the Michigan content of vehicles made in new foreign-owned U.S. assembly plants.

Michigan's approximately 70,000 assembly jobs underpin 200,000 captive and independent supplier jobs and another 280,000 state manufacturing jobs, for a total of about 550,000. Adding jobs at corporate and divisional headquarters, technical centers, and proving grounds swells the figure to 650,000, or about 55% of Michigan manufacturing employment. In our work to date, the Project has succeeded in describing, for all car and light truck assembly programs in Michigan, the first tier suppliers of major frame and body stampings or plastic panels, engines, and major drivetrain elements, including unit volumes. Combining that information with the vehicle program siting data summarized above, we have been able to identify areas of risk and opportunity.

The phaseout of GM B-, D-, G-, and T-body cars will impact volumes at Chevy Flint Met Fab, Grand Rapids 1, Chevy Flint Engine, Chevy (Detroit) Gear and Axle, and Three Rivers Hydra-Matic. Termination of the Fox (Mustang/Capri) program would endanger output at Dearborn Stamping, at the Utica and Chesterfield trim plants, and (to a lesser extent) at Sterling Axle. Increased imports would hurt Michigan plants producing stampings, engines, and transmissions for GM J-body, Ford Escort/Lynx, and Chrysler Omni/Horizon models. Rising market penetration by low-U.S. content domestically-assembled cars will reduce traditional U.S. OEM part demand by at least 14%, and perhaps by as much as 34%, just between now and 1987. Increased vehicle outsourcing by the OEMs — some of it offshore — will reduce partsmakers' volumes still further, with significant costs to Michigan businesses.

In major frame stampings, the Rouge Frame Plant is at risk unless additional truck frame work is added. The emerging trend, in GM at least, toward space frames (or "bird cages") may be an opportunity for Michigan producers, within and outside the OEMs, especially if space framed vehicles begin to appear in light trucks, many of whose frames are made in Illinois and Wisconsin.

In body panels, vehicle program phaseouts endanger five Michigan OEM stamping operations. GM's Conner Stamping and Olds (Lansing) Met Fab #1 facilities and Ford's Dearborn Stamping plant seem at greatest risk. The trend to greater use of some or all plastic panels in vehicle outer skins presents dangers and opportunities. Two of the five at-risk stamping plants, plus several other Michigan plants – OEM and independent – may find new openings in the plastic panel field by the early 1990s.

In engines, the redesign of many if not most current programs will likewise present risks and openings. The good news is the reported possibility of siting GM's new 3.2-L V6 engine in the former DDA (now CPC) Romulus facility. Michigan siting of some or all of 1991 4-cylinder Manhattan engine production is a strong possibility. Chrysler's Trenton Engine plant is adding a 2.5-L to its current 2.2-L line, and putting a 3.9-L V6 truck engine in Mound Road. Ford's Dearborn Engine Plant has received significant investment in its 1.9-L line, and even exports some engines to England. On the negative side, the trend to more and more use of aluminum blocks and especially cylinder heads may be a high-cost event for Michigan. Some of GM's and all of Chrysler's Michigan-assembled engines have heads from Mexico, Brazil, or Italy. Blocks for Buick's (Flint) 3.0-and 3.8-L V6s are being moved out of Pontiac's foundry (which closes in 1986) to Defiance, Ohio; foundries in Indiana and New York also appear to have an edge over Michigan facilities in aluminum casting experience.

In automatic transmissions, Michigan is the nation's dominant state. GM Hydra-Matic facilities supply most GM cars and light trucks; Ford's Livonia plant provides most of the company's large car automatics. Only Chrysler, with transmission plants in Indiana and New York, lacks a presence here. None of this is likely to change much; domestic market share will determine volumes and hence risks. In manual transaxles, installed in over half of small cars, the state has no presence at all. GM gets its domestic manual from its own and Warner Gear's plants in Indiana, and imports from Isuzu; Ford buys from Warner, Ford of Europe, Tremec (Mexico), and Mazda; Chrysler makes its own manuals, but in Syracuse, New York. The trend to front wheel drive benefits transmission and hurts axle plants; Michigan has many of both.

Finally, the outlook is not terribly bright for significant new component orders for Michigan suppliers from the new U.S. plants of foreign-based automakers. While Honda has announced and Mazda is considering U.S. engine plants, the typical foreign-nameplate U.S. operation imports engines and transaxles, and stamps on-site using mostly Japanese steel. Often, new foreign-based suppliers come with these assembly plants, adding jobs but also competing away Big Three business from established Michigan suppliers. At NUMMI in California, 1450 parts are shipped from Japan and

400 are U.S.-sourced. Of the latter, many are low-value added, energy-intensive inputs (sealants, paints, wire and cable), while many of the rest (e.g., air conditioners) are supplied by U.S. plants of Japan-based suppliers.

Manufacturer-Supplier Relations

There will be substantially increased outsourcing by the OEMs, and a shakeout of independent part suppliers. The resulting supplier base will have fewer and larger firms, arranged in tiers under producers of complete subsystems or "modules." While these first-tier module suppliers will tend to cluster around assembly plants – a plus for Michigan – only the most cost-competitive and technologically sophisticated among lower-tier suppliers are likely to survive in the emerging setup.

The internationalization of automotive competition is creating pressures for significant and rapid cost reductions, and as a result OEMs and major suppliers alike are shopping more, and more selectively, outside their own boundaries. The OEMs all intend to reduce their vertical integration, citing the fact that in Japan the typical OEM builds very few components in-house beyond engine and drivetrain assembly.

Five developments – the end of secure contracts to captive parts plants, the need for world-class quality, the desire to use Just-in-Time (JIT) methods to reduce inventory costs and quickly identify defects, the possibility of shifting to or sharing with independent suppliers the responsibility for component design and engineering, and the decision to try to source pretested modules rather than only discrete parts -- are driving the emerging set of relations between OEMs and their suppliers. All five are closely interwoven, and all tend to push in the same direction.

All of the Big Three OEMs have committed to reducing the cost of light vehicles by approximately $2,000 per unit, with initial emphasis on smaller cars. With 50 to 70 percent of the value of each car originating outside the OEMs, it makes sense to seek some, if not most, of the $2,000 in sought-after saving in purchased inputs, while making parallel efforts in in-house stamping, assembly, engine, and transmission operations.

To reduce costs, rationalize delivery, improve quality, and reduce inventory carrying costs, the OEMs have decided to reduce their number of direct suppliers, opting instead for a more explicitly tiered arrangement in which they deal with a smaller number of first-tier suppliers, which in turn ride herd on a larger number of lower-tier suppliers.

Wherever possible, the first-tier suppliers will deliver not discrete (loose) parts, but completed, built-up subassemblies or "modules," such as an instrument panel, a front suspension, or a wheel-brake-tire "corner." Such modules will be delivered on a JIT basis, pretested.

The module supplier will have had significant responsibility for the design and engineering of the module, and to remain a first-tier supplier will have to continually find ways to deliver the subsystem more cheaply. Early cooperation between such suppliers and their OEM customers will, of course, be crucial if the modules are to be combined efficiently into high-quality vehicles. That cooperation will include supplier-OEM electronic links, particularly in the CAD area.

Such shared design and electronic linking cuts two ways for Michigan. First, to the extent that it makes possible lower levels of OEM vertical integration, it results in lost business for Michigan's many captive supplier facilities. On the other hand, the advantages of proximity to customers for JIT methods suggests that the state will be home to more and more first-tier module suppliers. To complicate things further, however, those first-tier Michigan supplier operations may be reduced to mere subassembly sites or even, in some cases, warehouses; the real manufacturing activity – casting, machining, stamping, extruding, molding, etc. – could be done in lower-tier suppliers outside the state. Finally, electronic linking makes possible, though not necessarily likely, the outsourcing of certain engineering and design work that traditionally has been sited close to OEM headquarter locations.

On balance, we believe that the coming tiering of the supplier base bodes well for larger, more technologically sophisticated Michigan partsmakers and engineering services firms, but on balance ill for smaller and less technically able producers. First-tier module suppliers will retain significant manufacturing activity (though Ohio and Indiana locations are nearly as functional for JIT as Michigan sites), but they can be expected to react to OEM price-cutting pressure by sourcing the constituent elements of their modules more widely, including to shops in Mexico and the Pacific, something made more feasible by declining transport and electronic communication costs.

While the trends described above seem inevitable, the rate at which they occur, and the extent to which they benefit or harm Michigan, are not fixed in stone. The continued "political" power of captive parts plants places some (though decreasing) limits on the extent and rate of OEM outsourcing. The degree to which full JIT implementation (first-tier supplier plants adjacent to assembly customers) is required is very much in doubt; to the degree that OEMs instead use JIT not as a quality driver but only to shift inventory costs to suppliers, the result could be more Michigan warehouses rather than production operations.

In any case, some work now done in Michigan is likely to be lost to foreign sourcing, including drum brakes, simple steel wheels, interior fabric and soft trim, small plastic parts, small metal stampings, and labor-intensive subassemblies such as copper wire harnesses. There is, of course, some possibility that such work could return to the U.S. and Michigan in the future, as technology reduces labor content and parts complexity. One example, treated below under Emerging Product Developments, is the prospect of multiplexing and fiber optics replacing copper wiring harnesses. Worrisomely, some of the Michigan independents most likely by virtue of their size and technological capabilities to be future first-tier module suppliers now make some of the parts and components most likely to be foreign-sourced.

Finally, our review of the U.S. results from the U.S.-Japan Supplier Survey finds Michigan's large and small suppliers at least as competent in engineering as their out-of-state competitors, but turns up some evidence that medium-sized Michigan suppliers may be lagging technologically. If true, this is a problem that needs immediate attention, if such shops are to win contracts from first-tier suppliers.

Labor Relations

New, flexible technologies and increased competition – from abroad and from new foreign-owned assembly and parts plants – are likely to produce turbulence in the State's labor relations climate. Traditional work practices will continue to be eroded, and defended. Long-stable pattern bargaining relationships will give way to multiple agreements more tied to the competitiveness of particular plants and product lines.

The period between now and 1992 is likely to see increasingly turbulent labor-management interactions. On the one hand, common interests in maintaining and reclaiming market share lost to imported vehicles and parts will be a powerful motivator of "deals" in which labor trades wage moderation and work rule flexibility for management commitments to invest, and keep work, in existing organized plants. On the other hand, increased international competition will mean more outsourcing. That, combined with new U.S. parts plants of foreign-based firms, will produce pressures to pay small car and parts workers less than large car workers, with sharp pattern-defending reactions likely. Resistance to wage and work rule demands may drive investment to lower-cost sites, with the resulting displacement heightening reluctance to modify job-preserving work practices.

The State interest is neither in breaking pattern labor agreements nor in freezing existing arrangements, but in promoting a smooth transition to a state automotive culture based on explicit labor-management deals covering investment, pay, and work organization. To promote and incentivize such deals, the State needs to promote a wide discourse on the relationships between technology, skill requirements, and production costs; between work practices, costs, and flexible automation investments; and between pattern bargaining, costs, and the future of automotive sector trade unionism. Our work has focused on these three sets of relationships.

New technologies are increasing the skill requirements of most production worker jobs in OEMs and first-tier suppliers. On the other hand, machinists' and diemakers' traditional crafts are being devalued, while machine repair tradespeople, millwrights, and pipefitters are so far little affected. New skills are required in both hydraulics and electrical trades. Because recent umpire decisions permit a growing share of relatively routine diagnostic work on electrical/electronic hardware to be performed by production workers, the trades' share of auto jobs is likely to stay constant at about 18%. But the scarcity of tradespeople may give this minority a great deal of power in the next few years, including the power to stand in the way of deals that might secure work for U.S. and Michigan plants in return for increased work rule flexibility.

Under the pressure of increased imports and outsourcing, many of the work rule "horror stories" have been cleaned up since 1980. In the OEMs, the least movement has occurred in large car plants and in captive facilities producing their parts. Our work suggests that in 1981–83 OEM workers made small concessions (or forewent scheduled increases) in pay but often large ones in local work practices, while in many suppliers larger cuts in pay rather than in job rules were more typical. The key, of course, is the effect of workforce flexibility on costs. How much do restrictions on how management deploys workers matter? Which relaxations would save the most money in which kinds of plants? How much? Enough to change any significant component or vehicle sourcing decisions? Are there "disjustified" investments in programmable automation that would be justified if work practices were changed?

We found little hard evidence with which to attempt answers to these and similar queries. The UAW made a clear distinction between combining skilled trades classifications within versus across basic trade lines, and their position found support among plant-level management; both of these groups felt top managers were overreacting to past rigidities, and seeking a level of flexibility that might undermine needed specialization. Pay-for-knowledge systems tended to have the backing of top company and union leaders, but some plant managers feared they led foremen to promote insufficiently-trained workers, hurting quality.

Existing work practices are, of course, a response to the traditionally low levels of job security within the industry. Where in Western Europe and Japan job security is more uniformly underpinned by government policy and tradition, respectively, rigid job-protecting local work rules have not evolved. This logic gives reason for optimism that if and as the U.S. industry comes to treat hourly labor more as a fixed cost, resistance to flexible workforce deployment may fall away. The new Job Opportunity Bank program is the latest and most thorough-going evidence of an evolution in this direction: not only does it represent a new level of job security, but also explicitly trades that for fewer restrictions on the assignability of Banked employees.

Heightened competition is eroding more than traditional work practices; negotiated wage and benefit patterns are also under attack. More and more supplier plants have been split off from master agreements, and talk of similar pattern breakout among OEM captive parts plants abounds. Certainly, new competition from the U.S. plants of Japan-based suppliers is creating pressure in this direction. The 1982 and 1984 UAW-Big Three contracts permit terms of the national agreement to be waived in cases in which "major outsourcing decisions" may hang in the balance. While pure two-tier agreements are unlikely, it is probable that independent and captive parts plants alike will see lower starting rates, slower progression to maximums, and longer benefit grow-in periods. In addition, we expect OEM parts plants producing at-risk components (some trim, batteries, bearings, die castings, small assemblies, etc.) to negotiate lower-cost agreements than assembly, stamping, engine, and transmission plants; this tiering could occur in 1987 bargaining, but is more likely to come in little by little over the next six or so years, driven by particular competitive developments in specific product lines.

There is also some, though less, chance that small car assembly, engine, and drivetrain plants may come to constitute a lower tier. As of now, it appears that pay and benefits will be similar, but that there will be few if any restrictions on work organization. It seems certain that whatever arrangements eventuate at NUMMI, Mazda, and Saturn will set the post-1990 pattern for small cars, and become the quid pro quo for future domestic small car investments, including the domestic programs (if any) that replace Escort/Lynx, Omni/Horizon, Encore/Alliance, and GM J-bodies.

Whether the erosion in traditional work practices and pay-and-benefit patterns we predict occurs in the context of bitter acrimony or of constructive deal-making remains to be seen. We believe that these changes can best be nurtured and accommodated by a tripartite productivity coalition, but that will require much fuller articulation of the competition, cost, and work organization issues raised above. Without that, labor will be unwilling to give up long-standing pay and job practices and management will be unwilling to forego the exercise of its traditional outsourcing prerogatives.

Emerging Product Developments

By 1992, most new cars and many light trucks will have front-drive, new engines with much more aluminum, simpler and higher-quality transmissions, and far more electronic controls than today. Some 10% will have space frames with plastic panels, a configuration that may dominate by 2000. Impacts on engine, mechanical control, steel, and stamping plants are thus likely.

The market itself is an increasingly significant driver of the product decisions made in the Michigan corporate and technical centers of the Big Three and their first-tier suppliers. Increased international competition is shortening product cycles, creating new requirements for product differentiation, and splitting the U.S. market into high-volume "commodity" and lower-volume specialty segments. Technology is playing and will play a growing role in all three of these areas. A qualitatively new and profound sense of urgency is apparent within the industry: unless new world-class quality products that fit the new market demands can be produced at competitive cost, a major shrinkage in domestic market share is expected, with obvious dire consequences for auto-dependent Michigan.

The trend to unibody and space frame structures, the need to redesign mature engines and transmissions, the replacement of mechanical with electronic controls, and the successful deployment of flexible automation to accommodate modular assembly and the other requirements of a more variegated marketplace will dominate the efforts of automotive technologists in the 1985–92 period. An emphasis on systems engineering and parts plant entrepreneurialism will characterize these efforts.

In drivetrains, 72–93% of passenger cars (up from 51% in 1984) will be front wheel drive by 1992, with resulting increases in demand for CV joints. Over time, electronic controls will replace many hydraulic controls, and more McPherson strut front suspensions will be used to accommodate transverse engine/front drive. More four-wheel drive vehicles (perhaps 15–25% by 1992) could mean major new opportunities in prop shafts, U-joints, and sophisticated transfer cases. More manual transaxles will be used, with negative impacts on Michigan (see Input Sourcing, above), with five speeds dominating. By 1992, if belt manufacturability problems are solved, some cars up to perhaps 2.5-L may be equipped with Continuously Variable Transmissions (CVTs), with resulting opportunities in belt-making and viscous dampers but some negative impacts on volumes in gears, friction surfaces, and clutches.

Continued movement away from separate body frames in passenger cars and low-load light trucks is likely. By 1992, moreover, use of bird-cage or space-frame structures will have moved out of low-volume applications (Corvette, Fiero) into several high-volume vehicles. This will greatly increase the chances that many more vehicles will have bolt-on plastic body panels for part or all of their outer skins (see Input Sourcing above, and Automotive Materials below). On-site steel panel stamping will be used increasingly for new assembly plants, but major impacts on OEM regional stamping facilities are not expected before the mid-1990s.

Gasoline engines will be extensively redesigned between now and 1992, and even more in the 1993–2000 period. Four-cylinder engines will maintain their roughly 50% market share, but the six/eight mix — now about even — will move to about 35/15 in 1992 passenger cars, as peppier sixes, turbocharging, and more efficient transmissions permit V8-type performance without the weight and fuel consumption penalties. Greater use of aluminum blocks and especially cylinder heads is expected (for Michigan impacts, see Input Sourcing above and Automotive Materials below). Electronic controls, overhead cams, fast burn combustion chambers, and roller lifters are expected on an increasing share of U.S.-made engines by 1992. Ceramics may begin to play a role in cam followers, piston crowns, valves, and exhaust port liners, though their biggest contributions may come in heavy duty diesel applications. Flexible automation and the possibility of integrating casting and machining operations together may make economic much smaller engine module sizes than today's 400,000-unit floor.

Electronic componentry is taking off. Some 12% of the value of 1992 passenger cars will consist of electronics; for the high-volume "commodity" segment, the figure will be 6–8%, while lower-volume specialty segment cars may be 15–25% by value. While much of the latter segment's additional use will be in "gadgets" and luxury features, concepts proved out in these lower-volume applications may spawn greater future use of more functional electronic features in high-volume vehicles. Michigan producers of hydraulic and other mechanical controls will face declining business opportunities, particularly after 1990.

Finally, a major engineering challenge is presented by all of the changes described above. There is a shortage of trained, experienced, systems-oriented people in the design and manufacturing areas. In some departments, such as electrical systems design, 100% of engineers have CAD workstations; in other departments, however, the figure is as low as 5%. Increasing competence in techniques such as finite element analysis is apparent at all three OEMs, and there was broad understanding — if as yet little action — that there needs to be greater use of FEA/kinematics/simulation in earlier stages of the design process. Except in the ceramics area, materials technology was seen as an area in which the U.S. enjoys a lead over its Japanese, though not its European, competitors.

Automotive Materials

Huge increases in electrogalvanized steel demand between now and 1992 will give way, by the late 1990s, to much wider use of plastics in car bodies. This will imperil some steel and stamping facilities, but create an opening for a huge new automotive plastics industry in the state. New engines will embody far more aluminum and less cast iron, endangering many Michigan foundries and raising the odds of increased offshore sourcing.

In a normal year, the auto industry consumes about one-quarter of the nation's steel, one-sixth of its aluminum, half its malleable iron, one-third of its zinc, and one-eighth of its copper. As the average weight of U.S.-made cars has declined from 3800 pounds to 2800 pounds between 1975 and 1985, half the iron, a quarter of the steel, and a third of the copper has been removed.

The period between now and 1992, and even more the years 1993–2000, will see a revolution of even greater impact. A major drop in carbon steel is in the offing, with galvanized body steels enjoying a boom as automakers move toward greater corrosion resistance. Demand for electrogalvanized steel could exceed five million tons by 1988; that could be nearly twice the U.S. capacity to produce it, creating opportunities for Michigan steelmakers but also an invitation to greater imports. There is also the discomforting possibility (see below) that the galvanized steel boom may be of limited duration, if plastic skinning comes to dominate post-1995 new vehicle designs. In the next decade at least, however, galvanized steel demand may be the salvation of many U.S. sheet steel makers, some of which could even give up some of their noncompetitive operation in favor of cold strip "market mills" with galvanizing facilities that buy hot band from integrated mills.

There is likely to be increased aluminum usage in cars by 1992, but more in castings than in wrought parts. Average aluminum per car has risen from 75 pounds in 1970 (of which 60 pounds was in castings) to 130 in 1985 (110 in castings). This figure is expected to rise only modestly, to perhaps 150 – 200 pounds, by the mid-1990s. Major applications will be in cylinder heads, intake manifolds, and -- though to a lesser extent – engine blocks. In the case of cylinder heads, this will present opportunities for Michigan casting operations, but also risks of lost business to such foreign sources as Fiat-Teksid (maker of most of Chrysler's aluminum heads) and to more experienced domestic sources in Indiana and New York. Wheels and possibly radiators are among other applications in which increased aluminum usage is predicted, with mixed implications for Michigan companies. The state's concentration of iron foundries, captive and independent, however, suggests some significant negative impacts for establishments that do not quickly master aluminum casting technologies.

Even more revolutionary in its potential future impacts is the accelerating use of engineering plastics in a widening range of structural and decorative applications. As redesign permits the realization of some of the system simplification and contouring possibilities of these materials, plastic per car should increase from about 220 pounds today to over 300 by 1992 and perhaps 350 by 2000. As many as a million light vehicles may have mostly or entirely plastic outer skins by 1992, and many more (perhaps 50-70%) by 2000. This will have obvious implications for steel demand, for stamping plants and presses, and for diemaking establishments in the state. It will also present major openings for new business in molding, patternmaking, heavy presses, and the like, openings that need not, however, be filled by Michigan firms.

Product differentiation possibilities expand at low cost with the use of plastic panels: common mounting points allow different panels on the same space frame, and tooling costs for plastic are about half those for steel, permitting 3- rather than 6-year reskinning cycles. Even more exciting from a cost reduction standpoint, significant parts consolidation is permitted when a properly-designed plastic part replaces several welded subassemblies; this could revolutionize seats, underbodies, and (see below) fuel tanks in the 1990s.

Beyond plastic skins, bumpers, headlamps, springs, and – if legal liability issues can be solved – fuel tanks are all areas in which plastics promise to make major inroads. In the bumper and fuel tank areas, this could mean significant negative impacts for certain Michigan OEM plants, while presenting new opportunities to others and to certain independents: stamping press and molding press companies, and makers of tooling for stamping dies and for plastic molds, are not typically the same firms. Stamping plants that have received significant recent investments are probably secure; it will be 2000 at the earliest before any near-complete changeover to plastic bodies could occur.

Finally, by 1992 we may begin to see somewhat greater use of magnesium castings and of ceramics in engines and heat exchangers. Magnesium applications might increase as a way for the auto industry to avoid overdependence on aluminum suppliers. If that occurs, the main impacts would be felt by die casting firms supplying such castings as transmission and transfer cases, alternator and air conditioner brackets, valve covers, clutch housings, and steering column brackets. We know of no Michigan facilities involved in die casting magnesium. In ceramics, systemic use will likely remain limited to diesel engines; slow penetration of ceramics into cam follower facings, turbocharger hot wheels, piston crowns, and exhaust port liners is possible by 1992. At least one Michigan independent and one captive plant have been cited for interest and prowess in the field, with regard to ceramic fiber-reinforced aluminum pistons and diesel engine applications, respectively.

Production Technologies

New advances in programmable automation promise a more competitive state automotive economy, and make plausible a Southeastern Michigan "Automation Alley." These advances also pose mighty challenges for Michigan machine tool and tooling firms; in the near term, at least, much more offshore sourcing will be seen in major production systems. If, however, Michigan firms can master the new technologies, especially in the software area, a wealthier "CIM Economy" is possible in the 1990s and beyond.

Emerging technological changes will be the major determinant of whether the U.S. remains the dominant producer in its home market. Those changes will also do much to determine where new facilities are located, which existing plants survive, how large new component and vehicle modules will be, the relations among tiers of producers, and the demand for labor and its skill requirements. The trade and popular press already trumpet a CIM Economy; the extent to which reality catches up with the rhetoric, and islands of automation become integrated systems, will write the industry's history between now and 1992. It could provide the basis on which the equities of all stakeholders are preserved in a more competitive future, or simply be disruptive and expensive without reducing costs enough to restore competitiveness.

The nature and pace of arrival of a CIM Economy will depend on politics as well as hardware and software capabilities. For all stakeholders to benefit, the transition must be bargained. The OEMs will seek across-the-board cost reductions, forcing suppliers to transform tools and methods. Labor will have to bring to the table a plan for its participation in a new regimen of flexible adaptation and heightened competition. State government must seek to maximize Michigan's share of the value embodied in the vehicles sold in North America.

Flexible manufacturing systems can deliver both adaptability (the ability to sequence serially different designs within a part family without equipment resetting) and convertibility (the ability to switch between, say, six- and eight-cylinder blocks), and so promise to allow component plants to achieve high productivity despite highly variable day-to-day and week-to-week volume requirements for particular products. In bodies, flexible assembly promises to permit a wide range of body styles to be produced on the same line with the same equipment, which includes robotics and AGVs, and to convert a line much more quickly. This would allow elimination of mobile work assignments, solving the problem of fabrication time differences between modules. A major obstacle to wider implementation of flexible systems remains the economic justification process.

Michigan automation suppliers are at various levels of readiness to play on this field. Some are strong in dedicated systems that may suffer as flexible equipment takes over. In other cases, e.g., machine vision, Michigan is emerging as a leader; in robotics – particularly complete systems – the state is also doing well. The vision of a southeastern Michigan "Automation Alley" is increasingly plausible.

Flexible systems demand flexible delivery. JIT methods, discussed under Manufacturer-Supplier Relations above, are being closely studied to determine the extent to which frequent modifications of 10- and 20-day build schedules are necessary; the answers reached by each OEM will have a substantial effect on the degree of flexibility demanded of various parts producers.

Increasing use of aluminum rather than iron castings is about to be accompanied by major technological shifts within aluminum casting, away from permanent molds and toward lost foam and similar processes that aim at smoother and more repeatable surfaces, more cast details, and hence less subsequent machining time. Mastery of lost foam technology could speed conversion to all-aluminum engines, with Michigan impacts already noted in Automotive Materials above.

Among the keys to more flexible assembly is the emergence of adhesive bonding to replace some welding operations. Use of galvanized and zinc-coated steels and of plastic composites can be expected to increase the trend to adhesives. This will have potentially serious impact on Michigan producers of welding guns and other equipment, and cut electricity demand considerably.

The data communications requirements of flexible systems present a major challenge to the state's many machine tool companies as well. Nearly 30% of 1986–92 automotive automation spending will be in the communications area, as machines and islands of automation are joined together and with management information systems into true CIM. Yet the state's two largest machine tool companies employ 38 programmers between them; clearly, the missing link in these companies' systems capability is in software skills. Michigan firms, many of which began as tool, fixture, or die builders and later made the move to dedicated transfer machines, got good at meeting OEM purchasing departments' low-bid and fast-delivery demands (often producing to OEM-supplied process specs) but not at supplying leading-edge technology. Meanwhile, European and Japanese machine tool makers – many owned by auto OEMs – were used as laboratories as well as job shops. This explains the increasing import share in flexible systems, as well as one U.S. OEM's recent equity purchase in a European-based automotive machine tool company.

Tooling firms are going to have to move quickly into NC and CAD/CAE if quality and productivity are to improve. Smaller outfits are likely to lack the skills and capital to make the move, and those that survive may do so by forming consortia in which some concentrate on providing CAD/CAE services, others on prototype tooling, others on NC machining, and still others on construction and tryout.

Activities in tooling may also influence the rate and extent of plastics usage in parts, skins, and space frames. Though tooling costs for plastics are only 40 – 60% as high as for steel parts, there is a chance that a new stamping die production method based on casting rather than machining may reduce or eliminate the tooling cost gap.

Finally, it must be noted that these and other emerging flexible technologies will have implications for facility size, capacity, and location. If programmable automation really achieves economic production at sharply lower volumes than today's dedicated lines, it could signal the breakup of large centralized parts plants. That would spell trouble for Michigan's many regional foundries and engine, stamping, and transmission plants. On the other hand, more and more vehicles may be produced in low-volume runs, making it impossible to justify multiple sets of tools for decentralized part/module production at or adjacent to most assembly plants.

AIM PROJECT RECOMMENDATIONS TO THE STATE

In the very large and turbulent arena of auto in Michigan, there is obviously much to do. The body of this report contains hundreds of what might be termed micro-recommendations for State and local government, company, and trade union action. We recognize that for each party, and perhaps especially for the State, it is not easy to set priorities and invest limited resources.

In the pages that follow, we identify twenty fronts of State activity that we believe are proper priorities. Success on these fronts is most likely to secure or expand industry opportunities for Michigan citizens, communities, and companies.

We possess no realistic way to "cost" these efforts, but the nascent strategic plan they represent would obviously require a major investment by the State. We believe such investment is justified. Indeed, we call these recommendations strategic because we think their successful execution will bring a high return to the Michigan economy. Just as intense competition has compelled industry to unprecedented investment, so State government is similarly challenged.

We also acknowledge that even a selective effort on some of these twenty fronts would exert heavy pressure on the current staff capacities of the State. We hope State government will continue to add able staff who work with the industry, for we believe that in this area expanded public employment is a very sound investment. We also think it is time to seek support and closer cooperation from industry. The AIM Project, itself, may be a good example of such partnership.

We see these Recommendations as a "living document" constantly evolved by unfolding events and a continuing dialogue with the automotive industry and all its Michigan stakeholders. That dialogue should be lively. We are aware that some of our recommendations are unusual in their specificity. The times require candor, and action.

AIM RECOMMENDATION I : WORK TO SECURE EXISTING MICHIGAN ASSEMBLY PLANTS BEYOND CURRENT PROGRAMS

This should be the State's most important single front of activity.

Most Michigan assembly plants house currently healthy young programs or have been scheduled in solid company plans for successor programs. Thus it is possible to focus State attention on those few assembly plants currently at risk. Let there be no complacency regarding the others, however. The auto industry is volatile as never before. The proposed AIM method for monitoring the prospects of each Michigan assembly plant should be improved, and this rough tool must never be seen as a substitute for regular, candid discussions between the Governor, the Commerce Director, and the senior leadership of the Big Three.

We have identified four Michigan auto assembly plants at high risk in the 1986–92 period and thus a priority for State attention. These are:

General Motors CPC Pontiac Plant 8: The risk can be redeemed by the contemplated siting of the GM80 program there. The State should work to consummate that investment and provide programs and planning that will assure a major contribution to the program from suppliers in Michigan.

General Motors BOC Clark-Fleetwood: This aged, landlocked, split complex presents serious difficulties. It is an important source of employment for Detroit. The State should work with GM and with the City of Detroit to develop a post-1990 plan that will preserve at least some of the job-generating potential of the two sites. One possibility may be assembly of a low-volume niche vehicle less compromised by the configurations of Clark-Fleetwood. Another may be rededication to component fabrication within or external to GM. A third, but expensive alternative, is clearance of the sites for presumably less job-intensive new projects, an option preferable only to mothballing.

Ford Wayne and Dearborn Assembly: The two Ford assembly facilities at risk are best addressed with a coordinated strategy. As we argue in the Report, the Wayne Assembly plant building Lynx/Escort has a good reputation within Ford, but houses an import-vulnerable program with a secure future at best through 1991. The longevity of Dearborn Assembly, the stressed keystone of the once-mighty Rouge Complex, may determine the ultimate future of most of the 16,000 jobs still at the Rouge.

The State should set an objective of maintaining high-employment, highly Michigan-linkaged assembly programs at each site well into the 1990s. What those programs might be, their allocation between the two facilities, and their potential ties to other Ford or Ford-related capacity in Michigan would clearly be determined primarily by Ford's evolving global strategy. The contingencies of market size and segmentation, and Ford's anticipated market share, future production efficiency, labor relations and so forth will determine what successor programs are at least candidates for one or either of the two facilities. We think there might be a number of viable combinations. Posing the State's objective to Ford and the UAW now, and evolving a variety of plans for the State's participation in and contribution to extension of high-volume Ford assembly in southeastern Michigan will, we believe, provide the best possible context for eventual success. Such an approach may also be the best way to bring Alpha to Michigan if that project becomes a production program.

AIM RECOMMENDATION II : PURSUE NEW VEHICLE PROGRAMS OF U.S. AUTO MAKERS THAT WILL REQUIRE GREENFIELD ASSEMBLY FACILITIES

From the public viewpoint, adaptive reuse of existing major assembly facilities is to be preferred as the least-social-cost path to continuing auto employment and tax base. Buick City, Dodge City, and Lansing Assembly are excellent examples.

As assembly technology rapidly evolves, however, some of Michigan's older plants may not remain viable, and the number of U.S.-based vehicle programs may exceed the stock of U.S. assembly facilities.

The State should constantly monitor the forward plans of the auto makers to identify new vehicle programs and siting plans. As the market becomes more segmented and as niche and near-niche cars proliferate, these plans will become more complex, especially as more flexible production and assembly operations permit multiple program production within single plants.

Within the increased complexity, one factor is certain. The U.S. auto makers <u>will</u> build new assembly facilities. These huge chunks of investment may not come at the pace of the past half-decade, but constant State attention to the prospect of major greenfield investments is essential.

Unfortunately, greenfield development is expensive, complex, and quite "mobile" before the siting decision. In the post-Saturn environment, regrettable but inevitably intense inter-state competition for these flagship facilities will increase. The State's well-proven capacities as a competitor should be reinforced with a larger staff complement focused exclusively on these prospects. Michigan's highly-praised effort on Saturn can serve as a precedent.

Fortunately, Michigan is in a superior position to justify and redeem the large public investments now required to secure greenfield assembly facilities. The existing agglomeration of automotive capacity in Michigan offers the State an opportunity to maximize its return on these investments through programs that are designed to intensify the links between the facility and the Michigan automotive base. The higher the proportion of Michigan value added embodied in the car or truck, the greater the eventual state and local government revenues realized. To the extent that the Michigan automotive base is modernizing to remain competitive, sourcing from Michigan will usually be the cost-efficient decision for the Michigan assembly facility.

We do not propose a rigid "Michigan Content" policy; that would be absurd. We do strongly advocate direct State-OEM discussions regarding sourcing of inputs to major programs on a project by project basis. Such discussions should be a regular feature of program development comparable to ongoing dialogues about specialized tax and regulatory treatment, labor training, infrastructure, and technical assistance. Success in encouraging high Michigan content in Michigan-assembled vehicles will be a direct function of success in promoting the competitiveness of the Michigan supplier base. We also suggest that the State constantly improve its ability to model input-output and econometric projections of the public returns from major industrial investment.

AIM RECOMMENDATION III : CONTINUE AGGRESSIVE COMPETITION FOR ASSEMBLY PLANTS OF FOREIGN AUTO MAKERS INVESTING IN THE U.S.

During the next few years, a window of opportunity is open to attract a limited number of Japanese assembly facilities that will be sited in the U.S. for both logistical and political reasons. The State should seek to replicate its success with Mazda.

The landing of Japanese (or possibly other) foreign assembly plants does pose special issues. These plants are likely to build vehicles that will be market winners anchoring secure assembly jobs. Based on past and current practice, however, their product will have low U.S. content, at least in the initial years of operation.

In crafting the package of State incentives that will attract and support these desirable facilities, special attention should be given to programs that will help the auto maker build up a competitive Michigan supplier base, especially among existing Michigan firms. In instances where a foreign supplier is considering a U.S. facility to serve the auto maker, the State should always explore the prospect of a joint-venture with an existing Michigan firm. Such relationships require care and diligence to consummate. Success on this front, however, will tend to contain both the economic and political costs of a rising tide of Japanese supplier firms that will also quest for the business of U.S. OEMs in direct competition with traditional sources, often in Michigan.

AIM RECOMMENDATION IV : COMPETE TO HOST NEW ENGINE FACILITIES

The U.S. industry has begun a major program to redevelop its powerplants. New engine designs, new materials choices for principal components, and new machining methods are the order of the day. Michigan has already benefited from substantial OEM reinvestments in existing engine facilities and appears to be in line for more. Because powerplant transformation will surely generate several more facility decisions in this decade, engine plants should be a priority target for Michigan.

To compete aggressively, Michigan should try to increase aluminum smelting and casting capacities in the state, since a significant increase in the aluminum content of engines is certain. This may require actions focused on specific facilities (see Recommendation VII, below). Michigan's engine plant prospects will also be advanced by the establishment of the GM CPC Prototype Production Facility in Auburn Hills, and perhaps by offering assistance to Michigan's traditional specialists in engine machining line systems as they improve their relations with the OEMs.

AIM RECOMMENDATION V : ATTRACT ADDITIONAL GALVANIZED STEEL CAPACITY TO MICHIGAN

The surging automotive demand for galvanized steel will create a projected shortfall of as much as two million tons by 1987 despite the five U.S. electrogalvanized mills that will be in production by then. If the State can confirm the magnitude of this shortfall and the need for new capacity, communications should be established with all potential investors in the steel community. The State should commission a detailed study presenting the opportunity to serve automotive demand in the Midwest, perhaps in partnership with a leading utility.

AIM RECOMMENDATION VI : ESTABLISH MICHIGAN AS A WORLD CENTER FOR ENGINEERING PLASTICS APPLICATIONS IN AUTO

Light weight, corrosion resistance, ease of complex configuration, and low tooling costs for many fabrication processes are among the features increasing the appeal of engineering plastics in the automotive industry. Michigan has a solid opportunity to establish clear leadership in both plastics engineering and high volume production.

With Fiero production solidly established in Pontiac and the strong prospect that the GM80 program will also be sited there, southeastern Michigan may host assembly of the only mid- and high-volume plastic-skinned cars to reach the market in the 1980s. With State attention and support, the demand generated by the two programs could become a magnet drawing additional investment in applied research; specialists in molds, presses, and other tooling for plastics; and parts production, especially body panels.

The State should encourage and perhaps even help convene "vertical plastics consortia" of materials producers, tooling firms, engineering/design services, parts makers, and auto OEM customers. Such consortia have promise as integrated, problem-solving teams that can help the industry "build quality in." The State might use the good offices of the planned Michigan Materials Processing Institute (MMPI) to accomplish this specific objective and as an ongoing source of applied research in the area of engineering plastics.

AIM RECOMMENDATION VII : ADDRESS THE OPPORTUNITIES AND RISKS IN THE SHIFT FROM IRON TO ALUMINUM

The modest shift in automotive demand from iron/steel to aluminum during the next decade could have a significant impact on Michigan if the state hosts some of the new aluminum-intensive engine programs. This shift could pose a serious challenge to Michigan's ferrous foundries. The most cost-efficient means for the State to address this risk may be to approach the leadership at one of the largest ferrous foundries with an offer to explore means of State support for conversion to aluminum capacity and expertise. This pro-active tack may or may not generate interest. Nothing ventured, nothing gained; and should Michigan be building two mostly-aluminum engines by the early 1990s, there is much to win, and lose. The Michigan value-added in those engines will be much higher if most major components are cast in our foundries.

Should a conversion strategy prove unsuccessful, the State should aggressively recruit independent casting firms with expertise in aluminum. If OEM aluminum component demand does surge in Michigan, a timely independent, State-sponsored "market opportunity" study could target both casting firms and smelters.

AIM RECOMMENDATION VIII : MONITOR THE POTENTIAL SHIFT FROM REGIONAL TO ASSEMBLY-PLANT-DEDICATED MAJOR COMPONENT FACILITIES

If flexible automation should dramatically lower the volumes at which economic production of some major components becomes possible, and this flexibility can encompass the demands of specific assembly plants with multiple programs and models, then the industry may enter an era in which smaller stamping, transmission, and even engine plants are built to serve specific assembly operations. This could lead to an eventual break-up of Michigan's many regional component plants that now serve several assembly facilities here and elsewhere, at painful cost to Michigan's share of U.S. automotive value added.

This is not a mid-term prospect. Major investments in key regional components plants by all three Michigan auto makers suggest they are viable for many years to come. However, the possible cost of this particular aspect of a future CIM-economy does suggest careful monitoring and an open dialogue with the car makers to anticipate the development, should it come.

AIM RECOMMENDATION IX : SPONSOR PLANNING FOR MAJOR COMPONENT PLANTS AT RISK

Even if regional transmission, stamping, axle, and other major component plants are not at long-term, wholesale risk from flexible automation, individual plants may be in immediate danger as demand swings away from their distinctive capacities. In the chapters that follow we identify some Michigan facilities that are cause for concern. The State should develop procedures for handling major reductions of operations and closures at problem plants.

Trusted liaison with the auto makers and major supplier firms on this front will yield early warning. With time to evaluate options, and with company, labor, and government stakeholders at the table, plans for conversion to viable operations are at least more likely. Where rededication within the auto industry under the current ownership and contract is impossible, buyouts may be an acceptable if difficult option. Even when a shutdown is unavoidable, a failed early effort to plan reuse may at least provide better mechanisms for managing the termination. In light of the huge social costs of a major plant closing, State sponsorship of plans that seek adaptive reuse, or at worst managed shutdown, are a wise public investment.

AIM RECOMMENDATION X : SUPPORT MODULAR SOURCING "CHAINS" IN MICHIGAN

Modular sourcing is coming. Key first tier suppliers with design and concurrent engineering expertise will increasingly take responsibility for developing whole chunks of the car, organizing their production, and assuring their delivery to final assembly sites.

Michigan can best defend its interests in this new environment through a deliberate policy of sponsoring relations among Michigan firms that combine their talents for successful development and production of modules. Maximizing the Michigan content of modules purchased for North American assembly operations, especially those in Michigan, should become an important State objective.

Facilitating "Michigan module chains" logically begins with identifying those modules that are likely to be required by OEM assembly operations in the state. Learning which firms have been or probably will be selected for modular responsibility is the next step. (In subsequent years, the AIM Project can assist the State in this task.) These winners or strong candidates should be invited by the State to discuss ways in which State actions and targeted incentives can assist them in organizing clusters of competent Michigan firms for producing the module. These discussions may well work best when a Michigan operation has the module contract, but are also appropriate for non-Michigan firms considering modular production in the state. In the latter case, State technical assistance may be particularly valuable.

This strategy will be effective only to the extent that Michigan's potential subcontractees in modular clusters are seen as attractive participants in the multi-year, highly-interactive, mutually-dependent interfirm relations required. The State should find ways to support effectively the technological modernity of Michigan's smaller suppliers. The State should provide industrial parks for modular production clusters where geographic proximity is desired. The State should do all it can to facilitate Michigan siting of OEM and first-tier supplier engineering and prototype operations, for these are where the informal vertical consortia of firms involved in modular cooperation will often be formed and nurtured. In cases where the chain of relationships is being organized, the State should address the needs of the chain as a whole, and openly craft its labor training, development finance, technical assistance and other resources to maximize participation by Michigan firms.

AIM RECOMMENDATION XI : SUPPORT THE TECHNICAL DEVELOPMENT AND FLEXIBILITY OF MICHIGAN SUPPLIERS

Only those firms that stay in command of the new technologies relevant to their operations will remain the low-cost, high quality participants demanded by the auto industry.

In this case, the State may already have developed a plan of action. Assisting the broad base of Michigan manufacturing to adapt to the new environment through providing information, direct technical assistance, labor training resources, access to qualified industrial consultants and occasional financial support for acquisition of new technology is a worthy if ambitious mission for the State's new Technology Deployment Service. Because that announced Service will operate at the forward edge of the State's campaign to support Michigan's industrial competitiveness, it should be rigorously evaluated at the end of its 1986 pilot year.

AIM RECOMMENDATION XII : PROVIDE ORIENTATION ON JIT METHODS FOR SMALLER SUPPLIERS

"Just-in-Time" objectives have become part of the vocabulary of the industry over the past three years. True acceptance of JIT methods as a potential source of cost-efficiency throughout the tiers of automotive supply is less developed, however, in part because OEM implementation has proceeded quite deliberately. The pace of JIT is now quickening. Many more medium-sized and smaller suppliers will soon be required to adapt their operations or risk rejection in the automotive market.

The State has a clear interest in building the JIT abilities of the supplier base in Michigan. For the OEMs, all other factors being equal, the closer supplier will be preferred. Given the huge demand generated by Michigan OEM facilities, Michigan can win, or lose, major shares of supplier business depending on how well most suppliers in the the state can perform to their JIT standards. Indeed, the "modular sourcing chain" strategy proposed above is compromised without JIT capacity in the broad supplier base; the same may be said for the State's prospects in attracting major investors that must depend on proximate suppliers who "get it right the first time and get it there at the time."

The State has already shown it can make effective use of the Michigan community college system as a means to bring resources and training to the smaller manufacturing firms that do not have large internal training staffs and cannot be a priority for the OEMs' supplier development efforts. The 1984–85 pilot project in training such firms in statistical process control is widely regarded as a success. The State should build on this base and launch a comparable program in JIT methods. The Automotive Industry Action Group has already piloted appropriate materials and is prepared to work with a State-sponsored program.

AIM RECOMMENDATION XIII : IDENTIFY PRIORITY TECHNOLOGY-TAKEBACK AND TECHNOLOGY-KEEP OPPORTUNITIES

The promise of a CIM-Economy is premised on the prospect of technology-driven cost reductions large enough that their realization could return to, or at least retain in, the U.S. and Michigan work that has left or will otherwise leave. Unfortunately, some proponents of the "automate or die" thesis – correct as far as it goes – stop with the rhetoric and fail to note the products or product types in whose production the application of advanced manufacturing technologies may have the biggest payoff.

The State needs to know which those are, so that its limited resources may be brought to bear where they will accomplish the most. Increased capacity to cast and machine alloys of aluminum and to design and mold plastic panels have emerged from the work herein summarized as among the opportunities to win for Michigan work increasingly being done in Europe, Mexico, Brazil, and in the U.S. but out of the state. Breakthroughs in multiplexing and fiber optics have also been noted as possibly permitting retention of the function now performed by copper wiring harnesses, more and more of which are being imported from Mexico and the Pacific. The possibility of more local production of manual transaxles as a result of simpler designs and the aluminum processing capabilities noted above is another such potential opportunity.

More such "technology takeback" and "technology keep" opportunities must be identified. The AIM Project should make such prospecting a priority in future work. Once opportunities have been identified, specific technology application programs can be explored with the producing companies, the Industrial Technology Institute, the Technology Deployment Service, and other Michigan resources.

AIM RECOMMENDATION XIV : ENCOURAGE AND ASSIST INVESTMENT - WORK PRACTICE AGREEMENTS BETWEEN UNION AND COMPANY

The State should be prepared to act as a catalyst for the negotiation of agreements between trade unions and Michigan manufacturers that embody explicit deals linking more flexible union work practices with management commitments to maintain and increase local production. The recent labor-management atmosphere of cooperation could be short-lived absent such contractual tradeoffs. While a particular company may have no strong preference for local versus distant production in a particular product situation, and while a union may wish to maximize short-term employment through retention of certain work practices, the public's interest is clearly in attracting to, and anchoring in, Michigan work that might be performed elsewhere in the absence of a more flexibly-deployable workforce.

The key here is not the a priori virtue of greater work rule flexibility, but its potential synergy with the kind of "tip-point investments" described in the previous recommendation. Just as the State's efforts on the technology deployment front should be focused on product lines in which flexible automation could confer a location-determining technological edge, so too its encouragement of investment-work practice deals should place emphasis on situations in which work practice changes would be most likely to justify the flexible automation investments that can "tip" the location scales in Michigan's favor.

AIM RECOMMENDATION XV : PURSUE PARTICIPATION WITH GM/UAW AND FORD/UAW BUSINESS DEVELOPMENT GROUP INVESTMENTS IN MICHIGAN

The 1984 UAW contracts with General Motors and Ford featured promising innovations enabling co-development of new business opportunities that will employ UAW-represented labor. Company-Union Groups are now meeting to develop the respective structures for decision-making and to seek worthy projects for investment. If appropriate opportunities are found, $ 100 million of General Motors and $ 30 million of Ford capital is available during the next two years.

These new departures are important to Michigan far beyond the welcome prospect of additional private sector business development capital. Properly approached, they can become "learning labs" in which the union, the companies, and the State can discover ways in which to support one anothers' interests while cooperating in job creation.

The State must win the privilege of participation with the partners that have created the Groups and their funds. State representatives who understand the industry and the union should meet with the Groups to inform them of State government's substantial economic development resources and convey the State's strong interest in supporting projects brought forward by the Groups. Projects could take the form of planned conversions of existing capacity, or new product development, or combinations of both. The State has tools that can address any of the possibilities.

If Michigan's future as a successful industrial community depends in part on the quality of the cooperation at the Development Bargaining Table we imagined in our Preface, then the State should make it a matter of pride that the initial projects funded under these 1984 contract innovations be sited in Michigan, home of the industry and birthplace of the union.

AIM RECOMMENDATION XVI : SPONSOR A MICHIGAN TRAINING ACCORD THAT CAN TARGET FUNDING TO SYSTEMATIC RETRAINING OF THE WORKFORCE

The U.S. automotive industry has now entered an era in which systematic training and retraining of the workforce is an essential condition for continuing successful domestic operations. As the tools and methods of the industry are transformed, the skills of the auto workforce must keep pace.

Unfortunately, neither the industry nor government has made sufficient progress in determining the best means to accomplish such a massive training effort, nor have the public and private sectors reached a satisfactory division of responsibility for funding and implementing the required programs. In the present environment, it is inevitable that training assistance – or, more precisely, promised funding for undefined "training programs" – become an additional, and extremely expensive, incentive offered by competing governments whipsawed in contests for automotive investment.

This is no way to run a railroad. We believe the continued escalation of ad hoc bidding wars will subvert the opportunity for intelligent bargaining of development. Funding necessary (and unnecessary?) training through a series of project-specific programs jerryrigged by incentive-mongers will surely introduce "disefficiencies" into this crucial work.

To avoid this unwelcome future, the State should explore the possibility of a Michigan Training Accord between government, the industry, and the unions (in the case of auto, predominantly the UAW). Such an Accord might embody the participants' common definition of the magnitude of the training/retraining task; the new institutions, programs, and arrangements that can best accomplish the task; and the proper division of fiscal and programmatic responsibility among the corporations, the Union, and the State.

The first step toward a Michigan Training Accord might be a State-commissioned study that would deliver a detailed analysis of the magnitude and specificity of the training needs of auto, in Michigan, during the next decade. Such a study should also provide working proposals for addressing those needs through cost-efficient means that allow all the parties to plan properly their contributions. Achieving long-range stability in the massive training effort necessary is certainly the best way to garner for the State to a defensible comparative advantage in the inevitable contests for future automotive investments.

AIM RECOMMENDATION XVII : INCREASE MICHIGAN'S SUPPLY OF CIM ENGINEERS, TECHNICIANS, AND SKILLED TRADESPEOPLE

Within the broad array of skills development efforts required for future U.S. automotive production, there is a particularly acute need for specialized talents at the "top end." Michigan's future prospects in auto will be based on continuing technological development in the industry. Thus the State should have a strong interest in producing and renewing the the skills of the engineers, technicians, and skilled tradespeople essential to the emerging CIM-economy.

The State-commissioned study and Michigan Training Accord envisioned in the previous Recommendation should focus special attention on the best ways to redress the continuing shortfall in what might be termed "CIM skills." The State is now sponsoring pilot projects at Michigan community colleges committed to modernizing their technical programs in CIM areas. With organized counsel from the auto industry and the UAW, these efforts might be matured into certificate programs tailored to the needs of auto.

Producing and retaining in Michigan the advanced engineering abilities required in the auto industry of tomorrow poses a special challenge. Bold actions may be required. We propose for consideration a Michigan Manufacturing Sciences Scholarship Program that would combine features of the NSF scholarships, GMI's cooperative engineering education, and the ROTC's of the U.S. military. The State-generated Fund would provide a full graduate engineering degree program scholarship to Michigan residents if the following criteria are met:

1) The candidate has been accepted into a post-baccalaureate engineering program at a Michigan institution of higher education;

2) A Michigan manufacturer, on the basis of the candidate's record and proposed course of study, has made a conditional commitment to employ the candidate in an engineering capacity upon completion of (and perhaps during) the degree program; and

3) The sponsored candidate agrees to work for the sponsoring Michigan firm in an engineering capacity for not less than three years, contingent upon satisfactory performance.

Michigan Manufacturing Sciences Scholarships could be in the form of convertible loans provided at no interest. If the candidate successfully completes the degree program and the three-year employment with the Michigan sponsor, the loan would be forgiven. Should the candidate deviate from this course, the loan would have to be repaid, in part or in full, unless otherwise determined by the Fund. As a matter of policy, the available scholarships might be divided between auto makers, auto suppliers, and other Michigan manufacturers with a demonstrated need for CIM-trained engineers.

AIM RECOMMENDATION XVIII : MARKET GREATER DETROIT AS AMERICA'S "AUTOMATION ALLEY"

Southeastern Michigan's credibility as a center of flexible automation comparable to previous "high tech" agglomerations in Silicon Valley and along Boston's Routes 128 and 495 will be based primarily on the interactions among firms in the area rather than on simple counts of establishments, jobs, and sales. The State can serve a legitimate purpose in marketing greater Detroit as the U.S. epicenter of industrial automation. That message will gain substance and specificity as the State works with the auto industry to intensify and enlarge our automation endowment.

Superior market analysis will serve the State's ability to retain and attract desirable automation producers. State government should seek the assistance of auto makers and first tier suppliers in projecting the potential future markets for industrial automation generated within the industry in Michigan.

Michigan's best sell as America's "Automation Alley" will be the State's proven ability to support continuing development of those firms, operations, and institutions that already constitute the infrastructure of our automation endowment. The well-launched Industrial Technology Institute and the proposed Michigan Materials and Processing Institute should remain priorities.

The emergence of large, newly capital-intensive engineering service firms in Michigan is a highly desirable event worthy of State attention. Of equal importance are the several new corporate research and development, engineering sales, and production prototype facilities that have been or may soon be sited here. The engineering interactions that take place within and between these centers are the wellsprings of innovation that can generate jobs and wealth in an automating Michigan. The power, and perhaps the legitimacy, of the "Automation Alley" metaphor may depend on how well the State links its substantial economic development capacities to the opportunities emerging in these greenhouse centers of auto in Michigan.

AIM RECOMMENDATION XIX : AID MARKET ADJUSTMENTS BY TRADITIONAL MICHIGAN TOOLING FIRMS

The mutually reinforcing development of Michigan's auto industry and the state's machine tool and tooling endowment is now at risk. We discuss the origins and scale of this problem at some length in our chapter on Production Technologies. The move toward flexibility in auto now challenges machine tool builders whose historic competence has been in the dedicated, hard automation systems most appropriate to very high volume standardized production. At the same time, smaller tooling firms face huge investments in order to integrate their operations into the increasingly digital environment of their historic automotive markets.

On the Michigan machine tool builder front, we believe useful discussions are now proceeding between the leading firms and the auto OEMs, particularly General Motors. The proper State role is to facilitate such discussions in any way requested and to consider modest forms of sponsorship that might quicken the repositioning of Michigan machine tool builders within the automotive market. One means might be a challenge grants fund targeted to applied research and development that adds to the flexibility of their products. For Michigan tool builders that are contending for or have been awarded major auto orders, the State might agree to fund a portion of carefully specified applied R&D projects relevant to the order. The State grant would be to the Industrial Technology Institute to underwrite part or all of its participation in the specific project.

Given the impending turbulence in Michigan's large community of smaller tooling and tooling accessory firms, the State might take an experimental approach in its efforts to facilitate adjustment. Michigan has much to lose if the talents resident in our smaller tooling firms are lost because a technologically transformed tooling market now requires capital investments that most smaller firms can not support. The State might consider partial sponsorship of small firm consortia that would combine the complementary abilities of several companies in larger operations that share expensive computer-based equipment, key personnel, management services, business development efforts, and a common facility. There is reason to believe that such experiments might become sources of modest product innovation as well as preserving important talents within Michigan's rapidly changing tooling sector.

AIM RECOMMENDATION XX : CONTINUE THE AIM PROJECT, DEEPEN ITS RESEARCH, EDUCATION, AND INDUSTRY DIALOGUE ACTIVITIES

Those responsible for the AIM Project have attempted an objective assessment of our capacities to make a continuing contribution to the State's relations with auto, in Michigan. We conclude we can. We believe the Project has already delivered important services for its client, and for Michigan companies, trade unionists, and local development agencies. All participants in the Project are eager to pursue the work we have begun. Like any other supplier within the industry that we study and serve, the AIM Project must pledge continuous development of its products. We are gratified that as this is written the State has already funded the AIM Project for a second year. We recognize that this new multi-year, sole-source relationship carries commensurate responsibilities.

AIM CAPSULE SUMMARY OF ANTICIPATED 1986-92 DEVELOPMENTS

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	 NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Aging RWD car assembly programs	Three Michigan OEM assembly plants at risk, '89-'92.		o Axle plants o Clark/Fleetwood o Dearborn Assembly o Pontiac Plant 8	o Unlikely to outlive B run o No plans after Fox program o Reportedly to get GM80 in '90
Increased import share in light vehicles	From 25% in '85 to 30-40% by '92		Big 3, esp. Chrysler, and AMC and VWA small car plants, and component plants that supply them	This will have a major effect on plans for successors to Escort/Lynx, Omni/Horizon, Alliance/Encore, and J cars, and could start affecting GM's N, P, and W; Ford's Tempo/Topaz; & Chrysler's C&P programs as Japan moves upmarket.
Increased share of low-content U.S.-assembled light vehicles	From 5% in '85 to 10-15% in '92	Suppliers able to sell to new foreign-owned and JV assemblers	o Big Three and AMC plants assembling small cars o Captive and independent part suppliers selling to Big Three and AMC small car plants	Even if Michigan attracts several of these assembly plants, lost supplier business may be severe, as Japan-based suppliers compete away their Big Three work.

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Big Three increased offshore parts sourcing	From 4-8% in '85 to 8-15% by '92		o Producers of drum brakes, simple steel wheels, small stamped metal and plastic parts, small electric motors, and wire harnesses o Foundries and machiners of iron engine parts switched to aluminum if latter outsourced	Major Michigan losses are likely absent rapid progress toward competitive new braking systems, plastics-intensive modules, multiplexing, and aluminum processing technologies by Michigan firms.
Decreasing OEM vertical integration, partly through outsourcing of complete modules	By '92, a 5-7% decrease in OEM vertical integration	o Larger, first tier suppliers with world-class technology that can assemble full doors, corners, etc. o Small suppliers with proprietary technology	Producers of many discrete parts with no current relationship with larger suppliers	Main beneficiaries of OEM outsourcing will be offshore and larger, multinational suppliers. Smaller firms will have to find the appropriate position in the more tiered structure. The higher the tier, the greater the technological competence required. Sourcing based on personal contacts may become less important, as telecommunications permits rapid interactions among distant players.
Smaller, more clearly tiered supplier base	Continuing shakeout of small suppliers			
Requirements of delivery and of design electronic connection to OEM customers		o CAD/CAE vendors	Suppliers lacking CAD and electronic communication know-how	

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	 NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Just-In-Time	Probably dominant by '92 for OEM assembly plants	o First-tier suppliers that locate close to assembly plants o Short-haul carriers o Suppliers of automated testing equipment	o Remote first-tier suppliers o Smaller suppliers if discrete parts sourced offshore and out-of-state to offset first-tier suppliers' new warehousing costs o Long haul carriers	Big question mark is whether JIT will result in clustering of many, or only of first, tiers of suppliers. Worst result for Michigan would be proximate first-tier suppliers assembling modules composed of parts made out-of-state—a distinct possibility.
Trend toward more flexible job assignment and work teams	Continuing trend in import-competing or at-risk assembly and stamping plants	Michigan plants tied to small vehicle programs	o Skilled trades employment o Production worker employment unless flexibility returns or retains enough work to offset	The key is whether new arrangements that allow work practices and compensation to reflect product-specific competition will make a difference in major Michigan/non-Michigan sourcing decisions.
Increased wage and benefit tiering, and effect on pattern bargaining	Possible end of Big Three masters' application to many OEM parts, and perhaps small car assembly, plants	High-labor cost suppliers	Labor unions' internal solidarity	

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Continuing shift from RWD to FWD and 4WD	By '92, some 85% of cars and 10% of light trucks FWD, up from 50% and 2%, respectively, in '85. 4WD could be 10-25% by '92.	o Transmission plants making front-drive transaxles. o Major independents making 4WD cases and other parts, including CV joints	o Axle plants o RWD-based transmission plants o Producers of prop shafts, U-joints, and some rear suspension components o CVT: gear and clutch makers	Michigan stands to gain about as much in transmissions as it loses in rear axles and other RWD parts, but losses concentrated in Detroit area. Advent of CVT could mean more offshore sourcing and/or new opportunities for OEM transmission plants.
Changes in transmissions including possible CVT	If belt manufacturability problems solved, could have a few CVT's in '87-88, and 5-10% by '92 in cars up to 2.5L. Simpler transmission designs requiring less machining could bring offshore manuals home after 1990.	o Captive and independent transmission makers o Aluminum casting and machining plants o CVT: belt manufacturerers		
Trend toward unibody and space framing in passenger cars	By '92, body frames will disappear from cars. Unibodies in 90%, space frames in 10%.	Space frames: if steel, die shops; otherwise aluminum extruders and plastics makers (resins, molders, etc.)	o Frame plants o Captive stamping plants	Space frames may dominate by 2000, if their assembly can be automated, providing an edge over Japan. Even if Michigan is a major player, though, expect big losses in regional stamping plants.

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Emerging trend toward on-site dedicated body panel stamping operations	All Japanese-owned plants, NUMMI, Saturn, and one W car plant by '88; more by '92?	o Flexible press line manufacturers o OEM or independent stampers willing to build next to assembly plants	o Regional OEM stamping plants o Transporters of body stamping o Independent large panel stampers not near assemblers	If on-site stamping catches on, regionals would be hurt after 1992. Recent major OEM investments suggest <u>non</u>-Michigan stamping plants more at risk.
Increased use of galvanized steels	75% of steel for post-1986 vehicle programs will be galvanized	Electrogalvanizing mills	Conventional sheet steel mills	Electrogalvanized steel for body panels may be a stage between uncoated steels now and plastic panels in the 1990's, so large investments may have short lives.
Major engine redesign efforts	50% of car and light truck engines redesigned '86-92; 80% '86-95	o Aluminum suppliers o Producers of valves & hydraulic lifters o EFI makers o Equipment cos. that get new orders	o Old engine plants o Iron foundries o Stampers o Carburetor makers o Equipment cos. that lose out to European and Japanese competitors	Most Michigan engine plants are secure through 1992, but if flexible automation reduces module size and/or if casting and maching operations are integrated, after '92 could see engine plants dedicated to assembly plants, spelling trouble for Michigan engine facilities.

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	 NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Trend to aluminum engine blocks	From 1% in '85 to 10%+ by '92	o Aluminum foundries o Joint ventures with foreign experts (e.g., Fiat) o Independent and captive aluminum casters that master lost foam technologies	o Cutting tool manufacturers o Iron ore mining and shipping o Captive foundries and machiners w/o aluminum capabilities	o Could begin to see union of casting and machining, bringing risks to existing foundries and engine plants. o Excess iron casting capacity will endanger captive foundries. Trend to offshore sourcing could intensify, and include blocks as well as heads.
Trend to aluminum cylinder heads	From 10% in '85 to 45%+ in '92			
Increasing use of aluminum in intake manifolds, wheels, and radiators	By '92, nearly 50% in intake manifolds, 10-30% in wheels, and 20-70% in radiators		Independent wheel manufacturers if OEM make own aluminum wheels	o Unless steel wheel makers switch over, net Michigan losses expected. o Radiator materials depend on price of copper; big determining investments will be made soon.
Increased use of magnesium castings	Could increase sharply in '89-'92 period if aluminum use rises significantly	Magnesium diecasters	Aluminum diecasters	Main impetus for switch would be to avoid overreliance on aluminum industry. Application candidates include transfer cases, valve covers, clutch housings, and steering column brackets.

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	 NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Plastic body panels	From full-skin niche applications (1985: 100K cars) to 300-500K light vehicles by '92; major panels on 1.5 million+ '92 vehicles	o Resin-makers o Moldmakers close to assemblers o Large press makers o Molders o Patternmakers	o Steelmakers o Stamping plants o Die shops o Machine tool forming press manufacturers	Major impacts likely, esp. after 1990. Big Three stamping is centered in Michigan, so our steel and stamping facilities are in danger.
Increasing use of plastics in bumpers, fuel tanks, headlamps, wheels, springs, and radiator tanks	By '92, about 50% of bumpers plastic. Others slower to penetrate market	o OEM plastics plants o Resin-makers o Moldmakers close to assemblers o Injection molding machine firms	o Small metal part stampers and machiners o Platers	Headlamp switch well along. Slow change in springs, wheels, and fuel tanks. Bumper plants at some risk. Post-'90, large impacts possible as redesign could mean less use of non-integrated parts.
Electronics usage rise, especially in controls for engines (incl. EFI) and transmissions	By '92, 12% of average vehicle's value will be in electronics; some specialty vehicles could be 20-25% by value. 90-95% EFI by '92	o Major integrated suppliers with electronics capabilities o Semiconductor makers o Fuel injection equipment makers	o Many small cos. producing mechanical and hydraulic control parts o Carburetor makers	Michigan's problem may be that electronics companies and OEM divisions (often non-Michigan) get work that replaces what's now done by Michigan producers of mechanical controls and carburetion components.
Switch from copper to multiplexing and fiber optics in wire harnesses	Wild card: interface breakthrough could mean 90% non-copper by '92	See Electronics, above	o Copper wire makers o Wire harness makers	Impacts could be severe, as product is highly labor-intensive; but switch could also keep part from being permanently outsourced to Mexico and Pacific.

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	 NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Increased requirement of CAD/CAE, FEA, and materials expertise by automotive engineers	100% of electronic componentry CAD-designed now. Rest (now 5-70%) to 100% by '92. Tooling and die work to 60-90% CAD by '92	o CAD/CAE vendors o Design software manufacturers o Designers, esp. in engines	o Draftspeople o Tool and die shops w/o CAD capabilities	Small Michigan shops need to move quickly to survive, and to keep work from being sent out-of-state—something CAD allows. Production, manufacturing, and design engineering need to be integrated.
CIM and its effects on establishment size and location		o Makers of electronic drive machine tools o Automated equipment makers ("systems houses") o Software eningeering companies	o Makers of hydraulic-driven machinery o Makers of electro-mechanical controls o Suppliers tied to long production runs of visible parts o Large, regional engine and drive-train component makers	Economic justification problems abound. More off-line work may mean that more plant configurations are suitable for assembly. But economic production at low volumes could spell trouble for large foundries and machining (engine, drivetrain) facilities. On the other hand, faster model convertibility and "mixability" will make plants' fates less tied to particular product programs, reducing investment risks.
Flexible production equipment, modularity, and economic volumes	By '92, could have economic annual assembly runs of 30,000 engines and transmission below 200,000	o AGV manufacturers o Robotic systems makers o Custom-parts suppliers		

(1) DEVELOPMENT FORECAST	(2) IMPORTANCE IN 1986-92 PERIOD	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED POSITIVELY	(3) PROJECTED TYPES OF MICHIGAN ESTABLISHMENTS IMPACTED NEGATIVELY	(4) CRT VIEW OF NATURE OF IMPACT
Software and systems capability in machine tool manufacturing	Leading Michigan machine tool cos. have few programmers; will need many by '92.	Southeastern Michigan machine vision and software companies	Old-line machine tool firms	Lack of systems expertise and software experience predict continued offshore sourcing by OEMs of major programmable systems orders. Unless can integrate material handling, gauging, etc. with MIS, don't get full CIM payoffs.
Tooling firms' use of NC and CAD/CAE	See CAD/CAE above	o Advanced technology tooling cos. o Europe- and Japan-based entrants	Most body die manufacturers	Consortia may be necessary for smaller firms to afford equipment and avoid duplication of personnel training efforts. Vehicle programs may be delayed due to shops' slow adjustment to numerical definitions of tooling.
Adhesive bonding vs. weldments	By '92, over half of welds could be replaced by adhesives	Glue producers	o Fasteners o Welders o Welding gun manufacturers o Electric utilities	Move to greater aluminum and especially plastics use will accelerate this trend. Many small Michigan firms would be losers.

SITING OF VEHICLE PROGRAMS

Michigan is the core state of the U.S.-based assembly companies, for the past several decades accounting for approximately one-third of North America's annual production of 9 to 14 million cars and light trucks. Thus, while the future of a number of Michigan assembly facilities is by no means assured beyond the end of this decade, there is considerable basis for optimism that the state can retain —and perhaps increase — its historical share of domestic builds. At the same time, there is every reason to expect that sharp increases in imports' market share and heady gains in assembly efficiency will translate into a sharp decline in Michigan auto assembly jobs. Despite this conclusion, all of our interviewees stressed that the State needs to pursue aggressively the siting of new vehicle programs if it is to keep employment losses in both assembly and associated automotive manufacturing to an acceptable minimum.

The Central Research Team (CRT) took 29 vehicle program siting questions to a small number of corporate- and division-level managers in GM, Ford, and Chrysler. In addition, we retained the services of two consultants who have, between them, fully sixty years of immersion in the industry, virtually all of it in Michigan.

The main issues we sought to illuminate in this area can be simply stated. What vehicle programs are currently produced in Michigan assembly plants and how long will these programs continue? What new vehicle programs have been announced that will or might be sited at Michigan assembly plants? What new vehicle programs will require greenfield sites, and which of these might be sited in Michigan? What foreign-based auto makers may conduct North American assembly operations during 1986–92, and is Michigan a contender for hosting those operations? Which OEM older assembly facilities are most at risk? For those, are there innovative solutions that could extend their productive lives?

The answers to the first two questions begin with the data summarized in Table V1 at the end of this chapter.

Key Findings: Pockets of Risk

Five factors, in our view, constitute the main determinants of which of Michigan's 19 OEM assembly plants are at risk in the 1986–92 period. These are: 1) the age of the vehicle program itself; 2) the age, configuration, and labor relations history of the plants; 3) the continuing trend, particularly in passenger cars, to front wheel drive (FWD); 4) the number and segment structure of the domestic light vehicles displaced by additional imports; and 5) the segment structure of consumer preferences based on fuel prices and federal fuel economy requirements. These factors, and the risks they pose for Michigan assembly operations, should be continuously monitored; their current implications are discussed below and summarized in Table V2 below.

Three Michigan car assembly facilities are at risk due to the irreversible shift toward FWD cars: GM's **Clark/Fleetwood** operation, its **Pontiac Plant 8**, and Ford's **Dearborn Assembly** plant. All three of these facilities are old, multistory structures; none has on-site dedicated major panel stamping capacity or a fully modern new-style paint shop. By today's new plant standards, all except Pontiac #8 are labor-intensive and at most lightly robotized. All produce rear wheel drive (RWD) cars introduced more than a decade ago. Plans do exist to extend facility life through, but not beyond, 1990 at two of the three. Clark/Fleetwood apparently will be the North American plant that finishes out the decade-long run of *B* body Cadillacs and *B* body Oldsmobiles; the Chevrolet *B* body will be added in 1986 to keep the operations near capacity through at least 1989. Beyond 1990 or 1991, however, the Clark/Fleetwood complex appears to have little future, at least as a high-employment assembly operation. Age, configuration, the $200 million-plus investment required for an extensive overhaul, and the existence and output capacity of the nearby Poletown plant all point to a shutdown before 1992. There is talk of a Clark-based extension of a RWD car based on *B* and *G* body components, but no mention of such an intention on the planning schedules.

Pontiac's Plant 8, a significant success story when it reopened in late 1984 after a two-year shutdown, will cease making *G* body Oldsmobiles in or before 1989. However, we are optimistic that a major renovation of several Pontiac area facilities to accommodate a) the *GMT 400* light truck in 1987, b) the 1990 siting, either in Plant 8 or a nearby greenfield facility, of the *GM80* successor to the current Camaro/Firebird and the plastic body panel operation likely to accompany it, c) the possibility of redoing the current foundry building to house the 1991 high-volume all-aluminum 4-cylinder Manhattan engine, and d) consideration, perhaps for Plant 8 if GM80 is a greenfield project, of a new plastic-skinned Pontiac van will render the demise of *G* car output and the closing of the Complex's foundry defacto non-events.

Dearborn Assembly, where the Mustang/Capri (program name: *Fox*) is produced, appears likely to close in the 1990–1992 period. The model line will be abridged to a reskinned Mustang (renamed Mach 1) only in 1988, as half of the (Mazda) Flat Rock plant's output replaces Capri. Despite reskinning and renaming, the Mustang will at that point be an old car line indeed, one whose sales volume seems unlikely to support a complete plant for long. The cost of investing in the facility to accommodate a FWD model would certainly be substantial, though Ford (like Chrysler) has shown more inclination than GM to retool RWD plants to FWD.

Finally, Ford's Wayne Assembly Plant's Escort/Lynx/EXP (program name: *Erika*) line is at mighty risk from increased imports. The threat to *Erika* volume has already begun with the 1985 non-extension of limits on Japanese imports, and will intensify with the 1988 importation of 130,000 of Ford's Mazda-designed Mexican subcompacts. Despite this, the Wayne plant appears to be relatively safe through the late 1990's because of significant recent investment, FWD status, high quality and labor relations ratings, and its secure truck line, which is scheduled for reskinning 1992. Even if continued fuel price moderation, fuel economy law loosening, and low incremental profitability of high-U.S. content subcompacts lead to termination of the *Erika* nameplate in the 1990–92 time frame, Wayne is a likely site for a future Ford vehicle program. Moreover, unless *Erika* volumes fall over 60 % from 1985 levels, Wayne appears to be Ford's core plant for the model, and hence the last of the three North American *Erika* plants to close.[1]

Effective Policy Targets

Opportunities exist for constructive state action in each of these probable model line terminations. In the case of **Clark/Fleetwood**, public policy interventions could include 1) assistance in plant demolition to prepare a site for a future facility, assembly or com-

[1]The other two are Edison, NJ and St. Thomas, Ontario.

ponent, b) incentives to induce conversion of either or both buildings to component production,[2] and c) marketing help in transferring ownership to a foreign-based vehicle or component manufacturer.

State efforts in focused training and other areas have played a major and continuing role in raising the probability that the **Pontiac complex** will continue to operate and even grow. The success of the *P* body (Fiero), the decision to site the *GMT 400* light truck, the reported selection of Pontiac as the home of the high-volume (300,000/year) *GM 80* successor to Camaro/Firebird, the possibility of the 1991/92 Manhattan engine in the place of some current iron casting operations, and even consideration of a new plastic body Pontiac van all suggest that the Pontiac Complex may well become GM's most ambitious exercise ever in "radical brownfielding." Continued state effort to secure these programs is an obvious priority.

Ford's **Dearborn Assembly Plant** poses a mightly challenge. Unless it becomes possible to site production of the final several years of a currently non-Michigan RWD vehicle line (perhaps a truck now assembled in one or more out-of-state facilities), any effort to extend Dearborn's life may conflict with steps to site a new program at Wayne, should *Erika* be terminated (see below). One implication of this is that the state could begin to develop, working with Ford, a retention strategy that considers Wayne and Dearborn jointly.

As for **Wayne** (car) **Assembly**, its future—and state efforts to ensure that future—rests on a complex web of factors. These include Ford's decision about how to allocate future output reductions among its three North American *Erika* plants, its potential role in the expected 1991 launch of additional (to Taurus/Sable) big car capacity to replace LTD/Marquis, the siting of Ford's clean sheet *Alpha* program, the extent and timing of import competition threats to *Erika* line volumes and, as noted earlier, future plans for Dearborn Assembly.

One approach would be to seek a state working agreement with Ford that it will continue to operate three high-volume Michigan car assembly facilities (i.e., two in addition to Wixom); within such a framework, a variety of outcomes including: 1) continue *Erika* at Wayne, *Alpha* to Dearborn—brown- or greenfield; 2) *Alpha* at Wayne, new car or truck at Dearborn; and 3) *Erika* at Wayne, a new greenfield plant elsewhere in the state) would be

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[2]If pursued, this option—to be of net social benefit—should be exercised so as not to divert business from existing Michigan facilities, such as Chevy Gear and Axle or Saginaw Steering Gear.

possible, all anchoring comparable wealth creation in Michigan. The rationale is straightforward: because both *Erika* (Wayne) and *Fox* (Dearborn) are at risk programs, Michigan may need *Alpha*, some other new Ford car, or both just to stay even; this contrasts with the quest for *Saturn*, which does not directly replace or compete with any programs currently assembled in Michigan.

None of Michigan's three **Chrysler** car and light truck assembly programs appears to be at significant risk in the 1986–1992 time frame. Jefferson should get the *A* body replacement for *K* cars; Sterling Heights will add the *P* car to its current Lancer/LeBaron GTS (*H* car) line in 1987; and Dodge City in Warren, despite the loss of utility vehicles to Mexico in 1985, will add the high volume compact pickup Dakota *N* truck in 1986. However, because of the effect that a recession, coupled with a sharply higher import share, could have on small car-dependent Chrysler's future capacity plans, the State should vigilantly monitor *A* car siting developments, and be prepared to act to assure a Jefferson home for the program.

For short descriptions of likely futures for Michigan light vehicle assembly plants, see Table V3.

Foreign Direct Assembly Investments

Michigan is made wealthier when vehicles that otherwise would be shipped from Japan are instead assembled in Michigan. The State is justly proud of having landed the Mazda assembly/stamping operation in Flat Rock, and there are grounds for optimism in the quest for the announced U.S. Toyota and Chrysler/Mitsubishi plants.

That said, our work (see also this Report's chapters on input sourcing, OEM-supplier relations, and labor) suggests that primary emphasis must be placed on retaining or increasing the state's share of Big Three assemblies. Because of higher U.S. content (85-95% versus 20–50%) and greater propensity to purchase major inputs from existing Michigan suppliers, the typical Big Three Michigan assembly plant generates at least twice, and in some cases six times, as much Michigan manufacturing wealth as the typical foreign-owned or joint venture Michigan assembly operation. Moreover, that estimate of differential wealth creation is probably on the low side: not counted are the Big Three and associated supplier output losses due to displacement by Flat Rock-NUMMI-Smyrna-Marysville cars that add to, rather than merely replace, imports shipped from Japan.

None of the aforegoing is to downplay the desirability of attracting foreign direct automotive investment. Rather, it is to suggest, first, that priority one should be on retaining Big Three assembly programs and, second, that State overtures to foreign- and domestic-based OEMs alike should condition at least part of State assistance on the achievement of relatively high Michigan content.

Conclusions to Date

Despite the best efforts of the CRT and its able consultants, we have been unable to arrive at a simple yet reliable tool for predicting assembly plant endangeredness in the context of multiplant vehicle programs. While older, multistory, RWD plants that have received little major recent investment of course face a higher risk of closing, the more detailed determination of facility futures seems to require a wealth of data, often unavailable, about the internal politics and global strategies of particular companies and divisions within them.

Because of the remarkable extent to which the industry has opened its planning book to the CRT, we have some of the concrete data on which this chapter and others are based. As a result, we have concluded that landlocked assembly facilities are riskier, and that among current programs Wayne is the "core" plant of the **Erika** program, while Orion (behind Wentzville) and Willow Run (behind Flint's "Buick City") are number two plants for the C and H programs, respectively.

Still, the overriding conclusion must be that there are few predictive shortcuts; ongoing expert state monitoring is therefore essential to developing and keeping up-to-date a useful public map of the State's automotive "path to prosperity."

DOMESTICALLY-ASSEMBLED

BIG THREE CAR LEGEND

PROGRAM CODE(S)	DRIVE AXLE	DATE OF PROGRAM LAUNCH	DATE OF PROGRAM TERMINATION	NAMEPLATES
GM				
A	FWD	81		Celebrity, 600, Ciera, Century
B	RWD	77	89?	Caprice, Parisienne, 88, LeSabre
C	FWD	84		98, Electra, Fleetwood, DeVille
D	RWD	77	90?	Fleetwood Brougham
E or GM30	FWD	86		Toronado, Riviera, Eldorado
F or GM80	FWD	90		(New) Camaro, Firebird
G	RWD	78	88?	Monte Carlo, Bonneville, Grand Prix, Supreme, Regal
H or GM70	FWD	86		(New) LeSabre, Delta
J	FWD	79		Cavalier, 2000 Sunbird, Firenza, Skyhawk, Cimarron
K	FWD	86		(New) Seville
L or GM 25	FWD	87		Baretta, Corsica
N or GM 20	FWD	85		Grand Am, Calais, Somerset
P	RWD	84		Fiero
T	RWD	76	88?	Chevette, 1000
TVX or GM 60	FWD	86		(NUMMI) Nova
V or GM 35	FWD	88		Allante
GM 33	RWD	87		Reatta
W or GM 10	FWD	88		Bonneville, others
Y	RWD	84		Corvette

DOMESTICALLY-ASSEMBLED

BIG THREE CAR LEGEND

(CONTINUED)

Program Code(s)	Drive Axle	Date of Program: Launch	Date of Program: Termination	Nameplates
Ford				
Erika	FWD	81	90?	Escort, Lynx, EXP
Fox	RWD	79	90? 87	Mustang Capri
Topaz	FWD	84		Tempo, Topaz
DN5	FWD	86		Taurus, Sable
LS	RWD	84	87	Continental, Mark
L	RWD	83	90	LTD, Marquis
Panther	RWD FWD	79 90	89+	Crown Victoria, Grand Marquis, Town Car
FN9	FWD	87+		(New) Continental
S	RWD	83	88+	Thunderbird, Cougar
MN12	FWD	89		Thunderbird, Cougar
GN34	RWD	89		?

DOMESTICALLY-ASSEMBLED

BIG THREE CAR LEGEND

(CONTINUED)

Program Code(s)	Drive Axle	Date of Program Launch	Date of Program Termination	Nameplates
Chrysler				
A	FWD	88+		?
CV	FWD	83	88?	600 & LeBaron convertibles
E	FWD	82	88	Caravelle, 600, E, LeBaron, New Yorker
G	FWD	84		Daytona, Laser
H	FWD	85		Lancer, GTS
K	FWD	81	88	Reliant, Aries
KC	FWD	84		Limousine
L	FWD	78	86?	Omni, Horizon
M	RWD	82	87?	GranFury, Diplomat, Fifth Avenue
P	FWD	86+		Sundance, Shadow
S	FWD	84		Voyager, Caravan

TABLE VI

LIGHT VEHICLE ASSEMBLY PROGRAM SITING IN MICHIGAN, 1986-1992

FACILITY	CURRENT PROGRAM VEHICLES	ENDS	FUTURE PROGRAM VEHICLES	BEGINS
General Motors				
Clark/Fleetwood	B	89?		
	D	90?		
Pontiac #1	P			
Pontiac West #5	S10 trucks			
Pontiac East #6			GMT400	87
#8	G	87	GM 80	89
Willow Run			H(GM70)	86
Lansing	N			
(Buick City) Flint #4			H(GM70)	86
Orion	C			
Chevy Flint Truck	C/K trucks			
Poletown			E/K(GM30)	86
			V(GM35)	87
Lansing 2			GM33	87
Ford				
Wixom	LS, Panther			
Michigan (Wayne) Truck	Utilities			
Wayne (Car)	Erika: Escort	90?	?	
	Lynx, EXP	87		
Dearborn	Fox: Mustang	90?	?	
	Capri	87		
Chrysler				
Jefferson	K	87+	A?	88
	E	87?		
	CV	87?		
Sterling Heights	H	85	P (Added to H)	87
Warren (Dodge City)	D/W Pickups		N (added)	86+
	Utilities	85		
Mazda				
Flat Rock			727	87+

TABLE V2

CRT RISK RATINGS OF MICHIGAN
CAR AND LIGHT TRUCK ASSEMBLY PLANTS,
1986-1992

(Scale: 0=no risk,..., 9=grave risk; a plant risk score over 10—absent firm future plans—indicates signficant danger.)

			Risk Factor					
Co.	Plant	Current (1985) Program(s)	Age of Pro-gram(s)	Attri-butes of Plant	Cost of Change to FWD	Imports or Out-sourcing	Fuel Prices or Rules	Plant Risk Score
GM	Clark/Fleetwood	B,D	9	7	8	0	3	27
	Pontiac 1	P	2	0	3	4	0	9
	Pontiac 8	G	9	5	6	0	2	22
	Pontiac 5	S10	3	2	0	2	0	7
	Willow Run	H	0	1	0	2	0	3
	Buick City	H	0	0	0	0	0	0
	Lansing	N	1	2	0	4	0	7
	Orion	C	1	1	0	2	2	6
	Flint Truck	C/K	4	2	0	0	4	10
Ford	Wixom	LS,Panther	4	1	6	0	3	14
	Wayne(Truck)	Bronco,F	3	0	0	0	4	7
	Wayne (Car)	Erika	5	0	0	9	4	18
	Dearborn	Fox	9	7	6	5	0	27
Chrysler	Jefferson	K,E,CV	6*	3	0	2	0	11
	Sterling	H	0	0	0	3	0	3
	Warren	D/W	0**	2	0	2	3	7

*Likely to decline to 0 due to siting of A's in 88.
**N truck (Dakota) coming in 1986+.

TABLE V3

REFERENCE GUIDE TO MICHIGAN LIGHT VEHICLE
ASSEMBLY ACTIVITIES, 1986-1992

PLANT	PROGRAM	
GM:		
Clark/Fleetwood	B,D	This 2-plant site will likely be the plant at which all remaining GM full-size RWD (B and D) production will be sited, as Fairfax (KS.) #1 closes (replaced by W car at new Fairfax #2 plant in 1988) and as Ste. Therese (Ont.) loses B's in 1987. The 1987-88 addition of Chevy B's to Olds and Cadillac gives Clark/Fleetwood life through at least 1989, but not beyond 1990 or 1991.
Pontiac #1	P	Recent introduction of the space-frame/plastic panel Fiero should sustain Plant 1 into the early 1990's. However, burgeoning Japanese competition in the two-seater niche makes volume, and hence employment, a source of concern.
Pontiac #5	S10 pickup	Successful recent product sustains Plant 5. Multiplant nature of S10 program, plus cyclicality of truck demand, make temporary shutdown a possibility.
Pontiac #6	See Chapter text	Successful medium trucks are being shifted to make room for the high-volume, three-plant GMT 400 pickup launch in 1987. Not known if Plant 6 is "core" GMT400 facilty (versus new plant in Indianapolis and newly-automated Oshawa, Ont. plant).

TABLE V3

REFERENCE GUIDE TO MICHIGAN LIGHT VEHICLE
ASSEMBLY ACTIVITIES, 1986-1992
(CONTINUED)

PLANT	PROGRAM	
Pontiac #8	See Chapter text	While Plant 8 itself may close in 1987 (any remaining G car output likely to be consolidated to Mexico), current plans call for Pontiac to host the 300K/yr, plastic-skinned GM 80 Camaro/Firebird successor in '89 and perhaps, the new Manhattan engine in '91 and/or a future plastic body van program.
Willow Run	H	Closed in early 1985 after building GM's final X cars, Willow Run is to start up in late 1985 as one of the three (with Flint and Wentzville) H car plants.
Lansing A,B	N	Recent N car launch should sustain this plant into the mid 1990's. The compact which shares many parts with the subcompact J, could however suffer from heightening foreign competition in its segment.
Lansing (Delta Twp)	GM33	A 1987 1/2 launch is expected for the upscale, low-volume Reatta, giving new life to the old Delta Twp rear axle facility.
Flint #4 ("Buick City")	H	The fall 1985 launch of the new FWD full-sized H could sustain the JIT-exemplary Plant 4 to the turn of the century.
Chevy (Flint) Truck	C/K pickup	Flint is truck town, USA, and likely to stay that way. All signs, however, point to Truck & Bus Division supremacy in future facilitizing.

TABLE V3

REFERENCE GUIDE TO MICHIGAN LIGHT VEHICLE
ASSEMBLY ACTIVITIES, 1986-1992
(CONTINUED)

PLANT	PROGRAM	
Orion	C	This relatively new BOC plant is, despite ballyhooed robotization, labor-intensive. But its upscale FWD cars are likely to sustain it, at least into the middle 90's. Analysts say, however, that if sales falter, Orion would lose a shift before the other C car plant (Wentzville, which will also have the H car).
Poletown	E/K, GM35	If FWD and new and expensive and luxury cars mean long-term safety, this is the safest facility in North America. E/K launch in 1986 to be followed by GM35 (or V) in 1988.
Ford:		
Wixom	LS, Panther	Though the current Continental, Mark, and Town Car programs end in 1987, 1989, and 1991, respectively, Wixom is probably secure. Continental and Mark are to be replaced by new FWD designs based on Taurus/Sable platform. Town Car moves to St. Thomas (Ont.) in 1986 1/2 but is slated to return in 1990 1/2 with FWD. Wixom would then be a fully FWD luxury car plant, second in long-term safety only to Poletown.
Michigan (Wayne) Truck	Utilities, F Pickups	Solid-selling full-size light trucks anchor this plant against anything short of $3 gasoline. And they're slated for total reskinning in 1991 1/2.

TABLE V3

REFERENCE GUIDE TO MICHIGAN LIGHT VEHICLE
ASSEMBLY ACTIVITIES, 1986-1992
(CONTINUED)

PLANT	PROGRAM	
Wayne (Car) Assembly	Erika	Core program plant of 3 in North America, but threats abound: a higher import share and relaxed CAFE rules, followed by a Ford/Mazda captive from Mexico (perhaps sold in Lynx line), followed by Alpha which could be Erika's successor. High quality rating, however, suggests the plant would get a new program even if Erika ends in 1990 or 1991.
Dearborn	Fox	50% of Mazda (Flat Rock) output will replace Capri in 1987 1/2 or 1988. Major freshening of Mustang in 1987 secures Dearborn to, but not beyond, 1990. One hope: A 90 termination would fit with the tentative 1991 1/2 or 1992 launch of FWD Panther line.
Chrysler:		
Jefferson	K,E,CV	K's and CV's slated to end in 1987 1/2 and to be replaced in 1988 by A's. E's may continue, or be dropped. There is a small danger that Chrysler could instead site A's at St. Louis (MO) or Belvidere (IL).
Sterling Heights	H	Recent H car launch, plus 1987 addition of P line, secure this efficient, refurbished FWD plant. Slow sales and mounting midsize foreign competition, however, are keeping volume well below capacity, leading to P car siting decision.
Dodge City (Warren)	Pickups	Full-sized utilities were moved to Mexico in 1985, but compact N pickup (Dakota) will be added to remaining full-sized pickup line, securing the facility and anchoring the Dodge City complex.

TABLE V3

REFERENCE GUIDE TO MICHIGAN LIGHT VEHICLE

ASSEMBLY ACTIVITIES, 1986-1992

(CONTINUED)

PLANT		PROGRAM	
Mazda:	Flat Rock	727	626-based successor with on-site major stampings. Output starts 1987 1/2, split between Mazda and Lincoln-Mercury dealers. A U.S. engine plant is rumored for 1989.

INPUT SOURCING

For every U.S. job in the assembly of cars and light trucks (about half of SIC 3711), there are an additional 2.5 manufacturing jobs producing parts for those vehicles (the balance of SIC 371, plus SIC 3714). Moreover, for each auto job (SICs 3711 and 3714 combined), there are about 1.25 other manufacturing jobs in industries such as steel, glass, textiles, and rubber. Thus the U.S. automotive manufacturing economy can be thought of as an inverted pyramid, in which some 200,000 light vehicle assembly jobs support about 500,000 direct supplier jobs and those 700,000 together underpin a million more. Since Michigan is, if anything, more highly auto-agglomerated than average, our approximately 70,000 light vehicle assembly (blue-collar) workers provide the underpinning for many of the State's 200,000 supplier jobs and perhaps 280,000 of our other manufacturing jobs, for a total of 550,000. Add to that some 100,000 white-collar jobs at corporate and divisional headquarters, technical centers, and proving grounds, and the figure rises to 650,000. In fact, a 1981 MESC study found that fully 55% of Michigan's manufacturing employment is linked to auto production; in metro Detroit, the figure is 73%.

Nurturing the prospects of the State's thousands of non-assembly auto-related establishments is thus the single largest task facing Michigan's attempt to realize the wealth maximization goal set out in "The Path to Prosperity." Despite its obvious importance, retaining and attracting assembly plants cannot be the State's only strategy for pursuing that goal. Rather, direct attention must be focused on maintaining the strong and identifying the weak links in the State's supplier base, and improving the latter's competitiveness. Done successfully, this will sustain existing firms and jobs, improve the cost position of Michigan assembly plants and, perhaps most important, justify the State's efforts to assist assemblers to intensify their Michigan linkagedness.

Key Findings

In our work to date, the CRT has succeeded in describing the structure of supply for the major body panels, frames, engines, transmissions, and axles of all cars and light trucks assembled in Michigan. Table I1 presents that description for both 1986 models and, where known, for new programs announced for 1987-92. Even cursory inspection of Table I1 reveals the extremely high level of Michigan vertical integration of all of the Big Three in major body stampings, of GM and Chrysler in engines, and of GM in automatic transmissions as well. While many Michigan component makers, both captive OEM plants and independents, could survive on sales to non-Michigan assembly programs, many could not. The loss of any of our Big Three assembly plants would be a huge blow to the supplier base.

Significant elements of that base seem headed for difficult sledding, even if the U.S. auto market can avoid a sharp cyclical downturn through the early 1990's and even if no major assembly facilities are definitively closed. As we demonstrated in the previous chapter, at least four Michigan car assembly programs –*B/D* at Clark/Fleetwood, *G* at Pontiac #8, *Fox* at Dearborn, and *Erika* at Wayne – are at risk. Absent similarly Michigan-linkaged replacement programs, loss of those plants' demands will endanger investment, employment, and derived input demand at [via *B/D* and *G*:] Chevy Flint Met Fab, Grand Rapids #1, Chevy Flint Engine, Detroit Gear & Axle, and (perhaps to the point of closing) the Three Rivers Hydramatic plant; and [via *Fox* and *Erika*:] Woodhaven and especially Dearborn Stamping, the Utica and Chesterfield trim plants, Dearborn Engine, and – though to a lesser extent – Sterling Axle.

Beyond the *B/D, G, Fox*, and *Erika* programs, risks face Michigan plants that produce parts for GM's *T* (Chevette) and *J* bodies [volume losses due to more imports] and Chrysler's Illinois-assembled Omni/Horizon line. In fact, if State policy-makers had to ask themselves only one question about how to identify at-risk suppliers, that question should be: **Which Michigan facilities currently supply at-risk vehicle programs and are not assured of supplying successor programs, if there are any?**

Many of the State's less at-risk assembly plants produce less Michigan-intensive vehicles than those whose production is imperiled. Indiana, New York, Ohio, Canadian, and offshore plants are significant suppliers for GM's Fiero, S-10, *N* cars, and *C/K* trucks; for Ford's Wayne-built light trucks; and for most of Chrysler vehicles' transmissions and engine cylinder heads.

Other dangers threaten the all-important intrastate chains of automotive value added. Rising market penetration by foreign-assembled and low-US content small "domestic" cars will reduce traditional U.S. OEM parts demand by at least 14% by 1987 even if a recession is avoided, according to work done at ITI by two AIM CRT members. Where in 1978 the Big Three produced in the U.S. and Canada 14.3 million (or 86%) of the 16.6 million new cars and trucks sold in North America, in 1984 the Big Three proportion had declined to 74%; by 1987, it could well be below 65%; and Chrysler has recently stated that by 1990 it will be just 51%. Increased outsourcing of the parts for those Big Three cars that continue to be made in North America makes that figure a conservative estimate of likely volume losses, though one OEM describes such increases as temporary, "only until we get our U.S. production costs down through better technology."

Identification among supplier companies of the probable winners and losers from all of these developments is inevitably risky; to the extent that changes in modular sourcing, materials, or technology are key factors in suppliers' prospects, the reader should consult the chapters on those topics. Here, we confine ourselves to broad aggregates and emerging trends.

First among these trends is the continuing surge in imported auto parts, which have risen since 1978 at a 25% annual rate, reaching about $14 billion in 1985, up from $3 billion (nearly all of that Canada) in 1978. Canada and Japan top the list, but the dramatic recent increases belong (in order) to Mexico, Taiwan, Brazil, South Korea, and Singapore. Low labor costs, local content and export requirements, and an overvalued dollar tell only part of their success story; and a cheaper dollar alone won't change the trend. Growing scale economies and industrial infrastructure gains by many Third World producers explain why the new wave of exports to the U.S. is not restricted to labor-intensive and low-skill products, but includes growing shares in small engines, aluminum cylinder heads, shock absorbers, pumps, wheels, and springs as well. Moreover, Japan – feeling itself barred by threats of protectionist action from taking more than about one-quarter of the U.S. market with finished vehicles shipped from Japan – expects to increase its exports of parts and "knockdown sets" (essentially, kits of preassembled subsystems making up some 80%-plus of the vehicle) by 13% a year between now and 1990.

Suppliers' profits are even more at risk than their sales volumes. Imports are now taking some 23% of the lucrative U.S. aftermarket parts business, which for many suppliers constitutes 10–20% of sales but 30–50% of net earnings; a recent Arthur D. Little study forecasts aftermarket sales lost to imports at $3 billion a year by 1994. Shorter product cycles, more "niche" vehicles and the associated devaluation of economies of high volume, materials changes, and their customers' technology and price demands all add to the perilousness of most suppliers' environment.

Suppliers at risk of losing work run the gamut from small independents to giant Big Three plants. Captive OEM component plants are no longer assured of the parent's business; this makes some Michigan plants less secure, while creating business opportunities for aggressive captives and non-captives alike – in Howell but also in Hiroshima. For example, GM engine part outsourcing has meant gains for some Michigan firms that cast aluminum heads, cam carriers, water pumps, and intake manifolds, but also for Comau

(Italy) and Cosworth (U.K.) castings. Chrysler purchasers reportedly have been told to get $1,150 out of each car in purchased parts by 1989 (versus 1984); one result has been intensified parts shopping in Korea and Taiwan. Some OEM interviewees told us that over $1,000 per car can be saved if Midwestern suppliers become assemblers of modules made up partially of subparts from the Sunbelt, Mexico, Brazil, and the Pacific. Firms benefitting from, or at least able to prosper despite, increased offshore and modular sourcing include those protected by technology, hard-to-ship product type, or their own multinational character. Among these, interviewees were bullish on plastics suppliers, assemblers of electronics-intensive modules, and diversified multinationals such as TRW, Eaton, and Rockwell. Predicted net losers include most RWD axle plants, many trim plants, non-galvanized steel plants, bearing makers, and smaller suppliers of castings, forgings, extrusions, and powdered metal parts.

Detailed Input Sourcing Factors

In this section, we explore likely developments in the sourcing of frames; of major body panels, both steel and plastic; of engines and their major parts; of transmissions, transaxles, trailing axles, and their component castings; and the major constituents of U.S.-assembled foreign-nameplate light vehicles. AIM work in fiscal 1986 will continue the analysis of input sourcing, and extend the inquiry to include suspension, steering, brake, wheel, and other subsystems.

Frames

Fewer and fewer passenger cars have frames as such; partial frames, front crossmember assemblies, and unibodies now predominate. The current Chevrolet Corvette and Pontiac Fiero, the 1990 GM 80, and perhaps an early 1990's GM van herald a possible future of "bird cage" or space frames to which easily redesigned body panels are attached. Many light trucks, on the other hand, continue to be constructed on at least a partial welded steel frame. Michigan has already lost much of the remaining frame business, and what's left is at considerable risk. A.O. Smith in Milwaukee, Wisconsin is the leading frame maker for GM *B* and *G* bodies, and its Granite City, IL. plant has landed the Dodge *N* truck frame contract. The Ford Rouge frame plant remains, but is dangerously dependent on the large RWD cars assembled at Wixom and in Canada; unless more truck frame work can be secured at Dearborn Frame, a 1988–1991 period closing cannot be ruled out as Continental, Mark, and Town Car are changed over to FWD. In space frames, Lobdell-Emery (Alma, MI) is a likely winner, especially if it lands the GM 80 frame to go with its current Corvette work.

Body Stampings and Plastic Panels

Excess OEM large panel stamping capacity and the growing attractiveness of molded and stamped plastics place a number of captive Michigan stamping plants at risk in the 1986–92 period, while creating business opportunities for certain independent stampers (see Table I1). GM stamping facilities at risk include Conner (tied to *B, D*), Willow Springs (Chicago), Mansfield (Ohio), Pittsburgh, Oldsmobile Met Fab #1 (tied to Olds *B*), Flint 2A (Chevy Pressed Metal), and Pontiac Met Fab. Either or both of the last two have some chance, based on demonstrated know-how, of being converted to plastic panel plants, particularly if (as seems likely) GM decides to make the panels for its 1990 GM80 line in-house. While a number of GM Michigan stamping plants produce panels for vehicle programs facing declining volumes,[1] an emerging modular sourcing system[2] makes forecasting perilous.

Ford too has excess major panel stamping capacity; Dearborn but probably not Woodhaven is at significant risk. Ford is looking to outside stampers more and more for both complex curvature outer skin stampings (e.g., to Budd [Detroit] for luxury car fender outers and deck lids) and for non-body surface stamped parts. Table I1 lists some of its suppliers, all of which stand to gain work, barring major Ford volume losses to imports.

Chrysler shed much of its excess captive supply capacity in its draconic 1979–82 downsizing. Its remaining large panel stamping facilities – Sterling, Warren, and Twinsburg (Ohio) – appear secure. In fact, Chrysler is investing $120 million (mostly in foreign press equipment) between 1985 and 1987 to add modular subassembly capacity at Warren and Twinsburg, after which it will pull in-house one-fourth of its now-outside major stampings.

In plastic panels, our interviewees expect more Big Three in-house fabrication, either alone or jointly with plastics firms. If GM80 proves plastic skinning viable in non-niche volume applications, the need for 3,500–4,000-ton presses and the efficient dedicated volume size of 200,000-plus vehicle sets both suggest that OEM insourcing predictions are

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[1]Grand Blanc stamps *B* doors, *G* roofs, and *T* and *J* body panels, quarter panels, and roofs.

[2]Beginning with the 1986 *L* body, each new GM steel-skinned vehicle program will have all hoods, fenders, and front doors (front module) stamped in the same plant, and so on for the rear module (roof, deck lid, quarter panel, rear doors), black metal module, floor pan module, and rear compartment module.

accurate. In smaller panels and parts, however, plastics may mean net Michigan losses. Many of the steel parts displaced by plastic components – bumpers, small panels, cowls, etc. – are (or were) Michigan-made, while their plastic replacements are not.[3]

Engines

The 1986–92 period will be a tempestuous one in U.S. engine production. Most of today's engines embody incremental refinements of 30-year-old designs; by 2000, those designs will have been radically changed, with many of GM's and some of Chrysler's engines transformed in the 1988–91 period. The light vehicle engine changes predicted by CRT interviewees include smaller, lighter all-aluminum designs and even the appearance of "unicast" power plants with integral block-and-head.

Michigan produces the majority of GM and Chrysler's domestic car and light truck engines, and about one-fourth of Ford's. GM also casts a majority of its engine blocks and cylinder heads in the state. However, while all these statements may still be true in 1992, there is a significant chance that some will not.

First, the blocks for the high-volume Buick 3.0- and 3.8-liter V6's will be moved to Defiance, Ohio in late 1986 when Pontiac's foundry closes. Many of the aluminum cylinder heads for GM's 60-degree V6's are made in Italy and Brazil by Fiat-Teksid, and will only be eligible for resourcing to GM Central Foundry Division plants if and when they master "lost foam" aluminum casting technology. Second, while the high-volume 3.2-liter V6 GM "3200" engine that will debut in the Fiero in late 1988 and in GM10 (W) cars in 1989 and power GM80 in the 1990's may be sited in Bay City, it may also go to Tonawanda, New York; if so, Michigan will suffer a drop in its engine share and miss a major opportunity.

On the plus side, Pontiac may get a large proportion of the 1991 Manhattan "unicast" 4-cylinder that will replace its current Pontiac 2.5-liter engine. Chrysler's Trenton plant is adding a 2.5-liter version of its current 2.2 that will replace the imported Mitsubishi 2.6; Mound Road will soon add a 3.9-liter V6 truck engine as well, and an all-new Chrysler 6 is being contemplated, though a vacant Chrysler plant in Windsor, Ontario would probably get that engine. Finally, Mazda is rumored to be considering a U.S. engine

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[3]Fiero panels come from Ohio and Mexico in addition to Ionia, Michigan. Chrysler's plastic cowls come from Budd in Indiana, its plastic faciae [bumpers and associated trim] from Davison Rubber (Excello) in New Jersey and North Carolina, and many of its other plastic parts from Modern Tool & Die in Cleveland. Only at Ford, whose Saline and Milan plants are plastics specialists and many of whose outside plastic parts come from C&F in Grand Rapids, does growing less-than-full skin plastics use bode well for Michigan.

plant to supply Flat Rock, with some volume left over for other customers. Obviously, the State should try to get the plant, though (see below) some of its output could end up replacing other Michigan engines.

Ford, finally, makes its only Michigan engines at Dearborn, and all but about 8% of them (which are exported to the U.K.) go into North American-assembled *Erika* vehicles, at risk from imports from Japan and Mexico. In addition, the availability of small engines for Ford from a possible U.S. Mazda engine plant could make Dearborn Engine worrisomely expendable.

A partial listing of independent suppliers of engine castings and forgings to Michigan engine plants appears in Table I2.

Drive Trains

Michigan is the nation's leading producer of passenger car and light truck automatic transmissions and transaxles. Capacity is dominated by GM Hydramatic Division facilities in Ypsilanti (Willow Run), Warren, Three Rivers, Flint, and Bay City; Ford's Livonia plant supplies most of its large car transmissions. Only Chrysler, which gets all its transmissions from its Kokomo, Indiana and Syracuse, New York plants, lacks a Michigan facility. The State —and the U.S. as a whole — is much less involved in manual transaxles: GM gets its domestic manuals from its Muncie, Indiana line and from [Borg] Warner Gear, also in Muncie, and buys some from Isuzu (Japan). Ford gets all its manuals from Borg Warner, Ford of Europe (Cologne), Tremec (Mexico), and Mazda (Japan). As of now, none of the Big Three plans any Michigan production of manual transaxles, though GM is expanding its Indiana Getrag lineup.

Of the Michigan plants producing automatic transmissions, only the Three Rivers GM Hydramatic facility is at obvious risk, owing to its dependence on large RWD cars slated for phaseout by 1990. However, major volume losses due to more mid-sized imports could imperil other Hydramatic plants.

In transmission parts, a new U.S. plant that will cast aluminum parts is planned by the Ryobi-Sheller Globe joint venture; if the State can attract that facility, it could significantly increase the chances of future Michigan transaxle investments.[4]

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[4]Ryobi plants in Japan already have contracts to supply the cases of *Erika's* Ohio-made 3-speed automatic, the Taurus/Sable 4-speed automatic, and a new Hydramatic model.

Some of the good news has a bad side. The shift to FWD has a meant new work at Saginaw and Hydramatic, but lost work at the axle plants of all of the Big Three. Chevy Gear and Axle (Detroit) will lose half its *B* and *G* car RWD axles in 1986, and *C* and *H* cars have independent control arms (made in Oshawa, Ontario) rather than trailing axles. Ford's Sterling axle plant depends heavily, though far from exclusively, on RWD Ford models scheduled for phaseout by 1991. Chrysler's Detroit (Eldon) Axle plant may also be at risk of closing; current volume needs could probably be met by outside suppliers, and not necessarily in Michigan.

Independent suppliers of transmission castings are listed in Table I2.

Inputs for Foreign-Owned and JV Plants

Great controversy surrounds major input sourcing for the new U.S. assembly programs launched or planned by Toyota, Nissan, Honda, Mazda, Mitsubishi/Chrysler, and Toyota/GM. Most traditional suppliers report difficulty getting these plants' business, and fear that the Japanese-based suppliers clustering around the new assembly sites will compete away their Big Three work as well.

As of now, all of the new foreign-owned and joint venture assembly facilities import engines and drive trains; most import stampings or stamp major panels on-site using imported steel. Claims of North American content as high as 50% are alleged; 35% is more typical and truthful, and even that lower figure may overvalue certain U.S.-assembled parts that embody imported steel, castings, and forgings. On the plus side, Honda plans and Mazda is considering U.S. engine production by 1989.

The pattern as well as the level of domestic supply to the new foreign-owned and JV assembly plants merits concern and on-going monitoring. Analysis of input procurement for NUMMI in Fremont, CA. and for Nissan in Smyrna, TN. reveals that low-value added, energy-intensive inputs such as paints, sealants, and cable typify what NUMMI and Smyrna buy from existing Michigan suppliers. To the extent that Michigan suppliers do get contracts for more substantial inputs, these tend to be for non-complex subassemblies and often go to establishments set up by Japan-based suppliers,[5] most of which purchase some or all of their own inputs from Japan. At NUMMI, 1450 parts are shipped from Japan, including the engine, transaxle, emissions system, suspension, brakes, and steer-

[5]Takata Fisher in St. Clair Shores (seat belts), Nippondenso in Battle Creek (electronics, AC), Hitachi in Edmore (magnetics), Musashi Seimitsu in Battle Creek (ball joints), Dai-Ichi in Madison Heights (electronics), and Yazaki in Livonia (wire harnesses) are some of these.

ing. Of the 400 U.S.-sourced parts, none involves precision machining, casting, or forging, Michigan's fortes; in fact, tires, seats, radiators, and air conditioners are the only complex parts/subassemblies currently sourced from the U.S. As we noted in the previous chapter, this underscores the need for the State to encourage present and future small car assembly plants to move toward high Michigan content.

Table I1.
Major Input Sources for Michigan Assemblies

Unless otherwise labeled, all entries refer to 1986 through 1992 or later models.

Legend: FESM = front end sheet metal; BIW = body-in-white.
Stamping plant names include: SM - Sheet Metal, MF - Metal Fabricating, PM - Pressed Metal.

GM:

	DETROIT CADILLAC ASSEMBLY (1986-89) 23% Cadillac (D), 12% 88(B), 65% Caprice(B)
Major body stampings	FESM: Clark/Fltwd (Cad), Olds Lansing MF (88), Chevy Flint MF(Caprice) BIW, Chassis: Clark/Fltwd Underbody: Grand Rapids #1 Frame: A.O. Smith (Milwaukee)
Engines	
Olds 5.0 V8 307	29% Olds (Lansing)
Cadi 4.1 V8 249	8% Cadillac (Livonia)
Chev 4.3 V6	10% Chev (Tonawanda, NY)
Chev 5.0 V8	50% Chev (Flint)
Chev 5.7 V8	3% Chev (Flint)
Transmissions	Chevys (65%) THM 700 R4 - Toledo (OH) HMD Others (35%) THM 200 R4 - Three Rivers HMD
Rear axles	Chevy (Detroit) Gear & Axle (G&A)
	LAKE ORION ASSEMBLY Sedan DeVille, 98, Electra (C)
Major body stampings	FESM: Pontiac MF (Cad), Chev Flint MF (Olds), Buick Flint MF (Buick) BIW: Mansfield, Oh (Cad), Grand Rapids #1 (Olds, Buick) Underbody, Cradle: Chev Flint MF
Engines	
Buic 3.8 V6 231	24% Buick (Flint)
Cadi 4.1 V8 249	76% Cad (Livonia)
Transaxle	THM 440 T4 4-spd aut - Warren HMD
Indep Control Arms (instead of trailing axle)	Oshawa (Ont.), but may be resourced to Warren HMD

POLETOWN
E/K (GM30) in '86, V (GM35) in '87+

Major body stampings	FESM: Hamilton (OH) BIW: Grand Blanc; Underbody: Gd Rapids #1 Cradle: Chev Flint MF
Engines	
Cadi 4.1 V8	approx 50% Livonia
Buic 3.8 V6	approx 50% Flint
Transaxle	4-spd aut THM 440 T4 Warren HMD
Trailing Axle	Buick (Flint) MF

PONTIAC #1
Fiero (P)

Major body panels	Hoods, Fenders: Genl Tire, Ionia, MI Faciae: Fisher Guide (GM), Ramirez, Mex Deck Lid: Budd, Carey, OH Roof: Premix (div of Shell), Lancaster, OH Doors: Olds (Lansing); Qtr Panels: Pontiac PM
Engines	
Pont 2.5 I4 151	40% Pontiac
Chev 2.8 V6 173	60% Chev (Tonawanda, NY)
Transmissions	
	42% 3-spd aut THM 125C - Willow Run (Ypsi) HMD
	27% 5-spd man Getrag - GM Muncie (IN)
	31% 5-spd man MT2 - Isuzu (Japan)
Trailing axle	Pontiac MF

	PONTIAC #5 S-10 Pickup & Utility
Major body stampings	FESM: Chev Flint MF Cab SM, Box: Indianapolis (IN) Underbody: Parma (OH) SM; Bumpers: Livonia Frame: A.O. Smith (Milwaukee)
Engines	
Pont 2.5 I4	15% Pontiac
Chev 2.8 V6	85% GM Canada
Transmissions	
	71% 4-spd aut THM 700 R4 - Toledo HMD 29% 4- & 5-spd man T4, T5 - Borg Warner (IN)
Axles	Rear: GM Canada; Front: Olds (Lansing)

	PONTIAC (EAST) #6 GMT400 truck in '87
Major body stampings	FESM: Chev Flint MF Cab SM: Indianapolis, Pontiac Truck MF
Engines	
Chev 4.3 V6, 7.4 V8	Tonawanda (NY)
Chev 5.0 & 5.7 V8	Flint
Chev 6.2 V8	Moraine
Transmissions	
	3-spd aut THM 400 - Willow Run HMD 4-spd aut THM 700 R4 - Toledo HMD Manuals - Muncie
Rear axles	Detroit G&A (8.5" and 9.5")

	PONTIAC # 8
	Cutlass Supreme (G) '86-'88 or '89
	GM80 in '90 (unless greenfield)
Major body stampings	FESM: Olds (Lansing) MF BIW: Grand Rapids #1 Frame: A.O. Smith (Milwaukee) Bumpers (RIM Faciae): GM Canada [GM80: plastic body on space frame]
Engines	
Chev 4.3 V6 262	65% Chev (Tonawanda, NY)
Chev 5.0 V8 305	35% Chev (Flint)
3200 V6 for GM80 & others	?Bay City, Tonawanda, or Pontiac
Transmissions	74% 3-spd aut THM 200 C - Willow Run (Ypsi) HMD 26% 4-spd aut THM 200 4R - Three Rivers HMD
Rear axles	65% 7.5" (with V6) - Buffalo G&A 35% 8.5" (with V8) - Detroit G&A
Control Arms	Warren HMD

	LANSING ASSEMBLY
	Somerset, Calais, GrandAm (N)
Major body stampings	FESM, BIW: Olds MF Underbody: Grand Rapids #1
Engines	
Pont 2.5 I4 151	45% Pontiac
Buic 3.0 V6 181	55% Buick (Flint)
Transaxles	70% 3-spd aut THM 125 C - Willow Run HMD 30% 5-spd man MT2 - Isuzu (Japan)
Trailing axle	Pontiac MF; Control Arms: Oshawa (Ont)

	BUICK CITY (FLINT)
	H (GM70) in '86
Major body stampings	FESM, BIW: Buick MF Underbody: Grand Rapids #1; Cradle: Chev Flint MF
Engines	
Buic 3.0 V6	33% Flint
Buic 3.8 V6	67% Flint
Transaxle	4-spd aut THM 440 T4 Warren HMD
Indep Control Arms (instead of trailing axle)	Oshawa (Ont)

	WILLOW RUN ASSEMBLY
	H (GM70)
Major body stampings	same as Buick City above
Engines	
Buic 3.0 V6	4% Flint
Buic 3.8 V6	96% Flint
Transaxle, Indep Control Arms	same as Buick City above

	CHEVY FLINT TRUCK
	C/K, K trucks
Major body stampings	FESM: Chev Flint MF Cab SM, Box: Indianapolis SM Underbody: Parma PM; Bumpers: Livonia Frame: A.O. Smith (Milwaukee)
Engines	
4.3 V6	11% Chev (Tonawanda, NY)
5.0 V8	51% Chev (Flint)
5.7 V8	23% Chev (Flint)
6.2 V8 diesel	7% Moraine (OH)
7.4 V8	8% Chev (Tonawanda, NY)
Transmissions	52% 4-spd aut THM 700 R4 - Toledo HMD 23% 4-spd aut THM 400 - Willow Run HMD 3% 3-spd aut THM 350 - CPC Parma (OH) 22% 3- & 4-spd manuals - GM Muncie (IN)
Axles	Rear: Detroit G&A Front: 80% Detroit G&A 20% Dana (Toledo, OH) - to Detroit G&A in '87

FORD:

DEARBORN ASSEMBLY

Mustang (1986-90)/Capri (1986-87) [Fox]

Major body stampings	Qtr panels, fenders, floor pans, doors: Woodhaven Bumpers, Trim Moldings: Utica Trim Valance panels, fender liners: Maumee (OH)
Engines	
Ford 2.3 I4 140	46% Lima (OH)
Ford 2.3 I4 turbo	2% Ford do Brazil
Ford 3.8 V6 232	25% Windsor
Ford 5.0 V8 302	27% Windsor & Cleveland
Transmissions	56% automatics - 3-spd: Ford (Bordeaux, Fr) - 4-spd: Livonia 44% manuals - Ford (Cologne, Ger), Borg Warner (IN)
Axles	Sterling

WAYNE (CAR) ASSEMBLY

Escort ('86-'90?), Lynx, EXP ('86-'88?) [Erika]

Major body stampings	same as Dearborn above
Engines	
Ford 1.6 I4 98	Dearborn Engine
Ford 1.9 I4	Dearborn Engine (incl some exported to UK)
Transmissions	45% 3-spd aut ATX - Batavia, OH 55% manuals - Mazda (Japan)
Trailing Axle	Sterling
CV Joints	GKN (Sanford, NC) - could come to Sterling

	MICHIGAN (WAYNE) TRUCK Utilities, F pickups
Major body stampings	Doors, hoods, fenders: Woodhaven Interior moldings: Saline
Engines	
4.9 L6 300	46% Cleveland
5.0 V8 302, 5.8 V8 351	54% Cleveland, Windsor
Transmissions	58% 3-spd aut - Sharonville, OH 42% 4-spd manuals - Tremec (Mexico)
Rear axles, U-joints	Sterling
4WD transfer housings	Global Die Casting (Buchanan, MI)

	WIXOM ASSEMBLY Mark, Continental (LS now, then Panther) Town Car to St. Thomas, Ont. '86+, but returns '91 (FN9)
Major body stampings	Budd (Detroit): Mark qtr panels & fenders, Cont deck lids, Town Car doors Hoods, roofs, doors (exc Town Car): Woodhaven Trim/moldings: Utica (exterior), Saline (interior)
Engines	
Ford 5.0 V8 302	Cleveland & Windsor
Transmission	4-spd aut AOD - Livonia
Axles	Sterling

Independent Ford Suppliers of Automotive Stampings

include Budd (Detroit), Active Tool (Roseville), Allied Products (Hillsdale), Creative Industries (Detroit), C & F Stamping (Grand Rapids), Checker Motors (Kalamazoo), Lobdell-Emery (Alma), Aetna Industries (Centerline), Logghe Stamping (Fraser), Hawthorne Metal Products (Royal Oak), Lake Odessa Machine Products (Lake Odessa), and Means Stamping (Saginaw).

CHRYSLER:

	JEFFERSON ASSEMBLY K Cars (incl CV), E Cars ('86-'88) A Cars in '88
Major body stampings	Plastic cowls: Budd (Indiana) Hoods, fuel tanks, front frame x-members: Sterling Stmpg Fenders, doors: Warren Stmpg Floor pans: Twinsburg (OH) Other (many): Active Tool (Roseville), Allied Products (Hillsdale)
Engines	
Chry 2.2 I4 135	83% Trenton
Mits 2.6 I4 156	17% Mitsubishi (Japan), replaced by
Chry 2.5 I4	Trenton, in mid-'86
Transaxles	
	62% 3-spd aut - Kokomo (IN)
	38% 4- & 5-spd man - New Process Gear (Syracuse, NY)
Trailing Axle	Detroit Axle
CV Joints	GKN (Sanford, NC) & Citroen (France)
	STERLING HTS ASSEMBLY Lancer/LeBaronGTS
Major body stampings	same as Jefferson above
Engine	
Chry 2.2 I4 135	100% (about 1/3 turbo) Trenton
Transaxles	
	90% 3-spd aut Kokomo
	10% 5-spd man New Process
Axles, CV Joints	same as Jefferson above

	DODGE CITY (WARREN TRUCK) D/W Pickups, N (Dakota) '86
Major body stampings	Cargo box, fuel tanks, front frame crossmembers: Sterling Doors, fenders, hoods: Warren N truck frames: A.O. Smith (Granite City, IL)
Engines (D/W only)	
3.7 I6 225	60% Chrysler (Mexico)
5.2 V8 318	31% Mound Rd (Detroit)
5.9 V8	9% Chrysler (Mexico)
3.9 V6 (new in late '86 for N)	Mound Rd
Transmissions	
	76% 3-spd aut Kokomo
	24% 4-spd man New Process
	new 5-spd man New Process (in '87 for N trucks)
Rear axles, U-joints, etc.	Detroit Axle

Independent Chrysler Suppliers of Automotive Stampings
include all of the stampers listed above that supply Ford, except for Creative and Lake Odessa.

MAZDA:	
	MAZDA (FLAT ROCK) 727 series car in '88
Major body stampings	70% from onsite stamping plant
Engine	Mazda (Japan), but a U.S. plant possible after '88
Transaxle	Mazda (Japan)

Table I2. INPUTS INTO MAJOR SUBSYSTEMS OF MICHIGAN-ASSEMBLED VEHICLES

GM Engines and Transmissions/Transaxles

Engines

	BLOCK	CYL HEAD
Chev 2.8 V6 173	Saginaw	Saginaw
Chev 4.3 V6 262	Saginaw	Saginaw
Chev 5.0 V8 305	Sag, Defiance	Saginaw
Chev 5.7 V8	Sag, Defiance	Saginaw
Chev 6.2 V8 diesel	Defiance	Defiance
Chev 7.4 V8	Defiance	Saginaw
Pont 2.5 I4 151	Pontiac*	Pontiac*
Buic 3.0 V6 181	Pontiac**	Pontiac*
Buic 3.8 V6 231	Pontiac**	Pontiac*
Cadi 4.1 V8 249	Bedford	Bedford
Planned new engines: 3200 V6	Bay City or Tonawanda, NY	
Manhattan	?Pontiac, other(s)	

Transmissions

	CASE	DIFFERENTIAL ASSY
Manuals	Muncie	Muncie
THM 200 4R	Three Riv HMD	Three Riv HMD
THM 440 T4	Warren HMD	St. Cath. (for now)
THM 700 R4	Toledo HMD	Toledo HMD
THM 125 C	Willow Run HMD	Buick (Flint)
THM 200 C	Willow Run HMD	Willow Run HMD
THM 350	Parma	Parma
THM 400	Willow Run HMD	Willow Run HMD

Blocks and heads cast in Central Foundry Div. (CFD) plants.
HMD= (GM) Hydramatic Division

* = To Saginaw in '87 when Pontiac foundry closes.
** = To Defiance in '87 when Pontiac foundry closes.

Ford Engines and Drivetrains

Blocks and heads for Ford engines are cast in foundries associated with Ford engine plants in Cleveland and Windsor. Except for some work done in Windsor, virtually all aluminum castings are purchased outside, mainly in Ohio and Michigan. Engine connecting rods are a specialty of Ford's Dearborn Vulcan Forge. Some Ford Livonia transmission cases are purchased from GM Central Foundry Division in Saginaw. Some Ford V8 engine intake manifolds are cast and machined at Metalloy in Hudson, MI. Independents that supply some engine and transmission castings and forgings include CMI, Metalloy, and Ryobi (Japan). Ryobi has a casting joint venture with Toledo-based Sheller-Globe, and the JV is scouting for a site for a transmission component casting plant (see text for details). 4WD transfer housings are purchased from Global Die Casting in Buchanan, MI.

Chrysler Engines and Drivetrains

Chrysler's main engine and transmission castings come from its facilities in Indianapolis, Kokomo, and Etobicoke, Canada. A number of New York independents supply castings and forgings to New Process Gear in Syracuse. Unfortunately, all of the cylinder heads (aluminum) for Trenton-assembled engines are supplied by Fiat plants in Italy and Mexico. Ryobi (Japan) supplies additional transmission castings (see note on Ryobi and Sheller Globe under Ford, above). Trenton's hydraulic valve lifters come from Sealed Power in Muskegon. Turbochargers for Trenton's engines currently come from Garett (California), but reportedly will be outsourced to Mitsubishi in 1986 or 1987, where they will be produced in a highly-automated new plant.

Capital Goods Suppliers to the Big Three in Michigan

All of the Big Three purchase the bulk of their steel sheet from the Great Lakes division of National Steel, U.S. Steel, Republic, Armco, and Inland; Ford also relies heavily on Rouge Steel. A good deal of the OEMs' weld-assembly equipment is supplied by Progressive Tool of Southfield, Key Welder of Roseville, and Newcor of Bay City. Lamb-Technicon of Warren is the dominant supplier of cylinder head, transmission case, and differential case machining lines. Ingersoll-Rand's Rockford, IL. plant and Cross & Trecker (Fraser) dominate engine block transfer machinery. All of the Big Three have been looking worldwide for new capital equipment, with Italy, Brazil, and Japan all scoring gains in recent equipment orders. For additional detail, see this Report's chapter on production technology.

MANUFACTURER-SUPPLIER RELATIONS

The internationalization of production for the U. S. automotive market has permanently changed the domestic industry. Increased import penetration, domestic production of foreign nameplate vehicles, nondomestic sourcing options for traditional U.S. manufacturers, and changed bases of competition are all facets of this trend. Internationalization is clearly the key factor influencing the prospects of manufacturers (i.e., OEMs/assemblers) and their suppliers in the 1980s.

If we examine the impacts of internationalization on the structure of the domestic automotive industry — the patterned ways that business transactions and less formal exchanges between companies occur — the dominant theme is the way in which widened sourcing options shakes up the traditional relationship between manufacturers and suppliers. Internationalization has forced the industry to recognize that its time-worn ways of doing business have in many instances led to increased costs and lower quality, whatever short-term advantages they may have provided a particular company. Both manufacturers and suppliers are reexamining a wide range of sourcing criteria and arrangements, and some changes are occurring, however slowly and unevenly. There is movement towards longer term contracts and some sole sourcing, for example, and it is clear that piece-price is not as dominant a criterion as it has traditionally been. At the same time, the manufacturers are involving suppliers earlier in the design process, and placing greater demands on the suppliers for engineering and quality assistance. In general, the manufacturers are trying to reduce their number of direct suppliers, and approximate the tier system more typical of Japan. How effective all these measures will be and, in some cases, whether they are simply efforts to transfer costs to suppliers, remains to be seen.

If it is internationalization that sets the new rules of the game, it is the nature of the manufacturer-supplier relationship that arises in response to internationalization that will go a long way toward determining how well the traditional U.S. industry competes. In many instances, that relationship will have to change for the industry to be competitive. If the cost and quality benefits of Just-In-Time or other reduced-inventory manufacturing systems are to be fully realized, for example, a much closer coordination between manufacturer and supplier will have to develop. So, too, if the product-development cycle is to be substantially shortened, then suppliers will have to be identified and involved in that process at an earlier stage than is currently the practice. This requires a group of core suppliers with competitive manufacturing and engineering skills that can work cooperatively with the manufacturers, rather than ones that either simply make-to-print or fully develop and market a proprietary design.

The emphasis of this chapter will be on the impact of these emerging relationships upon the Michigan-based, traditional automotive supplier. The importance of these companies to wealth-creation in Michigan, and the advantages they offer in this effort compared to newer entrants from abroad, have both been discussed in this Report's chapters on vehicle program siting and major input sourcing. The initiatives in this area that will have broad impact by 1992 are most likely to be those that come from the manufacturers (or a few of the very largest supplier companies) because they have the economic power to make demands and enforce compliance upon large numbers of suppliers; most supplier initiatives, *per contra*, will only gradually diffuse throughout the rest of the supplier community. Consequently, our questions are formed around the **actions** of the manufacturers and the **responses** of the suppliers though, to be sure, we do not totally ignore supplier initiatives.

The CRT immediately faced two problems in addressing the issue of changing manufacturer relationships. The topic is clearly too broad to be treated *in toto*; some narrowing is required if we are to identify specific and practical implications either for the State of Michigan or for supplier companies located here. We have attempted to resolve these problems by drawing upon the results of the Joint U.S.-Japan Automotive Study supplier survey to focus on some specific dimensions of the overall issue; this strategy is reflected in the questions that we took to both manufacturers and suppliers.

The first dimension reflects likely developments in the sourcing strategies of the manufacturers. This includes the manufacturers' decisions to make a part themselves or to buy it from an outside supplier and, if the latter, whether the supplier will be domestic and, if so, located in Michigan. The second dimension covers the technical competence of suppliers, including their overall engineering capabilities, their response to specific technical capacities demanded by the manufacturers, and their views of the importance of technical competence as a competitive strategy. The third dimension addresses general changes within the industry, including both manufacturer actions, such as the establishment of Mazda at Flat Rock and the move towards modular sourcing, and supplier actions such as diversification efforts and investments in Michigan.

Key Findings

The complementary efforts of the OEMs to increase the sourcing of modules rather than constituent discrete elements such as parts and components and to reduce their number of direct suppliers present both n opportunity and risk for Michigan suppliers. The Michigan supplier industry includes large numbers of small suppliers that will no longer be able to supply the OEMs directly. To the extent that Michigan suppliers are successful in establishing themselves as the central source for a module, then these small suppliers may well be able to convert their proximity to a competitive advantage. If these core suppliers are not located in Michigan, then it is likely that many, if not most, small Michigan suppliers will lose much of their current automotive business.

The emphasis on Just-In-Time systems of inventory reduction should eventually convert to an advantage for Michigan suppliers, if we are successful in retaining vehicle assembly programs and in securing core supplier roles for modular sourcing. On the other hand, J-I-T may mean construction of J-I-T warehouses; to the extent that this approach offers some of the short-term cost savings that the OEMs are seeking to garner from J-I-T, it secures those savings by shifting inventory carrying costs to suppliers. Moreover, it undercuts the proximity advantage of Michigan suppliers. In theory, J-I-T warehouses interfere with the attainment of the complete cost and quality benefits such systems offer. Therefore, suppliers whose locations permit low in-transit inventory and no warehousing should eventually gain competitive edges in both cost and quality.

The development of electronic communication, especially in the design area (linked CAD systems, for example), may well undercut Michigan's current role as the engineering center for the traditional domestic OEMs, as it lessens the need for frequent face-to-face communication. The increased sourcing of engineering to Europe symbolizes this threat. On the other hand, it also allows the continuation of engineering in Michigan even when other activities are sited elsewhere. The location of the Saturn engineering activities in Southeastern Michigan represents this opportunity.

There is no question that most suppliers will need to develop distinctive technological competence, either product- or process-anchored, to remain major direct suppliers to the OEMs. Beyond this, they will have to develop sophistication in the new control and communication technologies. Low technology and high labor content parts and components are likely candidates for offshore sourcing, and even to the extent they remain here, unlikely to be core to emerging modules sourced by the OEMs. Suppliers that do not develop these technological capabilities are likely to fall into the lower tiers of the new supply structure, and some of them will simply cease to be automotive suppliers. For larger suppliers, then, broad technological and engineering competence are critical, while for smaller suppliers, narrower process technology capability may be key. Michigan suppliers appear to be no different from non-Michigan suppliers in the adoption of advanced manufacturing technologies, but small Michigan suppliers report larger allocations of their R&D efforts to automotive than do small non-Michigan suppliers. Michigan suppliers feel that product and process innovation, as well as engineering and manufacturing competence, are more important to the OEMs than do non-Michigan suppliers. If these beliefs convert to actions, then Michigan suppliers are positioned to develop competitive advantages.

The restructuring of the supplier industry and the emphasis on reduced total costs will result in the disappearance of some Michigan suppliers, and significant changes in current business practices and relationships for most. New responsibilities, new customers, and new roles in the chain of value-added will be commonplace. Those suppliers that can most readily identify their best niche, and adapt to it or encourage its development, will have maximum chance for survival. Under the logic of J-I-T, and the advantage it confers on proximate location, the siting of assembly facilities and the selection of core modular suppliers are likely to be the primary determinants of how many Michigan suppliers will survive in the 1992 time frame.

Beyond the standard forms of State assistance and continued attention to the details of Michigan business costs, there are two areas that the State might fruitfully pursue from the perspective of these changing relationships. First and foremost would be those broad-based efforts to contribute to the technological competence of the entire supplier base, to increase the chances that survivors on this criterion are Michigan based. A critical component of this effort would be the development of a technologically sophisticated labor force, at both the hourly and salaried levels. In tandem with this, efforts could be made to assist small and medium suppliers that lack necessary resources, either through direct aid or indirect aid, such as helping them pool their resources in design or even production consortia. The aborning Michigan Technology Deployment Service speaks to this piece of the solution. Second, the State may usefully play the role of "honest broker" in encouraging cooperative development of modular strategies among Michigan suppliers. Part of this activity would involve identifying suppliers with various product and process capabilities to potential core suppliers. Many likely core suppliers have facilities both in Michigan and elsewhere, and such assistance might tilt the location of modular programs to Michigan.

Product and Process Developments

The AIM interviews on the relationship between manufacturers and suppliers provided some interesting views on product and process changes, as well as on the role of the State in assisting the automotive industry. The themes that appeared most often were the increasing reliance on modular or system sourcing, the continuing push to full implementation of Just-In-Time, and the increasing utilization of computer-based technologies throughout the industry.

The push for modular sourcing by the OEMs is clearly related to their attempts to rationalize their own costs and the costs of the entire set of manufacturing operations required to produce a vehicle. It allows the OEMs to externalize some of their engineering, manufacturing, and quality assurance costs, but also permits the reduction of costs associated with effort duplication throughout the manufacturing chain. At the same time, it fosters the tiering of the supplier chain in much the fashion of the Japanese industry, reducing transaction and coordination costs and avoiding duplication of purchasing and inspection efforts.

To the extent possible, suppliers that provide the OEM with a module such as an instrument panel, rear suspension, a front "corner" (wheel and brake), or a door will become the first-tier suppliers; their need to be close to assembly customers will benefit Michigan, but it is far from automatic that the parts that compose the modular subassembly will be locally sourced. Module suppliers will be expected to have a high degree of technical sophistication, including good design and manufacturing engineering capability, and electronic communication facility. They will need to meet rigorous quality and productivity demands, and will in turn have to manage their own suppliers for the module to assure their performance. The lower tier suppliers will be allowed to have correlatively lower technical capacities, but will be held to similar productivity and quality criteria. The higher the tier, the higher the value-added for the supplier, and the more critical the supplier's own sourcing decisions become throughout the manufacturing chain. It is clearly of great importance to the State that as many emerging first tier suppliers as possible be located here, and that *they* be induced to source heavily in the state.

The basic change involved in Just-In-Time production systems is the flushing of inventory out of the system. While there are benefits in terms of reduced inventory costs, the long-term cost reductions promised by this approach are more those resulting from "stripping the system clean" so that process problems are revealed and corrected quickly. Hence J-I-T should result in more efficient use of capital equipment, better process design, more effective deployment of labor, reduced scrap and rework, and better product quality. To a certain extent, as we've noted, J-I-T has so far resulted in a transfer of inventory carrying costs to suppliers, partially reflecting the OEMs' more rapid implementation of these systems, but also reflecting the OEMs' reluctance to rely on their suppliers for the regularized, high quality production J-I-T requires. The automotive industry has been approaching J-I-T as a system whose pieces can be gradually implemented, rather than as one that needs full and systematic application if it is to force improvements throughout the process.

The different OEMs appear to have somewhat differing views on J-I-T, and there is disparity within each OEM on what J-I-T is and what its ultimate benefits may be. Thus one OEM interviewee stressed the advantages that J-I-T would provide Michigan suppliers if assembly facilities continue to be located here. Another stressed that because of lessening transportation costs, proximity is not worth much, especially if quality, technology, and productivity are lacking, except for those few elements of the vehicle that do not travel well because of damageability. One supplier pointed out that state lines are permeable, and that northeast Indiana is a major competitor that shares in whatever advantage proximity confers.

One development associated with J-I-T is the possibility that suppliers will locate dedicated satellite facilities close to assembly plants. Hoover has set up a number of such seat plants, for example. Some of the suppliers raised questions about whether this practice will be as major a development as some expect. One limitation is the economy of scale associated with different products, and the balance of capital and transportation costs. Another issue is the possibility that such plants will come to be simply extensions of the assembly facility; for suppliers that compete on low labor costs or different management-worker relationships, a nearby location might undercut their advantages. Other suppliers have noted that the assembly plant itself becomes a major competitor for the available workforce, and not only drives up wages, but also attracts the better workers.

If Michigan suppliers can compete on an even basis along other dimensions, proximity should provide a natural comparative advantage, assuming that assembly activity remains here. To be sure, this edge will be shared with Indiana and Ohio. Whether more distant suppliers implement J-I-T over longer distances, or pursue the option of warehousing close to their customers, there will be increased costs of higher inventory, as well as more of the quality problems that full J-I-T should reduce or eliminate. These costs are ultimately reflected in the final vehicle, however they may be apportioned in the short run.

The increasing implementation of computer technology in the automotive industry ranges from rather straight-forward communication, such as billing and order-release, to the integration of technical functions, to the exchange of engineering data and designs, to the control of the manufacturing process, with the implementation of control technologies from CNC machines to CIM. Suppliers that will have any chance of remaining first-tier into the 1990s will have to make broad advances on all three of these fronts, and suppliers in any tier will have to make advances on the first and, quite possibly, the third. These advances will require management and labor skilled in both the hardware and software aspects of computer-based technologies.

If proximity confers an advantage in the delivery of physical goods to the OEM, it is unclear what computerization might do the the traditional advantage of proximity in engineering and design development. Michigan historically has been the center of research and development activity in the automotive industry and this, as one supplier noted, tends to keep the manufacture of new products and the introduction of new processes here too. It is clear that the OEMs see in the computerization of technical functions the opportunity to outsource, and even offshore source, much of this effort. One OEM respondent especially highlighted the need for Michigan supplier to become technologically sophisticated, because the OEMs now can go to Japan or Italy for their engineering; another identified small engineering "job shops" as high-risk facilities.

The extent to which on-line communication and exchange of data can replace face-to-face meetings is very much an open question, and Michigan probably will retain some advantage in the concentration of OEM research and development activities here. One supplier noted that proximity is important in design and engineering. However, it appears quite likely that Michigan suppliers would lose this advantage if they fall behind their out-of-state counterparts in their efforts to computerize: the OEMs are likely to opt for technological over face-to-face communication, if forced to choose.

The U.S.-Japan Joint Automotive Study conducted a survey of automotive suppliers in late 1983. Fewer Michigan than non-Michigan suppliers reported that they were likely to make investments in programmable controllers and in CAD/CAM over the next five years. Both these differences, however, reflect the disproportionate number of smaller suppliers in Michigan. It turns out that Michigan and non-Michigan large and medium-sized suppliers did not differ in their reports, but that fewer Michigan small suppliers reported likely investments in these technologies than small suppliers located elsewhere. If, as we believe, the supplier industry comes to approximate the pyramid structure suggested by the development of tiers, and if the necessity for engineering capabilities is lower in the lower tiers, then the results for CAD/CAM are not likely to be important in the long run, though without CAD/CAM fewer Michigan suppliers may be able to move up the pyramid in the years ahead. However, the results for programmable controllers are more immediately worrisome. To the extent that these devices contribute to productivity and quality, these small Michigan manufacturers may find themselves at a disadvantage, and may in fact not survive.

Increased modular sourcing (and the associated tiering of the industry) and the increasing computerization of manufacturing and its associated functions place a premium on State efforts to upgrade the technical capacities of the supplier base. There is little reason to think that we face a disadvantage here, but neither is there any reason to suppose that we enjoy an advantage. Just as proximity confers an advantage in J-I-T only after more fundamental competitive requirements are met, electronic communication may seriously undercut the historic advantage of proximity in developmental activities.

Sourcing

We asked our respondents to comment on the OEMs' patterns of making parts and components themselves versus purchasing them outside, and how this balance might vary from now through the early 1990s. We further asked them to identify patterns of OEM offshore sourcing for purchased parts, and to comment on how free the OEMs are to vary their patterns in the light of the constraints they face.

There was unusual unanimity across supplier and OEM respondents with regard to how free the OEMs are to alter their sourcing patterns. Long-term contracts are not seen as serious impediments by either group, because (suppliers complain) they contain clauses that allow the OEMs to escape. The UAW is not seen as an effective constraint, because the economic reality is that "they lose some jobs now or more later." Some suppliers did say that the internal political clout of the OEM captive supplier divisions might constrain the OEMs a bit.

The OEMs see increased purchasing from outside sources, and not many components as candidates for pulling in-house. The suppliers see a somewhat smaller increase in outside purchasing, and express more apprehension that some current purchases might move inside. The OEMs stress high labor content and the need to impose coherence on their own activities as drivers for outsourcing, while the suppliers see low labor content and mature products (with no further development costs) as attractive for the OEMs to bring back in-house.

One supplier noted an interesting development in the pattern of OEM outsourcing. He felt that the OEMs are relying on high capability suppliers to perform the most demanding work, in terms of development, precision, technical content, and skill content. The less demanding work, on the other hand, is sourced to less capable but lower cost suppliers or moved back in-house. This creates problems for the high capability supplier, because it denies it the opportunity to cover the costs of the more difficult work with the easier work. This pattern of "tier-jumping" has been noted in Japan as productivity improvements have resulted in reallocation of work within the manufacturing chain. (There, the OEMs' need to keep busy a permanently employed labor force, while protecting the technically capable suppliers, has led the OEMs to pull back in-house some work from *lower* tier suppliers). Here in the U.S., it appears to be more a matter of allocating rewards and costs between companies, and may in fact pose some danger to the technically capable supplier.

There was divergence among the OEMs in expectations about future levels of offshore sourcing. One respondent felt that, in the long-term, the trend is definitely toward increased offshore sourcing to remain cost competitive, while the others felt that there would be a temporary increase, and not an especially sharp one. Our respondents noted that labor savings can be illusory and temporary, and that many parts from offshore are not in fact cheaper. Moreover, technology may reduce the labor content of some subsystems, lessening the incentive to offshore source them. Wire harnesses, for example, have been increasingly sourced from Mexico and offshore, but could soon be obsoleted by multiplexing or even fiber optics (see chapter on emerging product developments).

The suppliers expect and fear a much sharper increase in offshore sourcing by the OEMs. The lack of familiarity with potential sources of supply on the part of OEM purchasing people may be the biggest obstacle to a surge in offshore sourcing; some suppliers also feel that the OEMs' need for control may limit the rate at which they can move work to distant supply sources.

Our interviewees generally had difficulty specifying items for which sourcing patterns are likely to change. By and large, they were comfortable identifying the attributes of parts and the considerations that would factor in the decision, but either would not or could not commit themselves to specific cases. This probably reflects the extent to which this whole issue is new territory: the old rules for these decisions may no longer hold, and the old patterns may not be good guides to the future. For the most part, respondents mentioned factors such as value (and value-to-weight ratios), labor content, technology content, system integrity considerations, elements of modules as they develop and, in the case of offshore sourcing, transportability. The following list reflects the comments the small subset of our respondents that were willing to hazard specific predictions.

- **Parts likely to be outsourced:** soft trim, interior fabrics, plastics, smaller stampings, wiring, wheels, brakes.
- **Parts likely to be pulled in-house:** electronics, machined cast parts, larger stampings.
- **Parts likely to go offshore:** drum brakes, interior fabrics, anything involving small parts assembly, and tooling.

Worrisomely, *our interviewees had similar trouble identifying areas of opportunity for Michigan suppliers due to increased outsourcing,* and viewed the threat of offshore sourcing to the current business of these suppliers as more immediate. The same suppliers were often mentioned as the ones facing the greatest threat and as having the greatest opportunity. Budd, Kelsey-Hayes, and Allied Automotive's Michigan facilities were all seen as facing threats from offshore; yet all three were also seen as the type of supplier with the potential to become responsible for various modules. The feeling that Michigan suppliers need to emphasize their technical capacities -- both in terms of product and process innovation and execution -- came through frequently. The other possible opportunity area might be in those lower technology, high labor content items that lend themselves especially well to J-I-T, although this would apply equally (and perhaps better) to areas of Ohio and Indiana, and is not a realistic -- and perhaps not a desirable -- option for many traditional Michigan suppliers.

On balance, then, our interviewees expect more net outsourcing of OEM work. However, much of this work is likely to go offshore, and there is the added risk that work currently domestically outsourced will also go offshore. The changing patterns of make-buy decisions appear to present more threat than opportunity for Michigan suppliers. The importance of Michigan suppliers playing the central role in supplying modules to the OEMs emerges again, as does the necessity of developing the technical capability required for that role.

Supplier Technical Competence

The frequent mentions of and references to supplier technical capacities in the prior sections of this chapter highlight a basic characteristic of the automotive industry in the United States today: it is a very technology-conscious industry. Most manufacturers and suppliers view technology as a basic competitive dimension, one that offers them the hope of regaining an edge over their foreign competition.

All our OEM respondents stressed the critical importance of supplier engineering competence in the 1986 to 1992 period. One suggested that technical competence would be more important than cost, and all agreed that it would only become more important over time. The suppliers certainly feel that product and process innovation are important to their survival, and will in fact protect their business with the OEMs.

The respondents were not able to distinguish particular strengths or weaknesses of Michigan suppliers in technical areas. In some cases, they just were not sure about the comparison; in others, they were reluctant to make specific comparisons. Because of that, this section will draw heavily upon two parts of the U.S. supplier survey mentioned earlier. The first part provides an assessment of the level of engineering service provided by Michigan suppliers, and the second suggests how they compare with non-Michigan suppliers in their view of the importance of technical competence.

The supplier survey asked respondents to identify whether or not they "black-box" their major OEM product. Black-boxing describes designing a part or component to functional specifications, rather than relying on drawings from the OEMs, so it involves a higher degree of engineering or technical resources. Among Michigan suppliers, 36% report black-boxing, compared to 46% of non-Michigan suppliers. While this difference is not statistically significant by research standards, it is cause for concern that Michigan suppliers may indeed lag in this area. Since black-boxing does require more resources, it is not surprising that it is related to size: larger suppliers are more likely to black-box than are small. Since we know the Michigan supplier base contains a larger proportion of small suppliers, it is worth asking whether the possible difference in black-boxing is due to differences in the size of Michigan and non-Michigan suppliers. When we look within the groups of small, medium, and large suppliers, a troublesome pattern emerges. Reassuringly, there are no differences at all between Michigan and non-Michigan suppliers that are small or large. However, among medium-sized suppliers, those located in Michigan are much less likely to black-box than those located elsewhere (16% compared to 46%).

This is disturbing because these are the very types of suppliers that may most require technical competence in order to survive, and the type whose level in the developing tier structure of the industry will be influenced most by their technical competence. Small suppliers are likely to lose their direct supplier business, and become indirect suppliers. They will compete on their process capabilities, cost, quality, and perhaps location. Large suppliers will compete for first-tier or second-tier status, and their technical competence will clearly be important. The medium-sized supplier is thus the one with the most uncertain future: some will become first-tier or second-tier, continuing to function at a relatively high level in the chain of value-added; others will fall into the lower tiers, and find their economic role diminished. Moreover, these medium-sized suppliers may play a critical role in influencing the OEMs' selection of core modular suppliers, because they represent the supplier base available to that modular supplier. Certainly Michigan does not want to find its medium-sized suppliers slipping into the lower tiers, especially if that drags large Michigan suppliers out of the critical first-tier.

The U.S. automotive supplier survey collected information on suppliers' views of the importance of different criteria in the OEM vendor selection process. Specifically, it asked the suppliers how important a variety of supplier characteristics are to the OEMs as they decide where to place their business. These ratings were asked with regard to the past (the mid-seventies); the then present (1983); and the near future (1984–1987). Characteristics included engineering competence, manufacturing competence, product innovation, and process innovation. These supplier perceptions, whether accurate or not, are important: they represent the suppliers' view of the importance their OEM customers assign to a variety of supplier capabilities, performances, and attributes. These supplier views represent the action premises of the suppliers as they formulate business strategies and make associated investment, diversification, and research and development investments, and as they decide how to balance efforts in the areas of quality, productivity, and cost reduction.

On engineering and manufacturing competence, Michigan suppliers do not differ from their non-Michigan counterparts for the past or present, but do anticipate a greater importance for this supplier characteristic in the future. Similarly, while there are no Michigan/non-Michigan differences in the ratings for the past importance of either product or process innovation, Michigan suppliers rate product innovation higher than non-Michigan suppliers for the future. On process innovation, Michigan suppliers ratings are higher for both the present and the future.

These supplier ratings suggest that Michigan-based suppliers may well undertake broader initiatives and/or put more effort into their initiatives than suppliers elsewhere. The higher importance assigned to the combination of engineering competence and product innovation implies that Michigan suppliers may well make greater efforts to contribute to product development efforts. The higher ratings given to manufacturing competence and process innovation suggest greater attention to the details of the manufacturing process, with likely payoff to themselves and their customers across a variety of dimensions: quality, productivity, cost-reduction, and dependability. On balance, these data suggest that Michigan suppliers have responded and are responding somewhat more rapidly than their out-of-state competitors to changing OEM concerns and priorities. They certainly put more emphasis on technical strength than their non-Michigan competitors.E This should convert to a variety of activities and efforts which will increase their value as suppliers to the automotive industry. Whether these efforts will be enough to overcome what appears to be a debit in *current* technical contribution among Michigan suppliers of medium size remains to be seen — and will matter.

Michigan suppliers, then, are aware of the importance of technical competence both for their survival and in shaping the role they will play in the changing automotive industry; they are more aware of this than non-Michigan suppliers. At the same time, the low rate of black-boxing among medium-sized Michigan suppliers may represent a critical potential weakness in the Michigan supplier chain, one that may disadvantage the Michigan supplier base in retaining or expanding its current level of activity in the industry.

Investing in Michigan

Our respondents see the effect of the on-going reorganization of General Motors much as they see the development of Saturn: more OEM outsourcing, but not necessarily to local suppliers. Rather, the purchasing philosophy will be to secure the best quality at the lowest price, whether inside or outside of the corporation, here or abroad. The resulting need for captive suppliers to become more entrepreneurial is not expected to have much effect on their ability to compete with independent suppliers, since most suppliers feel that they are lower cost than the OEMs and can respond more rapidly and flexibly to changes in customer demand.[1] On the other hand, these captives may lose some of their current influence on the sourcing of smaller subcontracted parts, a prospect that worries many Michigan suppliers of OEM component plants.

The implications of the Mazda decision to assemble vehicles at Flat Rock, and of the more general profusion of foreign-nameplate assembly and stamping operations in the state, are less clear to our respondents. By and large, they appear to be taking a wait and see attitude. Some commented that they suspect that Flat Rock/NUMMI/Honda sourcing patterns have already been set (with no role for them), while others are more hopeful that such foreign investment will provide them new business opportunities.

While staying power is uncertain for small and medium-sized suppliers, and while large suppliers have the option of being footloose, our supplier respondents are committed automotive suppliers. Despite the experience of the early 1980s, they are not actively seeking to diversify away from the automotive industry. Those respondent that did expect to increase the nonautomotive component of their business made it clear that this would result from faster growth in their nonauto sales rather than from active disinvestment from automotive operations.

Furthermore, most of our supplier respondents report continuing capital investment in the state. Whether this is a sign of commitment, however, is less clear: many suppliers stressed the pressures they felt to move out-of-state, reflecting the feeling that wages and other costs of doing business here are high. A distressing comment, but one with actionable policy implications, is that many suppliers *want* to maintain their Michigan operations, but see greenfield investments and an out-of-state move as closely linked if not synonymous. While this does not provide grounds for optimism about new Michigan plants of traditional suppliers, it does highlight the critical importance to the state of retaining

[1]Both of these perceived independent supplier advantages could evaporate if captive parts plants "fall out of" the Big Three wage/benefit pattern – see our chapter on labor relations – and/or if their superior access to capital allows them to leap ahead in flexible automation.

and upgrading existing facilities. Those upgraded facilities can become, or supply, first-tier modular suppliers to the OEMs. If that occurs, many suppliers will come to enjoy sufficient stability and cash flow to consider further investments, including greenfield ones. To the extent that their second- and third-tier suppliers are here, and to the degree that the OEMs fully implement J-I-T, many of those greenfield investments will be made in Michigan as well. The bottom line, then, is the need to nurture each level of supplier in order to ensure that the advantages of proximity to assembly is not more than offset by other factors. According to this analysis, an effective retention strategy will yield gains in facility attraction, while an attraction-focused approach alone is unlikely to bear fruit.

LABOR RELATIONS

Introduction

Contending forces are buffeting labor relations in Michigan's automotive economy. Cooperative efforts and union-busting are both at a peak. Traditional wage, benefit, and work rule patterns are under attack, and crumbling. With the end of import restraints, the OEMs face a shrinking market; the resulting excess production capacity means that plants and local unions are pitted against each other for survival. In the supplier sector, increased offshore sourcing and burgeoning competition from newer Sunbelt plants and new Japanese-based entrants threaten many Michigan establishments.

At base, the driving force is the increased competition at every level. Every plant siting decision, every sourcing change is a response to heightened competitive pressure. The result, whether welcomed as "dynamism" or disparaged as "turbulence," is a higher level of capital mobility. The deployment of competitive capital has become automotive management's primary strategic activity.

Since there is no uniquely correct strategy, a variety of approaches to dealing with workers and unions has appeared since the mid-1970s. Even within a particular company, a bewildering array of practices may be seen: one diversified supplier we interviewed had, since 1975, closed a unionized Michigan plant and put all its major new investments in a non-union southern plant — *and* added its newest, most innovative product line to an old Michigan plant in which it had no QWL-type program and a history of labor militancy.

We talked to OEM and UAW representatives committed to industrial democracy, others who dismissed QWL as a fad that can't last, and still others who hoped — or feared — it would help shift bargaining from a company-wide to a plant-by-plant activity. We heard pay-for-knowledge alternately described as the key to competitiveness, the end of the union contract, and a dangerous inducement to foremen letting untrained workers advance to top pay rates. The OEM executives we interviewed accepted the UAW as a fact of life, though most hoped that plant-by-plant bargaining would come to replace a common pattern. Most also thought that the UAW had grown weaker and less militant, and were grateful. Supplier management was more likely to cite high union labor costs as the basis for decisions — past and prospective —to make any significant capacity additions elsewhere and non-union.

Everywhere, contradictions are encountered in the labor-management field. GM and the UAW – from the 1982 agreement through the Saturn understanding – seem to have agreed implicitly to trade large pay hikes for job security; yet outsourcing grows, and a leaked 1984 GM Labor Relations memo lists the discontinuation of pilot employment guarantee efforts as a priority. Suppliers launch QWL groups in plants doomed by years of conscious underinvestment.

Why this confusion? German industrial relations expert Wolfgang Streeck has noted that enlightened auto managers would like to join with labor in a "productivity coalition."[1] This would involve "an undertaking by trade unions to cooperate in industrial restructuring and modernization in return for institutionalized influence on the process." Deals of this kind have been struck in Europe under the labels "social partnership," "industrial democracy," and "codetermination." These arrangements, however, have proved stable only with the help of some "external facilitation" by government, mainly in the form of enough protectionist elements to prevent sudden shocks to the deal. A productivity coalition in the auto industry would mean that unions would have to ensure the acceptance of structural change by their members, while management would have to cede some of its prerogatives to the unions. Management also would sometimes have to accept economically suboptimal solutions, e.g., reduced flexibility to outsource or lay off. In exchange, it would be guaranteed relative tranquility in production, and lower costs through reduced restrictions on the assignment of work.

We believe such an arrangement is what the UAW leadership seeks at the present time, and that the job losses since 1979 have put most of the rank and file in the same mood. Unions are prepared to sacrifice a significant proportion of the jobs in the auto industry in order to save others; to go along with technical rationalization and higher productivity; and to accept lower wage increases if they get a real say in how the industry is managed. Such "say," however, would have to go beyond input at the plant (EI/QWL) or even the vehicle program (Saturn) level to include company-wide joint determination of production siting and component sourcing.[2]

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[1]Presentation to MIT Future of the Automobile Project, Philadelphia, 6/30/81.

[2]Absent such an arrangement, critics of current cooperative programs have a valid point when they contend that such programs can be used to play locals off against one another, though of course such competition did not originate with EI/QWL.

However, in the U.S. case at least, and particularly at the supplier company level, it is not at all clear that unions will be offered an opportunity to make this deal. As Streeck notes, "employers may lose interest in a cooperative solution and may instead prefer to let the market do the job. It may be that the bargaining power of organized labor in the U.S. auto industry has been eroded to such an extent that capital no longer depends upon union cooperation, and that it feels no need to offer unions a productivity coalition on acceptable terms." One would have to be blind to ignore, despite the spreading talk of cooperation, a simultaneous and rising call to roll back trade unionism, the welfare state, and the rest of the New Deal-era social contract. The increasing weakness of unions in the U.S. today no doubt heightens the temptation on the part of management to go for an outright win. At the least, it can be expected to lead employers to drive harder bargains. The reluctance of employers to pay a visible price for union cooperation may add to the problems union leaders have with their members when taking part in cooperative solutions to problems of industrial change.

Based on our AIM work, we cannot yet predict whether the tension between cooperation and conflict will be functionally resolved in the next half-decade, and in favor of which set(s) of interests. We are convinced that more constructive labor relations can create competitive advantages for the industry in the U.S. and in Michigan. Like Streeck, we find "the exclusion of labor from industrial governance so costly in terms of motivation and quality that real cooperation, although it carries its own costs, is on balance more economical." Auto manufacturers, their suppliers, unions, and workers will in the near future have to make up their mind — and be prepared to act on —whether they agree with that assessment.

It matters how this decision comes out. Without sharply higher productivity and lower costs, we see greatly reduced output from Michigan's auto industry; the work will leave. Moreover, because developments in the automobile industry set the pattern for the industrial relations system as a whole, events in this industry will tell us much about whether, and how, we will cope with the fundamental problems of structural change in the world economy, and whether the historical compromise between labor and capital upon which liberal democracy depends can be preserved in a period of crisis and transition.

Sources of Indecision

We see in the present period parallels to the 1910's movement for scientific management. The early Taylorists were antagonistic to old style management, but not able to accept a thorough-going alternative that diluted prerogatives over the size, nature, and siting of investment. Then as now, a labor movement weakened by job loss was ripe for new wage-moderating deals. Taylorists cited cases in which unions tried to "require owners . . . to install new and modern devices" in order to stay in business.[3] It took more than ten years for Taylorist ideas on work organization to take hold in U.S. industry. By the time this occurred, those ideas had been shorn of their cooperationist content and, ironically, have become the basis for narrow and contentious work organization that inhibits investment and productivity gains.

The period between now and the early 1990's seems sure to provide a turbulent terrain for the development of new forms of labor-management interaction. On the one hand, an unprecedented opportunity exists: common interests in maintaining and reclaiming market share lost to imported vehicles and parts will be a powerful motivator of deals in which labor "trades" wage moderation and fewer work rules for management commitments to invest, and keep work, in their plants.

On the other hand, most of the forces likely to impact the U.S. auto market seem destined to increase labor-management strife. Increased international competition will tend to engender more outsourcing. That, in turn, will produce pressures to pay parts workers[4] and small car workers less than large car workers; that will be perceived by many as an attack on hard-won contractual patterns. Resistance will tend to drive investment to lower-cost, often non-union sites, with the resulting displacement heightening reluctance to modify job-preserving work rules. Deals will be harder to cut to the extent that the need for them is traceable to Big Three outsourcing rather than to more thoroughly foreign factors.

The State Interest

Despite the contradictory signals, the uncomposed class forces, and the obstacles to constructive, investment-anchoring deals the State's interest is clear, albeit difficult to pursue. In a period of footloose capital, collapsing and multiplying wage and benefit patterns, and burgeoning competition, the public interest is in maximizing wealth creation in the State. As explained in the chapters on vehicle program siting and input sourcing,

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[3]1912 ASME Transactions, quoted in Donald Stabile, Prophets of Order (Boston: South End Press, 1985).

[4]For parts sector workers, new Japan-based entrants also exert downward pressure on contract settlements.

retaining and replacing existing operations anchors more Michigan activity than does the attraction of new entrants. Thus, the State earns a high return on its effort when it is successful in keeping in Michigan work that is at risk of moving elsewhere.

To earn the highest available return, however, requires more. It requires attention to the net cost of turbulence, and policies to minimize it. New labor contracts that undermine long-established patterns may keep some firms in business, but may also spell the end for others that depend on manufacturing workers' discretionary spending. Lower labor costs may move the State up a notch in the Alexander Grant business climate sweepstakes, but may also invite underinvestment in labor-saving technologies. Two-tiered pay or benefit structures may save some establishments money, but may also increase the militancy (and the resistance to deal-making) of lower-tier employees.

The State interest, then, is neither in "zapping" labor or in freezing existing arrangements, but in promoting as smooth as possible a transition to an automotive economy based on explicit labor-management deals covering investment, pay, and work organization. As an increasingly active investor in the industry, the State already brings to the table many of the "chips" needed to incentivize such wealth-anchoring deals. In the pages that follow, we present the results of our preliminary efforts to secure the information on skill requirements, work rules, and pay patterns the State will need if it is to facilitate, and serve the public's interest in, these new constructive agreements. In the near-term, the State may also have to play an educative role: our interviews make clear that few in labor or management have as yet thought beyond the rhetoric of cooperation to the complex relationships among investment, technology, cost and work organization on whose full articulation we believe the new labor relations will have to be based.

In the sections that follow, we report on and analyze responses to the labor relations questions we took to management and labor representatives during the first eight months of 1985. These address, in order, issues of skill requirements, work rules and lines of job demarcation, multiple-tier wage and benefit agreements, and the impacts on pattern bargaining of new small car programs.

Emerging Skill Structures

The conventional wisdom holds that, while productivity gains and market share losses will mean fewer U.S. auto jobs in the future, the jobs that remain will require far higher average skill levels. This prediction provides the rationale for heightened training efforts[5] among disemployed[6] and active workers alike. New product launches are now typically preceded by about a year of skilled trades and several months of production worker training and orientation.

Blanket predictions of across-the-board upskilling fell away before specific CRT questions. Management interviewees stated that skilled trades workers were and would continue to be fast-rising proportion of the remaining workforce, yet surprisingly head counts and hiring plans for programs launched or set to debut between 1983 and 1990 showed roughly the same 18% skilled trades proportion that the industry exhibits today. Union and management respondents agreed that programmable automation is reducing diemakers' skill needs, but not having much effect on skill requirements for the machine repair trades or for millwrights and pipefitters. In both hydraulics and the electrical trades, however, skill requirements and the need for new, specialized electronics training have increased.[7] Our labor respondents, however, see this as perhaps temporary, "only until the debugging phase is complete." At Rouge Steel, for example, the continuous caster will eliminate nearly 250 production jobs and require 80 new skilled jobs—but "about 40 of those 80 (skilled trades) slots will be downgraded to production once the bugs are out."

What is seen as coming after that point may explain why new technologies may not expand the trades' share of jobs. Umpire decisions have consistently backed management's right to have production workers perform routine diagnostic work. As repair and maintenance of electronically-controlled equipment becomes a matter of checking and replacing easily removable circuit boards or chips, diagnosis requires less specialized skill. The argument that the function of the circuit board is identical to the function of the wiring it replaces is, trades representatives admit, an apparent loser.

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[5]Since mid-1982, company contributions to negotiated union-company training programs have totaled in excess of $250 million; information on expenditures, in total or by type of training, is not easily available.

[6]Training for displaced workers is a subject of some controversy. Once Big Three workers lose rehire rights by being laid off too long, they also lose eligibility for "nickel fund" training opportunities. Equally important, for obvious reasons, the automakers main interest is in their active workforces. A reorientation of training efforts away from displaced employees was listed as a goal in the leaked 1984 GM bargaining memo.

[7]There will, of course, be continuing bargaining at the national, but particularly the local, level over the extent to which construction, repair and maintenance, and programming tasks connected to new technologies will be performed (a) in-house by the OEMs, and (b) by UAW members.

Among production workers, the future skill outlook is likewise mixed. Job setters will see skill needs rise, but many other will find machine operation skills obsoleted by technologies that make it possible for many types of equipment to run unattended. As in the trades, near-term average upskilling may reflect the newness of most programmable equipment. To the extent that the new, more computerized production process becomes more mature and routinized,[8] a more mixed skilling picture seems likely.

The overall picture, then, is not unambiguously one of long-lived general upskilling or of deskilling, but of a continuing change in the distribution of skill needs. Other developments that will be considered in our discussion of work rules – including trends toward pay-for-knowledge, work teams, and classification depopulation – will all tend to increase the number of different tasks and responsibilities expected of the average worker, yet the substance of those tasks will not necessarily or uniformly embody increased skill.

Rules and Lines

A great deal of discussion about work rules has occurred since 1980. Impressed with Japanese assembly companies' productivity advantage, top U.S. auto executives have sought to modify and loosen certain work rules and to combine certain job classifications across lines of demarcation. In some cases, changes in work rules – including limitations on how seniority can be exercised, in order to reduce bumping of experienced workers from a job – and classifications have been amicably achieved. In small car assembly and engine plants, the obvious import threat has greased the skids for such loosening of union work practices. In other cases, notably in stamping plants, management has used plant closing threats to achieve the same result, but with correspondingly greater ill feeling.

Based on our discussions, local bargaining over work rules and job classifications has produced more flexible organization in the majority of OEM facilities; as one respondent put it, "Most of the horror stories have been cleaned up." Such increased flexibility is the rule in small car plants, stamping plants, and some older plants whose workers saw clear benefits in acceding to management demands as the *quid pro quo* for extending facility life. As a rule, the least change has occurred in large car assembly plants and in captive parts plants producing parts for large cars and for trucks. In suppliers, the picture is even more mixed. Some small- and medium-sized suppliers had never evolved the complex set of

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[8]It should be noted that many analysts dispute whether such technological maturity will occur, and they point to the increasingly *short* period between automation purchases and their competitive obsolescence.

restrictions that took hold in OEM plants.[9] In larger first-tier suppliers, however, our interviews reveal an even split between those in which closing threats have produced major loosening, and others in which work structure is now more rigid than in most OEM plants. There is also a large body of anecdotal evidence that suggests that in 1981–83 OEM workers made small concessions (often "merely" foregoing increases) in pay but often large ones in local work practices, while in many suppliers larger cuts in pay and benefits rather than rollbacks in job rules were the rule.[10]

How much do restrictions on how management deploys employees matter? How costly are they? How much has been "conceded" in this area so far? Which changes in work rules, which combinations of classifications save the most money? How much could further changes save? Enough to change any significant component or vehicle sourcing decisions? For which components, which vehicles? Are there "disjustified" investments, particularly in programmable automation, that would be justified if changes in negotiated work rules ceased to inhibit the realization of flexibility (if indeed they do inhibit it)?

We took these and related questions to respondents in the OEMs, independent suppliers, and the UAW. Conclusion number one must be that the level of rhetoric on this set of questions exceeds the level of precision by a stunning margin. Even in our "literature search," we turned up but a single quantification of work rule costs: a GM spokesman told Business Week in mid-1982 that changes in local agreements had, "at some locations," cut hourly labor costs "as much as $4.50." At one assembly plant interview, we were told that having operators clean their own work areas had allowed a reduction in sanitation workers from 140 to 60, saving about $15 per vehicle. Beyond that now-three-year-old quote and the sanitation anecdote above, we got few hard answers. We did get one OEM statement that "continued progress" in local work rule loosening was "a big factor" in whether some upcoming investments were or weren't made -- but no further details.

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[9]These restrictions, it must be noted, are the joint creation of management and unions. Rules governing task division and the application of seniority were, and are, a predictable response to Taylorized work and a lack of job and income security. In West Germany and Sweden, fewer work rules and classifications are permitted by greater job protections and by "co-determination," while in Japan "lifetime employment" makes restrictive rules unnecessary. In fact, the U.S., Canada, and the United Kingdom are unique in this feature of industrial organization – and are now apparently paying the price.

[10]At least half of all 1979–1983 UAW agreements were reopened in mid-contract for "concession bargaining," and in the small supplier sector the trend toward giveback demands reportedly continues unabated.

Union respondents were extremely skeptical that work could be won or retained by agreeing to ease work practices. While work rule changes (and, to impurify the matter, new programmable controllers) had halved employment in one engine plant's crankshaft operation, cutting 125 jobs (or about $10 per engine), "they can build (the engine) in Mexico with the same technology, *no* work rules, *and* slave wages." (One exception was noted: SPC was seen as able to cut U.S. costs by eliminating the need for most inspectors; Mexico was seen as continuing to need an army of inspectors to achieve required levels of quality). As for the cost of particular work practices, unionists we interviewed didn't know but were sure management did. We wish we could agree.

Surprisingly, we found no cases in which management demands for relaxed work rules and for classification combination were supported by arguments connecting flexible work organization with flexible technology. Even more striking, we found only a few cases in which management had explicitly traded a guarantee of keeping or returning work in return for changes in local agreements, and none in which such a deal was struck after a union-company study of particular work practices' effect on product costs. Instead, unionists complained, management justified its demands with either blunt threats of "change the agreement or we'll close the plant" (stamping, mainly) or "the same old tune that we have to be competitive."[11] We believe, but cannot prove, that sharing of data on which steps can influence competitiveness, and how much, is a precondition to more trusted "tunes."

To return to an earlier theme, we suspect that the state of affairs just described owes to the unequal strength of management and labor in a context of globalized competition. To oversimplify, management needs to be competitive *or it will move production elsewhere*; while logistics and politics are forces tending to keep work here, the fact that the **option** of moving it exists reduces the pressure on management to trade significant unilateral prerogatives in return for labor cooperation. We hope, but cannot predict with

[11]Several respondents hear the same "tune" in EI/QWL-type programs, and worry that becoming more competitive may simply increase "whipsawing" of local against local. "Solidarity House shouldn't allow such local bargaining" without coordinating among the locals. This raises an important issue to which we shall return: are the appropriate "deals" properly a plant-, component- or vehicle-, division-, or company-level matter? Our view is that the component or vehicle level (often multiplant) is the relevant one, because that is the level on which sourcing decisions are based. On the other hand, subsystem interdependencies complicate the matter. For example, we were told that Ford's Batavia plant lost potential manual transaxle work to Japan (Mazda) not because of *its* own costs, but because it was saddled by high-cost casings from the company's (now closed) Sheffield foundry.

confidence, that technology and JIT may, along with politics, heighten the industry's resolve to solve cost problems in domestic – and especially Michigan – operations even if doing so means, in some cases, ceding the outsourcing alternative.

Though we lack the hard numbers, we have compelling evidence of helpful trends. The 1984 and 1985 UAW-Big Three agreements embody, in the Job Opportunity Bank (JOB) program, a significant symbolic first step toward a commitment to the current OEM workforce.[12] That emerging, not-yet-stable commitment, we think, has begun to reduce fear of work rule changes, though continued fear of share loss to imports plays a major role as well. In the next few paragraphs, we describe some of the emerging models of – and points of resistance to – new, more flexible work organization.

First, pay-for-knowledge (PFK) schemes, in which production workers can be assigned to any of a number of jobs in return for being paid for the highest-paid job for which they are trained, trade 20–70 cents an hour for flexibility while also creating incentives for workers to learn new skills. While this approach has generally worked well where it has been tried, there are dissenters and skeptics. GM's Wentzville assembly plant voted down PFK by a 4–1 margin. And some executives see PFK leading to foreman being "nice guys" by promoting less-than-competent workers into eligibility for high-paying jobs. According to this view, PFK (and perhaps other job-widening programs as well) provides the employment reductions of flexibility, but at a cost in quality.

Second, in some plants such as Pontiac Plant 8 (*G* car), narrow classifications have been dealt with through "depopulation": the classifications remain but where in 1982 there was at least one worker in 80 out of the roughly 100 skilled trades classifications defined by the UAW (See Exhibit L1), today only 15 are populated. (At Fiero, also in Pontiac, only seven are filled). Obviously, workers do a wider range of tasks now; but *basic trade lines* are not crossed. This distinction between **basic** and **non-basic** trades is essential to understand. The UAW Skilled Trades Department has no official objection to combining or consolidating classifications *within* a basic trade:[13] e.g., machinists, toolmakers, and diemakers of all kinds may be grouped into a single, consolidated classification. The trouble starts when attempts are made to combine *across* such basic trades as electrical, millwright, machining/tool- and diemaking, and machine repair. Such attempts, we were

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[12] The JOB programs is only a first step in this direction. Job loss due to recession and vehicle outsourcing is not covered, nor is displacement in one plant due to new technology in another.

[13] There are only about ten basic trades. The 37 listed under that designation in Exhibit L1 are not "basic" in this same sense.

told, are under dispute at the Chrysler plant in Sterling Heights and at the (not-yet-open) St. Louis minivan plant. At Sterling Heights, workers are assignable broadly within nine production and seven skilled trades classifications; some of the latter are, the UAW says, the wrong seven, i.e., basic lines are traversed.

An earlier case in which rules and lines were relaxed, but that did not violate basic lines, is the Pilot Employment Guarantee (PEG) program at Ford's Rawsonville parts plant. There, the labor agreement – whose first words are "Faced with ever-growing competitive pressures" – tradespeople are now in 14 classifications, many of which have overlapping duties, with the result that a good deal of work, especially in machine maintenance and rebuild, occurs in teams. In production, the "operator and/or set-up personnel may perform nonskilled maintenance and repair...". That reduces labor requirements, and *that* in turn necessitates the most radical and controversial aspect of PEG: unassigned "extra" production workers go into one of two flexibly-deployable groups, members of which may be assigned at management discretion, in some cases out of seniority order. That same sort of discretionary assignability applies to JOB-banked workers in the Big Three, thus making explicit (albeit little understood) the link between greater job/income security and less restrictive work rules.

Even more radical, of course, are the new streamlined classification systems being negotiated at new and future small car plants. At NUMMI (and, reportedly, Mazda), there is (will be) one production and three (plus one "leader") skilled classifications, formed in teams by department. Under the UAW-Saturn "memorandum of agreement," classifications apparently give way entirely to "work units" with a working "counselor." Eighty percent of the workforce is secure against non-"catastrophic events," and seniority is relegated to being a "tie-breaker" in assignment conflicts.

All of these developments represent evidence of management's belief that less rigid work organization will reduce costs by allowing lower employment levels and, perhaps, by justifying new automation investments. While the savings remain to be quantified, there is an emerging consensus on what flexible work organization can do in an assembly operation. Head counts tell an oversimplified but instructive story: Chrysler Sterling Heights produces nearly twice as many cars per worker as GM Orion or Ford Wixom; at full capacity, NUMMI and Mazda will produce three times as many; and Saturn, it is planned, four.[14] The keys, our OEM assembly respondents told us, are stability and machine up-

[14]Ford's Wayne [car] plant and Pontiac #8 both have impressive cars-per-worker figures, higher than Sterling Heights though still well below NUMMI/Mazda.

time. "Stability" encompasses managerial turnover, job bumping, and consistency of plant throughput. The last of these, clearly, depends importantly on uptime and plant layout. Uptime depends on investment, equipment choice, repair, and maintenance, but also on plant layout. In a proprietary analysis of one OEMs company-wide downtime, 45% was traced to machine failure (60% of that 45 was traced to production workers not doing set-ups and to delays in repair and maintenance due to skilled trades demarcation lines; 40% was traced to underinvestment in new machinery and underbudgeting for routine maintenance.) The remaining 55% was composed of 18% absenteeism, tag rather than mass relief, and "other," while the other 37% was traced to "inefficient arrangement of lines and excess buffering," including overly long lines, mismanagement of stock between stations, too many spindles at stations, and too many extra/just-in-case stations. This allows us to infer that up to, but not more than, about 35% of downtime may be related in one way or another to work practices. Based on the kind of calculation (Exhibit L2) we will use below in a different context, that 35% would cost about $180 per vehicle. We have, as of now, little data on other costs of work rules and lines of demarcation.[15] Those will have to be known and brought to light if constructive deals are to be struck.

We do, however, want to report an observation about the politics of work rules. We observe a split between top executives on the one hand and plant managers, foreman, and the UAW on the other. The former want to eliminate as many rules and to combine as many classifications as possible, as fast as possible. The latter see this as an overreaction to past rigidities: "They don't see all the downtime that will get them when non-specialists screw up repair and maintenance jobs," one respondent told us. Several interviewees recounted that GM, in its "southern strategy" of the 1960s, tried to go with three trades classifications (electrical, maintenance, and tooling), only to have to add more to avoid high downtime, even in new plants; we have no idea whether the story is apocryphal. Automation increases the number of formerly specialist jobs that can be done by "a good handyman," but "there's no substitute for a plumber when your pipes burst," one unionist noted.

[15]One interesting cost-related anecdote: the new contract between UAW Local 600 and Rouge Steel ends all formal job descriptions in favor of teams of tradespeople working on the new continuous casting line. How much does that save? Enough that management granted a 75 cent raise plus about 50 cents in increased average incentive yield.

Interviewees from both sides of the collective bargaining table agreed that many, if not most, of the work rules that create instability on the hourly side have been eliminated since 1980.[16] Several stamping plants in which every seventh worker was a non-working group leader in 1979 have no such rules today. Most plants that had daily output quotas, after whose attainment workers could go home, have given those up — though, surprisingly, the practice remains in some independent suppliers' skilled trades agreements. The main cause of loosening, of course, has been competition: until about 1973, OEM captive and large independent parts plants alike felt secure, understood their power over assembly plant schedules, and negotiated accordingly. Restrictive rules, to the extent they remain, are therefore centered in less competitive parts, such as major stampings, trailing axles, and automatic transmissions, though in the first two of even these cases plastic panels and the trend to front-wheel drive may now be competing away remaining restrictions. One independent stamper complained that "The UAW (local) has gotten off some work rules (break time, overtime, and bumping rules), but still won't budge on combining classifications. We're over a barrel on that because we can't get enough good tradesmen, especially diemakers."

We end the discussion with two clear conclusions. First, as noted, hard data on the cost of work practices are needed, but lacking. Second, for all the talk of combining trades classification, the biggest cost reductions will probably come from having production workers maintain and set up their own equipment. Automation should hasten this trend, simultaneously broadening the jobs of many production workers and reducing the need for what really costs in the trades: extra repair and maintenance personnel "just in case."[17]

Patterns and Tiers

If heightened competition is undermining traditional work practices, it is also wreaking havoc with long-established patterns of wages and benefits. Since the middle of World War II, with few exceptions the wages and fringes received by workers at the U.S. OEMs have been the same. By the early 1950's most elements of OEM pattern had become the

[16] We encountered several cases in which no one could even remember how restrictive practices had evolved. One assembly plant found itself with six classifications involved in moving parts from the truck to the line: "God only knows how *that* ever happened. It must have been late at night ... anything to put an agreement to bed!" Today, one worker does the job; the other five classifications are unpopulated.

[17] This conclusion poses a dilemma. How will the emerging shortage of skilled workers be addressed if there is a simultaneous devaluing of many skilled workers' privileges and (narrow) "craft"?

norm at major first tier independent suppliers as well, though pension benefit levels have often been an exception. Beginning in about 1981, however, these norms, these predictable relationships have come under increasingly fierce attack.[18] Citing the unequal *cost* of providing a given package (due mainly to different retiree-to-active ratios), and demonstrating markedly different competitive positions, suppliers have won contracts increasingly different from each other and from the OEMs. Often, this has been accompanied and/or accomplished through splitting particular plants off from master agreements. Finally, the announced contracts and memoranda covering NUMMI, Mazda, and Saturn appear to some as a harbinger of a different pattern – or even none at all – for plants assembling small cars, or at least *new* small cars. Paralleling this has been new (1982 and 1984) UAW-Big Three contract language permitting terms of National agreements to be waived in certain cases in which "major outsourcing decisions" are contemplated; as of this time, we know of no application of this newly-allowable waiver.

One would have to be blind, however, not to see signs of pattern breakdown. A March, 1985 article in Automotive News sees the end of pattern bargaining, and quotes a GM vice-president as saying that future national agreements will be limited to "philosophies and those kinds of things," and also notes the waiver provision just discussed. The 1984 JOB program, the New Venture fund, and the waiver language together suggest that lower labor costs in at-risk captive component plants are on the way as the price for continuing high (though falling) levels of OEM vertical integration.

At the same time, new competition from Mexico and offshore, and from new U.S. plants of Japanese-based suppliers,[19] spells major trouble ahead for many traditional UAW-organized suppliers, trouble that many aim to address by negotiating radically new and cheaper labor agreements. Pointing to the movement in certain other industries to "two-tiered wages", some supplier executives told us bluntly that only the knowledge that, five and ten years hence, labor costs will be $10 rather than $20 an hour will lead them to make substantial new investments in their existing Michigan facilities. These suppliers express dismay over State and UAW "breaks" for new entrants; their point seems to us to

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[18] Prior breaks in pattern had been limited to such minor differences as the size of quarterly COLA diversions.

[19] These new plants – and, to some extent, *all* new plants – have a labor cost advantage over more mature facilities. Few are unionized, but even those that are and whose workers receive UAW-auto style pay save from $3 to $5 per hour worked thorough lower pension, UI, and other benefit costs associated with older operations whose active workers support more laid-off and retired personnel.

have some validity, and it suggests the State should consider tilting such breaks toward entrants not in direct competition, or those joint venturing, with existing Michigan establishments.

Are multiple wage and benefit tiers in the offing? We are convinced that in some form they are, and found no disagreement — though some dismay at the prospect — on the part of our interviewees. Pure two-tier schemes are not predicted, but "We're going to see a lot of cases where it takes ten or fifteen years to get to maximum rate" in wages and fringe benefits. Supplier executives talk of future start rates at 50% of maximums with at least 10 years to the top; UAW respondents hope for 80% and five-year "grow-in" (compared to the 85% and 18 months typical today). OEM, supplier, and union respondents alike had taken close note of the Chrysler-IUE agreement trading two-tier wages for greater security for high-seniority workers; unionists were worried.

A big part of the attraction of abandoning the current Big Three/Big Supplier/UAW pattern lies in the widespread perception that labor costs in Japan's auto sector are steeply tiered. There, some 25% of the workers involved in manufacturing get the "OEM rate" (basically final assembly, major stamping, and engine and transaxle assembly), while 75% get a rate 20 to 70% lower. In the U.S., about 50% of the value of a car is produced in firms with labor costs exceeding $20 an hour. How, one respondent asked, could Ford's Batavia transmission plant compete with Mazda when the company's Sheffield casting plant had to pay upper-tier OEM labor costs (today, about $24 an hour) when Mazda's casting supplier pays $5? The answer he supplied was the "Either workers in plants supplying parts for small cars get paid less than the guys at Orion and Wixom, or you can kiss (domestic Big Three) small cars goodbye."

How will a greater spread in rates occur, if it does? The consensus was the NUMMI and Mazda herald a new small car pattern of full pay and benefits but with sharply fewer work rules. Some felt that, in addition, union acceptance of a Saturn-style pay system in which some 20% of pay is tied to productivity, quality, and profitability, might become the *quid pro quo* for new domestic small car programs, probably including the successors (if any) to Escort/Lynx, Omni/Horizon, Alliance/Encore, and even the *J* bodies.

In parts, competition will force one or more additional tiers for many OEM component plants, whose new pay levels will set the new, lower ceiling for first-tier independent suppliers. Types of captive component facilities slated for lower-tier futures (as the cost of the OEMs, especially GM, staying far more vertically integrated than Japanese OEMs) are those making small hardware, batteries, bearings, and die castings, and many kinds of foundries. Anything that has to be sold outside as well as inside, that's done outside much cheaper, or that's labor-intensive (e.g., copper wire harnesses) is seen as a candidate for one or more lower tiers. "Many patterns are coming," one union interviewee told us. "We won't let it happen randomly, a plant at a time. If bearings are a competitive problem, we'll take all the bearing plants down a notch together," he continued. An OEM respondent agreed: beyond (final) assembly and large car engines and drivetrains, "only proprietary technology protects against falling out of the (big car) master." Again, a tier cut was described as the price of high vertical integration. "Either we get $1,000 out of each (small and midsized) car in the parts plants, or we don't get the $2,000 (total) we need to catch the competition. Parts plants (workers) are going to have to understand," he concluded, "that the contract isn't really with GM or Ford; it has to fit the plant."

So What's the Deal?

The last few pages provide ample grounds for expecting that the 1980–92 period portends a chaotic labor-management playing field; we expect management to get much, but not all, of what it seeks in the way of breakouts from pattern agreements. We expect sizeable rank and file disgruntlement, and a resulting split between "cooperationists" and "resistors" in the labor leadership.

What we don't know is whether the automotive economy that will emerge from the fray in the mid-1990's will be one that continues to hold its own in the marketplace while providing high living standards for many Michiganians. The reason for this agnosticism is that we don't know whether the labor-management engagements we foresee will result in bargains that anchor and nurture wealth-creating automotive activity here. Will labor see greater job security as worth a cut in living standards and, if so, will increased intra-labor inequities be tolerated as the means to the latter? Will management make the offer, or use resistance to justify plant closings and increased outsourcing? Will heretofore purely management prerogatives over sourcing be shared? Will backers of greater participation insist that the the *level* of participation go beyond Saturn's "work units" to include codetermination of investment? Will the skilled trades – who may feel that technological change makes their employability and living standards secure – stand in the way of deals linking work rule changes and job security?

And perhaps most important, does it make much difference how these questions are answered? Can deals such as the ones at which this chapter has hinted, combined with new and well-applied technology, cut costs enough to keep most of the industry's production here,[20] or are successes quickly imitable in low-labor cost nations and non-union states?

The clear imperative is to find out in practice. The State can play a role in educating, in cajoling, in providing forums for OEMs, suppliers, labor, and itself in which the possibilities for new and better deals — some involving State resources — might be struck. To be sure, skeptics abound. Many managers prefer a purely market-driven restructuring, with the only State role in paying the losers' transition costs. Many unionists at all levels will resist any changes in work practices. Many on both sides of the table won't want the State involved.

We noted earlier that, even were labor composed on the question,[21] constructive trades might not be offered. Our interviews with all but the top level of UAW representatives made clear how distrustful many in labor are of recent deals. They cite AMC's promise to restore 1982 cuts as an example of "a good deal that wasn't worth the paper it was written on," though in the same breath they agree that the 1985 cuts were inevitable and saved the Kenosha plant. Despite all the obstacles to deal-making, we see no attractive alternatives. More important, there are emerging signs of good bargains; it is with them that we close.

- The IUE-Chrysler two-tier settlement included an agreement that new, viable work would be sought as untenably labor-intensive wire harness work was gradually — at a controlled rate — let go.

- A UAW agreement with Budd's railcar operation in Pennsylvania allows the plant to shed the terms of the master agreement, but only if and when Budd secures for the plant new work sufficient to occupy 60% of UAW hours.

- At International Harvester, the company got much-relaxed work rules in return for a guarantee not to reduce the UAW's share of total hours worked.

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[20]Exhibit L2 presents an illustrative exercise in which a plausible deal results in a 12% cut in engine production costs.

[21]We take as evidence the fact that in no case of which we are aware has labor proposed an arrangement in which EI/QWL programs, work rules changes, and pay for knowledge are part of a package that includes management commitments to make specific major investments.

- At Rockwell, relaxed work practices and a longer progression to top rates was traded for a provision that makes layoffs more costly through triggered hikes in severance pay obligations.

- Finally, at one large Michigan independent supplier, our respondent flatly backed a deal linking fewer skilled trades classifications and longer wage and benefit progression to plant-saving investments — and promised *not* to make those investments without those contract changes.

The next step is for new deals to become part of wider debate and discourse. The fuller articulation of these themes holds unique promise for a constructive automotive culture in the years ahead. Failure to proceed along these lines seems a perilous non-decision indeed. We have nothing to lose but our greatest industry.

Exhibit L1

APPROVED UAW® SKILLED TRADES AND CLASSIFICATIONS

BASIC TRADES

*1. Air Conditioning and/or Refrigeration Mechanic
*2. Auto Body Repairer
*3. Automotive Mechanic
*4. Blacksmith
5. Boilermaker
*6. Bricklayer
7. Cabinetmaker
*8. Carpenter
*9. Diecast Diemaker and/or Die Moldmaker
*10. Diemaker
*11. Diesel Mechanic
*12. Die Sinker
*13. Electrician
*14. Flight Line Mechanic
(a) Mechanical (b) Electric/Electronics
*15. Hydraulics
*16. Industrial Photographer
*17. Industrial Truck Repairer
*18. Industrial Welder
*19. Jobbing Molder and/or Jobbing Coremaker
*20. Machine Repairer
*21. Metal Modelmaker
*22. Metal Patternmaker
*23. Millwright
*24. Painter/Glazier
*25. Pipefitter—Plumber—Steamfitter
26. Plasterer
*27. Powerhouse Mechanic
*28. Pyrometer and Instrument Repairer
29. Rigger
*30. Sewing Machine Repairer
*31. Sheetmetal and/or Tinsmith
*32. Stationary Engineer
*33. Tool and Diemaker
*34. Tool Hardener
*35. Toolmaker
*36. Wood Modelmaker
*37. Wood Patternmaker

ASSOCIATED CLASSIFICATIONS

1. Boiler Operator
2. Die Fitter and Barber
3. Die Tryout
4. Gaugemaker
*5. Gear Shaper & Grinder Experimental & Prototype
6. Hand Engraver
7. Inspectors:
*(a) Layout Inspector
(b) Tool Inspector
(c) Tool Layout Inspector A.A.
8. Metal Spinner (Prototype)
9. Modelmaker Plaster and/or Plastics
10. Office Equipment Repair
11. Punch Finisher
12. Templatemaker—Tool and Die
13. Tool Boring Machinist
14. Tool Cutter Grinder
15. Tool Grinder Machinist A.A.
16. Tool Grinder Machinist—External
17. Tool Grinder Machinist—Internal
18. Tool Grinder Machinist—Surface
19. Tool Hydrotel Machinist
20. Tool Jig Grinder Machinist
21. Tool Jig Borer Machinist
22. Tool Keller Machinist
23. Tool Lap Hand
24. Tool Lathe Machinist
*25. Tool Machinist A.A.
26. Tool Milling Machinist
27. Tool Pantograph Machinist
28. Tool Planer Machinist
29. Tool Radial Drill Machinist
30. Tool Shaper Machinist
31. Tool Turret Lathe Machinist
32. Trailer Repairer
*33. Welder Fixture Repairer**
34. Welders:
(a) Welder—Maintenance & Construction
(b) Welder—Tool and Die

**Welder Fixture Repair Cards issued at plant locations in compliance with UAW® Guidelines and approved by Skilled Trades Department. Apprenticeship approved for these locations only.

ENGINEERING—DEVELOPMENT AND EXPERIMENTAL TRADES AND CLASSIFICATIONS

*1. Auto Body Developer (Plaster and Plastic)
2. Designers:
(a) Diecast Die Designers
*(b) Die Designer
*(c) Electrical Designer
(d) Product Designer
*(e) Tool Designer
*(f) Tool and Die Designer
3. Draftsman Developmental Layout (Blank and/or Equipment)
*4. Electronic Technician
*5. Experimental Product Engineering Layout and Assembly
*6. Experimental Engineering Test Technician
*7. Experimental Laboratory Paint Technician
*8. Experimental Trimmer
9. Instrument Maker (Electric or Electronic)
10. Instrument Maker (Mechanical)
11. Metallurgical Technician
12. Metrology:
(a) Metrology Technician (Electric and Electronic)
(b) Metrology Technician (Mechanical)
(c) Metrology Technician (All Around)
*13. Model Builder (Wind Tunnel)
*14. Sheetmetal Experimental and/or Development
15. Welder A.A. Experimental

* SCHEDULE OF WORK PROCESSES AND RELATED INSTRUCTIONS CONTAINED IN UAW® APPRENTICESHIP STANDARDS.

PROCEDURE FOR APPLICANTS REQUESTING UAW® JOURNEYMAN CARDS

1. Application forms are available at all UAW® Regional and Local Union Offices.
2. Application forms must be filled out completely, printed in ink or typewritten and in duplicate (except for signatures). Two Union Officers' signatures required in addition to applicant's signature.
3. Any Journeyman Card issued is the property of the International Union, UAW®, and may be revoked for good and sufficient reason, including failure to maintain membership in good standing while working in a UAW® plant or on layoff with recall rights.
4. Applicant must be working at a trade and be a member in good standing in the UAW®.
5. Applicants must have two completed application forms.
PLUS:
(a) Two copies of current work record on Company letterhead stationery from a Company under contract with the UAW®.
Plus:
(b) Work records from UAW® plants must be verified by a LOCAL UNION OFFICER, COMMITTEEMAN or STEWARD, attesting to the authenticity of the work record. The officer, steward or committeeman must indicate UAW® Local Union number, date and office held next to his signature.
(c) Work records from plants not organized in the UAW® must be notarized.
Plus:
(d) In the case of Apprentice Graduate, two copies of a certificate of completion of a bonafide apprenticeship. If the apprenticeship was served under an agreement other than a UAW® agree , two copies of a schedule of training from shop and school must be submitted.
(e) Applicants that are non-apprentice graduates are required to submit work records in duplicate from each individual employer on Company letterhead stationery signed by a Company official and designating the specific type of work performed and the dates of such work performance that confirms eight years at the trade or classification.
(f) Two passport-type pictures, 1" x 1¼", EXACT SIZE NECESSARY, of good quality on a single weight paper.
(g) **APPLICANT'S SIGNATURE ONLY** on pocket-size Journeyman Card and Master Card.
6. Applicants submitting foreign papers to substantiate journeyman status must have the foreign language papers translated by a source approved by the Skilled Trades Department of the International Union and must submit two copies of the foreign language papers and two copies of the translation.
7. Copies must be completely legible to be acceptable.
8. Experience gained in military service may be used to substantiate journeyman status provided the applicant can produce detailed records showing experience at the trade. Discharge certificate is not sufficient. To obtain military personnel records, write to:

MILITARY PERSONNEL RECORD CENTER, TAGO
9700 PAGE BOULEVARD
ST. LOUIS, MISSOURI 63132

CANADIAN SERVICE RECORDS:
DEPARTMENT OF NATI[illegible]AL DEFENSE
OTTAWA, ONTARIO, [illegible]ADA K2P OG3

Exhibit L2

Make in the U.S. or Buy Offshore?
An Illustrative Exercise

Component: 4-cylinder gasoline engine, undressed

U.S. Assumptions:

2 hrs per unit direct labor
Indirect-to-direct labor ratio: 1:1
Direct material per unit: $150
Hours per worker per year: 1880
Equipment amortization: $50 per unit

International Comparisons:

	U.S.	**Japan**	**France**	**Korea**
Hourly labor cost	$23.00	$13.00	$13.00	$ 3.00
Direct labor prod'y	100	120	90	50
Indirect: direct ratio	1:1	0.6:1	1.4:1	0.8:1
Hours worked per yr	1880	1960	1700	2400
Machine utilization	70%	85%	65%	60%
Materials cost (index)	100	100	110	95
Scrap factor	5%	2%	10%	20%

INITIAL RELATIVE PRODUCTION COSTS

	U.S.	**Japan**	**France**	**Korea**
Direct & indirect labor	$92.00	$34.67	$69.33	$21.60
Direct material	150.00	145.71	172.86	162.86
Equip't amortization	71.43	54.81	89.12	74.60
Transp'n & tariff	--	30.00	25.00	35.00
	$313.43	$265.19	$356.31	$294.06
As Pct of US Cost	**100**	**85**	**114**	**94**

... BUT WHAT IF A DEAL COULD BE CUT

... in which management and labor agree to take steps to reduce costs in an effort to retain work in, or return it to, the U.S.? For example ...

Labor agrees to modify work practices in return for
Management promises to

- invest in existing unionized U.S. facilities;
- co-redesign line balancing & buffering; and
- commit to CAE/DEM to reduce subpart and assembly complexity,

resulting in:

- 15% higher direct labor productivity;
- An indirect: direct ratio of 0.7:1;
- 80% machine utilization; and
- A 2% scrap rate.

AFTER-DEAL RELATIVE PRODUCTION COSTS

	U.S.	Japan	France	Korea
Direct & indirect labor	$68.00	$34.67	$69.33	$21.60
Direct material	145.71	145.71	172.86	162.86
Equip't amortization	62.50	54.81	89.12	74.60
Transp'n & tariff	--	30.00	25.00	35.00
	$276.21	$265.19	$356.31	294.06
As Pct of US Cost	**100**	**96**	**129**	**106**

Relatively More, but Absolutely Fewer, US Jobs

	Initial	After-Deal
Direct	425	361
Indirect	425	253
	850	**614**

EMERGING PRODUCT DEVELOPMENTS

Introduction

The automotive industry is changing at an increasingly fast pace, with a fundamental reordering of the entire business. This is certainly true of product technology. During the next ten-year period, we will witness unprecedented major technical changes throughout the industry. The purpose of this chapter is to develop a perspective on those product changes. The scope is necessarily limited, particularly with regard to impacts on particular firms in U.S. and Michigan industry. Future work will remedy that limitation.

Technology must today be viewed on a worldwide rather than a domestic basis. The competitive environment requires that technology become a more important factor in establishing a competitive advantage in the industry. In fact, many of the traditional consumer value factors that have been used to discriminate or differentiate between products on an international scale are losing their value as parity is achieved in many of the quality areas. U.S. cars are rapidly approaching the level of the Japanese in fit and finish quality, and the Japanese are quickly attaining the levels of corrosion protection found in U.S. products. This growing parity is increasing the emphasis on new technology as a product differentiation feature.

Consistent with rapid technological change is a shift in the basic structure of the U.S. market. The emerging automotive market can be characterized as having a commodity, or high-volume, vehicle segment and a specialty vehicle segment consisting of higher-priced but lower-volume vehicles. The latter market segment is a particularly important technological driving force because of the "high tech" expectations and even demands of many upper scale buyers, and it provides a real world laboratory for features that will later be embodied in commodity segment vehicles.

For this phase of the AIM study, our approach was to contact executive engineers at the various OEMs and at one integrated supplier. The OEMs surveyed included the C-P-C and B-O-C divisions at General Motors, the Ford Motor Company and Chrysler Corporation. The Hydra-Matic division at General Motors was also included in the study. A series of questionnaires was prepared which included the universal questions and a more detailed set of questions pertinent to the individual technical areas. With each group, a "roundtable" discussion was convened to address the universal questions in an interactive manner. Overall, more than 40 executives participated in these meetings. Following these roundtable sessions, CRT representatives met with the individual technical area groups.

The following areas were addressed:

- Drivetrain
- Frame/Structure/Body
- Spark-Ignited Engines
- Electronics
- Engineering Process

They were selected because of their importance to the competitiveness of U.S. and Michigan industry, the high rate of change in each area, and because each is a leading indicator of other technological change.

In the following pages, we present in the main the dominant respondent view, and generally refrain from attribution of trends to specific individuals or manufacturers. We found the roundtable participants to be candid, direct, and almost uniformly concerned with future challenges as well as eager to assist the State to better understand the industry. We also observed a sense of urgency: several key panelists expressed great concern of a coming crisis because of the growing intensity of international competition. There was general agreement that we are in an incredibly complex international environment that demands prompt, aggressive, and forceful moves toward greatly enhanced quality and productivity.

World class quality is now viewed as a fundamental condition of participation in the industry; anything less is viewed as unacceptable. This places enormous pressure on both the manufacturers and their suppliers to improve product quality to the best available in the world. The panelists agreed that unless supplier quality goals can be met, they will aggressively seek offshore sources and, in fact, this process is already occurring at an increasing rate. Concerns with productivity are consistent with the consensus view that the U.S car is \$2,000−\$2,500 more expensive to produce than a comparable Japanese car, partly because of tax, exchange rate, and capital cost disadvantages for U.S. producers. Anything less than cost parity is seen as unacceptable.

The urgency expressed is also associated with some noteworthy new ideas. Traditionally, engineers have focused on objects, things, and processes in discussions of this type. We were impressed with the panelists' sense of the growing importance of people and of improving human relationships. Participative management is viewed by most not as an option, but as fundamental to long term success. Those who have recently observed a U.S.-based plant organized and managed by Japanese were particularly emphatic about the importance of a dedicated, flexible, and turned-on workforce. Furthermore, the relatively "low tech" nature of the plant, together with the high quality and low cost of its products, have dramatically altered the view that the key to success is simply a "high tech" production environment.

Panelists emphasized the importance of systems engineering, which includes the interrelationship between various parts of the product and between the design and production functions. Systems should be viewed in an even broader context, one in which management, social and economic considerations, and technological factors are considered in total to ensure the production of a truly competitive vehicle. Our technical educational system was criticized for lack of emphasis on systems. There was also consensus that skills need to be improved through training and advanced schooling. Manufacturing engineers, designers, applied electronic engineers, and service personnel were viewed as being in short supply. Problems have been exacerbated by the early retirements of the last few years, and by the fast pace of recent technological change.

We also observed a strong sense of optimism along with the sense of concern and urgency. There was consensus that the industry had awakened from a deep sleep and would forego future "snoozes." The change within the industry is viewed as deep, fundamental, and all-encompassing. We found an almost consuming concern with the challenges of manufacturability and the aligning of product design and manufacturing people at the earliest stages in the product life cycle. Such phrases as "design for automation" and "simultaneous engineering" were used liberally. Much traditional manufacturing technology is increasingly viewed as obsolete, including the synchronous assembly line, which will more and more be replaced by a modular construction, parallel processing system.

Universal Questions

In this section, we summarize the product development panels' response to the Universal Questions.

A range of views was expressed as to what would be the three most important changes in cars and light trucks between now and 1992. Respondents grouped predicted changes into four categories: customer requirements, product technology, manufacturing considerations, and governmental concerns. Based on customer requirements, increased model proliferation and increased demand for high quality products were expected to be key factors prompting change in passenger cars and light trucks.

The two most prominent product changes mentioned were the increased application of advanced electronics, and the development of new materials. Changes such as improved engine performance, new engine requirements for fuel economy, aerodynamic improvements, reduced mass, and the trend to front drive were also mentioned.

In terms of manufacturing, integration of design and processing, design for automation, the rapid expansion of modular construction technology, parts integration into single components or subsystems, and the application of new joining technology were were viewed as critical.

Government regulations on passive restraints were viewed as prompting product change, already accelerated due to shorter product life cycles.

Views on the most important changes between now and 1992 from a manufacturing standpoint closely parallel those on product changes.

Much higher levels of automation are expected, and the resulting alteration in manufacturing operations will be extensive. Entire plants will be obsoleted by competitive pressure; retooling will be a massive undertaking. Computer-Integrated Manufacturing (CIM) and its relationship to overall improvements in productivity and quality was repeatedly noted.

Flexible manufacturing systems (FMS) are viewed as very important, prompted by disaggregation of the future market and the need to meet rapidly changing consumer expectations. This dictates a quick change (at modest cost) manufacturing system. A reasonable cost premium for FMS systems is expected.

Modular construction is coming on very quickly, and eventually could almost totally replace the synchronous line concept. This suggest that conventional assembly will be vulnerable, lending pressure toward greenfield siting of future programs.

Quality was observed as being a major factor in the revision of the production system, as was the need for major improvements in productivity. Design for automation was emphasized, indicating again the importance of bringing design and manufacturing more closely together.

Another factor receiving considerable mention was the role of outsourcing; manufacturers believe it is likely to expand, particularly on a complete subsystem or module basis. Suppliers are increasingly expected to be close to the production operation to better accommodate "just-in-time" requirements, which may prompt moves of remote plants to a satellite location in major production complexes. Absent on-location plants, local warehousing is likely. Supplier-manufacturer relationships are viewed as improving.

It appears that any major change within the manufacturing environment will be evaluated on the basis of long term return on investment, so automation for automation's sake is not likely to be a major independent force. The recent quality/productivity experience of the comparatively unautomated NUMMI operation is often cited on this point, at least for final assembly operations.

Management and personnel changes were viewed as tremendously important. A more skilled workforce will be required in order to operate the more productive and sophisticated plants of the future. Effective implementation of participatory management is essential. Jobs will on average be broader, as minimum efficient scale is decreased with flexible automation, in some cases leading to smaller plants rather than large complexes.

It is also clear that the growing materials revolution must be considered in the context of the processing steps required for those materials. Future materials considerations will be increasingly integrated with manufacturing considerations.

Detailed areas of change in the manufacturing system include application of advanced optical measurement systems to improve process capability and quality, reduced inventories, and less space devoted to rework.

In almost every instance, panelists viewed advances in CIM, which in many cases have already led to significant productivity improvements, as enhancing the potential of the manufacturing base being retained in the United States in general and in Michigan in particular. However, the point was strongly made that this result is not automatic. Parallel advances are required in the development of designs for automated manufacturing; in the skill of the workforce; in the proximity of key suppliers to the point of assembly; in effective cooperation between manufacturers, suppliers, labor, and governmental units; and in labor cost moderation. It was emphasized that one must look at the total system of costs to arrive at a final decision on competitiveness, although in general improved computer technology is expected to redound to the advantage of U.S.-based operations.

A wide range of plant types were viewed as being in the strongest positions through 1992. Modern plants and those recently receiving heavy investment are reasonably secure. Facilities that have demonstrated excellent cost and quality competitiveness are likewise not likely to be closed unless, of course, a fundamental change in the product occurs. Strong operations include Ford Livonia Transmission, new luxury car operations, plastic-composite materials operations, Ford Climate Control, Saginaw Steering Gear, C-P-C Bay City, (GM) Rochester Products Division in Western Michigan, Buick City, newer engine plants, and plants devoted to the manufacture of advanced electronics. In addition, manufacturing equipment facilities, especially those producing FMS equipment, appear to our respondents to be safe.

On the opposite end of the spectrum, heavy forging and casting operations and those with labor intensive operations such as cut-and-sew were viewed as particularly vulnerable. Also seen as at risk are facilities manufacturing a mechanical component likely to be replaced by electronics, and plants dominated by a militant third generation labor force and unenlightened management, through recent experiences have demonstrated that some fundamental changes can be made even with a well-entrenched, militant labor force, leading to a much more productive situation.

Finally, the extensive basic redesign of engines expected in the next few years means that many if not most engine production facilities are being thoroughly reevaluated. And, of course, the trend to rear-drive and independent control arms spells trouble for many axle operations.

The engineering executives asked to consider what the State of Michigan can do to help the changing automotive industry offered a range of answers, including the expected ones: tax incentives (especially for automation) and reductions in workmen's compensation and unemployment insurance costs. Retraining and overall training efforts also received prominent mention. There was support for assisting educational institutions to meet the need for people with design and manufacturing experience. In fact, concern was expressed that there is a mismatch between future job requirements and the educational system. A highly skilled workforce, from the plant floor to the engineering laboratory to top management, is vitally important to future competitiveness, and the State is being asked to play a prominent role.

The State is also viewed as being important as an encourager of new business, by making Michigan a more attractive location for entrepreneurial and creative businesses. Note was made of the State as a venture capital source and of how important this could be as we shift to a more entrepreneurial way of thinking. This is viewed as closely related to to developing an even stronger technological base in the State, one on which the auto industry can build. The auto industry feels it should be treated as an investment, in which the goal is preserve the health and strength of the strongest and most aggressive companies. The potential role of the State in helping marshal the support of rank and file labor was also noted.

From a political point of view, it was observed that the State should be increasingly aggressive in helping firms meet foreign competition through support of federal initiatives to improve the yen/dollar relationship and reimpose import restraints, though there was not unanimous support on these points.

The Department of Natural Resources' (DNR) interpretation of environmental regulations was also noted as a problem. Respondents suggested that less interpretive strictness could be very helpful in ensuring Michigan siting for new plants, as would swift resolution of waste stream issues raised by the increasing use of plastics.

In the aforegoing Universal Question responses, we have not explored the issues in great depth. However, we have attempted to capture the overall trend of thought. The views were diverse from one panelist to the next, but there were some consistent threads throughout.

Technical Survey Overview

We found reasonable consensus among the manufacturers in the various topic areas surveyed, with more differences in view beyond the 1992 time frame. Basically, the product of 1992 is reasonably well known and not widely subject to speculation, whereas forecasts for 1992-2000 elicited greater variance among the panelists.

Drivetrain

There is consensus that the move to front drive will continue, although some manufacturers indicated that rear drive will remain a significant configuration in their product lines for a number of years to come. The results of the current AIM forecast is shown in the table below. We believe the variation between manufacturers that led to the AIM ranges below reflects product strategy differences in the 1988-92 period, but not beyond. By the year 2000, front drive should reach a penetration of about 90%.

1992 AIM Drivetrain Forecast
Compared to Actual 1984 Shares and 1992 Delphi Forecast

	1984 Actual	Delphi 1992 Forecast	AIM 1992 Forecast
Front Engine/Rear Drive	48%	15%	5 – 25%
Front Engine/Front Drive	51	81	72 – 93
Mid-Engine/Rear Drive	1	4	2 – 5

It should be noted that light trucks (including most vans) will largely continue to use front engine/rear drive, particularly those intended for heavier loads. Four wheel drive systems could become increasingly popular, and one forecaster suggested that fully 25% of light duty vehicles could be four wheel drive in the late 90s.

Parts that will be eliminated with the continued shift to front drive include the conventional rear axle assembly with its differential, prop shaft, and universal joints, and peripheral parts. Major modifications are necessary to the floor pan and rear suspension.

Front drive demands more careful integration of the engine and transmission. Areas of opportunity associated with front drive are the overall front engine transaxle unit, which contains numerous similar (from a functional standpoint) components to rear drive transmission and axles, plus additional elements such as the constant velocity (CV) universal joints. Electronics will play a more prominent role as hydraulic control elements are replaced with electronic components. Considerable modification of the front suspension is also necessary. The transverse front engine/front drive design, in fact, has been the major stimulus behind the switch to McPherson strut front suspension.

Plants producing drivetrain parts thus face either a threat or an opportunity, depending on whether they serve the front or rear drive market. The possible expansion of four wheel drive is a very significant point, because of the considerable value added in the overall drivetrain. This would create new opportunities for volume in prop shafts, U-joints, and a sophisticated transfer case.

Specific facilities and producers that would be affected, either positively or negatively, include Ford Livonia Transmission, Chrysler Eldon Axle, Dana, GKN, Saginaw Gear and Hydra-Matic as well as facilities making engines that need to be modified to accommodate front engine/front drive. Several panelists observed that with a greater emphasis on aerodynamics there will be increasing attempts to reduce the hood line, which in turn could lead to rather dramatic changes in the front suspension.

Overall, panelists did not foresee major dislocations among those facilities presently involved in drivetrain production, particularly the in-house supplier operations. However, each old and new supplier, inside or independent, must meet increasingly rigid quality requirements to be considered a viable supplier.

A broad range of transmission forecasts was suggested. The range is dictated in part by the model mix forecast by the various manufacturers. Panelists generally responded in terms of their own product line rather than in terms of the industry. Also, it was noted that transmission manufacturing flexibility is desirable to address a fast-changing market. The following table demonstrates the broad range of transmission forecasts.

Manual transmissions are expected to be used more; five speeds will dominate, though it was suggested that, with new broad torque range engines, there may be little performance advantage for the five speed. In the automatic transmission, we found very mixed views as to the potential for the Continuously Variable Transmission (CVT). Some are optimistic, others quite pessimistic. This gives rise to the broad range of the forecast. When the forecast was extended to the year 2000, we found that the range of CVT forecast was still a very broad 5% – 30%.

1992 AIM Transmission Forecast Compared to Actual 1984 Shares and 1992 Delphi Forecast			
	1984 Actual	Delphi 1992 Forecast	AIM 1992 Forecast
Manual			
Four-speed	6.4%	10%	1– 3%
Five-speed*	9.0	16	10–26
Total Manual	15.4	26	12–25
Automatic			
Three-speed	**	19	20–21
Four-speed	**	41	48–68
Continuous variable (CVT)	**	14	2–20
Five/six speed automatics	**	**	0–5
Total Automatic	84.6	74	75–88

*Includes overdrive.
**No breakdowns available.

Because of the mystery and corresponding "hype" surrounding the CVT and the potential threat to conventional transmission facilities, we chose to investigate CVT feasibility in modest detail. Most current designs are based on the Van Doorn principle, which involves two variable diameter pulleys connected by a very special belt. It was acknowledged that there have been significant belt manufacturing problems with the CVT, although most expressed optimism that this problem will be solved. However, even with a solution, there are a number of areas of concern, including poor initial vehicle acceleration, lack of crisp off-the-line feel, and excessive engine noise. CVT cost projections were also very mixed. Some felt that it would be more expensive than a conventional automatic transmission; others expected a lower cost. Rather significant concern was also voiced over CVT consumer acceptance. Our conclusion is that the future of the CVT is too close to call at this time, although with the solution to its present problems, it will likely begin to moderately penetrate the small vehicle market by 1992.

Panelists expressed a range of opinion as to the maximum engine displacement and weight for a CVT-equipped vehicle. Some suggested 2.2 liters maximum; others extended the limit to 2.8 to 3.0 liters. The key is not so much displacement as torque output of the engine. Maximum vehicle weight for a CVT vehicle is expected to be in the area of 3,000 lbs. In general, the CVT is viewed as a competitor to the automatic transmission, and would probably not have much effect on manual transmission designs, although there is a strong minority view, particularly when one considers the European market as the likely first area of application. It was also observed that at this point there is relatively little fuel economy advantage of the CVT over the manual transmission.

There are several key unique elements or components in the CVT that make some conventional transmission components vulnerable. The belt and its special elements are the primary unique features of this transmission, and present significant opportunity for suppliers. Many conventional automatic transmission components, such as gears, various friction surfaces, and clutches would still be used, but in lesser numbers. It was emphasized that the components in many respects are similar, but there would be far fewer than in current designs. Various hydraulic control elements presently used would in large measure be replaced by electronic components. Spring or viscous dampers could also present opportunities.

All agreed that the transmission is a vital vehicle subsystem to retain in-house at the manufacturers. Therefore, GM, Ford, and Chrysler all expect to produce CVTs—eventually. However, special components suppliers are likely to play a prominent role. Borg-Warner, in particular, was mentioned as a likely supplier of key cut components.

Because of changing market trends, the growing use of flexible manufacturing systems, and our large existing transmission facilities, we explored the outlook look for production scaling. The following table shows the range of standard volume for a production module (including a forecast for the CVT).

Range of Standard Volume for a Production Module

Transmission Class	Module Volume (Thousands Per Year)
Automatics	400 – 600
Manuals	100 – 600
CVTs	500 – 600

We found a considerable variation in the production volume of a module among the various companies, leading to the broad ranges above. Flexible automation is expected to make considerable inroads in the transmission area, and perhaps reduce the minimum production volume of a module by a factor of two. It may even mean that in some cases engine and transmission operations will be brought together in a single plant.

Some key changes are likely in both product and process technology with respect to existing transmissions/drivetrains. Clearly, quality improvement and cost reduction are two aims of every transmission group. It was suggested that the most important technical changes, those that ensure the high quality of every transmission produced, require that the existing process be brought under better control through a combination of improved management and process and product technology: "A greater level of science must be applied to the manufacturing system," suggested one panelist. Such technical features as the use of ground gears, pre-formed gear teeth, and aluminum or composite shafts were mentioned as possible changes in existing designs. The transition from mechanical/hydramatic to electronic control is just beginning, and is expected to accelerate rapidly.

Frame/Structure/Body

During the past decade, there has been a basic shift in the construction techniques for U.S. vehicles, particularly passenger cars. The separate body frame design is being replaced by the integral body frame (or unibody), and we have also begun to see the emergence of a "bird-cage" or space frame concept. By 1992, the separate body frame is expected to disappear in cars and the integral or unibody to dominate. There is mixed opinion within the car companies as to the potential for the space frame. Some think it will be used in as many as 10 − 20% of 1992 vehicles, while others see no role in the product mix forecast of their company. With extension of the forecast period beyond 1992, however, there is some indication that space frame usage could expand well beyond 10% at some companies.

Vans and trucks designed for heavier load-carrying capability are likely to continue using the separate body frame design. Thus there will still be the need, albeit reduced, for some rather heavy frame stampings. Suppliers of heavy frame structural members will be further impacted by the reduction in separate body-frame use.

Major body and structural components will also be impacted by the change forecast above. With the bird cage or driveable chassis design, changes are particularly dramatic. These range from the steel, and possibly aluminum or composites, in the support structure to the use of polymer-based composite panels on the exterior. In addition, a truly unique frame manufacturing process is required.

Even in the integral body-frame, which is essentially the standard today, plastics are likely to play a more prominent role in various structural components. From a construction standpoint, the basic design of the vehicle will be such that it must accommodate the growing trend to modular construction.

One of the true areas of automotive revolution is in the basic materials sector. Perhaps the most interesting part of this revolution is the competition between steel and plastic for body panels. The technology panel forecasts were reasonably consistent. Steel is expected to remain the dominant material, but with plastics coming on strong, particularly beyond 1992.

AIM 1992 Materials Forecast
of Body Panels

	Steel	Reinforced Plastic	Total
Hood outer	80 – 95 %	5 – 20 %	100%
Door exterior	70 – 100	0 – 30	100
Roof exterior	97 – 100	0 – 3	100
Fender outer	70 – 95	5 – 30	100
Fender inner	0 – 99	1 – 100	100

There was major disagreement between panelists in a few key areas. For example, one manufacturer's engineer forecast all plastic inner fenders, while another forecast essentially zero plastics penetration for of the component. Clearly, reinforced plastic will be more heavily used in the future, but mainly after 1990: a common remark was that many post-1990 vehicles may be designed with essentially 100% plastic exterior panels. The key to the future of polymer-based materials lies in developments yet to be made, particularly in the processing area (see this Report's chapter on materials for details). Manufacturing considerations have improved, and there has been significant part integration with plastic components. While there is not universal enthusiasm for reinforced plastic panels, the list of supporters is growing and, clearly, plastics in all their forms must be viewed as a material on the move.

Another important material competition is in the frame and structural member area. Steel will remain the primary structural material in the integral body frame through 1992, although polymer-based composites could be used for 5% of the structural requirements. In the space-frame, on the other hand, a much more prominent role was envisioned for composites, and potentially for aluminum. In this design, rather easily fabricated basic shapes can be brought together in an automated facility to form the basic space-frame. By the year 2000, a far greater use of polymer-based composites is envisioned, although there is considerably uncertainty as to how far this technology will proceed in the next ten years. The processing, quality, and cost issues are critical with any competitive material. Selection will be based on a total systems analysis.

One of the key dichotomies observed in our interviews was the indication that on-site stamping would be used increasingly in new plants, yet that centralized stamping facilities still make a great deal of sense. Modern, dedicated major stamping facilities of the manufacturers are viewed as being secure at the present time, perhaps because, as one interviewee suggested, studies of on-site stamping operative do not show a cost advantage over centralized stamping facilities. On-site stamping can only be effective with rapid die changes to enable multiple parts production on a few press lines. It is still too close to call as to the ultimate impact on Michigan facilities. GM is presently heavily integrated in stamping and therefore little outside impact is envisioned. On-site stamping, led by the Fairfax, KS GM10 plant, is coming. At Chrysler, the view was expressed that assembly could be moved to the site of stamping operations. At Ford, on-site stamping is envisioned as a more common requirement; still, the Woodhaven plant is viewed as secure and well-equipped for the future. All respondents felt that independent stamping suppliers will be highly vulnerable to lost business.

Spark-Ignited Engines

One of the most important areas of technical change foreseen in the next ten year period is the powerplant, generally a spark-ignited or gasoline engine. While moderation in energy cost expectations has reduced considerably the demand for diesel engines and public clamor for fuel economy gains, there is still emphasis on improving efficiency and performance of the gasoline engine. Certainly the federal Corporate Average Fuel Economy (CAFE) requirements are a factor in this.

AIM Engine Cylinder Distribution Forecast
Compared to Actual 1984 Distribution and 1992 Delphi Forecast

	1984 Actual	1992 Delphi Forecast	1992 AIM Forecast
4 Cylinders	47%	58%	40–60%
6 Cylinders (V-6)	26	32	35–45
8 Cylinders (V-8)	27	10	10–20
Total	100%	100%	100%

In general, the trends forecast in the past Delphi study are holding up for engine configuration. Obviously, however, if there is a major dislocation in energy supply, there could be a more rapid shift to smaller engines, and with significant energy price cuts the demand for larger engines could expand. The V-8 is expected to be an important future powerplant, and remains under any future energy scenario a viable truck engine; 4- and 6-cylinder engines will dominate.

We found the industry in the midst of a major effort to update and improve its engines. The majority of U. S. light duty engines will be almost totally redesigned by 1992-95, in the opinion of our panelists. One major manufacturer suggested that 100% of its engine lines would be redesigned completely by 1992; another, 80%; and another, that 40 – 50% would be completely redone. The present typical powerplant design, which is 20-30 years old, is viewed as outdated. New engines will be "high tech," with micro precision and repeatably made components, lower weight, and significantly improved specific power and efficiency. As several panelists stated rather emphatically, engine component suppliers must be at world class quality and cost levels to even be considered for future products.

Present light duty vehicle engines have several major deficiencies, including excessive noise, vibration and harshness, high cost, greater weight and size per horsepower, and lower feature content per dollar than the Japanese competition. There is an unacceptable balance between power and thermal efficiency or fuel economy, and a general need to improve quality through manufacturing precision. Decreased package size and a higher level of customer satisfaction are also required.

New materials are expected to play a prominent role in new engines, particularly aluminum in cylinder heads and blocks. We observed a relatively wide range of expectations for aluminum in heads and blocks. The 1992 forecast for aluminum in heads ranged from 45 to 90% and for blocks, from 5 to 15%. And, there was almost a consensus that, if the experience is good by 1992, there would be a much more extensive conversion to aluminum shortly thereafter. Weight savings with aluminum heads are expected to be 20 to 30 lbs, one major motivator for the material change.

Another possible future material mentioned was magnesium. Weight savings would be even greater than with aluminum. With a complete vehicle redesign, this weight savings could be propagated throughout the vehicle as a secondary weight savings. However, where a direct substitution is made in an existing vehicle, the secondary weight savings are more difficult to achieve. In our judgment, based on the trends developing, we should prepare for rapid and almost complete conversion of major cast engine components to aluminum.

Numerous detailed technical changes are expected in future engines. Features foreseen by 1992 are shown in the following table, with expected market penetration. While this is not a definitive list, it is representative of the growing climate of change.

Feature	Penetration rate
Lean burn combustion	10%
3/4 valve and twin cam designs	10–15
Superchargers	2
Variable valve timing mechanism	5
Electronic controls	95+
Overhead cams	35+
Turbochargers	4–5
Fast burn combustion chambers	95+
Port fuel injection	34
Electronic fuel injection	95+
Roller valve lifters	50–100

In general, engines are in the process of being "high-teched"; the extent of advanced technology employed will be dependent on the market. With the increasing evidence that we are entering a two-tier market of commodity and specialty vehicles, it is evident that many of these advanced technology items will be focused on the specialty vehicle engine.

Recently there has been speculation about the role of a new "wonder material" for engines, namely ceramics. Since a major new material could cause dislocations in engine production centers, we explored ceramic materials' potential for causing change. Some inroads are expected from ceramic materials, although it is evident from panel comments that there are still many uncertainties. Such applications as a ceramic-faced cam followers are forecast in 10% of future engines. Other potential ceramic applications, including turbocharger hot wheels, piston crowns, and exhaust port liners, were forecast for a small percentage of engines by 1992. Another area in which ceramics are viewed as having potential is in reciprocating components such as pistons and valves. In general, components subjected to high heat loading and wear are candidates for ceramic materials, although often only as a thin coating. Ceramic materials are more critical to low-heat rejection or adiabatic diesel engines which, for the foreseeable future, are not likely as light duty vehicle powerplants.

Ceramic manufacturing technology is not yet sufficiently advanced to provide any basis for a significant forecast. It must also be noted that ceramics in the inner combustion area are not likely in gasoline engines because of problems with high temperatures and consequently high fuel octane requirements.

A large number of engine technology factors were suggested by the expert panelists, ranging from broad and aggressive application of statistical process control to flexible manufacturing systems. FMS was viewed as necessary to reduce the minimum efficient scale for a given engine model, as well as to reduce the investment when model changes are made. Other areas noted were increased use of automated assembly and inspection, self-diagnosis of equipment to reduce downtime, improvement in precision casting techniques, use of adaptive tools, and the appearance of some new machine tool concepts such as super-fast machining. Reduced and distributed inspection (in process inspection) will be used. Consistent with present trends, inventory will be reduced to even lower levels. Quality and cost demands are key in prompting change.

Many Michigan engine-related facilities are vulnerable to these changes. Any cast iron foundry making engine parts is viewed as being in potential trouble. In addition, plants more than about 25 years old, including foundries and old engine plants with quality problems, are seen as skating on thin ice in the present environment. Component suppliers must seek early involvement with new engines if they are not to sink with the old designs.

To assess the risks, we looked at the minimum efficient production volume of an engine module for two shifts today and in 1992. As observed with transmissions, we found a range of answers. Today the annual standard volume of an engine module appears to be in the area of 400,000 – 550,000 units. There is some indication that flexible manufacturing could reduce this figure, in some cases considerably. One manufacturer suggested that economic production volumes may already be achievable in a range from 15,000 to 550,000 units a year! Another suggested that it may be possible to think of one module broken up into three submodules, each with approximately equal volume, because of the potential of flexible manufacturing. If so, flexible manufacturing would be earning its somewhat more expensive keep by providing a more flexible product mix.

Electronics

The automotive electronics revolution is well underway and accelerating. There is a fundamental shift from mechanical control systems to an electronic control strategy. In addition, electronics are critical in entertainment and communication systems, and even the clock. In the most recent Delphi (III), more than 12% of 1992 vehicle cost was forecast to be in electronic components. The AIM panelists from the U.S. manufacturers generally support this forecast. Moreover, they have added an important increment of detail. As noted earlier, there is an expectation that the future auto market will be increasingly segmented into a "low tech," high volume and a low volume, "high tech" market. The former is expected to employ electronics to the extent of about 6 – 10% of total cost, while electronics use in specialty vehicles may attain a level of 15 – 25% of total cost. For both vehicle classes, this represents a continued significant expansion.

The unit cost of electronic componentry will be reduced considerably. Therefore, the number and complexity of electronic functions will not be directly proportional to cost, but much higher. This is all the more impressive because as more electronic components and systems are incorporated in the vehicle, functions and components are increasingly likely to be integrated, with a consequent reduction in redundant components. Technology such as multiplexing could expand feature content at relatively low cost, and cause the obsolescence of current components. Where electronics are competing against mechanical control components, electronics are likely to win rather convincingly.

Panelists were also queried as to which major components and controls will be fundamentally altered or changed by electronic technology in the next 8 – 10 years.

Viewed from a systems standpoint, electric power steering, suspension control, transmission control, sophisticated diagnostics, and onboard communication systems will be broadly used and have a major impact. There will be extensive emphasis on all comfort and convenience features. Additional systems that will make heavy use of electronics include electrical distribution (implying the likely application of multiplexing), brake systems (in particular, anti-lock features), and passive restraints.

On a component basis, there will be increased use of various surface-mounted devices, more powerful and faster microcomputers, and specially designed custom circuits. One key feature of such new technology will be a significant increase in part life; and, with a failure or even pending failure, diagnosis down to the electronic module within the overall system will be easily accomplished.

Again, it must be observed that wherever the standard today is a mechanical/hydraulic control element, by the mid- to late-1990s electronics will probably prevail. It is imperative for those engaged in the manufacture of most of these mechanical components to plot an alternative business strategy.

The electronics experts also spoke of factors that could limit the thrust to electronic technology. As with any new and rapidly expanding technology, there are certain limitations: reliability, cost effectiveness, and customer acceptance. Perhaps more than in any other current fast-paced area of technology, the personnel problems are acute: there is a lack of adequately trained electronic design and service people. One of the electronics experts stated with some conviction that in his field only 20% of the people do 80% of the work.

With multiplexing, either with electrical wiring or fiber optics, there is a substantial interface problem, i.e., in converting electrical to optical signals and vice versa. This is a significant issue, and at this point it is not resolved to the extent necessary to allow broad automotive multiplexing application.

Other key points noted were the remaining and still fairly major problem associated with the development of low cost and highly reliable sensors and actuators, and the lengthy time required to prove out and develop electronic technology in the very hostile automotive environment.

Several of the manufacturers stated that even with the growing importance of electrical/electronic systems, there will be only limited opportunity for additional outsourcing; a fundamental base will be maintained within the assembly companies.

Another major limiting factor in electronic applications is cost in relation to reliability: any electronic system must be substantially better than the system it replaces, due to the complexity and cost of repair and to the debilitating nature of some system failures. More system integration tends to reduce failure points, but a singular failure can be catastrophic in nature, e.g., a singular failure in the multiplex wiring control could incapacitate lighting and windshield wiper function.

From a competitive standpoint, in terms of the basic fundamentals of electronics and electronic application, the U.S. is in a strong position vis a vis Japan. But electronic technology has sped up time for the industry: many parts of the product and manufacturing system that are today viewed as state-of-the-art will become part of history very quickly. Any organization, either independent or within the OEMs, will have to possess sophisticated electronic capability in both the process and product areas to ensure future success.

Engineering Process

One measure of how quickly the auto industry can adapt and change to meet the international challenge in the years ahead can be gleaned from examining trends in engineering technology. In the present study, the major manufacturers were queried on a few significant factors related to progress in computer-aided design (CAD), engineering materials assessment capability, and forecast change in lead time. A recurring theme was evident: despite the rapid development and deployment of technological aids, there is a major shortage of trained, experienced, systems-oriented people in the design and manufacturing areas. Shortages of these critical skills may rather fundamentally limit the capacity of the industry to change and become competitive on an international scale.

One measure of how aggressively the various organizations are moving toward the electronic-aided engineering function is the availability of microcomputers, personal computers, and design terminals at the engineer's workstation. While the trend is to rapidly expand deployment of CAD-related systems, their application is not uniform even within a given organization. Some engineering departments use these devices extensively, others only modestly. However, the general goal is to provide every engineer with a basic computer workstation by 1992. Presently, work station deployment range from about 5 to

70% of the engineers, depending on the company and department. In some specialized staffs, such as electrical groups, all technical employees already have workstations. Few indicated that capital was a limiting factor.

Another measure of the application of advanced engineering technology is the amount of design work done using CAD. Again, a range was evident, with a low in some technical areas of about 30% to a high of 100% in electrical systems design. In the next 10 years, the goal generally is to achieve a much higher average percentage design with CAD, in the range of 85 – 100%. Still, it must be noted that the availability of computer technology does not replace the need for trained and skilled designers.

To further refine our assessment of computer technology, we chose to examine one detailed technique, finite element analysis, which is used to improve component structural efficiency. We found widening application of this technology, with a strong capability at all of the Big Three. Furthermore, it was suggested that there are a number of very competent suppliers contributing significantly to the design process. Some of these specialize in advanced computer-based design technologies such as finite element analysis.

Despite improving competence in this area, a shortage of trained personnel does not permit inhouse facilities to be used to the extent of their capability. By 1992, those facilities will need more and larger, high speed number-crunching computers, allowing much more computer-based analysis to be performed. Also, it was noted that much of the current computer-based effort is being used in the development process, which is really at a final stage of design. It will be increasingly important to expand the use of some of these advanced techniques to earlier stages in the design process to ensure the faster design of more optimal systems.

Lead time is a very critical issue in dealing with international competitors. Present product lead time ranges from 3 to 5 years, depending on the extent of the design effort and the definition of beginning and end of the interval, and they vary by manufacturer. We believe the greater part of observed difference across the OEMs is due to definitions of when planning ends. Substantial lead time reductions were forecast for the next 7 – 10 years. These range from over a year (relative to a 5-year current lead time), to 6 months (from a 3-year current lead time). One manufacturer made particular note of its concept of "Phase Zero," a part of the design process that occupies considerable time and involves some very basic planning, but is relatively inexpensive. A number of Phase Zero programs will be placed on the shelf and, if the market suggests a particular program is needed, the remaining (and far more expensive) parts of the design development and tooling process can proceed from an intermediate point.

Since materials technology is viewed as becoming an increasingly important part of the transformation of the auto industry, we asked a rather general question with respect to knowledge of competitive materials and their processing. In all cases, we found considerable inhouse expertise on materials: departments and staffs were specifically reviewing and investigating various materials and their processing requirements. Staffs are reviewing the technical literature; doing teardowns of competitive vehicles and products (including non-automotive products); and seeking and getting major assistance from suppliers that are aggressively developing and promoting new materials. Inhouse technology forums are useful, particularly for companies in a number of of engineering materials businesses.

Also, it was noted by several experts that in most of the basic materials, and particularly plastics, the U.S. is generally well-positioned. One exception: the Japanese were viewed as very strong in the basic ceramics and ceramics processing areas. It was also observed that the industry needs to look at materials technology in other industries, e.g., aerospace, in such basic areas as epoxies and sealants.

It is evident that the engineering process is undergoing a basic and fundamental transformation. Serious shortages of skilled and experienced people exist, but engineering technology is expected to provide U.S. manufacturers with an important competitive advantage as systems become more fully utilized and, by the mid-1990s, integrated with the manufacturing process.

AUTOMOTIVE MATERIALS

1. Introduction

Triggered by the oil embargoes and the resulting rush to downsize and lighten American cars, automotive designers have been and are making radical shifts in the use of automotive materials. The direct development impacts of these early shifts have been substantial for many Michigan companies, and for certain communities in Michigan's lower and upper peninsulas. In a normal automotive sales year during the 1970's, the industry consumed about 1/4 of the nation's steel, 1/6 of the aluminum, about 1/2 of the malleable iron, 1/8 of the copper, and 1/3 of the zinc. Hence, drastic usage reductions by the auto industry in any of these materials create serious economic consequences in diverse parts of the country, especially Michigan.

The average weight of American cars has been reduced from about 3800 pounds ten years ago to about 2800 pounds in 1985. We would expect that this trend will continue at a somewhat slower pace until in 1992 the average car might weigh 2500 pounds. The combined impact of downsizing and material substitution has removed almost half of the iron in cars, 1/4 of the steel, and 1/3 of the copper. With respect to Michigan's economy, the need for metal stamping plants and iron foundries has been reduced apace.

Most of our study in the materials area will, for reasons to be explained shortly, concentrate on specific materials alternatives in given applications. Nevertheless, it is worth looking first at the overall materials usage picture. Exhibit 1A shows the overall trend in materials usage by percentage of the car's dry weight in the years 1977, 1985, 1992 and 2000. (Obviously our forecasts have high degrees of uncertainty and are presented to provide a general context. The forecast for 2000 is at best a guess.) Exhibit 1B shows the same information expressed in pounds.

From a given materials (industry) point of view, one might think of the percentage chart as being useful for measuring the market penetration capability of the companies in that particular field. However, for purposes of planning capacity in a given industrial sector, the chart relating to pounds is important. For example, while steel's share is forecast to decline 11% from 1977 to 2000, its pounds/vehicle declines 49%. Employment in the industry is obviously more directly related to the latter number.

Materials decisions are not made for a car as a whole and certainly not on a material-by-material basis. Typically, specific decisions are made for specific components and subsystems on a specific vehicle. Thus we must look at each of these components and subsystems (by vehicle entry, if practical) and at how the materials decisions will be made in those. Then we can try to generalize the relative competition which will result between alternatives. Exhibit 1C is an attempt to do this between unprotected steels, galvanized steels, and plastics and composites for body panels and structural components of a unibody vehicle.

Despite the fact that material substitution takes place on a component or subsystem basis, there is a general frame of reference in which all these decisions are made. In the auto industry, generally speaking we are interested in minimum weight at approximately constant effective cost in place. This battle for weight savings at constant cost is described conceptually in Exhibit 1D. The ability to reduce weight by design is saturable, and eventually one pays an increasing cost penalty per pound saved (conceivably reaching infinite cost per pound saved, as we reach the limits of design technology within one material). We then try to find an alternative material for which we are in a more favorable part of the savings curve and switch from one to the other, as shown in the double line segment.

This substitution concept vastly oversimplifies the real situation, since almost invariably there is a fixed cost (often better expressed as a risk, due to lack of experience), or investment, in switching from material X to material Y. It is balancing all these factors, which are of necessity a great deal vaguer than this precise model would imply, that is the task of those involved in materials substitution decision-making.

Although materials substitution is an extremely complex process, the main considerations may be summarized into three variables: market pressures, technical developments, and supply base considerations. Often these three categories tend to be appraised by different specialists within the auto companies and their materials and components suppliers. The separate appraisals must then be integrated in order to come up with the strategy for a particular subsystem or vehicle. Thus in order for decision makers in industry or government to prepare well in advance for future changes, each of these three families of considerations (and their interactions and implications) must be tracked.

As will be seen in the discussions of specific materials alternatives, one of the primary market drivers common to most materials changes is the perception that consumer demands will require more market segmentation in order to compete effectively. This changes the competitive (cost) balance of various materials.

Obviously the technical issues with regard to the use of specific materials alternatives vary from application to application. However, several seem to be common to most. Weight reduction in the vehicle for increased fuel efficiency is a common driving force.

There is also a desire for parts integration, for modular assembly possibilities, for the whole concept of product/process integration and design for automation, and for new strategy of plant construction, be it for plant reintegration or small plant modules.

In our discussions with both the materials suppliers and the automotive companies, it was generally agreed that there was rather considerable in-house expertise within the auto companies on materials and that there are specialized departments looking at various materials and their processing. (The one exception to this may be in the area of "Engineered Plastics." These materials are so different from the experience base of automotive engineers — even their "line" materials specialists — that a critical knowledge gap appears to exist in this area.) However, although materials specialists act as a very important internal resource to the decision makers, the materials specialists themselves are not the decision makers. The decisions are generally made by product management functions in the general case (e.g., a plastic vs. steel body) and by product and process engineers on a specific application basis.

This makes marketing materials to the automotive industry (and other industries as well) a particularly sophisticated task. Generally speaking, materials promotion falls into the category of "push/pull" marketing, where the people who make the decisions are not the ones who eventually consume the materials in question. An example of this is a vehicle engineering function which specifies a certain plastic panel, whereas the actual plastic resin material is bought by an independent or captive fabricating plant.

We were fortunate to be able to study in somewhat more detail (in a related study described below) the decision-making process leading up to the implementation of galvanized steel in auto bodies. Even after the fact, it was extremely difficult to understand the dynamics of this complex decision. The use of protected steel for body panels is a multi-billion-dollar decision for the parties involved, and was taken in an environment where the technical and market future was particularly uncertain, typical of many major decisions in the automotive industry.

We have tried to stylize the galvanized steel decision process in Exhibit 1E. The decision process fell into three major stages: the market response decision (indicated by A in the flow chart), detailed strategy development and testing (B), and sourcing decisions (C). In addition, there is the post-decision-making phase of implementation, both with regard to the steel mill galvanizing line construction and to the implementation on a major scale in the stamping and downstream automotive plants. Exhibit 1E attempts to define the time frames in which the various decisions' "mileposts" were met. For given companies a given mile post might have been reached six to nine months earlier or later. The overall decision-making and implementation process took over ten years, and the interval between the conceptual market response decision and the implementation of that decision for vehicles was five to six years.

In the context of our looking at other ongoing decisions in the materials area, it thus is clear that we must look now for decisions that will be implemented in the late 1990's or about the year 2000. In fact, the majority of our interviewees felt that, with regard to materials decisions, virtually all the substantive decisions had been made through 1992, that many decisions are semi-firm through 1995 or '96, and that we really are looking at the end of the century in terms of being able to influence any major materials decisions.

2. Steels for Automotive Bodies

In the early 1970's the average U.S.-produced passenger car contained approximately 2400 pounds of steel. With North American cars being downsized and lightened, steel usage is expected to drop to about 1425 pounds by 1992. The major decline in steel will take place in carbon steel, which is forecast to drop to about 1050 pounds by 1992. High strength low alloy (HSLA) steel is expected to grow to about 300 pounds in 1992. Ford's usage trend is illustrative: HSLA usage increased from 115 pounds in 1975 to 169 pounds ten years later, to a published projection of 341 pounds in 1992 – an overall gain of 200%.

An even greater change in steel usage is expected by 1990 in the form of sharply increased usage of zinc-coated steel. The Office of Business Community Development of the Michigan Department of Commerce, under Grant 84–30AG, sponsored a study in depth of the "automotive demand for galvanized steel and its impact on steel galvanizing capacity" and its implications for the State of Michigan. This forms the core of these remarks, updated to the extent necessary by later AIM interviews.

By 1987, there are expected to be approximately 2.6–3.0 million tons per year of electrogalvanized steel capacity in this country. However, it strongly appears that there will be demand in excess of 5 million tons of the material by the 1988 model year in that sector alone. In the short term, it is expected that the excess demand will be picked up by foreign, primarily Japanese, steel producers (witness the recent decision to use Japanese steel for the 1986–87 Cadillac products), which have presently an excess of capacity. Our analysis suggests that domestic automotive steel demand will grow by the late 1980's to such a level that at least two additional hot dip mills and three or four electrogalvanizing mills will be required over and above those currently planned, assuming that present steel import levels are not expanded.

Whether or not (from the firms' viewpoints) these mills can and should be built in the U.S., let alone in Michigan, remains to be seen. The return on investment of these incremental mills may not be compatible with domestic steel companies' limited capital resources. However, many of the firms involved now have major foreign (mainly Japanese) partners; perhaps this will change the equation.

In order to obtain a satisfactory level (five years) of rust-through protection, car manufacturers have had to utilize more rust-resistant materials. Because substitute materials for steel (such as aluminum, fiberglass, reinforced plastics, etc.) are still relatively experimental and are not expected to be used in large scale in the near future, some form of coated steel appeared to be the likely choice (see Exhibit 2A). Zinc or zinc alloy coatings have been found to be the most effective, as they offer:

- a physical barrier preventing the corrosive agents from reaching the underlying steel; and
- a sacrificial action, preferentially oxidizing, to protect the steel substrate.

There are two primary processes for the manufacture of galvanized steel. The first and oldest is the hot dip method, in which the sheet steel is introduced into a bath of molten zinc. The zinc then cools when the sheet is removed from the bath and hardens into a discrete layer. Various mechanical devices may be utilized during the process to help make the coating more uniform, spangle reduced, and/or with differential thickness on the respective sides of the sheet. However, despite its cost advantage for thicker coatings, hot dipped steel has a number of handicaps: the spangle (which may show through paint), lack of ductility, lack of formability (mostly due to the annealing which occurs during the high temperature dipping), flaking of the zinc in dies and presses, and non-uniformity of the deposition of the zinc on the steel.

A second method involves the electrodeposition of zinc onto the steel. Although this process is energy-intensive, resulting in significantly higher (7–15% on the average) production costs, it avoids virtually all the disadvantages associated with hot dipping. Because it is a "cold" process, the mechanical properties of the base steel remain unaltered; the coating is also uniform in thickness. These properties make it an ideal material for automotive body stampings. The car makers have come to recognize this fact, and have signaled (by long-term contracts) steel companies, both in the U.S. and abroad, of their upcoming high level of demand for electrogalvanized steel.

For their part, steel makers have responded vigorously. Until this year, there was only one major electrogalvanizing line operating in the United States capable of producing automotive quality electrogalvanized steel. However in 1985, National Steel, U.S. Steel, and Bethlehem are expected to start up electrodeposition lines serving the demands of the automotive industry. By early 1986, there should be no fewer than five major new lines. All but one of these lines now under construction are joint projects. The four combined efforts are by Bethlehem Steel, Inland Steel, and Prefinished Metals Inc.; LTV Steel and Sumitomo Metals; National Steel and Nippon Kokan KK; and U.S. Steel and Rouge Steel. ARMCO Steel is the only company building its facility alone (although details of that facility are still hard to obtain).

Each of the North American automotive manufacturers has its own set of factors to determine the types and applications of coated steel it will use. Various areas of the vehicle suffer corrosion more quickly than others, depending upon exposure to salt spray, etc. The most vulnerable areas are the insides of doors, hood areas, especially inner hood sections, quarter panels, deck lids, and floor pans. These obviously are large material content items, and the ultimate selection of hot dipped, electrogalvanized, or Zincrometal will have major impacts on the fortunes of affected materials suppliers and processors. For example, Chrysler's 1985 front-wheel-drive cars each contain about 1000 pounds of coated steel. Some 750 pounds are two-sided galvanized, while the remaining 250 pounds are either 1 1/2 sided or Zincrometal. Roof panels are uncoated. Chrysler's 1985 Lancer model contains 88% coated steel. The T115 Minivan contains similar amounts. Of the 1155 pounds of steel in the van, 752 pounds are two-sided galvanized, 260 pounds 1 1/2 sided galvanized, and the remaining 143 pounds uncoated. By the 1988 model year, Ford plans to employ close to 1 million tons of coated steel, or almost 75% of all the steel it uses. Most of this will be in the form of electrogalvanized (1, 1 1/2, and 2 sided) and Zincrometal.

In late 1983, General Motors announced its decision to make a wholesale shift to galvanized steel, with two-sided coated steel on all external panels, as well as underbody, with a heavy reliance on electrogalvanized for outer body components. The decision led to the long-term galvanized steel contracts that triggered three of the installations cited above.

Traditionally, General Motors has bought virtually no steel abroad. Ford bought no more than 5 percent of its needs abroad. Chrysler, on the other hand, often bought significant parts of its needs abroad, often under quite advantageous conditions. Because of at least a short-term shortage of domestic capacity for electrogalvanized body steel (and the potential for medium/long-term capacity problems), both Ford and GM appear to be reevaluating their positions (informally, at least). GM has announced its first-ever major body steel procurement contract abroad in agreeing to source the electrogalvanized steel for the 1986 Cadillacs with Nippon Steel. This followed a year-long steel survey of Japan and Korea. The GM purchasing community is currently performing an analogous in-depth study of potential European sources, again focussing on electrogalvanized mills. Whether this is a portent of a fundamental change in supply strategy or just a necessary, temporary tactic remains to be seen.

A review of the information gathered thus far suggests that there are only two cars definitely expected in the 1985–1990 time period for which serious consideration is being given to replacing steel with plastic composites on body panels: GM's new Firebird/Camaro and perhaps Chrysler's Liberty — if Chrysler decides to produce it. (There is also a recent rumor that there may be a 1988 Ford Taurus derivative and a 1992 GM van with plastic skins. We have yet to check this out.) All the other cars to be introduced between 1985 and 1990 are expected to be designed with steel (unibody) frame and body panels.

Once a model is tooled for steel, a fundamental change to plastics is not likely until major redesign requiring new tooling is implemented. Thus, models introduced in the late 1980's with steel are not likely to be redesigned before the late 1990's, and therefore will continue to use the material chosen for the initial design. Obviously, significant shifts in relative material fuel prices could cause an earlier switch. Likewise, specialty derivatives of core vehicles could use a different material system.

In the longer term, there is a significant possibility for competition for steel bodies from plastic composites and, to a much lesser extent, from aluminum. Even in the absence of serious fuel price escalations, persons surveyed in the AIM interviews foresee an ongoing emphasis to lessen vehicle weight, and when this is combined with the determination to improve body structure integrity and skin corrosion defenses, reinforced plastics are expected by those surveyed to be the major competitor of steel. It is obvious that a successful assimilation of galvanized steel technology by the industry will set the stage for pitched material battles when plastics technology matures.

The basic application decision process for galvanized steel was discussed in Section 1.6. In our in-depth study of galvanized steel implementation, we also looked at the basic decision variables regarding production of this material and site selection. Direct and indirect labor is a relatively small cost in the entire equation for production of electrogalvanized steel, about equal to electricity and the zinc raw material. The single most important variable in the product cost is the amortization of the relatively expensive, limited use installation. To this end, the motivation obviously exists to make that installation flexible, so that the investment can be recovered as quickly as possible, especially given uncertain futures.

An example of the relative cost impact of the several variables is shown in Exhibit 2B. Hypothetical costs are shown under two sets of conditions; they give a fair indication of the relative cost importance of capacity versus labor. Case 1 might be thought of as representing the best information we have been able to gather (mainly by inference) from our interviews. Case 2 should be thought of as a "worst case" consideration, where, for example, there is a cost overrun in an installation and because of inappropriate specifications and steel-making production technology, effective capacity is reduced.

Furthermore, the financial markets and/or potential technological obsolescence imply the need for a shorter payoff period, and finally, the effective capacity utilization during this payoff period is reduced, potentially owing to overcapacity (either at a constant rate of auto production or conceivably at a time of reduced automotive production in North America). The basic concept of facilities amortization being a major cost factor is a vital one. The impact of this in the case of the galvanized steel implementation implied delaying the investment until production guarantees could be secured. This might very well also happen should the auto makers decide they want to make major shifts towards, for example, plastic body components. We would strongly suggest continuing attention to the potential investment and operating cost factors as determining the ability of our industry to compete for these new materials requirements.

The capability and competitiveness of Michigan's body steel suppliers currently focuses on two establishments: the Great Lakes facility in Ecorse and the Rouge Steel facility in Dearborn. Both have been granted new leases on life by major core investments by their shareholders (National/Nippon Kokan in the case of Great Lakes and Ford in the case of Rouge). At Rouge, the Rouge/USS joint electrogalvanizing venture is an important step, but still has several technical and commercial hurdles to overcome.

National is proportionately more dependent on Chrysler's fortunes than on GM or Ford, although it sells significant amounts to those firms as well. National has long been considered a creative marketer, particularly with regard to the markets on which it has chosen to concentrate, among which automotive is number 1. Its new Japanese shareholder should provide complementary capital and technological resources.

Rouge is obviously heavily dependent on Ford demand. Traditionally it has not been very effective in marketing outside of the circle of Ford and its direct suppliers. Lately, however, it has shown signs of getting better at this. Its management in all functions has been supplemented in the past few years with experts chosen from both within Ford and outside the mother company. Thus the prognosis of this firm is far better than a few years ago. Undoubtedly its future has been enhanced by the concessions made by its UAW local as a prerequisite to Ford's continued investment.

Michigan seems to have come through the restructuring of the U.S. steel infrastructure in general and the switch to galvanized steel in particular as well as possible. We must assure that its endowment is as modern and as competitive as practical if it is to survive the ongoing lean times of the domestic industry. So far, so good.

If, as our analysis implies, there is demand for one or more galvanized (hot-dip or electro) U.S. facilities, it would be in Michigan's interest to attract such a facility. (The ideal location, from a market point of view, would probably be in the southwestern part of the state.) As of now, the fastest and cheapest way to build such a facility would be to add it to an existing cold-strip mill. Unfortunately, Michigan does not have any more such mills on which to piggy-back, although one could conceive of adding additional galvanizing capacity at either Great Lakes or Rouge.

One could consider a cold strip "market mill" with galvanizing facilities which would buy hot band from an integrated mill elsewhere in the country or the world. Other new continuous casting techniques (e.g., the split horizontal techniques being implemented in the Soviet Union) might be in order. The point is if we want to compete for automotive steel facilities, we will have to learn much more – and soon – about the technologies and markets. In year two of the AIM project, we will seek continued contact with automotive steel buyers (especially, but not exclusively, purchasing departments) and with steel company specialists, to appraise the supply/demand picture in galvanized steel.

We will begin looking at shifting specification, supply, and demand patterns in what is called "Special Bar Quality" carbon and alloy steels, such as those used in automotive suspension, steering and transmission applications. European and Japanese specification patterns are quite a bit more sophisticated than traditional North American tendencies. Michigan has at least two excellent "mini-mills" (Quanex in Jackson and Northstar in Monroe) which might be able to benefit from these technological changes if they prepare properly – and which might miss opportunities if they don't. In addition, there are rumors that LTV might bail out of bar products (centered in Cleveland and Chicago) in its struggle for survival, creating space for Michigan entrants.

3. Automotive Usage of Aluminum

Since World War II there has been a continual, albeit uneven, growth in aluminum in passenger cars. Exterior trim, transmission cases, pistons, and air conditioning components were early and steady aluminum applications. By 1970, the typical car manufactured in North America contained 75 pounds of aluminum, about 2% of the average car's weight. By 1981, although some 500 pounds of total weight had been eliminated, aluminum had grown to about 130 pounds, and its proportionate content in the car to about 4% (see Exhibit 3A).

Usage of aluminum in cars has been heavily concentrated in castings rather than in wrought parts. Castings probably account for approximately 60 of the total 75 pounds of aluminum used in the 1970 car. By the 1984 model year, aluminum castings grew to 110 pounds of the total 130 pounds in the composite car. These castings include the primary engine castings plus a wide variety of aluminum die castings.

There have been short-term surges in wrought aluminum applications, especially during the 1970's when such usage turned out to be a temporary expedient in response to the Arab oil embargo and resulting quickly escalating fuel prices. Car designers switched certain body panels from steel to aluminum so that weight could be quickly eliminated and fuel economy increased. Such a switch was often a means for helping the manufacturer to meet both emission and fuel economy needs. Especially popular components in such a switch were hoods and deck lids. Because significant manufacturing and tooling changes were not required to process in aluminum a part originally designed for steel, it also was relatively simple to switch the part back to steel when cheaper methods were found to cut comparable weight elsewhere in the vehicle. Ford's use of aluminum grew by 56% between 1976 and 1980 but only 5% between 1980 and 1984.

In the United States, the Chevrolet Corvette is often cited as the vehicle to illustrate advanced materials concepts, especially with regard to aluminum. Exhibit 3C summarizes aluminum usage in the Corvette, showing some clearly innovative (at least for North America) applications representing approximately 12% of total weight. Exhibit 3D shows an analogous breakdown for aluminum components in the Porsche 928. In this vehicle, aluminum represents close to 19% of weight. The aluminum manufacturers would, of course, like this type of concept usage of aluminum to be extended to broader-based models as well. If this happened, the usage of aluminum as a proportion of total materials in a car would multiply by a factor of between 3 and 5.

Aluminum usage in light trucks generally has paralleled that in cars. Because vehicle materials directly affect gross truck weight, which especially limits the payload of commercial, heavy duty trucks, this different set of economic tradeoffs has encouraged more wrought aluminum in medium and heavy duty trucks. It is not unusual for most of the cab of a large commercial vehicle to be almost entirely wrought aluminum.

In the University of Michigan's most recent Automotive Delphi Forecast, a stable price of fuel (in real terms) was projected, and on that basis, aluminum usage was also forecast to remain flat over the balance of this decade at about 135 pounds per car. Material use trends published more recently by Ford are only a little more optimistic. Their designers forecast that Ford's typical 1990 car will contain 148 pounds of aluminum, barely 10% more than the 1984 level of 135 pounds.

By contrast, a recent study by the Aluminum Association forecasts the 1990 usage in the 200 pound range. For this to occur, the traditional parts listed above must continue to be made of aluminum, and most of the parts now under consideration for conversion to aluminum will have to make that switch; of these, the engine block and head are very important. A review of potential vehicle manufacturers' plans for new or increased aluminum parts production follows, with the exception of engine parts which are discussed elsewhere.

Wheels and Bumpers

Aluminum wheels are now offered by all North American car companies, for weight savings and styling appeal. In the case of passenger cars, these are quite often cast. In light trucks, other techniques are often used, e.g., Ford uses impact extrusion to make Aerostar aluminum wheels. Aluminum wheels have become the centerpiece of the marketing strategy of one casting company, and such wheels comprise 30% of its sales.

There is considerable manufacturing research being conducted to find the aluminum wheel production method most competitive with steel wheel processing. A set of aluminum wheels can represent a 50-60 pound net weight savings. Present aluminum wheel usage has grown quickly from about 5% to 11 1/2% of the North American market. With adequate refinements in aluminum wheel production methods, many engineers surveyed expect a significant increase from this level by 1990, causing some erosion of business for traditional steel wheel manufacturing companies.

One such Michigan-based company has already positioned itself in this regard, having bought and constructed "high styled" aluminum wheel production facilities. In addition, it has built in its main steel wheel facility an aluminum line with flexible capabilities both within the range of aluminum wheels and for conversion back to steel wheels. On this line, they will be producing all the 1986 Cadillac wheels, which will be spun formed out of heavy gauge aluminum plate. Apparently the aluminum usage in this program alone represents some 8 million pounds per year, one of the largest orders ever for aluminum usage in passenger cars.

Largely because of weight, steel bumpers are being replaced with plastics and aluminum. However, the transition to a lighter material has lately favored plastics, and this is expected to continue, unless consumers show a preference for bright bumpers.

Radiators

Starting in the early 1980's, Ford began introducing aluminum radiators and has gradually increased its usage to the point that about one third of its 1985 cars will have aluminum radiators. (Nissan's published estimate of Ford's aluminum usage is closer to 60 percent.) By the end of the decade, almost all of Ford's car radiators will be made of aluminum. The level in light trucks is not far behind.

General Motors has had a growth pattern similar to Ford's in the use of aluminum radiators. A recent article estimated its usage at 35 percent. The same article estimated European penetration of aluminum radiators at 80 percent (up from about 30 percent just a few years ago), while Japanese usage of aluminum radiators is of the order of 3-4 percent. One Nissan official has estimated, nevertheless, that that firm will be moving towards 90 percent aluminum radiators (undefined timeframe).

On the other hand, a recent Metalworking News article points out that Chrysler is using another approach to weight reduction in the heat exchanger area, sticking with copper and brass but redesigning the radiator to eliminate weight. Nevertheless, aluminum radiator usage is expected to spread unless some field problems should develop during widened customer usage.

Two key technologies had to coalesce to allow the practical widespread use of aluminum radiators: the development of aluminum-compatible antifreeze material and vacuum aluminum brazing techniques. In addition, automotive designers have had to take into account the different heat transfer characteristics of aluminum as compared to copper.

Drive Shafts, Other Chassis Components, and Engine Parts

Aluminum drive shafts were introduced on the Corvette several years ago and are being introduced on Ford's new Aerostar minivan (at least for partial production). If the latter application is technically and economically successful, we can expect to see expanded usage for (RWD) minivan production. However, there are no public indications as yet that aluminum drive shafts will be included in passenger cars, other than specialty vehicles such as the Corvette, though GM is looking at aluminum drive shafts for another rear-wheel-drive vehicle.

The motivation behind the minivan applications is to permit as large a vehicle as practical while still enjoying good fuel economy. The 1990 market for minivans could be significant if they continue to receive the consumer acceptance shown so far. Some forecasters see a 1990 market of close to 1 million minivans in North America, an apparent significant potential for aluminum and a threat to operations of companies tied only to steel drive shaft technology. Economically joining aluminum or composite driveshafts to the end yokes is only one of the production problems. (Another approach is being investigated by the automakers, a composite plastic drive shaft with aluminum end yokes. This might be an interesting application combination as well.)

Another class of chassis component conversion to aluminum shown in the Corvette program is that of control arms and similar structural parts previously cast or forged in steel. There is a cost penalty in converting this to aluminum, but we have seen renewed interest in this type of part in recent months.

Experiments have been performed in reinforced forged aluminum connecting rods. They are similar to chassis components from a process viewpoint, sometimes being made in the same plant. In a related engine part development, Honda announced that it has developed a pressure cast, stainless steel-reinforced connecting rod which reduces weight by 30%, particularly important in a reciprocating part.

General Motors announced recently it will switch this fall from 332 alloy to 390 alloy in die-cast pistons for some high performance versions of the Pontiac 2.5-liter engine supplied from GM's Bedford, IN facility. Apparently the switch is being made to increase durability in the piston ring and pin bore alloys. In some cases, a weight reduction may also result. GM indicated that this switch of alloy could become more general. Die casting and machining process changes were almost certainly required, although they were probably not major.

Body Components

The Corvette is the only North American production car that makes any appreciable usage of aluminum in the supporting body structure. However, interviews indicated that studies are being conducted to determine the feasibility of switching space frame material from steel to aluminum (or, for that matter, to plastics and composites). Persons interviewed speculated that the decision to use aluminum will depend on necessary advancements such as welding aluminum chassis components (some of which will undoubtedly be tubular) and the projected price of aluminum relative to steel. While the joining problems of aluminum have limited its use in body panels, this is essentially a cosmetic problem and one which is not significant with regard to substructure stampings and tubular parts.

With regard to body panels themselves, the main surge of aluminum use to gain short-term CAFE and emissions improvements seems to have run its course. However, there is still continuing interest in using aluminum body panels (essentially in competition with plastic panels) in short-run vehicle body panels. This might depend on the development of two unrelated technologies, namely epoxy die techniques for low cost tooling and adhesive bonding to eliminate some of the cosmetic problems referred to above.

In Germany, ALCOA and Audi have presented documentation on a high-intensity use of aluminum for a unibody vehicle, an entire midsize body which weighs only 149 kilograms. At the moment, this is still a concept car, but there are rumors that it might be put out as a limited production vehicle in the coming several years. In any case, we know that the aluminum manufacturers and car manufacturers in Europe are working very closely on increased use of aluminum in specialty vehicles..

The Impact on Michigan

Michigan has many plants producing wheels for cars and light trucks. Ford's "captive" wheel facility is part of their Monroe plant; GM's is in Warren. Chrysler does not have a captive wheel plant.

Among independent suppliers, Kelsey-Hayes' Romulus plant employs about 900 in passenger car and (mainly) light truck wheel production while (Goodyear) Motor Wheel's facility in Lansing employs about 800; Budd has a plant that makes heavy truck wheels. In addition, there are plants, such as Kelsey Hayes' Cast Forge operation in Howell that have peripheral wheel activities. As yet, we have only relatively limited knowledge about these captive and independent plants' activities and how changes in wheel materials specification might impact them.

Michigan has one major captive bumper plant, General Motors CPC-Livonia Plant, employing about 2,000 in bumper-related production. [Years ago, we also had Ford's captive bumper plant in Monroe and Houdaille's independent bumper plant on the east side of Detroit.] We should look further into the future of the CPC-Livonia bumper plant. That plant's spring product line, supplemented by a sister plant within the Buick complex in Flint, probably merit further study regarding risks of materials and process substitutions.

Michigan is not particularly dependent on radiator production. GM's radiators are mainly made in Lockport, NY and Ford's in Connersville, IN. Likewise, Michigan is much less dependent on RWD drive shaft production since GM's Saginaw Steering Gear Division has elected to concentrate on FWD component manufacture, ceding its former RWD drive shaft production to the CPC Parma (Ohio) parts plant. On the other hand, Ford's RWD drive shafts are still made at its Sterling Plant. To our knowledge, Chrysler's drive shafts are supplied from Kokomo, IN.

Michigan has several major captive forges which could be impacted by the substitution of aluminum for steel in certain forged applications. These include Ford's Vulcan Forge in Dearborn (producing almost exclusively connecting rods), Chrysler's Detroit Forge (employing about 400 and producing mainly chassis and transmission parts), and GM's New Departure-Hyatt Detroit Forge (Hamtramck, employing around 1200 and producing connecting rods, chassis parts and some transmission parts). In addition to potential competition (or opportunity, if they properly adapt) from aluminum substitution, castings and stampings always pose substitutional problems for forges.

While Michigan has many stamping plants, it is difficult as yet to single out those which might be affected positively or negatively if aluminum sub-skin body components are specified widely. However, logically, they might be those specializing in complex stamped and welded subassemblies. We will continue to monitor automakers' intentions of aluminum applications. In addition, we will interview Alcoa, Reynolds, Alcan and Martin Marietta, all of which have sales/application engineering offices in the Greater Detroit area.

A high priority should be set on understanding the potential impact of aluminum (and plastic) specification for wheels. Here, we must interview the wheel specialists within the automotive companies, as well as the management of the several wheel-making facilities within Michigan. A somewhat lower, but still significant, effort should be made tracking the aluminum impact on drive shaft, bumper and forge plants within the state.

4. Aluminum Engine Castings

Although aluminum engine (main) castings have been quite commonly used in Europe and Japan for many years, they have only come into reasonably frequent use in North America in the past 5 or 6 years. Earlier than that, their use had been limited primarily to specialty and high performance vehicles.

The principal driving force toward the use of aluminum in the principal engine castings (intake manifolds, cylinder heads, and blocks) is weight reduction. Quite aside from the gross mass reduction possibilities, there is a particular importance in reducing weight in front-wheel-drive vehicles, which tend to be "front heavy." In terms of both direct and distributional weight reduction, the effect of a pound less in the engine (or transaxle) tends to be larger than a pound in the support structure. A rule of thumb is that one pound reduced from the engine can yield 1–2 additional pounds of weight reduction in the structure.

Thus many current engines are being retrofitted to aluminum castings as their designs are updated. In addition, it appears that almost all engines currently being designed (for example, at GM, the Saturn and Manhattan engines) are being designed with as much aluminum usage as possible. A good application example is GM's (CPC) 3200 V-6 engine, which by 1989 could become the highest aluminum content mass production engine made by GM. Reported aluminum usage includes the cylinder block, head, two intake manifolds, oil pan, water pump, and pistons. The block design is thought to be of the sleeveless type, made from 390 alloy. Quite a few of the parts would be cast by outside suppliers with sand, permanent mold and die-casting facilities. In all, each engine might use 100 pounds of aluminum.

In addition to weight reduction, there are a variety of secondary motivators for the use of aluminum. One is that aluminum substitution provides a convenient excuse for resourcing castings. In some cases these resourced parts go to independent domestic firms, but frequently foreign firms are involved as well. However, a fair amount of the volume stays captive within the automotive companies, although quite often in different plants.

Another motivator is that it is easier to automate the manufacture of aluminum castings than of their iron counterparts. In part this comes from the lower temperature environments in an aluminum foundry but also from a variety of other process alternatives (e.g., permanent mold or, as yet, lost foam) available in aluminum but not in iron. A final secondary motivator is that aluminum has more remeltable scrap and less total scrap, so less total material is used.

Why, then, is aluminum not used universally? The primary demotivator to its more widespread use appears to be a combination of direct cost penalty for the aluminum material and a reinvestment requirement both in terms of the redesign of the component and, of course, the fixed investment for manufacture both in the casting plant and in machining. In addition, traditionally aluminum casting prices have been more volatile than scrap prices used for iron casting, although steps are being taken to damp that volatility.

The results of all these countervailing forces are shown in Exhibit 4A, which shows a dramatically increasing use of aluminum in all three of the major engine castings, approaching saturation by the year 2000.

Intake Manifolds

Intake manifolds were the first principal engine castings to be converted from iron to aluminum and will probably approach saturation the quickest. Generally speaking, these parts are sand cast or semi-permanent mold cast, although there were some efforts to use two piece electron-beam welded die castings (at Chrysler).

Traditionally, the vast majority of iron intake manifolds were cast in captive foundries. Some aluminum intake manifolds are now manufactured in captive foundries. However, many of these have been outsourced, particularly by GM and Chrysler, mainly to U.S. suppliers, including quite a few in Michigan. Ford has elected to make these manifolds using the lost foam process in their Windsor, Ontario plant. Generally speaking, these are cast from secondary alloys of either 319 or 356 aluminum.

Cylinder Heads

In the U.S., cylinder heads have been transformed to aluminum particularly in the case of selected four cylinder engines. In Europe, most cylinder heads have been made from aluminum for many years. These are typically semi-permanent mold cast and, to date, that has been the primary methodology for North American conversions as well.

However, it is well known that General Motors is working on the lost foam process for cylinder heads and in fact used it for the V-6 diesel engine which Oldsmobile produced for a while. Whether lost foam will turn out to be a truly cost and technologically competitive process for cylinder heads remains to be seen. GM is officially convinced that it will; competitors are generally skeptical of lost foam for this particular application. Generally cylinder heads are 319 or 356 alloy, quite often the latter. The process Chrysler went through in converting to an aluminum cylinder head from iron for their 2.2-liter engine six years ago is a case worth studying. At the time, Chrysler's engineers and buyers performed a worldwide survey of foundries competent in casting aluminum cylinder heads. They found none available in the United States with any breadth of experience and felt that, even with its relatively limited volume, Chrysler would have had to split production among various smaller foundries, with attendant logistical and quality concerns. On the other hand, in Europe Chrysler found several foundries which seemed competent in this field. As was mentioned above, the Europeans have used semi-permanent mold cylinder heads for some time. They finally settled on TEKSID, a Fiat subsidiary, which had 30–35 years of semi-permanent mold cylinder head experience. The Chrysler design is a relatively simple one, and had a particularly smooth launch with TEKSID. They have experienced less than .2 of 1% scrap over the years from TEKSID. They have since qualified TEKSID's plant in Brazil, which is apparently a smaller carbon copy of the Italian and which came onstream with virtually no problems. In addition, they have bought some cylinder heads from Nemak in Mexico, though there were some launch problems.

The Chrysler personnel with whom we talked about this were quite disappointed that they were unable to find a North American source. As they look on to other possible aluminum applications, they would prefer if possible to buy them domestically, but have at the moment relatively little hope of doing so.

Cylinder Blocks

Cylinder blocks will be the last of the major engine parts to be generally transformed to aluminum. American production experience with "production" aluminum blocks has been almost all by G.M., and can hardly be described as an extraordinary success. GM used a sleeved aluminum block on a V-6 engine used in smaller cars in the early 1960s. Later, in the early 1970s, it used an unsleeved design in the Vega.

Europeans have used aluminum cylinder blocks for some years, generally of the wet sleeve permanent mold design. Such American use as has been made of aluminum blocks in production has most recently been of the unsleeved type, using a hypereutectic silicon (generally alloy 390) approach. Originally, these were permanent mold cast or die cast, but GM in particular is looking at making aluminum blocks by the lost foam process, for example for the Saturn project.

Europeans to whom we have talked on this subject simply do not understand the avoidance of cylinder liners in American practice. They admit that there is an in-principle cost penalty to casting in the sleeves, but feel that sleeves so simplify other aspects of the process and add so much to engine durability that they prefer to use this approach. Apparently this feeling is not shared among their American engineering counterparts. The situation on cylinder blocks, therefore, is probably the least clear of all of the major engine castings.

The Impact on Michigan

Exhibit 4B shows the current sourcing of the major engine castings for General Motors, Ford and Chrysler, from which one can deduce the plants that are likely to be affected positively or negatively. We see several plants (especially in the Saginaw area) which could suffer significant business losses, and hence employment shrinkage, if the trend toward aluminum finds them unprepared technologically and from a cost viewpoint to compete effectively in this new medium.

The transition, in principle, offers an opportunity for independent foundries capable of casting aluminum and willing and able to learn the intricacies of casting cylinder heads and blocks, both of which are more difficult than intake manifolds. It is not clear, however, that Michigan's independent foundries have the human and capital resources to develop the necessary technology quickly enough and then to invest in the capital equipment to implement what they learn in time for the application schedule of the customer base. Second, several of them have shown a tendency to locate capacity expansions outside of Michigan.

Many of these aluminum castings will hopefully be machined in the major engine facilities located in Michigan. These would include GM's engine plants in Flint, Pontiac, and Livonia; Ford's engine plant in Dearborn; and Chrysler's Trenton Engine plant.

To machine aluminum engine castings, changes in speeds and feeds are required, and different coolant and chip removal systems are in order. Although this may not seem like much, they can require some investment time to implement. An example of the difficulty of changing to machining aluminum is illustrated by the following case. GM intended to introduce aluminum cylinder heads on their V-8 engines installed on certain Corvettes at the beginning of the 1986 model year. Since, from a machining viewpoint, these heads are nearly identical to their cast iron counterparts, it was decided to machine these 40,000–80,000 heads per year on the long-standing transfer line at the CPC plant in Flint. However, quality problems were encountered (perhaps due to speed/feed differences between aluminum and iron). It was decided to delay introduction of the aluminum head by at least six months and to outsource the machining which, of course, required the construction of new tooling more suitable for the lower volume and the special needs of aluminum.

There are often advantages of integrating the casting and machining processes for aluminum castings. Integration can assist in controlling leakage by faster feedback of problem areas. In addition, machining of aluminum is somewhat of a specialized field, and the traditional breakdown between the foundry and the machine shop may not make much sense. It is worth while noting that this appears to be the approach in the Saturn engine program and, perhaps, for the Manhattan engine as well.

Cast Metal Industries is a good example of a Michigan firm which has seized on this opportunity in the intake manifold area. Another (earlier) out-of-state example is Winters Industries in Canton, Ohio. If this integration of casting and machining of aluminum (or, for that matter, other materials) becomes widespread, however, significant dislocation may take place even if the net job effect for Michigan is neutral or even positive.

In year two work, we will focus on the impact the increased use of aluminum cylinder heads and blocks would have on the Michigan foundries currently making their iron counterparts. High level contacts should be made to see what, if anything, state government could do to maximize the potential for such facilities as the Saginaw Central Foundry to transform themselves in time. We will investigate what can be done to allow our independent foundries to acquire appropriate technology and to invest in the equipment necessary to produce competitively major aluminum castings in Michigan.

The strategy of integrated aluminum casting/machining plants should be investigated in detail. If it is found desirable and/or likely, we must develop mechanisms to maximize Michigan's share of this type of facility, and to ascertain the direct and indirect effects of this change in industrial structure.

Finally, we must continue to monitor engine design and technology trends with respect to aluminum casting usage. From this we can update our transformation timetables. Another technological trend worth tracking is porosity control, preferably in the casting itself but conceivably by more sophisticated impregnation techniques.

5. Plastics and Composites

We are entering an era in which entirely new plastics are being used in entirely new types of automotive applications, providing the basis for a materials revolution. Because of the overall importance of this revolution and the complexities of the "battlegrounds" and the "rules of war" (which are unfamiliar to many of the protagonists), we divide our discussion into two portions. In section 5, we discuss plastics and composites in general, excluding the area of substitution of plastics for the major "sheet metal" of automobile bodies; that will be discussed in section 6.

Because of the unfamiliarity of most automotive engineers (excepting, of course, the plastics specialists) with these materials, we begin with the vocabulary describing the myriad plastic materials and processes. In Exhibit 5A we have tried to define some of the terms more frequently used in plastics technology without getting into the details of specific plastic formulations.

Much confusion arises from the term "composite." Apparently the plastics industry, in order to put a better image on "plastic," has started using the term "composite" for high performance plastics when, in fact, these plastics may not necessarily have a filler material in addition to the resin base. We try to use the term composite in the stricter sense of its definition, although we advise readers to be careful in reading this and other articles; this discipline is not always applied.

The most important categorization of plastic materials is into major families of thermoplastic and thermoset materials. Our emphasis on the distinction between thermosets and thermoplastics is because, in many respects, the infrastructures for making and effectively using these two families of materials are quite different. For this reason, the decision by the automobile companies of which of the two families to use in which application will be extremely important: no raw materials company has meaningful product lines in both families.

Exhibit 5A-1 shows the relative situation of plastics and several other materials with respect to fracture toughness and stiffness. Exhibit 5A-2 characterizes these same materials with respect to fracture toughness versus material cost per pound. Note, however, that material cost per pound is not necessarily indicative of the final cost of the part in use. For example, although the material cost per pound of a thermoplastic composite may be the highest, efficiencies in processing and in the amount of material which must be used to serve a given function are such that it may be the lowest <u>total</u> cost choice for the automotive designer.

Plastics have been used for many years in various forms in the automobile (Exhibit 5B). In addition to obvious uses of plastics there are many materials which one does not normally think of as plastics which are in that family. For example, many of the "rubber" hoses under the hood are synthetic rubbers which are, in fact, plastics. Likewise, "rubber" tires have for many years been synthetic petrochemicals. Furthermore, most of the fabrics in a car are synthetics, plastic (petrochemical) fiber. Rigid or semi-rigid plastics have generally been used in non- or low-load-carrying situations. Where higher stresses were found, the plastic was quite often supported by some sort of metallic backing. In fact, one of the more important trends today is the substitution of different grades of plastics for "traditional" plastics, so that these applications become more load carrying or impact resistant.

One of the principal areas in which plastics have been used is in the interior of a vehicle, and it illustrates a key aspect of the general application trend in this material. The original use was simply to substitute a plastic molded part (for example) for the equivalent metal part. Very rarely was the shape changed to take into account some of the inherent desirable shaping capabilities of plastics. More recently, as cars and their interiors are redesigned, the designers are taking into account the contouring capabilities of plastics in specifying their use. This is a much more cost-effective technique and is particularly space effective in a shrinking interior of a car. Bucket seats are a good example of the changing role of plastics in the interior of cars. Plastic bucket seat back shells serve only a secondary structural purpose; there is still a significant interior metal frame which provides most of the strength of the overall seat structure and to which all of the mechanism and linkage to the vehicle is attached. In coming years (certainly by 1990, according to the thermoset manufacturers), we will have a truly structural plastic (blow molded) seat with an injection-molded shell.

It is difficult to pick up a trade journal related to the automotive industry without finding a dramatic headline regarding the use of plastics in the automotive industry. Exhibit 5C presents an Owens-Corning forecast taken form the Predicast computer file. Those materials and applications forecast to increase at the highest rate seem to be the load carrying and impact sensitive ones. The implied growth rates in different materials are so different as to imply a selective strategy on the parts of the automotive firms. In turn, the whole infrastructure of the plastics production and processing industry will depend on which of these different materials and applications are selected.

In our interviews with the automobile companies, we asked a variety of questions regarding general categories of applications and the plastic intensity in those applications. The people with whom we talked expected a relative increase in exterior uses of plastics. Exhibit 5D shows the percentages of selected components our interviewees expect to be made from plastics in 1990 and 2000. In some of these examples, there is a fairly narrow spread in opinion, whereas in others there is a much wider spread. Where the spread is narrower, this is a more likely forecast. The feeling was that between 275–280 pounds of plastic would be used in a car by 1990 and 300–350 pounds by 2000. Although this overall increase may not seem dramatic, it must be taken in the context of a considerably lightened car by the year 2000. Ford has publicly predicted that the plastic content of their 1992 average car will be about 260 pounds, barely 40 pounds more than their current level. While GM seldom publishes material usage projections, it would appear that their plans are more optimistic. GM uses plastic composite panels for two cars already, and is working on another with such panels.

Plastic Bumpers

Plastic bumpers have been in use in American automobiles for some time. Their use began in part due to the front and rear impact requirements of NHTSA and have since become more integrally designed into vehicles. Originally, bumpers were made with plastic fascias over steel supports, with the advantage that the fascias would come back to their original shape after low-speed impacts. More recently the trend is toward more completely plastic bumpers with less or no metallic support inside. In 1984, the Federal Government reduced the impact resistance standard for bumpers from a five-mile-per-hour impact to 2.5 miles per hour. Many expect that this will lead to still more use of plastic bumpers. Some new plastic bumpers have reinforced, reaction injected molded fascias covering a honeycomb polyurethane, impact-absorbing cushion that replaces conventional hydraulic energy absorbers. The honeycomb section may or may not be backed by a steel reinforcement beam.

Oldsmobile uses a three-part bumper system which includes a steel reinforcement beam, saving about 20 pounds per car as compared to an all-steel unit. Chrysler's LeBaron GTS model also uses the soft fascia bumpers on the front of its car, with aluminum reinforcements, but has retained steel-reinforced soft bumpers on the rear. Recent Ford Escort and Mercury Lynx models use bumpers made completely of plastic. These first all-plastic bumpers in production in the United States meet the five-mile-per-hour impact resistance standard. Ford is also using this type of bumper on Taurus/Sable and on Ford's new Aerostar van as an optional item. These bumpers, including the 10–12 pound valance panels, will weigh approximately 40 pounds when made of plastics. Ford's bumpers are produced in its Milan plant. It is publicly estimated that during the 1986 model year this plant will produce 1.4 million plastic bumper parts. Ford officials estimate that the 1986 bumpers will be approximately 35 pounds lighter than the comparable steel units and should be less expensive and easier to paint as well. The material used for the bumpers is a polycarbonate crystal – polycarbonate polyester alloy thermoplastic. (This approach was introduced by Ford in North America after extensive experience in Europe.) The Milan plant uses injection molding linear and sonic welders and a computer-controlled automatic material handling operation. Part manipulation is almost totally by robots, and the station-to-station movement is by guided vehicles or automated overhead monorail systems. The robots also paint the bumpers.

The 1985 AMC Alliance and Encore have a plastic bumper system as well, using injection molding honeycomb techniques. Recently this molding was moved in-house and replaces a urethane foam design previously supplied by an independent supplier; much of the design was done by a small, independent analytical firm in Plymouth, Michigan with heavy emphasis on CAD/CAM modeling.

Honda, too, is planning to make plastic bumpers, adjacent to their Marysville, OH assembly plant. It has recently purchased six 3000-ton highly automated injection molding machines for these and other large parts. The machines will be equipped with closed loop pressure and speed controls and an interfacing system for centralized control by a host computer (with processing information up- or down-loaded) and will be able to operate unattended.

Plastic Fuel Tanks

Plastic fuel tanks have a great potential for net weight reduction at an increased total fuel capacity. This comes not only from the light weight of the material itself but from the ability to mold unusual shapes which can conform to the surrounding environment. Plastic fuel tanks have been used fairly widely in Europe and in U.S.-built recreational vehicles for some time. There is a slow movement toward plastic fuel tank use in North American passenger cars, but a variety of (largely non-technical) concerns seem to be retarding its growth. The first passenger car use of plastic fuel tanks in the U.S. was Volkswagen's 1985 Golf. Two minicar manufacturers will be introducing plastic fuel tanks in the coming months. The upcoming Aerostar minivan features a plastic gas tank, and a plastic tank is highly probable for the forthcoming N-body trucks to be built by Chrysler in its Dodge City complex.

Plastic fuel tanks are manufactured by blow molding high density polyethylene. Although most objective tests seem to show that these fuel tanks are as safe as gasoline tanks, if not more so, the litigious U.S. environment makes many firms hesitant. In terms of process engineering, there are still some variables. The high-density polyethylene tanks are normally treated to eliminate permeation of fuel vapors. There is a variety of approaches to doing this and some debate as to which is the most efficient. The conventional approach uses fluorine, which has some environmental impacts that have yet to be considered.

It is now thought that blow-molded tanks are cheaper overall to manufacture than gasoline tanks. Tooling for metal stamping tanks costs approximately 4 times as much as for blow-molded fuel tanks. The cost-equal crossover volume between the two approaches might normally be of the order of 500,000 units per year. However, the increasing use of alcohol in fuel has caused certain corrosion problems in metal tanks, which have required specialized steels and treatments, increasing the crossover volume. Thus at worst, plastic fuel tanks seem to be a even-up in terms of cost and, under low volume conditions, significantly less expensive.

If the United States follows the European experience, blow-molded fuel tanks should become major market factors. In 1983, one out of four West German cars was equipped with a blow-molded plastic tank. In that same year in France, one out of three cars also had a plastic tank. By 1988 it is expected that 4/5 of West German cars and 3/4 of French cars will have plastic fuel tanks.

<u>Plastic Headlamps, Wheels, and Springs</u>

Another new application of plastics is in all-plastic front lighting systems. Front turn signals and rear turn signal/stop lamp assemblies have been plastic for a number of years. The use of plastic headlight assemblies provides several advantages, including a savings in weight. These all-plastic assemblies provide styling flexibility unavailable in the former sealed-beam approach, and are particularly good in terms of sculpturing the front end of the car for favorable aerodynamics. Furthermore, this approach to front lighting can be integrated into a whole front module, which goes along with the general design trends in the industry.

We now turn to several miscellaneous applications of plastics which are difficult to categorize. Plastic wheels are beginning to be applied in selected cases. General Motors apparently has a major interest in this. Motor Wheel of Lansing is among the leaders in developing these wheels, which it feels have the potential for redoing the entire competitive structure of the wheel industry, particularly as this development comes in parallel with aluminum wheels. A recent Motor Wheel advertisement describes their "Polycast II" wheel as being urethane molded on a core of steel. They cite styling advantages, including color choices. An earlier press report cited a "one-piece composite-fiberglass wheel intended for 1987 model Pontiac sporty cars."

It is estimated that plastic wheels produce the same weight savings as aluminum wheels, but (in production volume) it is hoped that plastic wheels will be less expensive to manufacture.

Plastics are also beginning to be used selectively in wheel covers. Apparently a nylon resin is used in this, and one application cited to date (the Pontiac Grand Am) is molded by Lacks Industries in Grand Rapids. The press report indicates that this plastic approach was chosen because of its resistance to high temperature (in painting, one assumes) and to impact damage in use.

Traditionally vehicle suspensions in North America have either been leaf or coil spring. Composite springs may take an increasing portion of the suspension market in the future. Composite springs are interesting insofar as they are the first major use of "advanced composites" in structural use in an automobile. The first use in North America was in the restyled 1981 Corvette. This was succeeded more recently by the use in the General Motors M van. In the 1986 model year, a composite rear suspension spring will be used in the GM 30 (Toronado, Riviera, El Dorado, Seville) to be assembled at the Detroit/Hamtramck plant.

In the Corvette application, it is estimated that the rear spring application saved 33 pounds. An additional 11 pounds were saved when the front end of the Corvette used composite springs beginning in 1984. In the M van application, these springs are used only in the rear and save about 32 pounds. It is worth noting that this is the first use by General Motors of the longitudinal composite spring design, the Corvette having been a transverse design. An additional advantage of the composite spring usage is the ability to use smaller stabilizer bars and, in some cases, to eliminate their use. GM production composite springs have been made by the Inland Division, located in Dayton, Ohio. Inland forecasts that use could double by 1990, and has recently entered into a joint venture with NHK Spring of Japan in the composite area. (NHK and Nissan, it has been reported, are working together on a fiberglass-reinforced plastic spring for light trucks.) Thus we foresee a significant amount of usage in selected vehicles of these composite springs over the coming years. Ford intends to use a composite spring in its 1988 Ranger pickup. In that application it is estimated that there will be a 40 pound weight savings. Plastic springs could also be used in the Aerostar, it is speculated, if a 4-wheel-drive version of that is used.

Advanced Composites

The distinction between composites and advanced composites is at best an arbitrary one. One publication defines "advanced composites" as those that contain a fiber-to-resin ratio of greater than 50% fiber, with the fibers having a modulus of elasticity greater than 16 million psi. A more functional definition, used by engineers in the field, is that advanced composites denote a resin matrix material that is reinforced with high strength, high modulus fibers of carbon, aramid, or boron and usually fabricated in layers to form an engineering component.

One of the important factors in the development of advanced composites will be the selective use of the filler material in highly stressed areas to limit the cost penalty of using these advanced fibers. One of the principal fibers being used in these high tech composites is carbon. Mitsubishi Chemical Industries has announced an "industrial grade" carbon fiber called Dialead for automotive and similar applications. They intend to begin producing at the rate of approximately 250 metric tons in 1986, increasing to 1000 metric tons by 1990. Mitsubishi Chemical is a partner of Fiberite Corporation of Winona, Minnesota. These firms have formed a joint venture in Japan called Kasei Fiberite Company, which is exploring the possibility of production of these new fibers in Japan.

Nippon Steel is also working in the area of more cost-effective carbon fibers. Their product development, like Mitsubishi's, is coal pitch-based. Nippon admits that the specific properties of its fibers are inferior to the best available, but not on a property per cost basis ($4 per kilogram versus about $15 for polyacrylonitrile-based counterparts.) These polymer fibers are also important candidates for use in advanced composites. Perhaps the best known is DuPont's Kevlar material (best known for its use in football helmets and flak jackets). An alternative has recently been announced by Allied Corporation called Spectra 900, an extended chain polyethylene fiber, which Allied says is pound for pound ten times stronger than steel and 30–50% stronger than Kevlar. Allied has estimated that the total market for these aramid and graphite fibers might be of the order of $300 million per year. Whether or not this can be produced at a cost compatible with automotive industry needs remains to be seen. Japanese producers in this area include Toray Industries and Toho Rayon.

Several examples of at least relatively advanced composites (drive shafts, leaf springs) were mentioned above. In addition, advanced composites have been used in the automotive industry for selected high performance vehicles. Since 1957, Lotus in the U.K. has been using advanced composites in the Lotus VARI (vacuum assisted resin injection) process to form their vehicle structures. In a recent article discussing potential applications of these advanced composites, the Lucas Research Center emphasizes engine parts. Inlet manifolds were mentioned as a technical possibility, but with prohibitive costs at the moment. The all-plastic "Polimotor" engine designed by Matthew Holsberg is also cited as a technical and yet not economical situation as yet. Composite piston skirts are perhaps a nearer-term application possibility.

The most interesting possibilities would be when certain parts of a spaceframe structure (particularly the complex corner sections) could be made from advanced composites. Here the great advantage would come from the ability to optimize the design and to reduce the number of components in what is now a complex subassembly into a single-piece molded structure. A similar situation would exist in such applications as steering arms, independent suspension arms, etc. In principle, coil springs made of composites are also possible, although we have yet to see a practical methodology for manufacturing them. There is also discussion of fiber-reinforced plastic connecting rods, with a major research program sponsored by the West German Ministry for Research and Technology.

Plastics Implementation Issues

Most automotive engineers have as their principal background mechanical engineering and were educated at a time when, at best, they were exposed to the rudiments of metallic materials. Even today, mechanical engineering university students normally get very little exposure to plastics and composites. Although each of the automotive companies has sections of specialists in materials, they are relatively less well endowed with experts in plastics and composites. Thus, automotive application and process engineers tend to have to rely unusually heavily on potential suppliers of materials and parts (particularly the former) for their technical information. It would be unrealistic to assume that these potential suppliers are fully objective as to the pros and cons of alternative materials when their product or products are among the candidates to be appraised.

Another major problem area cited by those interviewed is that of characterizing the properties of the materials being considered, particularly with respect to specific applications. Many of the mechanical testing systems that have been used in industry are not entirely suitable to plastic and composite materials. The plastics industry, of course, has also developed its test methods, but it is difficult to compare results with those in the metallic materials fields. In addition, quite aside from bulk property characterization, one must look at a characterization in a particular use or application, the testing methods for which may not optimize the potential use of plastics with respect to redesign.

Even assuming that properties can be properly characterized, there are so many varieties of plastic resins, fillers, and structures that the practicing engineer has trouble constructing an organized base of information. There is no uniform numbering system such as is used in steel alloys, and the automotive engineers obviously do not want to become chemical engineers or have to understand the implications of all the proprietary trade names used. Some sort of a structure of computerized or non-computerized database could be extremely helpful to diffusing the use of plastics in the industry. Both General Electric ("ERIS") and Borg Warner ("Plastivision") have databases available on a time sharing network. They are structured to help plastics designers make the primary materials selection and manufacturing decisions involved in new product development. Since these are developed by suppliers (one of thermoplastics, the other of thermosets), however, one must wonder about objectivity. Other systems include "PlastiServ" and "Plaspec."

Finite element analysis and similar modeling and simulation techniques have an important role in helping to refine and quicken the pace of component and system design in vehicles. There are several prerequisites to the effective implementation of these analytical techniques. One is a good characterization of the materials. Another is an understanding of boundary conditions and localized effects in the use of materials. While localization effects can often be ignored in metallic materials, this is generally not the case in many plastics and composites, as was discussed above. Therefore, there may be a need for some further development of practical, analytical models in order to better refine the design of plastic components.

A final, but absolutely crucial, area of implementation concern is that of environmental issues. There are, of course, certain fumes produced in the production of plastic parts (quite aside from the plastic material formulation itself). A more intractable problem (at least on the firm level) is the issue of how to dispose of non-recyclable (usually thermoset) plastic byproducts of broadened use of plastics. Several of our interviewees cited the need for an early policy in this area so as to provide the automotive planners with ground rules. Depending on the disposal infrastructure developed, decisions may be tilted towards thermosets or thermoplastics.

<u>The Impact on Michigan*</u>

Much of Michigan's industrial infrastructure and direct capacity may be dramatically impacted by the increasing use of plastics. It is difficult to specify with any accuracy all the Michigan establishments currently employing plastics processing to some extent or another. Often, this activity is ancillary to the main line of business and does not show up in SIC-based surveys.

Michigan has several captive plants and numerous independent firms which specialize in "traditional" plastics for interior use. For example, GM's Adrian and Ford's Milan and Saline plants come to mind.

GM's CPC-Livonia Plant is at risk in bumpers, and also faces technological competition with regard to composite springs. Ford's Milan Plant seems to have a growing role in plastic bumpers for its company.

Almost all of GM's fuel tanks are made in Michigan, about half in Lansing at Oldsmobile and the rest at Flint Pressed Metal. Should the decision be taken to make the switch to plastic, major dislocations are possible for these two plants. This is also true for Ford and Chrysler plants in Michigan.

The net effect for Michigan may not be all bad, however, as one of the major manufacturers of plastic fuel tanks is in Michigan, the Bronson Plastics Division of Kuhlman Corporation in Bronson, Michigan. However, fuel tanks are not convenient to ship and, given the more modular capacity of plastic tank production, the question remains whether the production will be as Michigan-centralized as that of metal tanks.

The net effect of switching to plastic headlamp assemblies may be positive to Michigan, as most of the conventional capacity is outside the state, while Michigan has significant optical plastics capabilities (Ford Saline and AMC's Evert Products subsidiary.) The current Ford plastic headlamp assemblies are made in Saline.

Michigan has several spring plants which have been and might be impacted adversely by increased use of composite leaf springs. Most of GM's leaf and coil spring needs are served by the CPC Plant in Livonia (employing about 2,000 in spring production) and one of the BOC plants in Flint. Livonia had a somewhat later "pultrusion" composite alternative to Inland's composite approach, but GM decided not to fund parallel programs beyond a certain stage. Ford manufactures most of its spring needs at its Monroe plant. Chrysler makes some of its springs at its Detroit Forge location; torsion bars are also made in that plant.

With respect to structural uses of advanced composites, these would generally be used to replace small stamped assemblies which are either made by independent specialists or (more in the past than currently) "off-line" in captive plants using offal material. The Flint Pressed Metal plant has specialized in engine cradles, which could logically be a candidate for advanced composite implementation. However, the engine cradle as we now know it may disappear from some or all future models. Of course, its functions must be redistributed to other structural members, which may be plastic or composite rather than metal.

6. Plastic Body Panels

The most difficult area to describe and analyze, let alone forecast, is the long-term use of materials on the outer "skin" of the passenger car, the principal "battle" between steel and plastic. The situation is relatively clear between now and 1992. As was discussed, the vast majority of the product plans for this time frame call for steel bodies; but the possibilities beyond 1992 multiply significantly.

The first use of a plastic body panel in North America mass-produced vehicles was the Chevrolet Chevette. Ever since its first appearance in the 1953 model year, it has had a "fiberglass" body – a relatively conventional unibody structure with a fiberglass skin, but not a driveable chassis. Corvette volume is relatively small, varying between 25,000 and 40,000 units per year.

The next major plastic vehicle skin implementation is the well-known Pontiac Fiero, which appeared in the 1984 model year. Much less expensive than the Corvette, it has a production volume of 100,000 units per year. It uses a "space frame" or "birdcage" driveable chassis with bolt-on panels. Exhibit 6A shows the 1984 body panel material and vendor selection for the Fiero. It is worth noting that all of these materials are thermosets and, significantly, that more of the parts are made by outside vendors than in any General Motors steel-bodied car. The Fiero has demonstrated that higher-volume vehicles can be economically made using a creative body structure, including large-scale use of plastics.

It has been rumored in the press that both Ford and GM are looking at a similar approach for plastic-bodied minivans based on passenger car chassis. Ford is rumored to be considering a minivan based on the new Taurus/Sable chassis for around 1990. It would be front wheel drive, as opposed to the Aerostar, and somewhat smaller. Likewise, General Motors has been reported in the press to be working (within CPC) on a plastic "personal van."

In addition to all-plastic or largely-plastic vehicles, we are starting to see the selective use of plastic panels in essentially steel cars. For example, the Cadillac Fleetwood Limousine produced at Clark Street uses glass-fiber-reinforced plastic rear doors, hoods, and roof spacers. In addition to having provided an economical mechanism for stretching the Fleetwood into a limousine version, this is an important test of whether certain classes of customers will accept plastic body panels and whether these can be intermixed under critical customer scrutiny with steel panels. Another current use of plastics in North America is the hood and lift gate of the passenger version of the just-issued Ford Aerostar minivan (Exhibit 6B). Chrysler is planning to use plastic double doors on some special cargo-type service versions of minivans. This is a relatively low volume application, and undoubtedly low tooling cost plays an important role in the decision. These 1986 plastic doors are a conversion product built by Creative Industries of Detroit from panels produced by Budd of sheet molded compound (SMC) with steel hardware and door frames.

We now turn to future plastic-skinned cars. The 1990 GM80 replacement for the Camaro/Firebird will be a space frame plastic car along the structural lines of the Fiero, but with the more traditional front engine front wheel drive configuration. Volume for the GM80 could be close to 400,000 units per year, making it by far the largest volume plastic car in production. It is anticipated that the core plant for this production will be in Pontiac, with sourcing of body panels split among captive and outside suppliers.

GM80 volume will be made up of four differentiable models. There will be some very low volume models and some medium volume models, not the high volume body panels that the total platform volume implies. This probably had a significant effect in the selection of the plastic strategy for this vehicle.

Saturn will be a largely metal vehicle, but may have plastic fenders. Much less is known about the Chrysler Liberty car, although it appears that plastics are being considered. In addition, apparently Chrysler has a parallel program for a completely plastic or composite vehicle. We know relatively little as yet about the Alpha; however, we would not exclude the possibility of major plastic body sections on this vehicle (or, as Ford prefers to describe it, vehicle concept), although we doubt that it will be an all-plastic vehicle along the lines of the GM80.

Product Planning

As we have seen, there are different ways to apply plastics in body panels. To oversimplify the situation, it is useful to distinguish among three major categories:

1. Hang-on panels;[1]

2. All-plastic/non-driveable space frame construction (e.g., the Corvette); and

3. Driveable space frame all-plastic vehicles, (e.g, the Fiero). In the rest of this section, we will focus on the driveable space frame, boltable plastic panel approach, and on the hang-on panel approach where this is a conscious part of the original product strategy.

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[1]In addition, it is important to make a distinction in hang-on panels between situations where the selective plastic use is conceived in the original design and production processing of the vehicle and those where it is an afterthought to lighten the vehicle.

The most important driving force is cost-effective market differentiation. Market volatility and the need for relatively short-term flexibility imply that single model annual volumes will be significantly lower than they were ten years ago, and this favors plastic body panels. Product planners are starting to look at the total life cycle cost of the platform/model during its life. Thus, if we have a vehicle that, to maintain consumer interest, must be restyled or "freshened" regularly, one must look at the capital and tooling investment over this whole cycle versus the total operating cost over that same time frame.

Product planners must have some feel for the crossover cost competitiveness of plastic versus steel. (The use of a selective plastic panel in a steel vehicle family would be analyzed somewhat differently, though crossover volume is still critical.) The crossover volume will depend on a variety of factors, including the base cost of the materials, processing costs,[2] and relative tooling costs. Exhibit 6C summarizes our general feel as to the historical, current and possible future crossover volumes between plastic and steel. At the moment we have assumed that the Fiero volume represents approximately a break-even choice between the two from a process cost point of view. In the past, we assume that the Corvette volume was the crossover point. The future, of course, is much less precise, but if we assume that the GM80 represents a target for 1990, we can speculate from this point out.

Design and Materials

Product differentiation possibilities become particularly impressive as space frames are designed and used with common mounting points to allow for different types of panels on the same frame. (There are, however, constraints on the degree of difference in the panels if they have to meet the frame at a given point.) Even more exciting from a cost-reduction standpoint is the fact that significant parts consolidation can take place if a properly designed plastic unit replaces several heretofore welded subassemblies. Particularly good examples of parts consolidation include one-piece fender assemblies and one-piece floor pans.

[2]One estimate is that at the current molding cycle time of 1.5–3 minutes, the platform crossover volume might be of the order of 100,000 units per year. At 1 minute, the crossover volume might jump to somewhere between 200,000 and 300,000 units per year, and at 40 seconds to 500,000 annual units. James Best of Market Search, Inc. is quoted as commenting that today 28 models are produced in annual volumes less than 75,000 per year.

We now turn to the consideration of the different classes of materials for plastic body panels. Thermosets used in automotive body panels include sheet molded compound (SMC), reaction injection molding (RIM), and reinforced reaction injection molding (RRIM). Thermosets have been used in virtually all exterior body panel applications to date. Thermosets have the advantage of relatively easy resistance to high temperature paint baking. On the other hand, they can have entrapped monomers which then "pop" in the painting process, causing surface blemishes. In addition, RIM and RRIM materials tend to be hygroscopic, which can result in thermal expansion problems unless appropriate measures are taken both in design and manufacture to account for this.

Thermoplastics are just beginning to be used in automotive body panel applications. Even the more optimistic thermoplastic manufacturers do not feel it is likely they will gain more than a ten percent penetration by 1990. Between 1990 and 1995 they expect somewhat of a shift, so that after that point they hope to have perhaps a 50 percent market share of plastic body materials. The first major application of a thermoplastic body panel in North America production is probably a DuPont "Bexloy" spoiler in the 1985 Fiero GT. The General Motors H Car may have a thermoplastic header painted in line with steel panels. The two main manufacturers of thermoplastic resins are General Electric (whose plastics operation is headquartered in Pittsfield, MA) and DuPont (based in Wilmington, DE). Both of these firms have for many years had major plastics application centers in the greater Detroit area, and both of them have significantly expanded their facilities in recent months. Each of them has gained recent publicity for product announcements of new thermoplastic materials for body panels.

DuPont's Bexloy material is based on thermoplastic amorphous nylon. Bexloy is actually a family of different but related materials whose chemical composition, molecular weight, and toughness can be manipulated over a wide range for different uses. Bexloy parts can be fabricated either by injection or blow molding, with various grades more suitable for fenders and quarter panels, for bumpers and backup beams, for spoilers, etc., depending on product performance requirements. General Electric has two categories of material of interest in automotive body panel use. "Lomod" (low modulus) is a combination of an amorphous segment to provide dimensional stability and flexibility and a crystalline segment for heat and chemical resistance. By varying the ratios of these two phases, the modulus can be changed, for example, from 20 to 200,000 psi. This type of material seems particularly applicable for the lower body applications (filler panels, valance panels, air dams, wheel flairs, side panels), where damage resistance is a primary consideration. GE's other body material is called "GTX." Developed to fill the high temperature gap which has traditionally kept thermoplastics from body panel use despite appropriate physical properties at room temperature, GTX combines polypropylene oxide (PPO) intermittently dispersed in a continuous matrix of nylon. This requires the use of compatibilizers and a process proprietary to General Electric. The result is heat resistance up to about 350 degrees Fahrenheit, very similar to the range which Bexloy claims (and that achieved by most thermosets). GTX also appears to have a very stable modulus over a wide range of operating temperatures. General Electric suggests the following applications: fenders, grills, header panels, rockers, rear quarters, and lift gates.

Machinery and Tooling

Machinery and tooling variables will be important factors in determining the rate of plastic body panel applications. Plastics equipment is quite different from stamping presses (their functional equivalents when metal body panels are used). Different manufacturers are involved in making them, and the design and process control requirements are different. The basic output rate of the two types of equipment has traditionally been quite different for a given size and shape of piece. Current injection molding presses tend to be more suitable for smaller vertical panels than for larger horizontal panels. The largest injection molding press manufactured in the United States is 5,000 tons. Horizontal panels such as hoods would require at least a 6,000 ton press. European presses are made up to 10,000 tons, but there are so few of them available that horizontal panel development seems to be hampered (in North America, at least) by the lack of tryout equipment large enough to properly make these parts.

We do not have any specific details as to the capacity for making plastic molding machines suitable for body panels. One planning engineer involved in plastic vehicle production told us that the lead times for molding equipment would describe the critical path for implementing plastic cars. At the moment, these lead times appear to be consistent with the normal product planning cycle of the auto companies. However, if several of the auto companies decide to go into significantly higher uses of plastic body panels at the same time, it is not clear whether the capacity and lead time of both American and foreign industry would suffice.

Just as machinery for plastic molding differs from stamping presses, so does tooling. Perhaps the most dramatic difference is in the better surface finish required in molds as opposed to in stamping. (On the other hand, the structural requirements in molds are considerably less demanding than for stamping dies.) The economics of the two types of tooling differ greatly as well. The cost of injection molding tooling for a given shape is considerably below that of stamping dies. On the other hand, output capacity and life of the tool may be lower in the case of plastics tooling than for stamping dies. But since more frequent design changes in automotive exterior panels seem likely, mold life may not be a substantive problem.[3]

The mold-making industry for plastics (very closely related to pattern making in the foundry, in many regards) is, at best, a fragmented one. There is a fair amount of mold making capacity, but it is broken up into so many small and relatively unsophisticated companies as to raise concern by auto makers. This concern would be particularly valid if several auto makers decided to get into major programs at the same time. Thus mold making is viewed as a potentially constraining factor in the development of plastic automotive panels. Moreover, significant mold-making learning curve is required regarding large body panel molds, both on the part of mold designers and mold makers. CAD/CAM programs do exist for injection molding and other types of plastic mold development, but many mold shops do not have this type of equipment. In fact, mold and pattern shops are somewhat less advanced than their stamping die counterparts in the CAD/CAM area. Mold design software does exist and can be "site licensed" or used on a service bureau basis. If one wants to use this in house, however, close to $200,000 in interactive graphics terminals is required. The software license itself costs about $20,000 a year.[4]

From the auto makers' point of view, there is an obvious strategic issue posed by the structure of the mold-making industry. On the one hand, they would like to use the flexibility and originality of independent mold makers. On the other hand, they see these under-capitalized and relatively low-sophistication management firms as risky partners in the evolution of plastic-bodied vehicles; joint ventures might be a possibility. The mold design/making strategies selected by the auto makers will have a significant effect on both the rate and the direction of plastic body implementation.

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[3]However, there is a concern as to whether one needs backup molds in case of a manufacturing accident. Due to long experience, quick die repair techniques have been developed in the stamping area. At least as yet, these techniques do not exist in the plastics area, and it can often be six weeks before one is back in business with a new plastic mold. In part, this comes from the very delicate surface finish requirements in plastic molds, an area which is absolutely crucial to the eventual competitive position of plastic panels in cars.

[4]Plastic body panel production would be as easy if not easier to automate than the metal counterpart, if for no other reason than the slower cycle times involved. In addition, everyone seems to be taking effective automation into account in the design of facilities for plastic panel manufacture and assembly.

Production Variables

The largest single production variable influencing plastics versus steel is the molding time for plastic panels. Molding time is dependent both on the material itself and on process/equipment optimization and die design. Generally speaking, molding time is a function of the cross section of the part and not its surface area. Thus, a large, thin panel may have a shorter molding time (in a much larger machine) than a thicker, smaller part. Depending on the shape of the part and the specific material from which it is being made, today's molding time is between 90 seconds and 3 minutes. In the laboratory, analogous molding times have been reduced to 60 to 90 seconds; in all probability, certain types of parts will be made at that rate in a plant environment by 1990.

Painting is the process area of most concern, other than molding. In an all-plastic car, one has the option of painting the panels in place (Corvette) or off-line on racks, after which the panels are mounted on the space frame (Fiero).[5] However, both cars are painted at significantly lower temperatures than if they were steel: 250 degrees Fahrenheit maximum.

Supplier and Locational Implications

The widening use of plastic body panels will have huge impacts on the structure of the industry, both with regard to winners and losers and with regard to geographical location. The first obvious impact would be on manufacturers of the steel which would otherwise be used in bodies. Steel companies may find a more cost-effective way of attaining the same type of durability as a plastic body might provide, but it is much less likely steel companies will be able to slash tooling costs. On the other hand, if they could work with tool development experts on reducing the cost of stamping dies (and the lead time required to develop them), the crossover volume for plastic and steel would once again be raised.

Pricing reactions are also a potential tactic for the steel companies. However, current margins on steel and the current financial condition of the domestic steel makers are such that this could hardly be used as a long-term strategy. In fact, even selective use of plastics for auto bodies may put into jeopardy the plans the steel makers have to upgrade their technological capabilities.

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[5]In fact, the Fiero body panels are pre-primed by the molders themselves, then reprimed with a constant material (the primer used by each molder sometimes being different) to avoid problems of color match.

Stamping plants are also dramatically affected by increased use of plastics. We surmise that the captive large body panel plants are proportionately much more affected than smaller independent plants, which tend to make smaller, often non-visible stampings. In addition, the ability to respond to this threat by diversification may be less available in the regional stamping plants than to smaller independents. One should point out, however, that all three of the major auto companies have been investing heavily in upgrading the stamping facilities in many of these regional plants, and so apparently still expect this investment to pay off in the time frame for implementation of plastic body panels.

As was discussed above, stamping press companies and plastic molding press companies are not, in most cases, the same firms. Thus to the extent that the plastic panels are increasingly used, the market for large body stamping presses will diminish dramatically. Similarly, at the moment at least, tooling firms for stamping dies and plastic molds are not the same; hence, dislocation in this industry is also possible. In this latter case, however, there is at least the possibility of mutating die plants into mold plants.

The switch from steel to plastics, to the extent that it happens, has significant locational considerations as well. There is an advantage to being closer to the sources of resins, although we think that is a second order consideration. On the other hand, there is a significant need, at least during the transition phase, to be close to the knowledge base for molding plastics. Perhaps most important, there seems to be a significant bias toward having the plastic panel molding plants close to the assembly plants they serve. It is very likely that, whether captive or independent, there will be a cluster of molding companies built up in the approximate vicinity of assembly plants. This also is compatible with the needs for damage control in plastic panels, the now-apparent advantages of JIT, and the probable lack of nestability of plastic panels as parts are consolidated to make more complex shapes. Thus the principal determinant of the location of plastic body panel plants may, in fact, be the selection of assembly plant sites.

A "Fearless Forecast"

In order to look into the future, we have chosen to divide the period between now and the year 2000 into three time frames. The first is 1985–1992, for which decisions must be made by 1986. The second is 1992–1995, with decisions made between 1987 and 1990. Finally, there is the 1995+ time frame, for which the decisions will be made after 1990. By the time the "gut" decision must be made between a plastic versus a steel bodied car, the decision makers must be confident that the requisite technologies and market conditions are extremely likely (90+% confidence level) to be right. One cannot afford parallel programs once a vehicle has a definite time frame for rollout. This may have been one of the reasons for limiting the use of plastics in Saturn.

We have also decided that it is necessary to provide a low, medium and high forecast. The "Low" forecast might represent a forecast were problems encountered, for example, on the GM80 vehicle. The "Medium" forecast should be thought of as an extrapolation of our current view of the situation. The "High" forecast might be though of as one where there is either a technological or a market breakthrough in the late 1980's.

Percent Plastic Body Panels			
	Low	Medium	High
1982	15%	15%	15%
1996	20	30	40
2000	50	60	70
Probability	10%	70%	20%

7. Magnesium Castings

For several years, automotive designers have looked at many parts being made of (die-)cast aluminum and considered the possibility of using magnesium instead. Magnesium alloys are some of the lowest specific gravity materials economically available to automotive designers. They do, however, suffer from potential corrosion and flammability (in manufacturing) problems. Furthermore, they have certain mechanical properties inferior to those of steel or aluminum. However, magnesium is stronger per pound than any current automotive material alternative except, for example, nylon glass filled plastic. Because magnesium is only 2/3 aluminum's weight, it has much promise for the future as a weight saver.

During the late 1970's, experts in automotive materials usage predicted as much as 10–15 pounds of magnesium per typical car within five to ten years. In actuality, current usage remains restricted at less than a pound, but growing use was again foreseen by some of the persons surveyed by the AIM project team.

If the North American automotive industry makes a wholesale switch to aluminum engines in the 1990 decade, it is very likely that magnesium will be tried as an alternative material for some components that are now aluminum. There would be a variety of technical motivations for this, but one of the primary business motivations would be to lessen the auto industry's dependence on primary aluminum manufacturers and to oppose the potential price dictates of the aluminum industry.

Such a switch from aluminum to magnesium would impact material suppliers, of course, but particularly die casting companies now supplying aluminum die castings. Manual and automatic transmission cases are examples of components, now containing 10–20 pounds of aluminum, that might be switched to magnesium.

Automotive materials economists suggest that magnesium's price premium must be less than 50% above aluminum's per pound price for magnesium to grow in automotive use. Because of magnesium's 1/3 lighter weight, at a price ratio of 1.5:1, magnesium ingot and aluminum ingot are roughly equal in terms of material effective volume cost. Recently, magnesium's price has been about twice the price of aluminum, the same as during 1982.

Exhibit 7A represents a start at cataloguing parts that have the highest probability of being converted to magnesium. Examples of past magnesium applications in the North American automotive industry include alternator and air conditioning brackets, engine valve covers, die cast steering lock mechanisms, wheels, clutch housings for light duty trucks, brake and clutch pedal supports.

European manufacturers also use some magnesium components. The Alpha-Romeo GTV6/2.5 Sport Coupe contains about 100 pounds of magnesium, including cast wheels, oil sumps, engine covers, and a few power train components. Probably the most widely known magnesium automotive application is Volkswagen's transmission case, which VW has produced for 35 million of its cars. The current VW Golf model has a 40-pound magnesium transmission case.

Recently there have been several public announcements of magnesium components for future models. For example, the 1987 Ford F Series pickup and full size Bronco utility vehicles will use a magnesium transfer case housing. The two piece housing will weigh about 14 pounds, 1/3 less than the 21 pound aluminum predecessor. The lighter housing reduces overall weight of the assembled transfer case nearly 10%. Apparently approximately 150,000–200,000 units yearly will be produced, thereby representing 2–2 1/2 million pounds of additional magnesium usage.

The next major application of magnesium in a production North American vehicle will probably be in the GM 10 or W car. Webster Manufacturing, a division of Canada's CAE Industries Limited, will be the primary supplier of a magnesium steering column bracket for this vehicle. Webster management was quoted as citing a $70 million single source long-term contract beginning in 1988; the plant is located in London, Ontario. Apparently the one piece magnesium bracket weighing 384 grams replaces two conventional zinc die castings which would have weighed 1.4 kilograms. This is an application in which magnesium means lighter weight <u>and</u> superior parts integration.

There are, quite properly, some technical concerns in moving to die castings. There is the susceptibility of molten magnesium or magnesium chips to ignite and burn. Second, in automotive applications, magnesium has been found to be susceptible to four types of corrosion: salt, galvanic, alcohol, and other chemical. Ford introduced three magnesium exterior castings in 1980 which they later withdrew, possibly because of corrosion problems, although the official reason was cost. Such experiences have, however, helped pave the way to solutions, such as better coating techniques.

On the plus side, efficiency during magnesium part manufacture is an advantage that interests automotive planners. The most common method for casting aluminum has been cold chamber die casting. The process is similar to aluminum die casting, where molten metal is shot under high pressure through a cold shot cylinder into the mold. Engineers we surveyed indicated that automotive companies are particularly interested in a hot chamber method, which has about a 2/3 cost saving over the cold process. The comparative savings result from lower porosity, thinner-walled castings, increased production speeds, better surface finish, and reduced scrap breaks. The hot chamber magnesium process, which has thus far not been universally perfected for automotive aluminum parts, gives magnesium an added advantage but only for parts under about four pounds.

Magnesium also offers superior machining characteristics relative to aluminum, cast iron, and mild steel. Volkswagen has reported that it machines magnesium transmission cases in a little over half the time required for aluminum. Excellent finishes are achieved with heavier cuts and without coolants.

The principal suppliers of magnesium materials to the automotive industry are Dow Chemical and Amax. There are several cost-competitive magnesium die casting suppliers, including Webster in London, Ontario, and Global Die Casting and Die Makers in St. Louis. To the best of our knowledge, there are no Michigan facilities significantly involved in die casting magnesium.

Dow Chemical is working to develop strong, lightweight composites of magnesium filled with alumina for the automotive market. They are beginning testing of prototype parts, from oil pump covers to chain saw engine cylinders. The purpose of this effort is to improve the structural strength and wear resistance of magnesium. The main ingredients in Dow's composites are molten AZ 91 magnesium alloy and alumina added with a proprietary mixing technique. 1–10% alumina by weight is added and dispersed evenly. The alumina provides the strength and wear resistance, while the light weight of magnesium is not increased significantly. While an optimum amount of alumina in the magnesium composites has not yet been determined, 1% appears to be a workable level.

Such composites could someday provide a useful cylinder block material. One of the problems in cylinder blocks always has been the cylinder wear problem, and it is for this reason that in sleeveless cylinder blocks 390 aluminum alloy is used. Would this magnesium composite casting material provide an even lighter block material with suitable wear characteristics? This is an early stage development which should be tracked closely.

Michigan is home to a whole host of die casting plants. More general adoption of magnesium as an automotive die casting material could put our firms at a relative disadvantage since they appear to be unprepared for manufacturing magnesium parts. With so many Michiganians employed in diecasting automotive and other parts in Michigan, the State has an interest in seeing to it that its die casters are capable of converting to magnesium, as this might provide them a competitive advantage.

In future work, we will seek out more specific application opportunities and trends by interviewing the magnesium manufacturers and specifiers in the automotive firms. Based on what we learn from this, we can assist the Technology Deployment Service in identifying which of Michigan's die casters might be most suitable for magnesium implementation. (Sealed Power in Muskegon, Kelsey Hayes' Cast Forge Division in Howell, and Nelson Metal Products in Grand Rapids come to mind. We will also check for suitable latent capabilities in captive die casting departments in the state, if any.) TDS might then consider informing them on application possibilities and operating cost parameters relative to magnesium casting production, and assisting them in deciding whether technological cooperation or a joint venture with magnesium capable diecasters (e.g., VW's transmission case supplier) would be desirable and, if so, starting them off in that direction.

8. Ceramics and Other Materials

In this section we will discuss a variety of miscellaneous materials matters to which relatively little time has been devoted during the current AIM term. These were deemphasized a priori because of a lack of resources compared to what we assumed to be the Michigan impact. What follows thus comes more from published reports and general knowledge than from specific interviews. It is meant to provide a base from which to build in later AIM work.

Ceramics

The use of so-called "fine ceramics" in industry is going to be a major field in the coming decade, and even more so around the year 2000. Charles River Associates recently concluded a study for the National Science Foundation which has been widely quoted. They estimate that the market for U.S. engine parts in ceramics should be of the order of $800–900 million by 1995 and $1.2 billion by the year 2000.

One can divide the logic for applying ceramics into "systemic" applications where ceramics are used systematically throughout a system (generally a diesel engine), and "selective" applications where they are used to improve certain subsystem and component functions. In the first case, virtually all the effort is directed toward increasing thermal efficiency in diesel engines. Increased thermal efficiency results in better fuel economy, both directly and indirectly. By reducing the heat rejection, one can minimize (or in principle eliminate) the heat exchanger (radiator), which yields a major weight reduction.

While the systemic use of ceramics is largely limited to diesel engines, in more selective uses ceramics can be used to advantage in gasoline engines. In the one AIM field interview where the application intensity of ceramics was discussed, interviewees felt that by 1992 one might see a ceramic faced cam follower in 10% of North American vehicles, turbocharger hot wheels in 1%, piston crowns in 25%, and exhaust port liners in 2%.

At least one Michigan company, Bohn Engine and Foundry Division of Gulf and Western in South Haven, has been cited in the press for its application of ceramics. Bohn supplies pistons to such companies as International Harvester, White Motor, and Ford. They are most enthusiastic about a ceramic fiber-reinforced aluminum piston. They say that silicon carbide, alumina, and alumina/silica whiskers will strengthen the aluminum casting while reducing its thermal expansion rates. This will in turn make feasible the addition of ceramic coatings over the solid piston caps.

Some ceramics research work is being done in Michigan today at the Big Three. We assume that Detroit Diesel is also doing some work because of their dependence on heavy-duty diesel engines, but that still has to be ascertained. [If they are not, they could be at a competitive disadvantage eventually to firms such as Cummins, which are investing in this technology.] It is not known to us what, if any, research in ceramics is being done in Michigan's universities.

Soft Trim

Without a doubt, the soft trim sector is one of the most labor-intensive part of the automotive industry. Although as recently as two or three years ago, it was thought that because of the color and damage sensitivity of the products there was relatively little risk of foreign sourcing, this is now less evident.

In fact, the soft trim industry is an excellent example of how it is impossible to segregate different forces driving change. For example, in soft trim there is a significant element of industry restructuring. The reorganization of General Motors has broken down the former dominant role of part of the Fisher Division (now part of the Inland Division) in soft trim management (and production) for GM. This combines with new sourcing strategies on the part of all the automakers, which emphasize the need for just-in-time, fully modularized manufacturing in the soft trim area and opens this up to independent function managers. Perhaps the most dramatic examples of that are Hoover Universal and Lear Siegler's advances in selling modular, just-in-time seating systems to the automakers, first just for specialized applications and, more recently, for general production at certain plants, such as Chrysler's Sterling Heights assembly plant.

Coincident with the new sourcing trends is an increased openness to new materials and processes in soft trim. In fact, many of the soft trim areas are elaborate forms of chemical engineering where materials and process development are closely integrated.

Another important coincident factor is the increased interest in developing soft trim packages that then can be automated in the "final trim" assembly of the vehicle. The "final trim" line in an assembly plant has traditionally been the one thought hardest to automate. However, it is also the most labor-intensive and, especially with the movement toward modular construction of vehicles, it is now time to attack the automation of the final trim line. This requires different design, process, and materials in the soft trim area.

The final factor impacting the soft trim area is the recognition that there is low labor cost competition available. Experimental "cut-and-sew" programs have taken place in Mexico, particularly in the border area, providing evidence that they can produce parts which are properly color coordinated and undamaged over long distances.

As for specific materials and technology changes in soft trim, molded carpets, headliners, and seats are particularly interesting. Both Ford and GM have discussed "foam-in-place" seats for some number of years now, and there now seems to be a significant movement in that direction. Finally, there seems to be — both within the automotive companies and among several independent suppliers (Allen Industries is cited in this regard) — an effort to look at some other way than cut-and-sew for bonding parts of seats, door pads, etc.

One general trend in the design area is that there is a return toward contourability with more upscale plushness in this area. This is contrary to a trend that was observed earlier, where the more functional (in effect "German") styling seemed preferable (at least to the engineers, if not to the American buying public). Apparently the automotive designers and marketing specialists find that the American public is willing to pay for the additional cost of the plusher look.

Although a relatively small amount of year one AIM time was spent on this area, this is not due to its lack of impact on the Michigan economy. Michigan has several significant captive soft trim plants: GM in Grand Rapids, Livonia, and Tecumseh; Ford in Utica; and Chrysler in Detroit. All can be thought of as being at risk (to a greater or lesser extent) over the next three to ten years.

Surrounding these plants, both literally and figuratively, is a whole support industry. This includes materials and parts fabricators and specialized tooling and equipment manufacturers. Most of these are relatively small; many are privately held. To some extent, these supporting plants have already migrated to lower labor cost areas to protect their competitiveness; this may continue as cost pressures upstream increase.

Miscellaneous

What follows is a series of extremely brief comments on miscellaneous materials which have at best second order impacts on the Michigan economy as a whole, though they are in some cases significant to particular communities.

Copper: Until recently the use of copper in the typical U.S.-built car was fairly stable at about 40 pounds. With downsizing and material substitution of key components, average copper usage was expected to have declined to 30–33 pounds by 1985. The University of Michigan's 1984 Delphi Forecast predicted that by 1990 the average car will contain only about 22 pounds of copper. The vast majority of copper usage in automotive components has traditionally focused on radiators and wiring harnesses. As was mentioned above, copper radiators are being increasingly supplanted by aluminum. In wiring harnesses there may also be a significant trend away from copper, assuming that fiber optics technologies can be substituted. Signal multiplexing techniques are going to be absolutely essential in the electronic-based car of the future, and it appears that the bandwidth and EMF insensitivity advantages of fiber optics will push us in that direction, Michigan has several copper wiring harness facilities, although far fewer than in former years. In principle, these could convert to fiber optics, although there is some question as to whether this would be done in Michigan or not.

Asbestos: There is a decreasing use of asbestos in friction materials such as clutch and brake linings. The EPA is considering banning this material as injurious to workers' health; there is even consideration of danger in terms of air pollution by normal braking activity. Commercially available substitutes include zinc and brass chips or aramid fiber products and, for heavy duty use, ceramics. To the best of our knowledge, there are no friction material plants of significant size in Michigan, so impacts are not likely to be significant here.

Powdered Metallurgy is changing of late, both in terms of process and materials. Although Michigan is a heavy user of powdered metal parts, it is not a particularly heavy manufacturer of those parts. The powder producers are exclusively outside the state, with the exception of a new firm founded recently by two Ford executives. While the direct effect on Michigan of powdered metals materials development is probably quite limited, the intensity of use of powdered metal parts can be an important competitive advantage or disadvantage in other industries such as transmission and axle manufacturing.

Developments in adhesives are going to be extremely important in the ability to apply certain other materials such as plastic body panels, and may result in greatly decreased use of weldments and hence in Michigan dislocations.

Exhibit 1A

Overall Materials Trends (%)

	1977	1985	1992	2000
Steels	62	58	57	55
Cast Iron	17	13	9	7
Aluminum	3	5	6	8
Plastics	4	9	11	16
Glass	3	2.5	3	2.5
Other	11	12.5	14	11.5
	100	100	100	100

Exhibit 1B

Overall Materials Trends (Pounds)

	1977	1985	1992	2000
Steels	2250	1610	1425	1155
Cast Iron	615	360	225	150
Aluminum	110	140	150	170
Plastics	145	250	275	340
Glass	110	70	70	55
Other	395	345	355	230
Totals	3625	2775	2500	2100

Exhibit 1C

POSSIBLE BODY PANEL MATERIALS USAGE PATTERNS

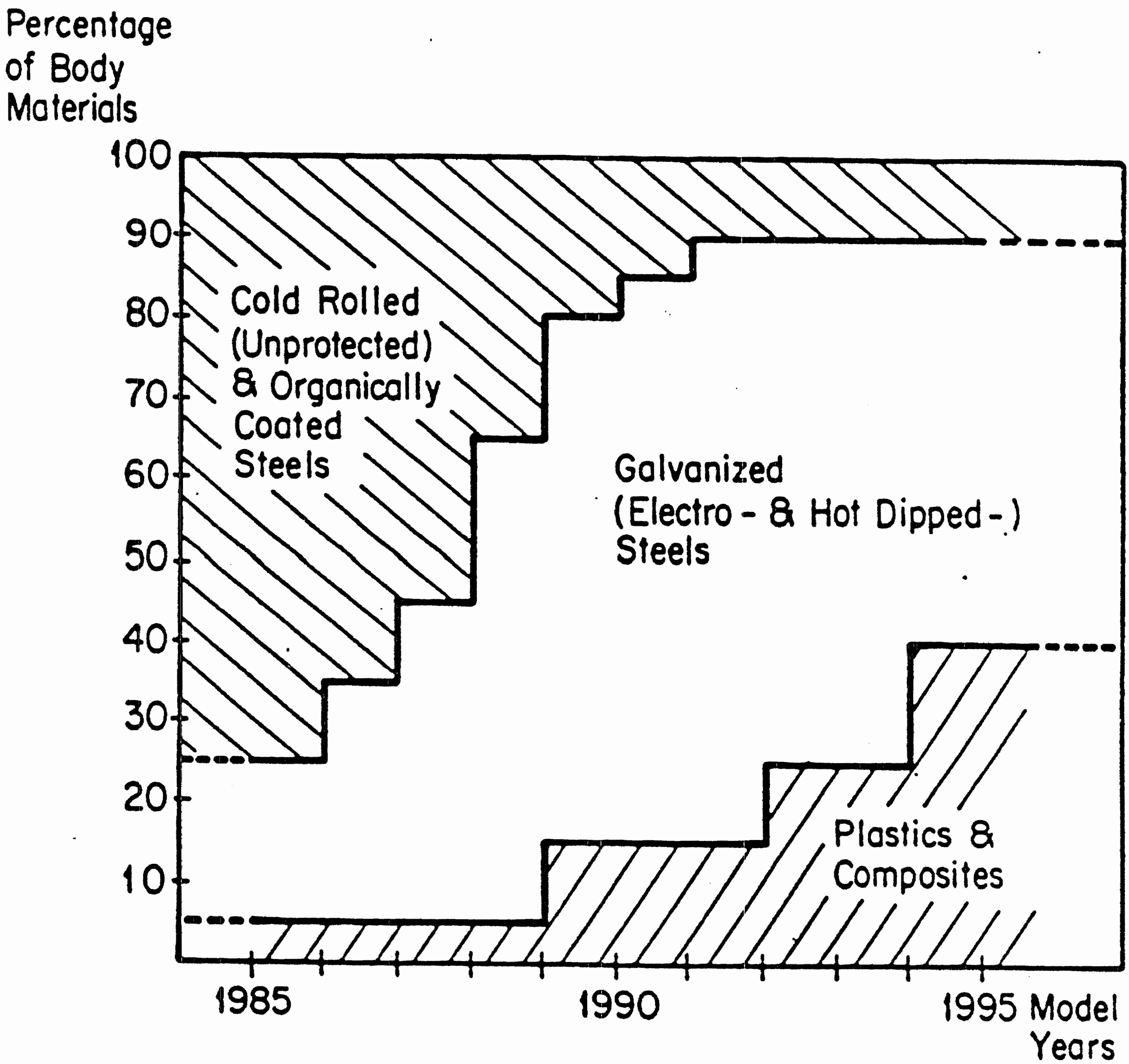


Exhibit 1D

AUTOMOBILE MATERIALS TRADEOFFS

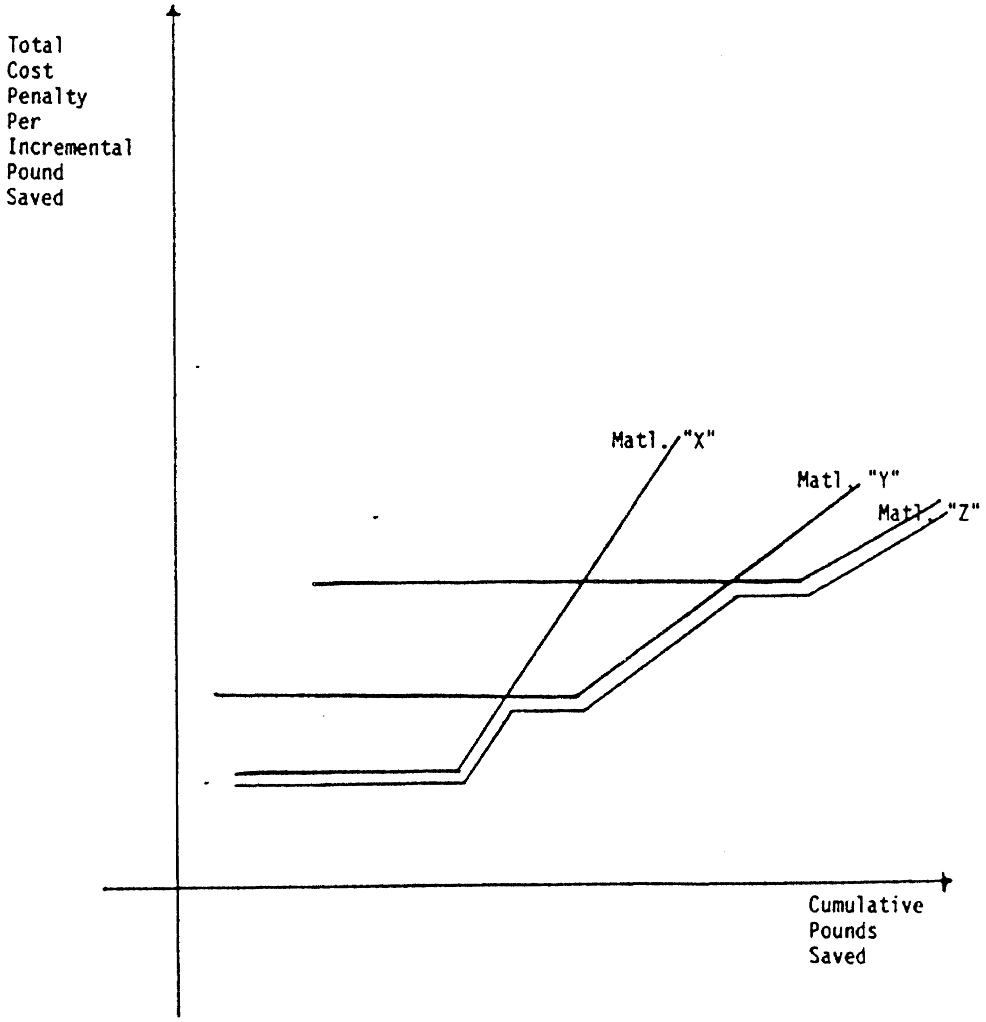


Exhibit 1E

Approximate Decision Timetable - Galvanized Steel

Step/Action	Apparent Typical Decision Dates
A2 - Awareness of Market Pressures	1975-1978
A6 - Conceptual Market Response Decision	Early 1981
B5 - "Finalize" Application, Process, and Purchase Specs	Early 1983
C10 - Conclude Supply/Implementation Negotiation	Mid to Late 1984
D - Key Implementation in Effect	Mid-1986 to Mid-1987

Exhibit 2A

COMPARISON OF ALTERNATIVE STEEL PROTECTION TECHNOLOGIES

	ZINCROMETAL	HOT-DIP GALVANIZED	ELECTRO-GALVANIZED
Basic Process:	Two-stage dipping and baking	Immersion of steel directly into molten zinc or zinc-alloy	Electrodeposition of zinc or zinc-alloy onto steel
Advantages:	* Lower cost than galvanized steel * Good weldability * Good paintability	* High degree of protection * Lower cost than electrogalvanized steel (below 60 g/m^2) * Standardized production technology	* High degree of protection * "Cold" process which does not affect the steel's mechanical properties * Very even deposition, yielding smooth surface * Better bonding of zinc to steel * Good formability * Ease in making differential coatings
Disadvantages:	* Only 3-year protection for external automotive applications * High baking temperatures affect mechanical properties	* Heat from dipping causes annealing, adversely affecting mechanical properties of steel * Spangling very difficult to control * Comparatively rough surface texture * Facilities economical only on large scale	* Cost premium * Short-term capacity
Probable Applications, 1988 Model Year	* Some roof panels	* Underbody components * Door, hood, and deck lid inners	* Most external body panels * Some roof panels * Possibly some underbody components * Door, hood, and deck lid inners

Exhibit 2B

Relative Costs Under Two Operating Hypotheses

		Case 1	Case 2
A.	Capital Investment	$80 million	$120 million
B.	Annual Capacity	400,000 tons	300,000 tons
C.	Investment/Annual Ton (A/B)	$200	$400
D.	Required Payoff Period	10 years	6 years
E.	Effective Capacity Utilization During Payoff Period	80%	60%
F.	Amortization Charge/Ton Sold (C/(D x E))	$25	$111
G.	Annual Labor Charge (Assumed Fixed at 75 people x $25/hr. loaded rate x 2000 hrs/yr.	$3.75 million	$3.75 million
H.	Labor Cost/Ton Sold (G/(D x E))	$12	$20

Exhibit 3A

Estimated Amount of Aluminum in U.S. Passenger Automobiles

Model Year	Average Passenger Car Weight, Lbs. (1)	Aluminum Application Lbs./Car (2)	Percent of Aluminum
1978	3587	114	3.2%
1979	3507	118	3.4%
1980	3283	120	3.7%
1981	3099	130	4.2%
1982	3009	133	4.4%
1983	3115	135	4.3%
1984	3103	137	4.4%
1985	3082	139	4.5%

(1) Light Duty Fuel Economy Trends through 1982. SAE Paper 82-0300.

(2) Auto & Truck Committee, Aluminum Association and industry sources (Model Years 1972 - Present)

Exhibit 3B

Aluminum Applications List

Engine Components

- Air Cleaner
- Air Pump Housing
- Alternator Housing
- Aluminized Coating on Intake Valves
- Camshaft Housing
- Carburetor
- Cover Plate
- Distributor Body
- Engine Temperature Sensors
- Fan Spacer
- Front Engine Covers
- Front Wiring Harness
- Fuel Injection Injectors
- Intake Manifold
- Oil Pump
- Pistons
- Water Outlet Connectors
- Water Pump

Body, Chassis, Accessories

- Air Conditioner
  - Evaporator and Condenser
- Carburetor Overflow
- Battery Tray
- Catalytic Converter
  - Dust Cover
  - Heat Shields
- Deck Lids
- Front Bumper
  - Bumper Bracket
  - Face Bar
- Rear Bumper
  - Face Bar
  - Reinforcements
- Hood
  - Hood Hinge Supports
  - Hood Inner Panel
  - Hood Outer Panel
- Instrument Panel
  - Tie Bar
- Tulip Panel
- Disc Brake
  - Brake Cylinder
  - Brake Piston
  - Master Cylinder Piston
  - Brake Caliper
- Radiator
  - Radiator Core
  - Radiator Support Assembly
- Transmission
  - Case
  - Miscellaneous Internal
- Trunk-Load Floor
- Wheels
- Hub Caps

Trim

- Door/Belt Trim Support
- Door Lock Spacer
- Grille Surround - Moldings
- Headlamp Bezels
- Head Rest Bar
- Luggage Rack/Air Deflector
- Rear Window Moldings
- Rocker Panel Moldings
- Scuff Plate
- Side Moldings
- Seat Side Shields
- Side Trim
- Sill Plate
- Sun Roof Hatch Frame
- Tail Light Moldings
- Wheel Well Moldings

Exhibit 3C

Aluminum Usage in Chevrolet Corvette

Wheels	83 pounds
Front Suspension	27
Rear Suspension	23
Drive Train	82
Brakes	19
Bumper System	41
Engine	48
Steering	4
Miscellaneous	50
	377 pounds

or about 12.1% of total weight

(Source: Aluminum Association)

Exhibit 3D

Aluminum Components - Porsche 928

Engine Group	166 pounds
Transmission Group	69
Body Group	93
Suspension Group	34
Other	224
	586 pounds

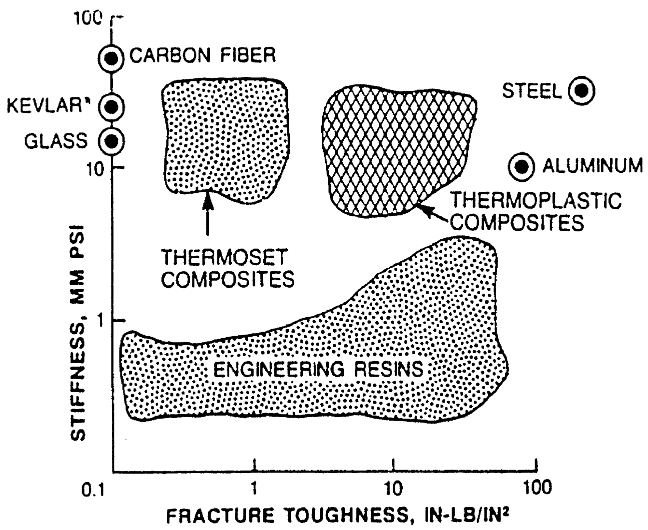
Exhibit 4A

Usage of Aluminum in Major Engine Castings

	1980	1985	1992	2000
Intake Manifolds	30	60	90	95-100
Cylinder Heads	>10	30	60	80-100
Blocks	--	>5	25	50- 70

Exhibit 5A

Situating Resins & Composites



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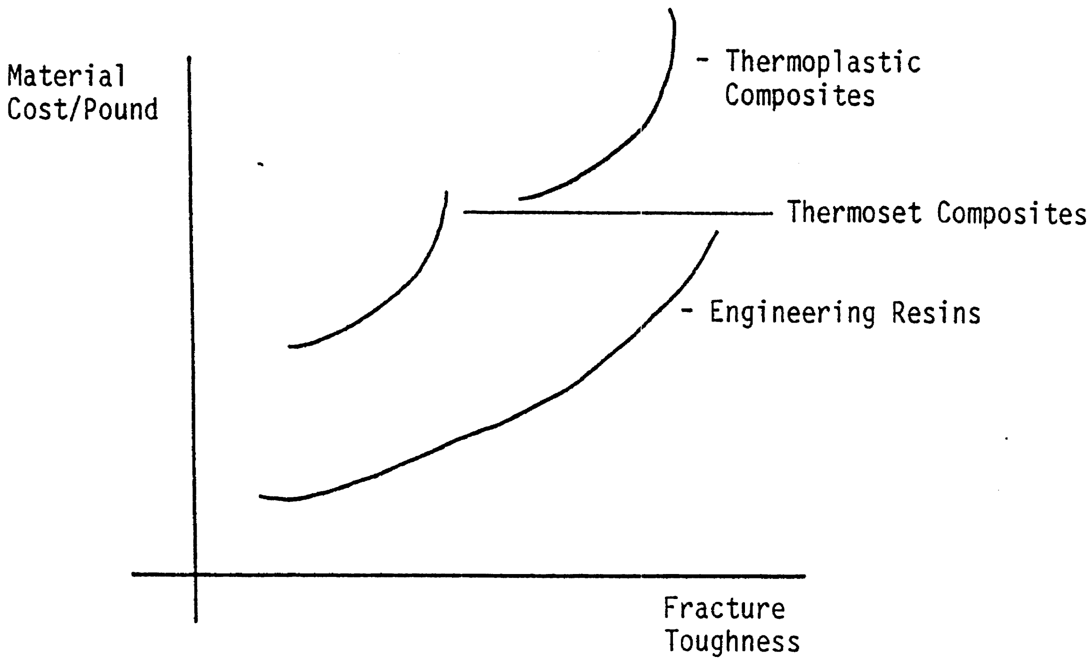

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Exhibit 5B

Current Automotive Plastics Applications

Body (and Related) Applications

Grille Opening Panels
Fender Liners
Tail Lamp Surrounds
Head Lamp Surrounds
Grille Opening Panel Retainers
Sports Car Racing Gear
Hoods
Bumpers
Fenders
Doors
Other

Underhood Applications

Air Conditioning Housings
Fan Shrouds
Heater Housings
Fans
Battery Trays
Radiator Parts
Brake System Parts
Other

Passenger Compartment Applications

Instrument Panels and Parts
Steering Column Parts
Window Surrounds and Parts
Armrests
Door Handles
Soft and Firm Trim
Other

Electrical Applications

Ignition Housing
Distributor Cap and Parts
Lamp Sockets
Switches
Junction Boxes
Other

Engine and Drive Line Applications

Small Transmission Parts

Exhibit 5C

Owens-Corning Forecast of Auto Plastics Usage

Item	Millions of Pounds 1985	1989	Growth Rate
Glass Reinforced Thermosets			
- Rear End Panels	23.9	53.3	22.2
- Front End Panels	80.6	104.4	6.7
- Station Wagon Tailgates	0.9	2.8	34.7
- Deck Lids	2.4	7.5	33.8
- Underhood Parts	22.7	19.4	- 3.9
- Frame, Suspension Parts	3.1	38.5	87.7
- Interior Parts	3.5	16.3	46.9
- Electrical	0.21	0.20	- 1.3
- Exterior Panels	164.9	262.3	12.3
Low Pressure GRP Thermosets	2.5	2.6	1.3
RRIM Glass Reinforced Thermosets	31.4	69.7	22.1
Filament Wound GRP Thermosets	1.7	7.5	44.6
Injection Molded GRP Thermosets	22.1	23.6	1.7
Compression Molded Thermosets	0.13	0.23	14.3
Deck Lids	5.0*	13.0	17.3
Doors	4.0*	20.0	30.8

Source: Predicast (Automotive News 4/24/85)
*1983 Predicast (Plastics World 1/85)

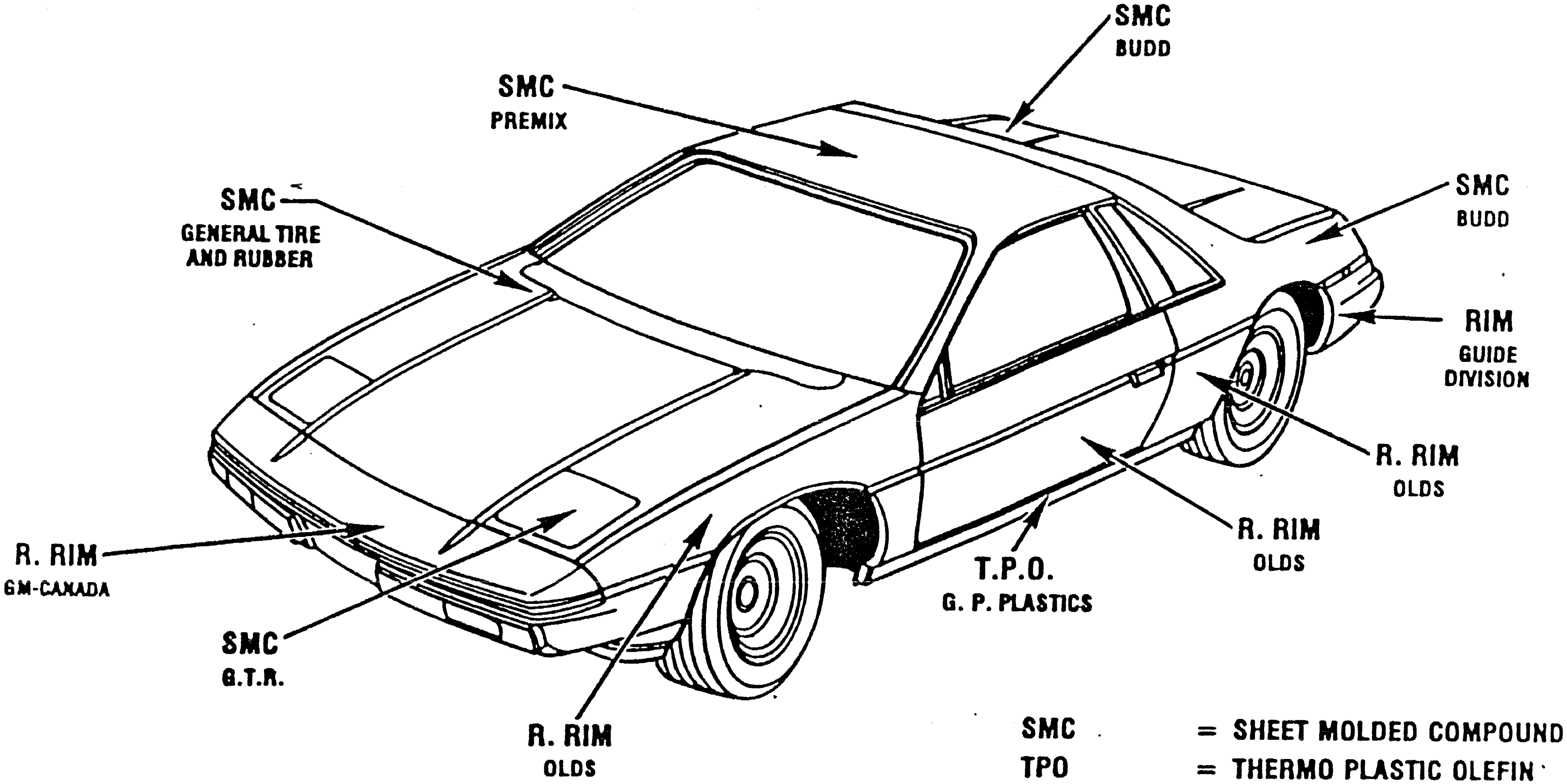
Exhibit 5D

Proportion of Components for U.S.-Built Cars Made from Plastic

	Year	
	1990	2000
Hood - Outer	5 to 10%	20 to 50%
Hood - Inner	5 to 10%	20 to 50%
Roof	5 to 5%	10 to 50%
Doors	5 to 8%	15 to 50%
Wheels	0 to 2%	10 to 20%
Gas Tank	0 to 5%	10 to 30%
Bumper - Fascia	50 to 50%	80 to 80%
Bumper - Support	5 to 5%	20 to 40%
Fender	5 to 8%	50 to 60%
Suspension Springs	2 to 2%	5 to 20%
Suspension Control Arms	0 to 1%	3 to 20%
Radiator Supports	1 to 5%	10 to 50%
Radiator Tanks	60 to 60%	100 to 100%
Floor Pan	2 to 5%	20 to 50%
Cylinder Cover	2 to 5%	20 to 30%
Drive-Shaft	0	10 to 10%
Headlamps	40 to 50%	70 to 80%

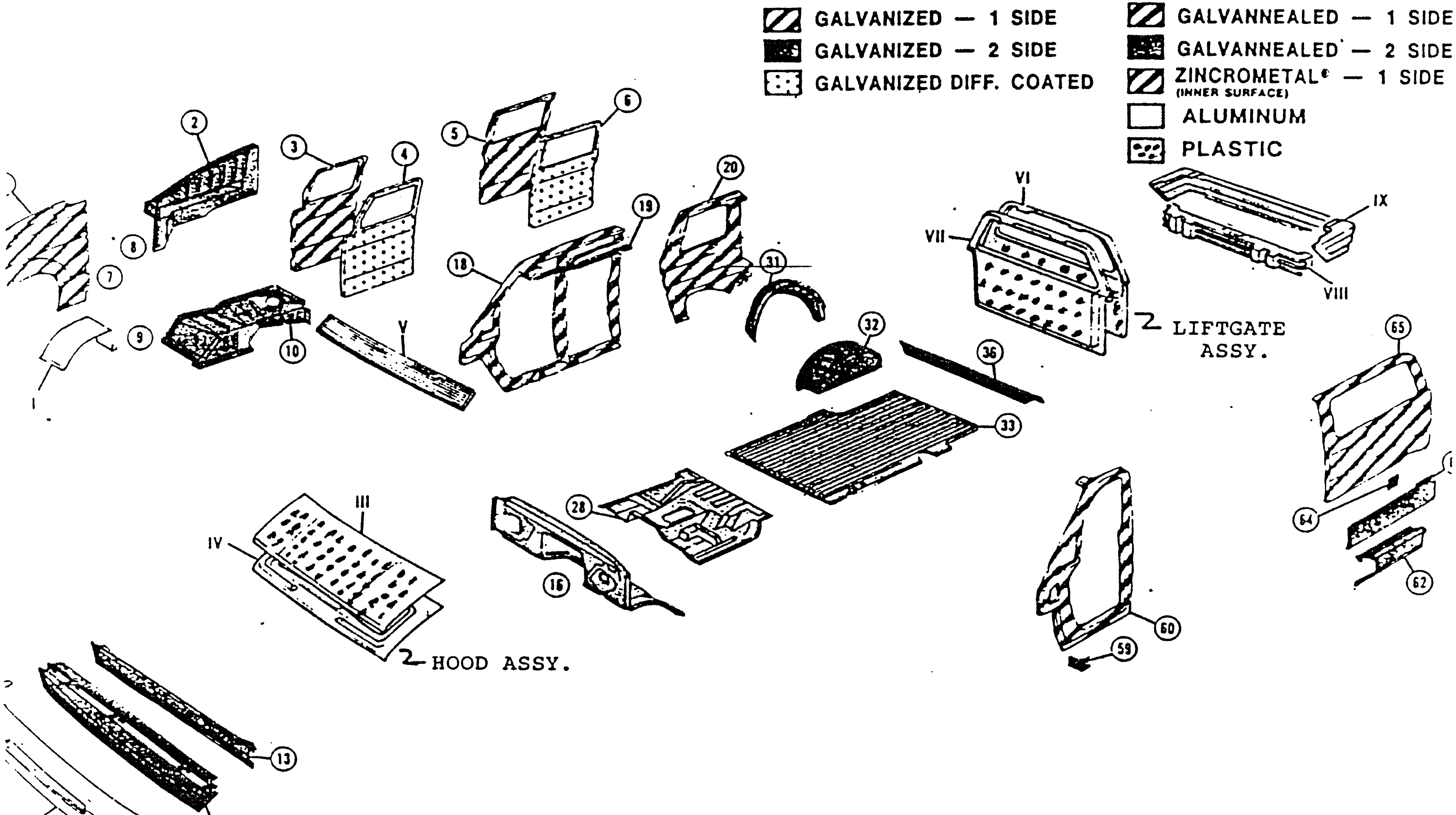
Exhibit 6A

1984 FIERO BODY PANELS



SMC = SHEET MOLDED COMPOUND
TPO = THERMO PLASTIC OLEFIN
RIM = REACTION INJECTION MOLDED URETHANE
R. RIM = REINFORCED RIM

85 AEROSTAR (BASE PROGRAM) BODY CORROSION PROTECTION
PRE-COATED AND NON-FERROUS



Exhi : 6B

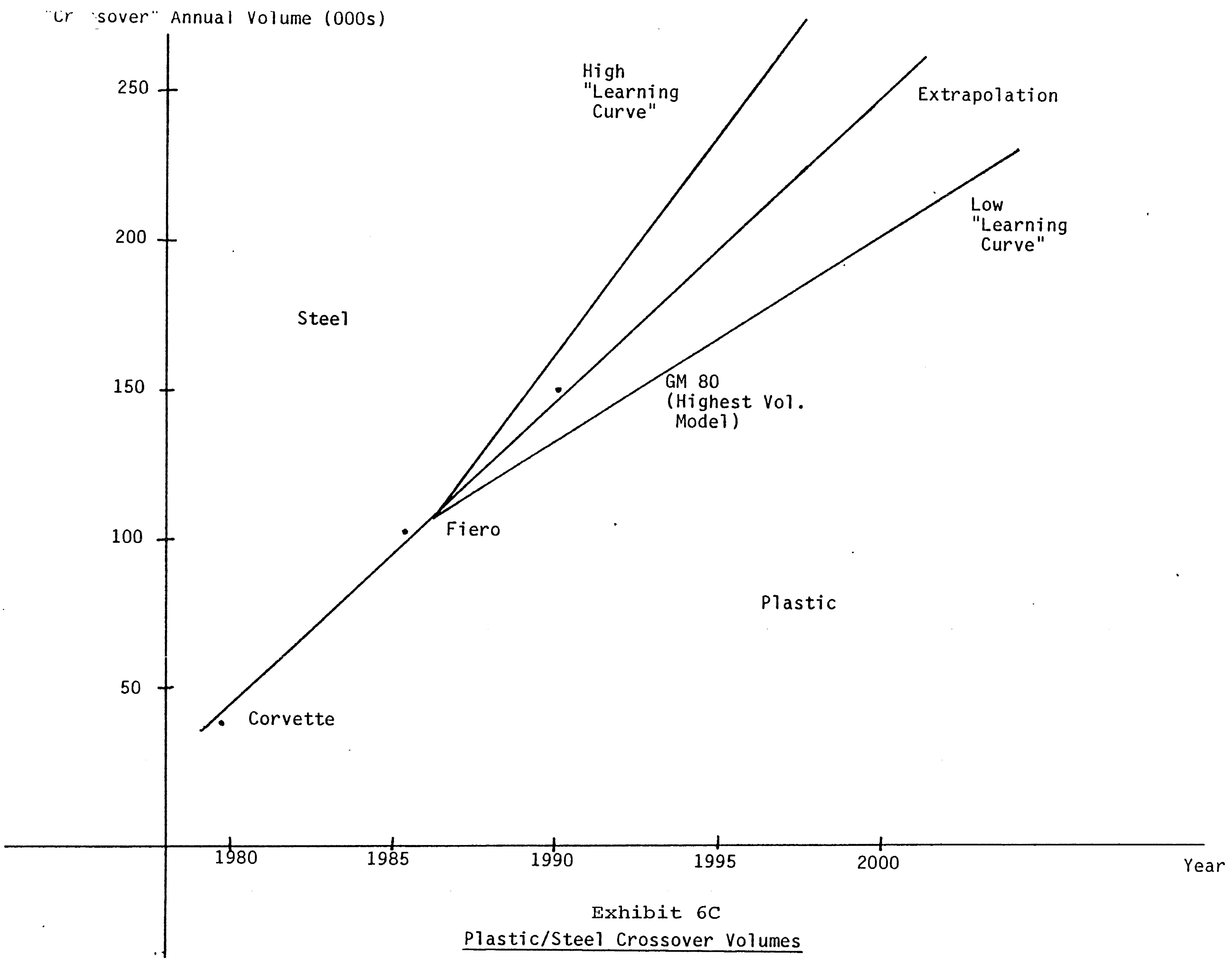


Exhibit 6C

Plastic/Steel Crossover Volumes

Exhibit 7A

Potential Magnesium Applications

Floor Gearshift Housing
Windshield Wiper Housing
Steering Column Housing
Headlamp Door Bracket
Wheels
Accelerator Pump Cover
Air Conditioning Mounting Brackets
Air Pump Bracket
Air Pump Housing
Distributor Base
Timing Chain Cover
Engine Valve Covers
Engine Oil Sumps
Fuel Pump Body
Ignition Module
Oil Pump Body
Power Steering Body
Starter Motor Housing
Oil Level Indicator Boss
Manual Clutch Housing
Accessory Drive Pulleys
Transmission Components
- Governor Body
- Carrier - Forward/Reverse
- Clutch Pistons
- Convertor Housing
- Transmission Housing
- Transmission Kickdown Servo Rod Guide
- Intermediate Band Servo Cover
- Intermediate Band Servo Piston
- Lower and Upper Valve Bodies
- Rear Band Servo Piston
- Output Shaft Retainer
- Stators
- Cases

THE AUTO IN MICHIGAN PROJECT

A State of Michigan Program with
Office for the Study of Automotive Transportation
The University of Michigan Transportation Research Institute
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PRODUCTION TECHNOLOGIES

Anyone who attempts to chart potential developments in the production technologies of the automotive industry and their specific impact on Michigan's future role in the industry faces a formidable array of interacting factors. Cars and light trucks are, arguably, the most complex high volume goods produced in modern economies. The technologies used to design, engineer, manufacture, assemble, and test light vehicles have constantly evolved during the auto age, but never more intensely than now. Future technological changes in the production systems of the industry may alter powerfully the location and size of new facilities, the materials used to build vehicles, the relations among firms in the tiers of the industry, the demand for labor skills, and perhaps even the flows of trade among the world's auto-producing countries.

AIM has been required to pursue selectively those aspects of change in the industry's production systems that we sensed were of most import to Michigan. We were guided in our focus by early roundtable discussions with some engineering leaders and staffs from the auto companies. Based on these discussions and several subsequent interviews with leaders from the auto firms, parts suppliers, capital equipment producers, engineering service firms, the UAW, and industry consultants, we can provide an initial summary report on eleven topics within our subject.

1. Flexible Manufacturing Systems
2. Just-in-time Methods and Flexible Automation
3. Ferrous and Aluminum Castings
4. Adhesive Bonding to Replace Weldments
5. Training in New Technologies
6. Machine Tool Technology and Future Productivity
7. Tooling
8. Toolmaking Opportunities in Plastic Composite Parts
9. Manufacture of Plastic Body Panels and Space Frames
10. Centralized vs. Decentralized Production
11. "Simple" vs. Complex Automation

These brief summary reports should be regarded as descriptions of pieces in a puzzle. The puzzle is constantly being redesigned. Without question, the strongest force disrupting and reshaping the puzzle of automotive production is the widening application of computer technology to the design, engineering, fabrication, and assembly of the product, and to the tiers of managerial activity that control the flow of materials and information within the great chains of automotive production. Because computer technology will form the future, some initial reflections on its importance are in order before we offer our provisional findings.

Programmable Automation, Computer-Integrated Manufacturing, and Auto in Michigan

It is now possible to envision the power of a truly computer-integrated manufacturing economy. Indeed, visions of a "CIM-economy" abound in our industrial press. The vista encompasses very large scale substitution of microprocessors for living labor. Efficient hierarchies of control swiftly aggregate and analyze millions of data elements from discrete engineering, fabrication, transport, and assembly operations, from factory departments, and from entire facilities, while simultaneously dispatching appropriate instructions downstream to several levels of automated decision-making and execution.

In the envisioned CIM-economy, communications within and among enterprises flow on an electronic pathway so broad that no matter is too complex to transmit instantaneously. Firms cooperate on joint development projects across great distances, the time-span from conception to production is much shorter, and nimble adjustments to meet the demands of volatile, highly differentiated markets are a commonplace.

Such a CIM-economy would be a mightly engine of wealth creation, could bring relief from many forms of toil that are unwanted and dangerous, and would provide powerful tools for constant innovation and invention. It is thus a compelling vision. Some argue that rapid progress toward a CIM-economy is the only basis on which the equities of most current stakeholders in the U.S. manufacturing economy can be preserved in a future that promises more intense international competition.

At present, this vision of a CIM-economy remains an elegant abstraction. Its realization through socially rational means is a challenge to private initiative and public policy.

Progress toward a CIM-economy will be disruptive, risk-laden, and expensive. It will be fueled by basic and applied research (a clear opportunity for government cooperation with industry, as in Michigan's Industrial Technology Institute) and by the bold real-world experiments now being conducted by all auto makers and several major suppliers. These efforts will yield larger islands of flexible automation and build a growing network of bridges between them. This incremental integration will depend on the continuing development of IGES, MAP, and subsequent industry standards for digital communication.

Initial projects in inter-firm cooperation, such as the AIAG, must expand their mandate to include more of the issues involved in CIM implementation. Consortia of firms contributing to all elements of a new production process must be formed, as prefigured, perhaps, in GM's objective of bringing together machine tool builders, materials suppliers, parts producers, and their own engineering staffs.

How fast will a CIM-economy emerge in the United States automotive industry? The most recent (1985) Arthur Anderson & Co. Delphi study tells us that the current industry consensus answer is by the mid-1990s, although without knowing the precise form of the Anderson question it is difficult to know if the stage of CIM implied is as substantial as what we term here the "CIM-economy."

The pace of progress toward a CIM-economy will be determined by political and economic factors as well as technological advances. The industry believes that vigorous development and deployment of computer technologies throughout the production system constitutes the best single source of cost reductions to meet the Japanese challenge in the North American market. If true, the push toward a CIM-economy in the U.S. auto industry becomes a drama involving the interests (and perhaps even the economic fate) of hundreds of firms, hundreds of thousands of workers, and entire auto-intensive regions such as Michigan.

Michigan's prospects for a stable share of future automotive value added and employment, and the world's perceptions of our maturity as an industrial culture, will be shaped in no small part by how well the key stakeholders in industrial modernization learn to bargain progress.

Imagine a four-sided Conference Table at which progress toward the benefits of a CIM-economy in Michigan's automotive industry is discussed (and, in a sense, "bargained") by the four parties with most at stake: auto makers, Michigan automotive suppliers, organized labor (principally the UAW), and state government.

What interests are brought to this imagined Table?

For the auto makers, the prime consideration is driving down the relative production costs of competitive products in order to meet the challenge of the still-substantial Japanese landed cost advantage in light vehicles. They are driven to seek cost reductions on all fronts, and believe that flexible automation offers the richest source. Auto makers will push toward CIM, constrained internally only by technical possibility and their capital resources. The unacceptable alternative is further erosion of market share to lower cost, higher quality competitors.

The OEM commitment to accelerated development and deployment of programmable automation in all forms establishes a new technological environment for their suppliers. Indeed, the pressures to accommodate the technologically transforming OEMs promise to restructure the U.S. automotive supplier sector. Suppliers are challenged to adopt new tools and methods that can integrate their capabilities with those of their major customers, and to help deliver some of the cost reductions expected of them by the OEMs. The capital and skills development costs dictated by supplier commitment to increased CIM are formidable. For many suppliers at our Table, continued participation in the automotive industry is at issue.

For labor, the choice is clear, and difficult. The UAW has always been supportive of technological progress, provided that the anticipated benefits of increased productivity are shared. Increasingly, the choice is between significant job losses through increased automation versus perhaps even greater employment declines through loss of market share to technically superior and thus highly competitive foreign producers. While this general choice is starkly apparent, how the union services its membership in each instance of modernization, and how work and the institutions governing work should be reconfigured, is no simple matter.

State government sits at the Table to represent the "general interest," a limited but potentially crucial role. Each of the other parties at the Table has a number of market relations with one another in the rough and tumble of the competitive private economy. OEMs compete (and cooperate) and contract with suppliers and with the union; suppliers compete intensely for OEM business, and with OEM captive suppliers, but they also cooperate (e.g., AIAG); the UAW bargains labor power and work organization with OEMs and suppliers, but knows security is tied to productivity, and to the skills required for tomorrow.

Each of the private sector participants will pursue their primary objective, but they share, in varying degrees at different times, an interest in Michigan's economic health. For the State, that objective is paramount. In the inevitable turbulence of future progress toward a CIM-economy, State government's interest is in maximizing Michigan's share of the value added embodied in the U.S.-produced automotive fleet. Uniquely, we have an interest in successful cooperation (and negotiation) among all participants at the Table. Michigan wins when we build the ability of each of the parties to serve one another's needs.

If Michigan is properly to facilitate technological modernization within the full range of automotive operations in the state, government must be more than a passive tender of the "business climate." It must understand what is occurring within the industry, it must become an advocate of change, and it must invest talent and treasure in the modernization process.

Given the charge of the AIM Project, our role is to suggest to state government the events it must anticipate if the state is to become a more resourceful facilitator in the high stakes movement toward a CIM-economy.

We identify five areas that will require priority attention. Michigan must try to anticipate:

- How auto OEM adoption of programmable automation and computer-integrated manufacturing practices will place new requirements on Michigan automotive suppliers;
- How progress toward larger-scale computer-integrated manufacturing will influence the location of future investment;
- How the widening deployment of programmable automation will change the structure of the auto industry in the state through a shakeout of smaller firms;
- How Michigan will fare as a site for the research and development, engineering and sales, and production operations of producers of programmable automation and computer integration technologies; and
- How the spread of flexible automation will impact the interests and needs of labor.

In the several sections that follow, we can only begin to address these areas.

Flexible Manufacturing Systems

Exactly how much flexible automation will be used in future U.S. auto manufacture is an issue that provoked considerable discussion, but little agreement during the interviews. There are two general aspects to defining flexible manufacturing systems (FMS): adaptability and convertibility. In general terms, adaptability is the ability of manufacturing systems, for example, machining lines, to serially sequence different designs of the same family of parts without adjusting the flexible manufacturing system.

Convertibility refers to the ability to switch a manufacturing system from one product or model to another version, e.g., to convert an engine block machining line from producing 6-cylinder blocks to 8-cylinder blocks. Many executives were more optimistic about the economic justification prospects of using FMS for convertability advantages than they were about the prospects of gaining adaptability advantages.

Largely because of the accelerating use of robotics in body assembly operations, recent progress toward flexible operations was judged to be somewhat ahead of other developments. However, both machining and stamping operations are lagging. One executive commented, "We still cannot adjust production in our stamping plants to meet shifting schedules because of our inability to change dies quickly." As will be noted later, nearly everyone agreed that considerably more use of modules will occur in vehicle final assembly, which along with other methods will radically increase flexibility. A concern is that more flexibility might be achieved at the cost of assembling 15 – 20% fewer vehicles per hour.

Most executives agreed that substantially more flexibility was essential in machining of drive-line components, such as engine heads, blocks, manifolds, transmissions, etc. One manufacturing executive commented, "Our traditional engine machining equipment is designed to machine approximately 1,600 to 2,000 engines per day. We feel that in the future we will need the flexibility to be able to efficiently produce engine blocks or other drive-train components on the same equipment at rates as low as 50 per day and as high as 2,000." The need for less dedicated and more flexible automation is supported by another drive-train trend. Typical minimum production volumes for a "high-production" transmission facility will drop from the present 2,000 automatic transmissions a day to 1,000 by 1992; and from 1,600 manual transmissions today down to 500 in 1992. These lower volumes are driven by needs to reduce inventories, to reorganize the assembly of major components among smaller decentralized plants contiguous to vehicle final assembly plants, etc. Here too, the challenge is to achieve greater flexibility without losing the high productivity enjoyed with conventional transfer machining systems. A partial list of techniques follows which the executives believe will be used to increase machining flexibility:

- Performing variable operations off-line, for example pre- or post-machining operations of a specialized nature.

- Equipping machining heads with sensors signalling operation or non-operation of each head as the workpiece is transported past that station, depending upon a preprogrammed code.

- Using indexing heads in place of fixed-position spindles.

- Integrating flexible numerically controlled (NC) machines into the serial transfer line to take advantage of the NC machine's flexibility.

- Supplementing the fixed serial transfer line with spur lines; common operations would be performed on a transfer line of conventional design, and the variable operations would be routed over spur lines.

- Flexible timing schemes for varying the pace of workpiece transfers to more readily accommodate the variability of work-station spacing.

- Manufacturing cells for relatively lower volume requirements.

- Adaptive control of metal cutting operations.

There was a general concern about the wisdom of abandoning conventional automation for high-volume machining systems, or about modifying them to gain flexibility at the cost of lower hourly output. Still, everyone envied the ability to convert manufacturing systems quickly to accommodate shifts between different types of related production, e.g., shifting from a 8-cylinder engine block to a 6-cylinder block with as little delay as possible.

Some of the techniques being considered to speed changeover times follow:

- Automatically changing index heads via computer command.

- Reprogramming machines' electronic controllers

- Designing universal clamping techniques, and designing parts according to the part family concept, which will more readily accommodate universal clamping.

- Advanced controls incorporating simpler reprogrammable servo mechanisms.

- Fast-change limit switches, or devices serving the same function, but which are easier to reprogram.

- Using solid-state controls in place of electromechanical devices, and integrating solid-state controllers with computer networks.

In the Saturn, Liberty, and Alpha projects of the Big Three, considerable attention has been devoted to increasing the flexibility of final vehicle assembly operations. While the actual implementation is expected to differ between companies, the techniques are all expected to be based on the increased integration within such modules as:

Engine
Transmission/Transaxle
Instrument Panel
Seats
Doors
Wheels
Front-End, with bumper, grille, lamps, radiator, etc.
Rear-End, with bumper, lamps, etc.

Most of these modules will be fully assembled at sites in or adjacent to the vehicle assembly plant. Thus, companies formerly producing any of these modules or components going into these modules, likely will be forced to relocate their production facilities near assembly plant sites.

By using modules in tandem with robotics, automated guided vehicles (AGV), and related flexible automation, the executives interviewed believe they will substantially increase the ability to assemble a wider array of related body styles over the same vehicle final assembly line. They also expect to be able to convert a flexible assembly plant to a new model in much shorter time.

With the old continuously moving assembly line having a semi-fixed number of work stations and workers, it has been troublesome to add even minor vehicle trim variations to selected vehicles for new developing market niches without disrupting work assignments or the balanced timing of assembly line processes. When the change was substantial, another worker was added to the assembly line. Sometimes, the new worker had little to do when standard vehicles came past the added station. Now with the flexible approach, differences in the time required to build up "standard" and "non-standard" modules will be more flexibly accommodated in the off-line "stationary" work stations.

A priority goal of these new, more flexible assembly concepts is to reduce mobile assignments on the final line. Some, but not all, of the plans for the future call for the use of automated guided vehicles (AGV), which will carry modules/subsystems, and, eventually, the car itself as it is being progressively built up. As the AGV stops at each work station along the final assembly line, each team of workers will be able to perform its tasks, including installation of the modules, while the car and AGV are stationary. Enthusiasts promoting such systems believe that eliminating mobile work assignments and handling the fabrication time differences between modules off-line improve both the quality of the module and the vehicle on the final assembly line.

The approaches to increase flexibility differ from company to company. Depending upon specific application requirements, e.g., a vehicle final assembly plant, a body in white fabrication operation, an engine or a transmission plant, etc., the requirements for economically useful technologies to achieve flexibility also vary substantially. And, because each of the Big Three operates many of its plants at different volume levels, and has variations in the outsourcing of component parts, different implementation approaches to automation (both dedicated and flexible) are dictated.

Still, some generalizations are possible. One of the vehicle manufacturers cited the following four criteria for deciding upon the level of flexible manufacturing technology it selected for a plant producing drive-line components.

- Market Flexibility: the ability to introduce new products quickly or to change product mix at the factory level at a minimal cost.
- Capital Flexibility: the ability to utilize flexible equipment purchased for one product for other products, should the initial product requirement disappear.
- Production Flexibility: the ability to produce a family of products across the same equipment.
- Operation Flexibility: the ability to continue operating the flexible system, often on a reduced capacity basis, should one of the stations in the flexible machining system breakdown.

Another criterion for increased flexibility in a final vehicle assembly plant was suggested:

- The assembly plant should be able to receive an incoming order from a dealer and have that vehicle built to the special order within one week, compared to the several-week lead time presently necessary.

All companies are at various stages of planning for implementation of flexible automation. Most companies consider flexible installations made thus far to be real-world production facilities, and also laboratories in which they are learning more about flexible automation.

A major challenge to broader implementation of flexibility is learning how to economically justify this new manufacturing technology in the U.S. vehicle market, which historically has been characterized by very large volumes of relatively stable production. Prior to the energy crises, the U.S. market conditions strongly encouraged the use of the most productive, but dedicated, vehicle production technology in the world. Flexible automation systems that have been installed thus far initially cost more than dedicated equipment, and yet they typically produce fewer workpieces per hour or day than the latter. They are therefore much more difficult to justify economically by traditional economic evaluation methods used for dedicated equipment.

Better measures of the indirect costs/savings factors will help answer the following generic questions as part of the audit of an economic payoff of flexible manufacturing systems:

- What are the quantitative direct expense benefits of flexibility?
- What are the quantitative indirect expense benefits of flexibility?

- How much of original investment in a flexible manufacturing system is reusable when a new product is introduced? In the past, because product change often meant that dedicated automation was obsoleted, little of the original investment was reusable.

- How can these direct and indirect expense measures be utilized in today's economic justification methods for capital equipment?

Suppliers of automation and vehicle parts are also seeking answers to these questions. In the case of automation suppliers, positive answers will open flexible automation markets worth billions of dollars, but at the expense of possible sales of dedicated automation systems. Companies finding the right answers first obviously stand to gain a strategic edge, while others will suffer lost sales and employment.

Michigan automation suppliers appear to be at quite different stages of readiness to meet the market for increased flexibility. The state's traditional strength, the builders of sophisticated dedicated automation systems, are now challenged to adapt their competence to incorporate much more microprocessor-based flexibility. At the same time, they are being pressed by aggressive Japanese and European producers.

How well Michigan's machine tool firms will adjust to position their abilities in the new environment is not clear. One positive sign is the obvious desire of General Motors to transform its past relations with these firms in the interest of developing and maintaining a base of U.S. machine tool builders that can deliver more flexible systems. The state has already made an important potential contribution on this front in sponsoring the Industrial Technology Institute. One mission of ITI is to be a source of contract research and development that can supply some of the focused expertise now required by Michigan's traditional automation vendors.

Michigan's prospects in other segments of the growing flexible automation marketplace are brighter. Southeastern Michigan is already a center of machine vision technology, with firms that have shown the way in automotive applications. Based largely (but by no means exclusively) on industry-leading GMF, Michigan remains the lead state in robotics development. The huge automotive market continues to attract the research/engineering/sales arms of automation firms with headquarters and production operations elsewhere. The vision of a southeastern Michigan "Automation Alley" to rival the economic weight of Silicon Valley or Route 128 is plausible. Nurturing its evolution should be a high priority for state government.

The Just-in-Time System and Flexible Automation

As the vehicle manufacturers increase the use of just-in-time (JIT) delivery methods, parts suppliers know they will see even more pressure on their manufacturing systems to be adaptive and responsive on shorter and shorter lead times. Their manufacturing engineers are closely following the experiences gained by the vehicle manufacturers so they can determine where flexibility works best before they make their investments.

For parts suppliers to win long-term contracts from U.S. car companies, they undoubtedly will have to agree to a base price, followed by annual cost reductions. To make a profit under such requirements, parts suppliers need to invest in more productive automation. However, with the new JIT requirements, conventional automation will no longer be the only approach.

Although the net value of the JIT system as applied in the American automotive manufacturing environment received mixed reviews, its growing use is inevitable. For the parts suppliers to meet the increased variability of delivery schedules, everyone agreed that the greater use of flexible automation will be necessary. Important questions for managers in parts supplier companies are: how much? and what type?

While most parts suppliers indicate a willingness to step up their investment in automation, including the flexible type where justified, they also believe that vehicle manufacturers could do a better job of controlling schedules which might somewhat lessen the need for flexibility. Vehicle manufacturers commonly change schedules for several reasons, e.g., abrupt shifts in consumer preferences, engineering change orders, component part shortages, etc. Various approaches are being tried to reduce schedule modifications. For example, one manufacturer is trying to establish a product mix with fewer sets of options; others are buying rather than making lower volume components and vehicles to reduce the range of part types their manufacturing systems must produce.

A more predictable schedule for vehicle assembly is fundamental to gaining the benefits of the just-in-time manufacturing concept. One manufacturing executive commented, "For JIT to work the way we would like in reducing inventories we must establish a production schedule and adhere to it." A recent scheduling system introduced in one truck plant, which now operates on a 20-day "firm-build" schedule (allowing for minor daily adjustments), could represent a model for the future. The 20-day schedule is updated daily so that all of the part and material suppliers have a better chance to optimize their plans.

Other executives talked about 10-day schedules for car assembly operations, with daily updates as required. However, most of the persons interviewed admitted that the "firmness" of present 10- and 20-day schedules was a relative concept.

All vehicle manufacturers are studying the extent to which the frequent adjustments that assembly plant schedulers seem to implement daily are actually necessary. Daily modifications to the 10- and 20-day vehicle build schedules not only undermine production plans in the vehicle assembly plant, but also those of all the component part and material suppliers. In the long run the frequency of the changes will have a major influence on the degree of required flexibility.

One parts supplier, observing the instability of schedules relative to the level of necessary flexible automation, suggested that the vehicle manufacturers might more carefully audit engineering change orders from product engineering groups in order to evaluate the actual tradeoffs between product performance, manufacturing quality, productivity, and delivery times.

Despite the understandable interest in schedule stability, greater variability in the future marketplace seems to be an irreversible trend. Buick City and Oldsmobile were cited as facilities that were initiating daily and even hourly delivery schedules. Suppliers to one vehicle manufacturer were cited as being contractually obligated to have a computer CRT terminal in their plants over which the customer could issue daily, hourly, or even narrower updates of production schedules. The suppliers are contractually obligated to have a module delivered just-in-time no later than seven hours after any change in delivery schedules.

Despite the currency of the concept, the OEMs and major suppliers are only now quickening the pace of JIT implementation. As they do, there are many hundreds of smaller auto-related firms in the Michigan economy that could benefit from some direct education and consultation. In Michigan, the number of such firms is so great that the responsibility cannot be fully addressed by the OEMs or even by the excellent educational efforts of the AIAG.

The State should explore ways in which it can sponsor provision of initial orientation and some consultation on JIT methods to the hundreds of firms now confronted with the need to acquire new equipment and skills. The successful use of the community college network to provide training in SPC methods might serve as a model.

While JIT requirements increase the need for flexibility by independent parts suppliers, it is even more of a shock for some captive plants owned by the vehicle manufacturers. Some executives questioned whether captive plants would be able to adjust to JIT which is predicated on the quick reaction capabilities normally afforded only by "job shop" automation—which contrasts sharply with the continuous processing technology commonly used.

Lack of universal agreement on the value of JIT systems suggest that they will not be implemented universally over-night. JIT was alleged to have caused General Motors to cut back too far on its engine production capacity, contributing to a recent loss of two or three percentage points of market share, presumably because they had been unable to manufacture the exact engine mix desired by consumers.

However, the new GM/Toyota joint venture in Fremont, California, apparently operates effectively with the JIT system. Because production has been underway for only six months, it may be too early to make meaningful comparisons. Nevertheless, some JIT skeptics commented that the Fremont plant may find it easier to follow JIT because it produces a relatively non-complex product with few option variables, allowing for more stable production schedules. Clearly, the optimal equipment investment decision for JIT will be influenced by the cross currents of equipment adaptability and stable schedules—conditions which are still in flux.

Ferrous/Aluminum Castings

Up until the energy crisis in the mid-1970's, the vast majority of all the castings in U.S. cars and trucks were made of iron, often mined in northern Michigan. By 1985, with vehicles being downsized, and lighter materials being substituted for iron, the amount of iron castings has declined by half to about 250 pounds. Not only has Michigan's employment in iron mining and ore shipping declined, but several foundries have also closed. Over the past few years, the decline in iron castings usage has stabilized. However, AIM interviews indicate that considerably more aluminum substitution for iron castings could be on the horizon, threatening more Michigan jobs in iron mining, shipping and ferrous foundries.

Currently, about three-fourths of the engine heads are cast in iron. By 1990, another fourth will be converted to aluminum. As noted in the materials chapter, some of the vehicle manufacturers are also interested in converting engine blocks from ferrous to aluminum materials. Engine manifolds have been heavily cast of iron, but intake manifolds are now being switched to aluminum or steel.

Most of the aluminum heads substituted thus far for iron heads previously produced in Michigan and elsewhere in the U.S. have been imported, largely from Italy. Foundries there have developed a leadership role in the difficult task of casting aluminum heads. U.S. companies in certain instances have designed aluminum heads, and put them into production in their own aluminum foundries using their own casting technology, with disappointing results. However, some captive and a few independent casting companies in the U.S. are beginning to master the technology, and one of these has an operation in Michigan. However, if Michigan is to avoid a net job loss, foundries, competitive aluminum casting technology must be acquired by more state foundries and casters.

A very large proportion of the aluminum engine components produced thus far has been cast using permanent mold technology. While this technology has important benefits, they are probably not significant enough in themselves to encourage a sharp acceleration in the switch to aluminum. However, General Motors and Ford in particular have been working intensively on a new casting process called the lost-foam method, which so far is not attractive for iron.

A major foundry advantage of the lost foam process is that it avoids several problems inherent in sand molds and cores because a coated polystyrene perishable pattern/core is used. Polystyrene patterns "mass produced" by injection molding permit engine and manufacturing engineers to design more complex castings—for example, allowing such details as oil drain and through bolt-holes to be cast rather than machined later. Other machining economies also result because the lost-foam casting creates a smoother and more consistently repeatable surface. All told, this technology, with advances in machining, can reduce the aluminum head and block machining time by about a third.

If manufacturing tests currently underway prove out, the lost-foam process could be the key that persuades GM to produce blocks and heads of aluminum. And it is likely at least that intake manifolds would be aluminum as well. Ford is readying an aluminum manifold for lost-foam production at its Windsor, Ontario foundry. If GM's experiences are positive, it is speculated that Saturn and another new engine design, the Manhattan, could also be made of aluminum. Similarly, success at Ford on the manifolds is expected to encourage more applications.

The Saturn engine will be produced adjacent to its new vehicle assembly plant. Because there has been no announcement yet from GM as to which four cylinder engine will be taken out of production when Saturn begins manufacturing, it is not yet known where the associated job loss will occur. More of this information should become available during the next several months.

Adhesive Bonding to Replace Weldments

Several manufacturing engineers commented that among the keys to greater flexibility, particularly in assembly activities, are advancements permitting the use of adhesive bonding to reduce welding operations. Despite the productivity and quality gains experienced recently from the development of robotic and other flexibly automated welding processes, manufacturing engineers continue their search for ways to reduce the number of welds in a car. One vehicle manufacturer described an experimental vehicle which was fabricated with adhesives to replace 900 welds. Besides saving as much as 40 dollars per car, test data suggest that the integrity of the vehicle may actually be improved.

Welding has been a source of quality and productivity problems for several years; these have become even greater with the increasing use of galvanized steel. Zinc multiplies the usual problems with the welding tips, requiring frequent equipment changes and higher consumption. Welding operations that have used lead also raise occupational health questions; the entire welding operation often involves an unpleasant work environment, causing worker turnover. It is also an occupation that requires considerable skill for high quality standards. Thus, a high turnover rate brings expensive training costs and quality problems.

The increasing use of plastic composites will also encourage more adhesive bonding. Plastic's inherent ability to integrate what would have been several discrete components if made of steel, into a one piece molding will in itself reduce the need for both bonding and welding operations. AIM II should explore the extent to which Michigan equipment manufacturers are involved with welding equipment and supplies, and evaluate the impact of the possible elimination/reduction of welding operations.

Training Problems

Flexible automation, especially the various forms of computer-assisted manufacturing, were viewed by many of the executives interviewed as being important potential sources of productivity and quality improvements. Yet it was their opinion that where these technologies have not been utilized effectively, the lack of worker training was a principal cause. The need for retraining at various levels, including technicians, engineers, and managers, throughout the industry, was cited again and again.

Several executives mentioned the lack of properly trained personnel as the reason that certain plants (both captive and independent parts suppliers) were having trouble achieving the flexibility necessary for JIT. A typical problem was characterized as follows:

too often the highest level of management fails to understand what computer-assisted and other flexible manufacturing technologies can do. And the younger managers, while they understand the technologies, lack the authority or the experience to promote and integrate these systems within the existing formal/informal networks in the plant.

And even when a plant management has aggressively installed computer-integrated manufacturing equipment, too often it has painfully learned that inadequate preparations had been made for training operations people. During interviews about flexible automation, CAD, CAM and computer integrated manufacturing, several executives mentioned repeatedly that people are the key and that for the foreseeable future they will continue to be the key to successful implementation.

The training problem is viewed as being so serious that many executives interviewed cautioned that flexible automation and related technologies such as CAM would never achieve anything near their full potential in U.S. plants because with prevailing training programs, the work force may not be able to cope with these technologies.

Some vehicle manufacturers reportedly have sent CAM-involved workers to specialized training schools where they achieve a level of proficiency adequate to program, operate, or maintain a flexible system. Frequently, these newly trained workers were soon transferred to jobs with other responsibilities. Untrained personnel were commonly assigned to replace the transferred persons. Not surprisingly, the performance of the automated equipment deteriorated. A work force with superior training was one of the reasons cited to explain why the Japanese have purchased automation from American companies and achieved an operating level of 80–85 percent, compared to an approximate operating level of 50 percent achieved by U.S. vehicle manufacturers having the very same machinery.

Two parallel, but related, trends are also bringing to the surface other dimensions of the training problem. The vehicle manufacturers want to involve both product design and manufacturing engineering personnel early in the design phase. At the same time they are increasing the outsourcing of component parts, which often includes more responsibility for the detail design of both the part and the manufacturing process. The vehicle manufacturers are requesting that the parts suppliers design with CAD equipment. This requires product people who understand how to design with CAD for CAM, <u>and</u> CAM people who understand the use of CAD. There is a serious shortage of these specialists in Michigan.

Because the shortage is serious, some OEM's are considering sourcing complete vehicle modules to Europe because these suppliers have the necessary engineering staff with CAD/CAM skills. One OEM indicated that without a proficiency in computer-aided design and computer-aided manufacturing skills, future parts suppliers will not be considered.

The problem was described by another executive somewhat differently at another interview. He said, "Our problem is to figure out how to get manufacturability consideration into the product design which is done on on CAD, when the manufacturing people do not understand how to use CAD." This problem is present not only in the independent part supplier companies, but also in the parts supplier divisions of the OEM plants as well. The vehicle manufacturers are finding it difficult enough to build a new culture which more closely links product designers in the vehicle manufacturing companies with the manufacturing engineers in their own operations and in the parts supplier companies using conventional design processes, but difficulties are compounded when they also try to do the engineering using new CAD processes.

It is a common practice in the U.S. auto industry to subcontract detailed vehicle and component-parts design to a specialized group of design companies. These "job shops" work out the design details and make thousands of individual drawings, once a preliminary design, at least, has been formulated by the vehicle designers in the OEMs. The vehicle manufacturers would like the design shops to do all of this detailed product and process engineering by CAD. However, the OEMs are also finding a shortage in design shops of designers who are skilled in CAD. Moreover, there are not enough product design shops around Michigan which have their own CAD equipment.

We asked several interviewees about the prospect of increased sourcing of engineering and design services from elsewhere in the U.S. and abroad as the development of CAD-CAE and telecommunications lays the technical foundation for this option. Most acknowledged the possibility, and several could offer examples, but the prevailing sentiment was that the value of continuous, intimate, even "subjective" interactions between engineering and (especially) design teams would continue to support a preference for contractors close at hand. In their judgment, there will continue to be a circle of engineering and design excellence in southeastern Michigan, even as global communications link the industry internationally. This continued strength depends, of course, on the ability of the state and the industry to attract and develop superior talent in CAD-CAE.

One OEM is near the point of going off-shore for these types of services. A group of executives commented that too few schools in the United States still teach drafting. They argued that there was a shortage of perhaps as many as 1000 designers in the Detroit area. They also commented that it was puzzling that Electronic Data Systems (a new GM subsidiary), which provides data processing services, could recruit thousands of programmers, but the product design and manufacturing engineering groups within the auto industry cannot find qualified designers.

One of the executives interviewed summarized the attitudes voiced at several interviews where the training problem was discussed: "The rapid introduction of computer aids to engineering and manufacturing results in a dearth of trained personnel." Perhaps the state can put its weight behind a training program that would yield engineers, model makers, etc., schooled in the use of computer techniques.

Machine Tool Technology and Future Productivity

Executives at the vehicle manufacturers cited the critical role that advanced machine tool technology must play in essential productivity and quality improvements. Nearly everyone interviewed expressed serious concern about the health of the Michigan and U.S. machine tool industry. Not only will the technological competitiveness of these automation suppliers directly impact the auto industry, but they are also important employers of thousands of highly paid Michigan workers.

One high-level official from a vehicle manufacturing company commented that during the period from about 1979 to 1984 he seriously doubted that the U.S. machine tool industry would be able to develop and supply technologically competitive equipment. Now, he has modified his opinion somewhat, and believes that U.S. machine tool companies are improving their technological capabilities relative to their international competitors. However, he and others are still concerned.

Most of the concern focuses on the machine tool industry's ability to deliver equipment with integrated computer technology. In response to the question, "What do the machine tool manufacturers have to do to become more technologically competitive," one official summarized the concerns as follows:

- Develop more reach in their product
- Increase their research and development investments.
- Improve the educational capability of their staffs.
- Assimilate available technology from all over the world and extend it.
- Increase their competitive ability to compete with leading industries and technologies around the world.
- Do more with computer networks besides stopping at the programmable controllers, leaving the balance of the engineering for the computer control/management information network to the vehicle manufacturer or another contractor.

A major thrust of the auto industry's drive to increase flexible manufacturing systems will be powered by linking management information computers and machine controls through a hierarchical data communication network. At present, one of the Big Three has approximately 45,000 programmable machine control devices in its plants, but expects a four- to fivefold increase over the next few years. Today, only about 10 to 20 percent of these devices can communicate with computers or networks outside the island of automation that the machine controllers manage.

In the future, one-fourth to one-third of the costs for automotive industry's automation is expected to be targeted for data communications, i.e., transmitting control data and management information around and between factories. The concern of the automotive industry is that there does not exist a systems engineering capability in the conventional suppliers of factory automation, especially machine tool companies. This concern is strengthened by the information that the two largest machine tool companies employ only 21 and 14 programmers, respectively. Executives interviewed commented that the missing link in the machine tool companies' systems capability is software skills.

The increasing requirement for automation companies to become systems suppliers is summarized by the following statement, taken from a 1984 speech given by Donald J. Atwood, Executive Vice President of the General Motors Corporation: "We will increase our emphasis on creating total systems of machine tools and related material handling devices. Thus, simply buying pieces of this and partials of that will be far less common." It is clear that some Michigan automation companies face both a challenge and an opportunity if they are to develop a systems capability.

It also looks as though the machine tool industry may be moving toward a structural realignment in which some companies will act as systems packagers, while others will supply speciality products to the systems-oriented companies. Without a proficiency in software, equipment suppliers will by default be relegated to specialty products, and be increasingly vulnerable to foreign competition.

Most of Michigan's machine tool builders began as small tool, fixture, or die builders. They expanded to include more of the "system"—an entire machine. As they grew, they tended to specialize in a single-purpose machine like a lathe, a mill, or a boring machine.

The first transfer machines, which Michigan machine tool companies can proudly point to as one of "their" key developments, were collections of several of these single-purpose machines connected together with mechanical handling devices.

A handful of the Michigan special-purpose transfer-line machine tool builders dedicated themselves to the needs of the automobile industry. Most of these companies were closely held, i.e., family-owned. Manufacturing officials thought that over the past several years there was not enough "risk-taking" or research and development performed by these previous technological leaders.

However, vehicle manufacturing company officials were quick to assign a good share of the blame for the machine tool industry's condition to both the machine tool companies and the purchasing policies of their own companies. Especially during the past 25 years, the automobile OEMs did much of their own process engineering, in-house. They wrote complete sets of process specifications. They turned these over to the machine tool industry through a purchasing group which, in turn, solicited low bids and the shortest delivery times. Conversation between the OEM's manufacturing engineering department and the machine tool builder normally was overtly discouraged by the purchasing community; it seemed to interfere with the analysis process.

While this process may have had the nearsighted result of forcing the lowest initial price for the equipment, it restricted opportunities for fruitful technological interchange between the OEM technical staff and the machine builder. Equipment price and delivery quotations frequently were requested on a "piecemeal" basis. When there was a need for more than one machine, transfer machines might have been ordered from more than one builder. The vehicle manufacturer ordered ancillary equipment, such as washers, induction hardeners, etc., separately.

Reportedly, up until recently, there was a low priority placed on innovation. A low priority was also placed on flexibility. The machine tool supplier was not involved with process until it was nearly time for the vehicle or component part production to start.

The machine tool industry became a customer-satisfying industry whose philosophy was, "Tell us what you want and we will build it." Their primary task was to satisfy the purchasing department's low-bid and fast-delivery requirements, with little emphasis on supplying to the industry "leading-edge" technology.

It was surprising to find in the AIM survey phase that so many manufacturing officials employed by the vehicle manufacturers recounted reasonably similar historical scenarios—a series of developments which helped create a machine tool industry in Michigan that became a world leader in certain technologies, and then helped accelerate its deterioration. The scenario places a significant portion of the blame for the delayed use of advanced manufacturing technology on the vehicle manufacturer's purchasing policies. One executive, now approaching retirement, commented: "Looking back, it was foolish that we were forced to save $50,000 to $75,000 by selecting the low bidder on a multi-million dollar system and ended up with technologically inferior equipment that ultimately resulted in lower productivity/quality on billions of dollars worth of engine blocks produced by that equipment."

Similar interviews can be summarized by the comment of one manufacturing official when he stated, "In a very real sense we (the automobile OEMs) made the U.S. manufacturing equipment building industry what it is." These policies, when combined with the allegedly historical conservativism (fostered by boom or bust business cycles) of the Michigan machine tool companies have created a questionable outlook for the vehicle manufacturers' ability to acquire technologically advanced automation from the Michigan companies. This dilemma likewise places in jeopardy the jobs of thousands of workers employed in the Michigan tool building industry.

A machine tool company executive emphasized other barriers at the vehicle manufacturers that dissuaded the acquisition of new production technology with the following rhetorical question. "How many manufacturing engineers at the car companies have been fired for proposing or selecting proven but outdated technology, compared to the number who were released because they selected new technology which required more time than planned to make it operational?"

When the criticism regarding a lack of technological advancement was discussed with a representative of a machine tool company, he conceded that the conservatism of the machine tool industry was a factor. He also elaborated on the short delivery requirements as another serious problem. As noted earlier, the machine tool company proposing the shortest delivery time commonly received the contract, assuming price compatibility. Short delivery requirements often meant that machine tool suppliers were discouraged from proposing new technology which was not completely proven out. Thus, the automotive industry commonly bought proven, but old technology.

In this type of competitive environment, Michigan machine tool companies seldom enjoyed the opportunity to test out their research in a real-world production environment. This barrier can be contrasted with some European and Japanese competitors, where the machine tool company is a subsidiary of, for example, for example, Fiat, Renault, or Toyota. These companies find it easier to take new technologies directly to a noncritical application on the production floor of the parent vehicle manufacturers for tryout—free of the pressures of needing to deliver workable systems to contractual specifications within a specific delivery period.

A partial solution of this type of problem was suggested to be inherent in the new approach General Motors announced in late 1984 that it intends to use in buying equipment. However, American machine tool companies contacted in the interviews said that while they had heard about GM's policy change, they had not as yet been asked to become involved in a contract that would incorporate these new policies. Further, it was noted that the "business-as-usual" purchasing policies of the other two vehicle manufacturers appeared intact. Manufacturing executives in vehicle manufacture and machinery companies believe that the continuation of these purchasing policies will greatly lessen the car companies' prospects for acquiring advanced manufacturing equipment, and eventually lead them to become dependent upon foreign machine tool technology.

As noted earlier, the Big Three are asking parts suppliers and automation builders to join their design teams early in the vehicle development programs to "simultaneously" engineer the product and "optimal" manufacturing process. Although the automation suppliers interviewed view such invitations as encouraging signs for changing procurement policies, they are reluctant to share their expertise and proprietary technology unless they are assured that they will receive subsequent orders for the equipment. Their mistrust grows out of past automotive purchasing tactics for both parts and equipment wherein a supplier funded the basic development on its own, and submitted the design to the vehicle manufacturers for evaluation. Often when the technology was accepted, the new business opportunity was then opened to competition and awarded to the lowest bidder. Additionally, automation supplier companies often incurred significant, unreimbursed engineering costs to prepare preliminary designs for new automation proposals. The vehicle manufacturers were accused of picking concepts from higher priced proposals and asking the low bidder to incorporate them in its design.

Despite these misgivings, automation companies believe that "simultaneous" engineering with appropriate safeguards will be an important step forward in developing technologically advanced equipment for automotive manufacture. Some people speculate that the Saturn program will procure at least some of its equipment on the basis of a firm commitment to companies participating in "simultaneous" engineering. Stamping press manufacturers report that GM plans to design and purchase the major stamping presses for Saturn by these methods. Saturn engineers and personnel from one or two stamping press builders will jointly and simultaneously work out the design of the stamped parts, the presses, and associated material-handling equipment. Once the equipment specifications have been jointly determined, the participating equipment supplier(s) will be paid for their design services; Saturn and the equipment supplier(s) will then negotiate price and delivery.

This new method of automation procurement contrasts sharply with the conventional approaches which grew out of the separation of product design, manufacturing engineering, and purchasing. It also promises to create a new atmosphere which should result in products designed for sharply accelerating the introduction of advanced manufacturing technology.

Tooling

Despite the progress made in the U.S. auto industry to tighten tolerances throughout vehicle bodies, considerable progress is still required in improving body panel fits. The following comment summarizes the present situation and the hopes for the future: "Compared to where we expect to be in a few years, the fit-quality of sheet metal parts and subassemblies is in chaos. We will eliminate the build-up of tolerances that result through the manual methods used for vehicle design and toolmaking by accelerating the use of CAD, CAE, and CAM, in conjunction with NC machining of tool components." While the compounding of tolerances occurs throughout the entire system of going from the product designer's sketches through to the fabrication of the production tools and checking fixtures, considerably more emphasis will be focused on the computer-aided design and production of stamping dies and plastic molds.

An essential element to extending the implementation of these CAD/CAE and NC systems is wide-scale implementation of NC in both the captive and independent design and toolmaking operations. Machining equipment for body tools, however, is very expensive, costing as much as $2 million for a single NC milling machine. Toolmaking operations committing to such techniques would require several NC machines, in addition to the CAD/CAE equipment. Both independent toolmaking companies and the auto industry are concerned that the small tooling firms cannot raise the capital to buy all this new equipment.

One of the vehicle manufacturing executives summarized the concern: "The objectives of higher quality and shorter lead time will drive the use of computer technology in the engineering, manufacturing, and assembly of automotive tools. This will result in heavy investments in computer-aided engineering and manufacturing equipment to replace the present system of drawings, die models, and prototype tooling, leading up to hard steel tools. The investment required will doubtless weed out the smaller, weaker supplier organizations.

It was noteworthy during AIM interviews that while the vehicle manufacturers place the responsibility for the needed improvement in body quality on the manual toolmaking methods, the independent tool and die shops argue that tooling which they have produced with the manual methods is superior to tooling produced by NC within the captive shops. It is apparent, however, that significantly improved quality tooling has been produced on NC by equally skilled toolmaking operations, regardless of whether they are captive or independent.

It is clear that there will be a declining (probably gradual) automotive demand for tooling manufactured by manual methods. The requirements for the use of CAD/CAE for designing and producing automotive tooling are clear. Yet, because the capital needs are so large compared to the resources of a small toolmaking company, it is not at all clear how these companies, which are vital to the vehicle manufacturers actually being able to use such technology to improve their body-fit quality, will be able to afford it.

Additionally, once the equipment is acquired, either by captive or independent toolmaking facilities, it is obvious that a considerable number of years will be required before all the managers and skilled trades can be retrained/trained in a sufficiently large number of toolmaking facilities to provide enough increase in capacity to make a difference in the huge tooling programs of the auto industry. The state can help fill this training/advisory need until new programs by trade associations and colleges can be implemented.

If the U.S. auto industry must wait until CAD/CAE and numerical toolmaking methods are fully assimilated by the captive and independent tool design and production operations without outside support on equipment financing and training—before the fit-quality of vehicle bodies is fully optimized, it is possible that this process will require 15 to 20 years.

As noted above, one of the persons interviewed indicated that it was his private expectation that only about one-third of the independent companies now building body tooling for the auto industry will find the resources to be able to buy the CAD/CAE, and NC equipment; the other two-thirds that are not able to afford it will need to shift markets. Should that forecast be accurate, it is doubtful that there will be a sufficient number of CAD/CAM NC operations to build the required tools during peak tooling programs.

Independent companies were urged by auto industry executives surveyed to work out cooperative arrangements were they can share CAD/CAE and the expensive NC machines. It was suggested that the state might create an industrial park where independent toolmaking companies could cluster. Within the park one company could concentrate on providing CAD/CAE services, another company on prototype tooling, and another might concentrate on NC machining of large tooling components; still others might specialize in construction and tryout, or other specialty services.

Apparently, there have been somewhat similar approaches to related problems in Japan requiring large amounts of capital investments by small businesses. A centralized effluent treatment system reportedly was installed by a unit of the Japanese government in a new industrial park specially designed for plating companies.

Independent toolmaking companies that have acquired an "entry-level" capability with CAD-numerical control reported in the interviews that software differences crop up even among the individual divisions of General Motors, as well as between the Big Three. Tooling companies have been further frustrated because they have purchased specially designed equipment/software that was advertised as making data from generally similar, but slightly different CAD systems compatible.

While GM divisions may have similar CAD equipment for tooling design, these systems often produce slight variations in software formats by the time the data reach tooling companies. Independent tooling companies that have acquired CAD systems are therefore unable to use a single CAD system which can accommodate all the different data formats coming from the several GM divisions. The problem is compounded by the still different data formats from Ford and Chrysler. A few years ago, it was thought that an emerging software system would be able to accept minor variations in data formats from different CAD systems and make them compatible for a range of CAD/CAM systems. The results have been disappointing for both the vehicle manufacturers and their tooling suppliers, and the software incompatibility problem is still holding back the pace of CAD/CAM toolmaking.

Some executives speculated that General Motors through its new subsidiary, Electronic Data Systems (EDS) is considering the establishment of a chain of CAD/CAE equipment centers around the country which suppliers to the auto industry, including independent tooling companies, might be able to utilize. This possibility could have a special tooling appeal, because General Motors, like Ford and Chrysler, has developed special CAD/CAE, and NC software for computer-aided design and toolmaking which might be marketed by EDS, or other similar commercial ventures.

GM has made other proprietary software available to EDS for its commercial purposes. Having GM's proprietary CAD/CAE/CAM software available for tooling design and manufacture, with appropriate computer equipment and advisory expertise on an as-needed commercial basis, would not only be of great assistance to the small independent tool and die shops, but be of great help to General Motors, and probably the other U.S. vehicle manufacturers in achieving their principal goal of improving the fit-quality of their body components as soon as possible. It is also possible that because of EDS's entrepreneurial interest, it would be willing to offer CAD/CAM advisory services exploiting this apparent gap in today's toolmaking marketplace.

It would be of definite value if the state government could provide the leadership for "EDS-type" organizations to establish Michigan operations concentrating on the development of CAD/CAE centers having the computer equipment and expertise necessary to bridge the gap between the CAD/CAE/CAM toolmaking systems of the vehicle manufacturers and the independent tool and die companies. In the interim, however, state-sponsored CAD/CAE/CAM toolmaking training and advisory programs may be needed.

The use of CAD for moldmaking activities is further advanced than it is in the companies making stamping dies for body panels. On many molded parts, it is customary to make more than a single mold. It is, therefore, easier to amortize costs of CAD and NC programming across multiple sets of molds. In some automotive applications it is not uncommon to build six to eight molds for the same plastic part, compared to one die for a steel part.

To summarize what appears to be a very volatile situation, the capital costs and new technical abilities required for continued (or new) participation in the independent tooling and prototype segment serving auto dictate that larger organizations will be required. The segment will be very turbulent during the rest of the 1980s. What kind of organizations will emerge from the turbulence is less clear. Several forms, not necessarily mutually exclusive, seem possible.

Some of the larger and now rapidly-expanding engineering service firms in the area will certainly extend their capabilities to embrace tooling and prototype development. Major first tier suppliers are expanding their engineering and design capacities to conduct concurrent development with their OEM customers, and may acquire some of the talent, or actual firms, from Michigan's historic tooling and prototype endowment. OEM-sponsored regional centers (as with the EDS idea) that might provide training and pooled equipment for trusted smaller tooling firms is an attractive prospect for those with an interest in encouraging an orderly, socially efficient transition to the new technologies. The same can be said for the bold concept of a consortia of smaller firms that, with public support, might reorganize to share a common facility in which expensive equipment is commonly owned or leased and firms are encouraged to share skills, jobs, and work on innovations that require the gifts of many "golden hands."

The state has a clear interest in renewing its historic leadership in the tooling segment. In the environment of the late 1980s, it may be appropriate for government to experiment openly, to share some of the risks with the private sector.

Toolmaking Opportunities in Plastic Composite Parts

The GM replacement for the Camaro/Firebird cars is expected to have composite plastic body panels. Toolmaking and molding capacities for plastic parts of the approximate size of body panels is in short supply in the United States, and could limit the ability of the car companies to make the switch from steel to composite plastics.

Executives outside GM speculated that the production molding requirements for the Camaro/Firebird would probably require a new General Motors plastics plant to produce plastic body panels—which would be similar in function (but smaller) to a stamping plant for a car with steel bodies. Because the Camaro/Firebird replacement is expected to be assembled at Pontiac, it is logical that GM, or its supplier of these panels, could be interested in a "just-in-time" site near Pontiac.

One study of plastic composite body tooling capacity concluded that there is a total capability in the U.S. for making about 150 body panel molds per year. The car companies estimate that this will accommodate production up to about 400,000 cars per year, at today's production rate for plastic composite panels.

Fiero production at 100,000 units and the Corvette at about 50,000 units is still well below the 400,000 units per year ceiling. However, by 1989, the Camaro/Firebird should be in full production at 300,000 to 400,000 units per year, pushing the total to about a half million units from just those three cars. In addition, other specialty cars are planned to have some plastic composite panels as well, creating more of a tooling opportunity for Michigan moldmaking companies. Because the increased plastic use will be at the expense of steel panels, there will be little if any net gain in overall tooling business. And because most of the body stamping dies are made in Michigan, any new body molds that are not built in Michigan will result in a net loss of tooling jobs in the state.

Beyond the toolmaking bottleneck, production capacity problems for molding body components are also expected. The extent of the capacity shortage is directly related to production molding and painting cycle times—affected by technological advances. It is estimated that for plastic composites to be used for body panels significantly beyond the 400,000–500,000 vehicles per year, the production molding cycle time will have to fall under one part per minute, compared to today's three to four minutes. Should that happen, it likely would create a "Catch-22" situation; wherein faster production times will encourage even more plastic composite applications, which in turn will stretch the capacities of moldmaking and plastic body panel producing companies. However, being able to identify these capacity shortfalls two to three years in advance should be adequate motivation for suppliers to expand their facilities—perhaps in Michigan.

One force driving the increased use of plastic composite body panels, and certain other types of components as well, is the attraction of achieving a 40 to 60 percent tooling savings compared to tooling for steel parts. However, some companies are working on a stamping die production method based on casting rather than machining to obtain the desired contour in stamping die. If this technology should prove out, and some of those we interviewed are optimistic about the prospects, the cast technology could reduce die costs for steel parts by as much as 30 to 40 percent—thus narrowing the cost gap between tooling for plastic composites and steel panels. While there are other motivations for switching to plastic composite body panels, (weight and corrosion protection, for example), successful implementation of casting technology for stamping dies would nevertheless be a mild depressant on the future prospects for plastic composite body panels, and help maintain employment opportunities in stamping dies and steel panel production.

Manufacture of Plastic Composite Body Panels and Space Frames

The possible switch from steel to plastic panels is expected by several executives to be the most significant manufacturing change over the next decade. Beyond the next few years, an acceleration in the use if composite body panels is expected because of projected solutions to the following problems which have slowed past applications:

- relatively slow production cycle times;
- painting or coating problems/penalties relative to steel; and
- surface quality problems on body panels.

While steel components are produced at very high rates, sometimes as high as one part every ten seconds, plastic body panels may require three to four minutes. However, improvements in resins, molding machinery and controls, and the technological advancements in materials, especially non-reinforced composites, will reduce the production cycle time to one or two minutes. Some engineers believe that ultimately, cycle times for body panels will be reduced to around 40 seconds per panel. Recently, there has been significant progress on reducing cycle times with non-reinforced materials, dropping them about 25 percent in the last five years.

Differences in cycle times as affected by part thickness is largely due to differing cure times, especially for non-reinforced materials. On fenders, about 1/10th of an inch thick, the processing time is 60 to 80 seconds. On bumpers which are about 1/4th inch thick, the processing time varies between 90 and 100 seconds.

Virtually all materials and manufacturing executives agreed that a 60-second production cycle time will make plastic composite body panel technology extremely competitive with pressed steel panels, especially on lower volume cars. However, considerable development is required before the new non-reinforced plastics technology is suitable for horizontal panels, such as the hood, deck lid, or roof. To manufacture such panels with non-reinforced plastic composites, it is still necessary to design the component with a heavy thickness—about 100 thousandths of an inch—to prevent sagging. The comparable thickness in steel would be about 30 thousandths of an inch.

Technological advances to produce hoods, roofs, etc. from non-reinforced materials are expected to require very large molding machines, probably having a capacity of about 6,000 tons and costing $1 to $2 million each. Popular molding machines used today for automotive applications are typically under 3,000 tons. Many of the large 10,000-ton machines used in other industries, such as for the manufacture of boat hulls, bath tubs, and refrigerators are made mostly in Europe and Japan. There will be advantages for these equipment manufacturers to be located near automotive customers if the plastic composite use takes off as some project. The Michigan Department of Commerce should establish communications with the foreign molding machinery manufacturers to acquaint them with advantages of Michigan as a manufacturing site.

The relatively slow paint curing times of plastic composites also show promise of being accelerated. Automotive companies have been searching for better paint materials and application systems, and especially for new plastic composite materials which tolerate higher paint-curing temperatures. Painted steel components are cured at temperatures around 325 to 350 degrees F. Because of the susceptability to thermal damage, most plastic components could not be baked at a temperature in excess of 250 degrees F. Now certain new non-reinforced plastics show excellent resistance to thermal damage when baked at the same oven temperature used for painted steel panels. Further tests are required by the auto companies before the full durability of these new non-reinforced plastic materials are proven.

Another important attraction suggesting the increased use of plastic composite body panels is the forecast usage of more space frames. Because of the flexibility provided by the space frame's body panel mounting pads, vehicle designers find it easier and much less expensive to configure a different-looking body off a common space frame. With tooling costs for plastic composite body panels only 40 to 60 percent of the tooling costs for steel panels, auto companies can economically justify tooling up body skins of a new design to attack a smaller niche than would be possible for steel. One future car, designed with a space frame, is planned to have four distinctive body shapes off one frame. The decision to use fiber-reinforced plastic rear doors, hoods and roof spacers on the 1985 front-wheel drive Fleetwood limousine is a contemporary illustration of how GM took advantage of lower tooling costs to configure a special vehicle for a relatively small market segment. Some tooling experts speculated that General Motors likely cut the tooling costs at least by a half in using plastics, rather than steel.

Should the move to plastic body panels sharply accelerate as some of the executives believe, this transition will have substantial industrial development implications for Michigan. Not only will there be a shift in the types requirements for machinery, and tooling, and in material handling-equipment, but many of Michigan's large steel stamping facilities that produce body panels will see a business decline. Examples are the stamping facilities of Ford and Chrysler in the Detroit area as well as GM facilities in Kalamazoo, Grand Rapids, and other Michigan cities. Added to those will be adversely impacted business opportunities of the many small stamping companies heavily represented in lower Michigan which for decades have been producing some of the smaller stamped components going into vehicle bodies, doors, hoods, deck lids, etc.

The developments in plastic composite manufacturing technologies need to be followed closely during AIM II. As noted earlier, a technological breakthrough in the critical factors currently limiting the utilization of plastic composites for body panels will have serious implications for many Michigan industries. The challenge will be to identify the growth areas in, for example, resins and other plastic materials, molding machinery, etc., and to establish programs to encourage their location/expansion in Michigan.

The space frame as an independent concept was frequently mentioned as one of the more significant manufacturing changes expected in the future. However, when it is combined with plastic composite panels and tooling economies, it may have revolutionary potential. Variations of the space frame have been used in race cars, and in at least one high-priced European sports car. In one space frame application, the structural framework of the car is fabricated from approximately 300 separate stampings. The frame consists of the front compartment subassembly, the floor pan, the rear or engine compartment (all welded together to form the underbody assembly), and the body sides, roof, and doors. The individual components are welded together by over 4,000 spot welds. While U.S. space frames are presently manufactured from steel, plastic composites will also be used later, and likely will reduce manufacturing costs and weight.

A quality advantage results from both the design of the frame's structure and the methods used to produce it. After the individual stamped parts of the structure are welded together, it is placed in a precision fixture equipped with drilling and milling heads. Here, approximately 40 mounting body panel pads are precisely milled to exact X, Y, and Z coordinate points. Rather than adjusting the outer panels of the car to achieve fit-quality, the milled frame-mounting pads provide <u>consistently</u> precise positions to locate and support the body panels. This dimension control creates extreme uniformity between the frames and promotes outstanding fit-quality of adjoining body panel surfaces.

On one space frame, the Pontiac Fiero, there are 39 mounting pads to which the exterior body panels are located and bolted. At the base of the Fiero mounting pads are blocks of sheet metal, approximately 3/4" square and 1/2" high, which are filled with an epoxy compound and spot welded to the space frame at points where the panels will be attached.

Besides the inherent precision benefits, many manufacturing efficiencies drive from the space frame design. Because the body skin panels are the last components bolted on, all the hard-to-reach inner modules, e.g., instrument panels, seats, etc. may be installed by technicians less encumbered by obstructions. Technicians no longer have to install the instrument panel lying on their backs and extending their arms. With the frame providing the structural strength, more extensive use of modules is also possible. For example, some manufacturing engineers would like to fabricate as a complete module door and the frame, and once all door-frame fits are secured, then install the door-frame module by connecting the set of bolts to the mounting pads. Besides providing for the off-line fabrication of the door and frame complete with hinges, windows, handles, etc., consistent margins around the periphery of the door frame could be more easily achieved than is possible with present methods.

Centralized vs. Decentralized Production

Many future assembly plants are expected to have just-in-time parts supplier plants clustered around them. In some assembly plants, the vehicle manufacturer may actually lease out space to independent parts suppliers. If this production reorganization proves effective, it could signal the breakup of large centralized parts manufacturing plants, many of which are located in Michigan, because they will need to redistribute their production to several decentralized facilities. Potential examples are foundry operations, engine operations, stamping plants, and transmission plants.

There is some disagreement among manufacturing executives on the universal economic justification of "magnet" assembly plants surrounded by major component parts-production operations. One executive, while acknowledging the economic merits of the clustered approach for high-volume cars, commented that production of some vehicles may not be large enough to justify multiple sets of tools for decentralized part/module production at assembly plants. For smaller volume operations, he speculated, it might be more efficient to bring vehicle final assembly to where the component parts' tooling is clustered. Others foresee more decentralized than clustered operations for different reasons. Worldwide sourcing of parts would restrict clustering around the magnet assembly plant.

As somewhat of a surprise, some executives suggested that parts supplying companies might simply locate warehouses near assembly plants to satisfy an important goal of the vehicle manufacturer, i.e., substantial inventory reductions. However, simply shifting the inventories form the vehicle manufacturer down through the system to various component suppliers does little to enhance quality.

Simple or Complex Automation

Throughout the auto industry's ambitious efforts to reduce costs by $2,000 to $3,000 per vehicle, there has been considerable emphasis on developing and implementing advanced, but appropriate, manufacturing technology. Some executives are concerned that expensive technology will create a much higher operating breakeven point for "high-technology" plants. One person commented, "We are concerned that with all this advanced technology in our expensive flexible and dedicated manufacturing systems, the depreciation costs will eat us alive during inevitable car sales downturns."

The GM/Toyota plant in Fremont, California was cited as an example of a somewhat different philosophy based on relatively simple manufacturing technology. It was a surprise to some that Fremont is a high productivity but low investment facility. Comparable plants of U.S. vehicle manufacturers were estimated to cost two to four times more than the equipment selected by the Toyota managers at Fremont. The Japanese strategy apparently has been to select simple, flexible, and efficient equipment, but then to rely on the plant personnel to be properly motivated and dedicated to provide the ingenuity for high productivity. One U.S. Executive commented, "We tend to throw money and sophisticated equipment at quality and productivity problems while the Japanese at the Fremont plant emphasize a people approach."

When General Motors announced its plans to establish a joint venture with Toyota, one motivation was to "study how the Japanese build cars." Although the Fremont plant has been operating only a short time, their approach suggest that American manufacturing engineers may re-evaluate how they design plant automation relative to rational investment levels.

It is curious to observe that manufacturing technology trends, projected by the executives interviewed, suggest the use of increasingly sophisticated automation. Flexible manufacturing systems, complete with computers and software cost anywhere from 20 to 50 percent more than past conventional automation. This trend heads in a different direction from that of the low investment/high productivity approach used at Fremont.

The Fremont facility raises several provocative questions, which increase even more the uncertainty about how much automation, and especially flexible manufacturing systems, are economically justified for automotive manufacturing in the U.S. It was not possible to answer conclusively this question in AIM I; a better evaluation may be possible in AIM II by supplementing the interviews of executives from American companies with visits to U.S. plants of Japanese auto companies. One possibility is that new technology is more essential in casting, molding, and machining than in assembly.

To finally re-emphasize the range of uncertainty which still prevails regarding the simple or complex automation question, especially as it applies to the U.S. approach to flexibility, the following comment of one manufacturing executive seems especially instructive. "In determining the degree of automation needed, we need to locate a proper balance between two extremes: no inventories and excessive manufacturing flexibility, or excessive inventories with full dedicated automation." The implication here is that the limits of these two options virtually cover the full range of possible approaches to the selection of manufacturing technology—implying that the more likely array of possibilities still cannot be narrowed down very much. Experiences gained over the last few months from the Fremont start-up would seem to imply that a universal answer to the question may in fact not be possible for some time.

DATABASE DEVELOPMENT

One of the key features of the Auto-In-Michigan (AIM) Project that distinguishes it from other studies of the auto industry is its emphasis on the current situation and future prospects of the industry in Michigan. The investigations of the Central Research Team are aimed at determining the industry's prospects in general terms and as they relate to the state. To support these efforts, an establishment-specific database of automotive manufacturers and suppliers has been constructed.

Purpose

This database is designed to:

- Provide information on the size of Michigan's auto-related industries, in terms of product, industrial category, business size, and geographic area.
- Provide a current mailing list for targeted mailings and research efforts focused upon the Michigan auto industry, including the continuation of the AIM project.
- Enable state and local economic development agencies to effectively service their auto-related facilities and market their areas to potential investors.

Characteristics of the Database

Economic development activities (including research) are most effectively carried out on an establishment-specific basis. It is at this level that many of the decisions that most directly affect a company's workforce are made. Retention and attraction efforts are also implemented at this level; hence the focus of the database on establishments.

The AIM database is constructed from establishment-specific information where each distinct location of a corporation is included as a separate entry. While our research focus is upon production facilities, all known distinct physical locations of auto-related companies are included. For example, over 110 separate entries are included for General Motors, representing each of their physical locations in Michigan. This method allows for a detailed analysis of industrial changes on particular geographic areas, the State as a whole, or on a variety of industrial segments that make up the state's automotive economy. For each establishment the following demographic information is generally available:

- Name of business
- Address including city, county, zip
- Economic development agency responsible
- Phone number
- Chief executive at that location
- DUN and MESC numbers
- Parent company information
- Annual sales (when available)
- Total employment
- Standard industrial classification code(s) (four and six digits)
- Short description of business activity
- Other contact persons

The database has been formed by a merging of several sources: 1) the Enhanced Duns Market Identifiers (obtained from Dun and Bradstreet Marketing Services), 2) the ES-202 file used in connection with the Unemployment Compensation Program and maintained by the Michigan Employment Security Commission, 3) the Iron Age Metalworking Data Bank (obtained from Chilton, Inc.), and 4) information provided by a number of local economic development agencies on the auto-related establishments in their area.

All establishments are included in the database, regardless of size. The list has been generated from a larger list of Michigan establishments by focusing on the approximately sixty Standard Industrial Classification (SIC) codes at the four-digit level that were known to include the bulk of the automotive industry. Businesses in both manufacturing and business services (which provide technical support to manufacturers) are included. Information provided by the local agencies has enabled us to include some establishments that would typically not be included by the use of a set of SIC codes, since many agencies had information on additional establishments that were auto-related. As the following tables present, the database currently includes approximately 12,250 establishments. Not all of these establishments are auto-related, of course. A key objective of our work has been to determine those that are.

Potential Auto Supplier Database
by Local Economic Development Area

Location	Approx. Number of Establishments
Downriver Area	250
City of Detroit	1,400
Other Wayne County	1,200
Macomb County	2,200
Oakland County	2,500
Washtenaw County	350
Jackson County	300
Grand Rapids Area	700
Bay County	175
Saginaw County	140
Lansing Area	275
Flint Area	430
Other Michigan Location	2,330
TOTAL	12,250

Potential Auto Supplier Database
by Broad Industrial Category

Industrial Category	Approx. Number of Establishments
Apparel	90
Furniture (Seating)	30
Chemicals and Paints	210
Rubber and Plastics	1,200
Glass and Stone	160
Primary Metals	350
Fabricated Metals	1,650
Non-Electrical Machinery	4,250
Electrical Machinery	350
Motor Vehicles and Equipment	700
Instruments	20
Wholesale Trade	720
Business Services	620
Engineering and Architectural Services	1,750
Other	150
TOTAL	12,250

The Office of Systems and Computer Services of the Department of Commerce has provided the essential computer expertise to integrate the various sources into a coherent and usable database. They have also produced a variety of reports and specialized routines to assist the users of the database. Data and technical assistance have also been provided by the Information Systems Center at the Industrial Technology Institute. The information is stored on the ADP Onsite computer and is accessible by Information Processing Language, a software package designed to manipulate large databases.

Survey Description

To enhance the descriptive power of the database, a survey has been administered to all of the automotive establishments included. This survey was designed to:

- Verify the existing demographic information on the establishments
- Determine their relationship (if any) to and position in the auto industry
- Provide more information on product, process, and material, going well beyond SIC code, so that CRT information on specific industry trends could be applied directly to Michigan establishments
- Obtain detail on the linkages between the various establishments in Michigan's automotive industry, both in terms of suppliers and customers
- Collect data directly from the industry on the key challenges that must be dealt with to remain competitive
- Define the current and future technological capabilities and plans of the firms including the means of implementation.

Summary results from the survey are provided in the next section. Data are shown primarily at the statewide level; detailed regional implications will be dealt with in the seminars conducted in local areas.

Survey Results

Of the 10,000 surveys mailed to the establishments in the database, approximately 2,500 have been returned, for a 25 percent response rate. 1,000 of these returned surveys are from auto-related establishments; the remainder are from firms not involved in the auto industry or from businesses no longer at the address listed (with no forwarding address available). As in the initial database, the largest number of establishments are concentrated in plastics, stamping, metal working, auto parts, and engineering services. Approximately 23 percent of the completed surveys are from unionized companies, although a larger percentage of the larger establishments are unionized.

Approximately 39 percent of the respondents supply components directly to auto manufacturers, while 37 percent supply components to other supplier establishments. (Many establishments are in both categories.) About 32 percent of the companies supply tooling directly to auto manufacturers, while 32 percent provide tooling to other suppliers. 14 percent of the establishments supply raw materials to other firms, while 32 percent of the respondents supply engineering or manufacturing services to auto manufacturers, and 28 percent provide these services to other suppliers. The total sums to considerably more than 100 percent, since firms are usually involved in multiple activities. Detailed information on products, processes, and materials is also available.

Information has also been collected on the major domestic auto manufacturers supplied by these establishments. The survey results indicate that 77 percent of the respondents supply General Motors, 62 percent supply Ford, 53 percent transact with Chrysler, 24 percent work with AMC/Renault, and 24 percent supply U. S. operations of foreign auto manufacturers. Once again, the total is considerably over 100 percent due to the inclusion of multiple answers. Information on particular establishments and products supplied is also available.

The survey also deals with the current usage and future plans for various forms of manufacturing technology. The most popular forms of technology are computer numerical control (CNC) machine tools (39 percent currently use or are considering using such equipment), computer-aided design (37 percent), programmable controllers (30 percent), computer-aided engineering (27 percent), and computer-aided manufacturing equipment (25 percent). Again, multiple responses are permitted.

The survey has been very successful in assessing industry attitudes concerning the most critical business challenges, technology usage, and possible state government assistance in technology programs. One question specifically asked for the greatest obstacle in remaining competitive in the automotive industry. Since this survey has been partially conducted by State government, the expected business cost issues are often mentioned. Other responses such as improved communication with the automotive manufacturers, the need for a skilled workforce, foreign and domestic competition, financing, and operating costs are also mentioned frequently.

A question concerning the usefulness of State assistance in technology implementation was helpful both in evaluating past and current programs, and designing new ones such as the Technology Deployment Service launched in Fall 1985. Overall, there was a desire for localized training, with community colleges being the most frequently requested provider. We also learned that a large number of businesses are unaware of what assistance the State can and will offer.

A completed survey is included at the end of this chapter to illustrate the responses. The surveys chosen illustrate a parts plant of one of the auto manufacturers, a medium sized independent parts maker, and a small tooling firm.

Survey Administration

The survey was designed by members of the AIM project, in consultation with local economic development agencies (LEDAs) and survey specialists, and then piloted to several firms. It was then administered by twelve LEDAs throughout the State. Local agencies and AIM staff have coded the responses, which have been added to the State's computerized database. In the fall, local agencies will have access to the computerized information for the establishments in their area. This information is also being used in AIM presentations to the LEDAs.

The LEDAs performed the critical function of coding the returned surveys. They were also involved in extensive follow-up, which enhanced the response rate. The coding of the response forms was a complicated and time-consuming task, but was required so that the data would be easily accessible by computerized searching routines.

The length of the survey may have been a detrimental factor in the quantity and quality of the responses received. This was evidenced by the decreasing number of responses on the final questions of the survey. This is a difficult issue to resolve, since the survey covered a number of independent topics, and therefore had to be rather lengthy.

The layout of the form may also have had a major impact. For example, one question asked the respondents to list their auto-related customers. Although company name and location were requested, the location of the facility was often not provided, thus making it difficult to pinpoint the proper establishment. This may have been due to the inclusion of only one line for this information, rather than separate lines for the plant name and its location.

Electronic Clipping Service

To ensure the timeliness of the database, the AIM project is maintaining an "Electronic Clipping Service" that includes current information from the trade and popular press on investments, products, site locations, and other factors that pertain to particular establishments. This information has been shared on the electronic conference, so that the varied expertise of the AIM Project is reflected and added to the original press report. Information of this type is invaluable to economic development officials as they contact companies for retention or expansion.

The following examples illustrate some of the major categories of the articles included: 1) Information on the future of a major Michigan assembly facility, 2) Data relating to a major Michigan parts facility and its suppliers, many based in Michigan, and 3) Articles concerning the use of technology as they affect Michigan plants. This information is generally applicable not only to the facilities explicitly mentioned, but also to other similar facilities.

REPLY from: Dan Luria 19:00 Jun16/85 TGKB:MF
REPLY from: Alan Baum 12:26 Jun16/85 TGKC:MF
REPLY from: Dan Luria 09:21 Jun10/85 TGKB:MF
MESSAGE from: Alan Baum 21:40 Jun09/85 TGKC:MF
LABOR TALKS AT JEFFERSON ASSEMBLY

Source: DN, 6/4/85

Categories: Detroit, Labor

Chrysler has reportedly told local UAW officials (Local 7, president is W. "Wolf" Lawrence) that future production at Jefferson Assembly depends on union cooperation in improving efficiency. However, a Chrysler official denied that the plant would close in late summer of '86 without an agreement. (Does it seem crazy to talk about the closing of Jefferson given Chrysler's shortage of assembly capacity?)

Lawrence says that Chrysler labor folks have asked for improvements in productivity, quality, and reductions in absenteeism. Bargaining on the local contract will occur this summer as the national agreement expires October 15. The future at Belvidere, IL is also being tied to favorable local agreements, so maybe this is a general negotiating strategy.

Jefferson builds Ks, which will be replaced in MY 87 by the As. Lawrence maintains that the workforce is good, and that quality levels were being praised by company officials several months ago. (False alarm?) Any comments?

REPLY from: Dan Luria 09:21 Jun10/85 TGKB:MF

Important stuff, this. Chrysler's too short of capacity to shut anything, so even if Jeff doesn't get A's, it gets something. Depends on demand, seems to me.

REPLY from: Alan Baum 12:26 Jun16/85 TGKC:MF

DAUCH STATES THAT JEFFERSON CLOSING NOT PLANNED

Source: DN, 6/14/85

Categories: Location, Detroit, Labor

Richard Dauch, Chrysler Exec VP for manufacturing, states that there is no specific plan to close Jefferson Assembly, but that no models have yet been scheduled there for production beyond 1987. He also stated that more efficient work practices will be a priority negotiating item throughout the company when negotiations begin with the UAW this summer. The Jefferson plant is unique in that it is bisected by a major street, Jefferson Avenue.

REPLY from: Dan Luria 19:00 Jun16/85 TGKB:MF
I'll ask around about what the UAW hears on A bodies — # plants & order of Jefferson, Newark, and St Louis. I assume that City & State have enough $ in Jefferson to warrant a close watch—and a plan—on this.

MESSAGE from: Dave Andrea 22:36 Mar27/85 TGKH:MF

CHRYSLER TO UPGRADE TRENTON ENGINE FOR 2.5L PRODUCTION
SOURCE: AMM (2/25/85)

FILES: WAYNE, SCAMP, PRODTECH

Chrysler Corp. is purchasing a non-synchronous transfer-type assembly system for cylinder heads, which is designed to run without human assistance.

The system incorporated European (Grob Werke of Mindelheim, Germany supplied by Grob Systems, Inc. of Bluffton, OH). design to put together the various parts of the heads for four-cylinder engines made at Trenton. Those parts include the main castings, valves, rocker arms, springs, retainers, and bolts.

The new system will be installed by late summer/early fall 1985 for production of the 2.5L engine (an upgrade of the 2.2L) The engine will be used in the T-115, New Yorker, LeBaron, 600, Caravelle, and K.

Final assembly system will be furnished by Wilson Automation Div., of Newcor (Warren, MI) and Visitrol Corp. (Detroit, MI). Washers and leak testers will be provided by Centri-Spray (Livonia, MI). Centri will also supply other between-machine equipment.

It is the first Grob cylinder head assembly system to be built in the U.S. Grob is also capable of producing flexible systems.

MESSAGE from: Lauren Hammett 12:00Aug01/85 SUBP:MF
FUTURE IS NOW FOR 2 FORD PLANTS

Source: Automotive News • 4/29/85 (page 17)

Categories: Wayne Sourcing Labor

Ford's transmission and engine operations at Livonia and Lima, Ohio, respectively, will make the drivetrain for the 1986 front-wheel-drive Ford Taurus and Mercury Sable. These two facilities are closer to the "paperless" factory of the future than any other North American transmission or engine plant. Both facilities will rely on high-speed flexible machining, robotics, local computer networking (so that machines can communicate with each other), computer-controlled machine functions and inventory, AGVs, modular assembly, and just-in-time inventory supply.

The Livonia plant will build the automatic 4-speed overdrive transaxle, (AXOD). It has implemented diamond and solid carbide tooling, laser welding and computer networking of machines on the plant floor, personal computers and data-processing equipment as well as an extensive use of AGVs, all in an effort to increase efficiency and quality.

There is a new, technically oriented production job classification for hourly and salaried personnel. The plant management and the UAW have established "manufacturing technician" jobs within the hourly work force. These multi-skilled "technicians" have undergone special technical training and are given new responsibilities with increased job authority.

The plants 62 technicians went through 10–14 weeks of full-time course work in preparation for the job. Training was done inside the plant using a multi-media operation. At Lima, Ford will turn out the 3.0-liter, V-6 engine for Taurus/Sable. Here the company claims to have installed more robots than any comparable engine line in the U.S.

Links With Other AIM Data

The data developed in the survey and the electronic clippings supplement the extensive data collected by the AIM project and described in detail elsewhere in this report. The survey's data on customers and suppliers augments the data contained in the input sourcing chapter, and focuses on the "chains of value added" in the supplier tiers below the major manufacturers. Although the response rate of the mailed survey precludes a systematic and complete description of the chains of supply, a significant amount of data is available and can be used to evaluate the likely supplier impact of a variety of product and technological changes.

Product codes assigned to each respondent from their completed surveys can also be used to determine the product(s), material(s), and/or process(es) of the establishment. This information, when combined with industry trends (described elsewhere in this report), can be used to pinpoint particular establishments in the state where risks or opportunities may exist.

Plans for Updating and Broadening Survey in AIM II

In order to keep the existing database current and expand its coverage to new establishments, AIM surveys will be administered again in the coming year. The original survey will be sent to establishments in six additional areas of the state.

In addition, a new survey will be implemented to some subset of the approximately 13,500 establishments (increased from 12,250 in the current database due to a new source that includes additional unique establishments) in all eighteen areas. Some of the new survey's queries will be identical to the old, in order to follow developments over time. Others will be new, reflecting project findings about sourcing patterns or eliciting new kinds of technology-specific information needed by the Technology Deployment Service, with whose staff it will be crafted.

Future Evaluation and Use of AIM I Survey Data

The data derived from the survey will be compared with other sources to insure its validity, and will be the basis for further survey efforts. In addition, longitudinal employment histories will be utilized to evaluate the extent of response bias (if any) in the survey sample. This step is designed to ensure that policies derived from these data are based upon a representative sample of the target establishments.

The data have been used extensively in state and local economic development functions including retention, expansion, and attraction activities. In addition, the database has been used to identify the Michigan impact of many of the conclusions stated elsewhere in this report.

The survey results have been coded and are now available to the state to supplement the original database. This information will be useful in illustrating the impact of very detailed developments at the product and/or establishment level. For example, if alternators were subject to a major process and/or materials change, some of the producers could be identified. In addition, suppliers and customers of the producing firms, as well as establishments that used the particular process and/or materials in question, could be found. With this information in hand, economic development officials and the affected businesses could then take appropriate action.

The section of the survey dealing with technology issues will be useful to the Technology Deployment Service as it develops and implements its programs. As the project continues into its second year, the database will be improved with continued updating and enhancement and will serve as a partial guide to some of the areas of future investigation.

Longitudinal Auto-Related Employment Data

A chart illustrating employment trends in the auto industry from 1979 to 1984 follows. Data from the company-specific database was not used here, since the database includes only one year of data. In some cases, figures have been constructed, since consistent information is difficult to obtain across time and at the detailed industrial level.

Auto employment has fallen substantially from its 1979 peak, although a recovery has taken place both in the state and nation since 1982. It appears, however, that this recovery has been stronger at the national level than in Michigan. In line with this fact, the share of the national industry in Michigan (in terms of employment) has dropped.

Several factors should be noted in evaluating these results: 1) The Michigan data for 1979–82 are from County Business Patterns, a source that tends to underestimate employment, 2) The 1983–84 Michigan data are from MESC surveys which utilize different sampling techniques than County Business Patterns, and therefore may not be comparable both to the national figures and the Michigan statistics for 1979–1982, and 3) Major new investments in Michigan's auto industry (such as Buick City, Mazda, and Detroit-Hamtramck Assembly) are not yet included in these figures.

AUTO-RELATED EMPLOYMENT IN MICHIGAN AND U.S.
1979 – 1984

Industrial Sector	1984	1983	1982	1981	1980	1979
Employment in Thousands – Michigan						
Auto Assembly*	122.0	114.9	107.0	119.0	120.5	165.0
Auto Parts	120.0	111.7	102.4	122.6	134.8	172.5
Other Auto Related	196.3	182.2	175.7	196.2	220.0	267.2
TOTAL	438.3	408.8	385.1	437.8	475.3	604.7
Percent Change from Prior Year – Michigan						
Auto Assembly	6.2	7.4	−10.1	−1.2	−27.0	
Auto Parts	7.4	9.1	−16.5	−9.1	−21.9	
Other Auto Related	7.7	3.7	−10.4	−10.8	−17.7	
TOTAL	7.2	6.2	−12.0	−7.9	−21.4	
Employment in Thousands – U.S.						
Auto Assembly	281.7	254.4	220.7	251.9	252.8	340.8
Auto Parts	303.7	265.5	247.9	283.7	268.8	355.2
Percent Change from Prior Year – U.S.						
Auto Assembly	10.7	15.3	−12.4	−0.4	−25.8	
Auto Parts	14.4	7.1	−12.6	5.5	−24.3	
Michigan as a Percent of U.S.						
Auto Assembly	43.3	45.2	48.5	47.2	47.7	48.4
Auto Parts	39.5	42.1	41.3	43.2	50.1	48.6

Employment in Thousands – U. S. Except Michigan						
Auto Assembly	159.7	139.5	113.7	132.9	132.3	175.8
Auto Parts	183.7	153.8	145.5	161.1	134.0	182.7
Percent Change from Prior Year – U. S. Except Michigan						
Auto Assembly	14.5	22.7	−14.4	0.5	−24.7	N/A
Auto Parts	19.4	5.7	−9.7	20.2	−26.7	N/A

Percent Change from 1979 to 1984			
Industrial Sector	Michigan	U. S.	U. S. except Michigan
Auto Assembly	−26.1	−17.3	−9.2
Auto Parts	−30.4	−14.5	0.5
Other Auto Related	−26.5	N/A	N/A
TOTAL	−27.5	N/A	N/A

Notes:
* In the Input Sourcing chapter, we cite a figure of 70,000 assembly workers. There, we refer to assembly plant workers only; in this table, "auto assembly" includes chassis manufacturing employment as well.

N/A=Not available.

Auto assembly and parts are production employment only, 1984 national figures are as of July, others are annual averages. 1984 state figures are as of July; 1983 are annual averages, and 1979-1982 are as of March of each year.

Sources:
Employment and Earnings, U. S. Bureau of Labor Statistics
County Business Patterns, Michigan, 1979-1982.
Michigan Employment Security Commission, BLS 790 Report, 1983-1984.
Michigan Employment Security Commission, Study of Auto-Related Employment, 1981, 1984.

EXAMPLE

The following is a list of all Oakland County auto-related establishments over 75 employees. In a county the size of Oakland, prioritizing retention calls is very useful for state and local economic development officials. By sorting the list by decreasing employment size, the developer can focus his or her attention on the largest establishments.

OAKLAND COUNTY AUTO ESTABLISHMENTS OVER 75 EMPLOYEES

Business name	Street address	City	Phone	Chief Executive	Employment	Description
General Motors Corporation	660 South Blvd E	Pontiac	3138575000	RW Truxwll Mgr	10000	Mfg Motor Vehicles
Ford Motor Company	50000 Grand River Exwy	Wixom	3133492400	Jerry Ouellette	3500	Mfr Motor Vehicles
General Motors Corporation	Hickory Ridge/Gen Mtrs Rd	Milford	3136855000	F D Smithson	2500	Automotive Testing
General Motors Corporation	701 N Glenwood	Pontiac	3138571007	Michael Tahy	1600	Mfr Gray Iron
General Motors Corp	4555 Giddings Rd	Pontiac	3133731000	Les Richards	1400	
Rockwell International Corp	2135 W Maple Rd	Troy	3134351000	A P Ronan	1000	
Federal-Mogul Corporation	26555 Northwestern Hwy	Southfield	3133547700	T F Russell Chb	750	Mfg Ball Roller
Newcor Inc	3270 W Big Beaver Rd	Troy	3136437730	Frank L Gofrank Chb	725	Welding Machines
Lectron Products Inc	1400 S Livernois	Rochester	3136560880	W S Mc Phail Pr	700	Mfg Automotive
Allied Automotive	20650 Civic Center Dr	Southfield	3138275000	William Agee Chb	600	Mfg Automotive
American Motors Corporation	27777 Franklin Rd.	Southfield	3138271000	W P Tippett Chb	530	Mfg Automobiles
De Vlieg Machine Company	Fair St	Royal Oak	3132801100	C R De Vlieg Pr	380	Mfg Metal Cutting
Volkswagen Of America Inc	888 W Big Beaver	Troy	3133626000	Noel L Phillips Pr	300	Mfg Motor Vehicles
Lear Siegler Inc	6841 N Rochester Rd	Rochester	3136519531	W S Lazich Pr	300	
Allegheny-Ludlum Corporation	1100 Mandoline	Royal Oak	3135859090	David Fenton	300	
Dover Corporation	250 Park	Troy	3135892008	W D Rogerson Pr	276	
Jabil Circuit Co	32275 Mally Rd	Madison Hts	3135893500	William D Morean Pr	275	Mfg Circuit Boards
Foamade Industries Inc	2550 Auburn Ct	Auburn Hts	3138526010	Morris Rochlin Pr	270	Mfg Plastic Foam
Eaton Corporation	26101 Northwestern Hwy	Southfield	3133842700	William Coleman	263	
Bendix Corporation	900 W Maple	Troy	3133621800	Jack Campbel	260	Mfg Motion Vehicle
Uniroyal Inc	3290 Big Beaver	Troy	3136498100	R W Bressler	250	
Hawthorne Metal Products Co	4336 Coolidge Ave	Royal Oak	3135645770	Charles Adams Pr	250	Mfr Auto Stampings
Quanex Corp	400 Mc Munn	South Lyon	3134371711	Richard Russell	250	Mfr Seamless Steel
Reichhold Chemcials Inc	601 Woodward Hts Blvd	Ferndale	3135646500	J A Broderick	215	Res Dev Resins
Adell Industries Inc	43700 Adell Blvd	Novi	3133496300	Robert Adell Pr	200	Mfr Auto Parts
D Square Company	650 W Twelve Mile Rd	Royal Oak	3135481360	Robert Shene	200	Electrical
The Bendix Corporation	32505 Industrial Drive	Royal Oak	3137556000	Mr Ginanetti	200	
The Budd Company	3155 W Big Beaver Rd	Troy	3136433500	J H Mc Neal Jr Pr	200	Mfg Automotive
Ford Motor Company	1315 Coolidge	Troy	3136432166	Doug Coats	199	
Jim Robbins Company	130 Stephenson Hwy	Troy	3135881550	R J Ososki V Pr	185	Mfg Plastic Parts
Waggoner Corporation	1400 Rochester Rd	Troy	3135646718	D E Waggoner Pr	180	Mfg Automotive
Ex-Cell-O Corporation	2855 Coolidge Rd	Troy	3136491000	E Paul Casey Pr	175	Mfr Industrial
Gte Valeron Corporation	750 Stephenson Hwy	Troy	3135891000	Donald G Otero Pr	170	Mfg Metal Cutting
Delta Model & Mold Co	1360 East Big Beaver Rd	Troy	3136895454	Rudolph W Mozer Pr	160	Indus Met Plastic
La Salle Machine Tool Inc	999 W Big Beaver Rd	Troy	3133624080	Robert R Cosner Pr	155	Mfg Metal Cutting
Haden Schweitzer Corporation	32200 N Avis Dr	Madison Hts	3135831900	Arthur R Geiger Pr	150	Mfg Install Metal

THE AUTO IN MICHIGAN PROJECT SURVEY

A State of Michigan Program with the
Office for the Study of Automotive Transportation
The University of Michigan and local economic
development agencies throughout Michigan

SURVEY PROCEDURES

The following survey is designed for Michigan establishments that are auto-related. We are requesting responses from establishments whose operations are auto-related by meeting **one** or more of the following criteria:

a. Manufacturing, design, engineering, and research operations of vehicle manufacturers.
b. Production of parts, materials, or components that will be incorporated as original equipment in passenger cars or trucks.
c. Production of machinery, tools, or tooling accessories used in the production of passenger cars or trucks.
d. Provision of manufacturing or engineering services to establishments defined in a, b, or c above.

Are any of your establishment's activities auto-related by the above criteria?

☒ YES ☐ NO

If your response is NO, please complete only the first five questions so that we may update our database.

If your response is YES, this questionnaire should be completed by someone who has broad knowledge of your establishment's customers and suppliers and of future plans for technological advancements. It takes approximately one hour to complete.

Your responses to this questionnaire should refer specifically to your facility location and **not** to the overall activities of your division, subsidiary, or parent company.

PLEASE COMPLETE AND RETURN THE SURVEY IN THE ENCLOSED POSTAGE-PAID ENVELOPE BY MAY 15, 1985.

Thank you for your time and consideration.

 5362249-0

1. Official name of your establishment at this location:

____

2. Address of your establishment at this location:

Street ______________________________

City ______________ State ______________ Zip Code ______________

3. Name and title of the person in charge at this location:

Name ______________________________

Position ______________________________

4. Name, title, and phone of preferred contact for this survey at this location:

Name ______________________________

Position ______________________________

Phone ______________________________

5. Name of your parent corporation, if any:

____

6. What is the single largest obstacle your establishment faces at this location if it is to participate successfully in the automotive industry?

Influx of cheap Japanese steel to Mexican and Canadian competitors. This is causing extreme competitive pressure. Stretch of our dollars and the import restrictions against steel commodities are destroying our markets.

7. Average number of employees at this location during January-March, 1985: 250

8. Average annual dollar sales of this establishment: $25.5 million
Of this amount, approximately what percent is automotive-related:

- [ ] 0 to 25%
- [ ] 26 to 50%
- [ ] 51 to 75%
- [x] 76 to 100%

9. Does a union(s) represent any of the workers at this location?
If yes, what union(s) and which local(s):

Union: U.A.W. Local: ______

Union: ______ Local: ______

10. Please provide a short description of your operations at this location.

We are currently manufacturing approximately ten million valve and Torque Converter Clutch springs per month.

11. Which of the following most closely fit your firm's activities at this location? (Check all that apply, and list up to three of the products, materials, or services you supply).

- [x] a. We supply components or parts directly to vehicle manufacturers.

  List of parts supplied: Valve/Torque Converter Clutch

- [x] b. We supply components or parts to suppliers of vehicle manufacturers.

  List of parts supplied: Valve

[X] c. We produce components or parts for the automotive aftermarket.

List of parts supplied: Valve

[ ] d. We supply machine tools, tooling and accessories, or other production equipment to vehicle manufacturers.

List what you supply:

[ ] e. We supply machine tools, tooling and accessories, or other production equipment to auto supplier firms.

List what you supply:

[ ] f. We supply materials to vehicle manufacturers.

Material(s) supplied:

[ ] g. We supply materials to auto supplier firms.

Material(s) supplied:

[X] h. We provide manufacturing or engineering services to vehicle manufacturers.

Services supplied: Technical assistance. Perform dynamic engine testing of vehicle manufacturers.

[X] i. We provide manufacturing or engineering services to auto supplier firms.

Services supplied: Same as above

[ ] j. Other (describe):

12. During the past two years, has your firm conducted business with any of the U.S. operations of these vehicle manufacturers (check all that apply):

[X] General Motors (any Division)	[ ] Volkswagen
[X] Ford	[ ] Honda
[X] Chrysler	[ ] Nissan
[X] AMC/Renault	[ ] NUMMI (GM-Toyota)

13. If you supply vehicle manufacturers directly, please list those auto company plants that are your largest customers and the product, process, or service that you supply. For example: "GM-Orion — Vinyl Trim" or "Ford Livonia — Casings." If you supply a central warehouse and do not know which auto company facility uses one or more or your products, please indicate that.

Auto firm/location:	Product or service you supply:
1. G.M./Delco Moraine	1. Torque Converter Clutch
2. Ford Motor - Lima	2. Valve Springs
3. Chevrolet - Flint	3. Valve Springs
4. Hydramatic - Ypsilanti	4. Transmission Springs
5. Oldsmobile - Lansing	5. Valve Springs

14. If you supply auto supplier companies, please list those auto supplier plants that are your largest customers and the product, process, or service that you supply. For example: "Kelsey Hayes, Jackson — Heat Treat" or "Lear Siegler, Detroit — Light Stampings."

Supplier firm/location:	Product or service you supply:
1. Borg and Beck - Sterling	1. Torque Converter Clutch
2. Caterpillar Tractor - Mossville	2. Valve Springs
3. Cummins Engine - South Carolina	3. Valve Springs
4. Teledyne Continential-Muskegon	4. Valve Springs
5. Barnes Group - Corry, Pa.	5. Valve Springs

15. Please indicate the approximate number of plants that supply parts, materials, tooling, and/or manufacturing services directly to your operations at this location: 30

16. Approximately what percent of the manufacturing establishments that supply your plant at this location are located in Michigan?

- [X] Less than 25%
- [ ] 25-49%
- [ ] 50-74%
- [ ] 75% or more

17. Please indicate up to five (5) Michigan manufacturers that are the most important suppliers to your operations at this location, in terms of dollar sales.

Michigan plant that supplies you:	Product they supply to you:
1. Frank Bancroft Co.	1. Abrasive Wheels
2. Ervin Industries	2. Shot Peening Supplies
3. Ann Arbor Machinery	3. Tooling
4. Packing Material	4. Packaging Items
5. Tubular Sales	5. Tooling

18. Is your firm considering acquisition of any of the following computer-based technologies during the next two years?

	HAVE NOW	HAVE PURCHASE ORDER	CONTEM-PLATE WITHIN YEAR	CONSID-ERING
a. Computer Numerical Control Machine Tool (CNC) **Use of a computer to provide automatic control of the machining sequence of a machine tool.**	☐	☐	☐	☒
b. Direct Numerical Control of Machine Tools (DNC) **A system in which NC machines are connected to a computer and to computer-controlled machine tools.**	☐	☐	☐	☒
c. Automatic Tool Changing **Changing of cutter, bit, etc., automatically by tape or computer control.**	☐	☐	☐	☒
d. Industrial Robot **Reprogrammable, multifunctional manipulator used to move parts or end effectors through variable, programmed motions.**	☒	☐	☐	☐

	HAVE NOW	HAVE PURCHASE ORDER	CONTEMPLATE WITHIN YEAR	CONSIDERING
e. Automated Storage & Retrieval System (ASRS) **System used to store and access parts and materials automatically.**	☐	☐	☐	X
f. Automated Guided Vehicle System (AGVS) **Computer-directed vehicles used for factory floor materials handling.**	☐	☐	☐	☐
g. Machine Vision **Ability to scan optically parts or assemblies to determine size, shape, position, or quality.**	☐	☐	X	☐
h. Programmable Controller **A solid state control system with user-programmable memory for storage of specific function instructions.**	X	☐	☐	☐
i. Other CAM Hardware/Software **Computer-linked machinery or computer-readable instructions used in programmable manufacturing.**	☐	☐	☐	X
j. Computer-Aided Design (CAD) **Creating or altering a graphic design using a computer.**	☐	☐	X	☐
k. Computer-Assisted Engineering (CAE) **Use of a computer to assist the total engineering function, including design, testing, development, planning, and manufacturing.**	☐	☐	X	☐
l. Group Technology **The clustering of parts into "families" using codes based on part shape, projection, or other characteristic.**	X	☐	☐	☐
m. Computer-Assisted Process Planning (CAPP) **An application program that interacts with CAD or CAE (see above) and assists in developing a manufacturing process/production plan.**	☐	☐	X	☐
n. Other (Describe): ______________________	☐	☐	☐	☐

19. With reference to the two technologies that you are most likely to implement at this location in the near future, what are the main factors in the purchase decision?

    Principle decisions will be made based on how far the technology will advance the product. How it will affect the quality of the product produced, service or services available to support the equipment, and capital expense required.

20. Will your firm seek outside technical assistance in selecting specific computer-based technologies for your firm?

    ☐ YES ☒ NO

    If YES, from what kind of source does your firm plan to seek assistance? (check all that apply)

    ☐ Equipment Vendors

    ☐ Professional, Technical, or Trade Associations

    ☐ Private Consultants

    ☐ Educational Institutions

    ☐ Others: ______

21. Would your firm be interested in State of Michigan assistance in training your workforce in any computer-based technologies you acquire?

☒ YES ☐ NO

Why are you interested/not interested in assistance from the State of Michigan? If interested, for which kinds of training would you look to the State? What sort of assistance from the State would be most useful to you at this location?

PLEASE PROVIDE THE NAME AND PHONE NUMBER OF THE PERSON WHO FILLED OUT THIS SURVEY SO THAT WE MAY VERIFY OUR UNDERSTANDING OF THE INFORMATION PROVIDED, IF NECESSARY:

Name ______________________________

Phone Number ______________________________

We would like to thank you for your cooperation.

LOCAL ECONOMIC DEVELOPMENT AGENCIES PARTICIPATION

The AIM Project work with Local Economic Development Agencies (LEDAs) has centered on:

a. identifying the LEDAs to approach regarding participation

b. contacting these LEDAs to arrange for discussion of the Project

c. meeting with them to reach agreement on their participation in the Project

d. preparing and mailing agreement letters

e. arranging for and hosting the first LEDA group meeting with members of the CRT and Project staff

f. arranging for and hosting a dinner meeting of LEDAs, CRT, Project Staff, and AIM Advisory Board members

g. preparing, printing and distributing the survey instrument

h. preparing and providing to the LEDAs instructions and suggested methods for administering the survey

i. arranging for payments to the LEDAs of incentive fees based on the number of surveys mailed, returned, and tabulated

j. initiating plans with LEDAs for scheduling local conferences with CRT members to review Project findings

The identification of the appropriate LEDAs began in January. The establishment of Community Growth Agencies (CGA) in the State contributed at this stage of the process by helping to consolidate many regional economic development activities. This helped the Project by establishing county-wide agencies with the authority to survey on a broad base, thus avoiding potential territorial questions. The CGA development also included an incentive that encouraged LEDAs to obtain computers. With the use of computers, the LEDAs could handle the AIM data to be provided by the State, and also record and access the data that would by gathered by the AIM survey.

By analyzing the location of the major auto manufacturing plants in the State and reviewing concentrations of suppliers, it was fairly easy to identify the LEDAs to approach for the initial AIM Project. With the pilot LEDAs, approximately 80% of the auto-related establishments are included in targeted areas. The addition of other LEDAs during the second year of the Project will bring even more of the State's auto-related establishments into the Project.

The next phase of the Project was to contact the identified agencies and mail to them a description of the AIM Project along with a summary of the role that LEDAs would be expected to play. The Project Director and the LEDA Coordinator called on several of the LEDAs to discuss personally the Project and request an agreement to cooperate. The Database Coordinator attended many of these meetings to explain what was planned and to assess the computer capability in each area. Time did not permit personal meetings with all LEDAs, but extensive telephone conversations were held to describe the Project and the expected agreement. A formal letter of agreement was prepared and mailed to the LEDAs after the "handshake agreement meetings" were held. This letter described in detail what the Project would provide to the LEDA and, also, what the LEDA was expected to provide to the Project.

A major event was held March 13th at the University of Michigan North Campus Commons. At this four-hour meeting, representatives of each LEDA attended, as did members of the CRT and Project Staff. A brief description of the AIM Project was given by the Project Director, with special emphasis on the role of the LEDAs. Each member of the CRT of then described one area of the CRT's research, and explained how the information gained would have implications for manufacturers and suppliers in the LEDA regions. Time for questions was allowed and used extensively. The Database Coordinator explained how information would be provided to the LEDAs and how it should be handled. A copy of the core database was distributed; LEDAs were encouraged to review the list of firms and make deletions, additions, and corrections to the list before the final survey mailing lists were prepared. The Project timeframe was discussed, and the meeting concluded after LEDA representatives from Jackson County and Flint/Genesse County described projects they currently had with their respective auto-related industries. This was done to assist in the building of networks, one of the planned outcomes of the Project.

A draft of the LEDA survey instrument was prepared in January and used in early meetings with the LEDAs. After review by a survey specialist, revision, and pretesting, it was prepared for printing and distribution to the LEDAs.

At the suggestion of a LEDA, the survey had an introductory letter from the Governor printed on its cover sheet. An instruction letter detailing a suggested method of distributing the survey was sent to the LEDAs. The intent was that the survey would be done by mail, but two of the LEDAs planned to use the survey along with a corporate call program they were concurrently scheduling. All LEDAs were encouraged to work for as high a response rate as possible. Funding was obtained from the Independent Business Research Office of Michigan (IBROM), and used to offer a significant monetary incentive to the LEDAs for achieving a high survey response rate.

After the surveys were distributed, the LEDA Coordinator communicated with the LEDAs and offered assistance and advice as needed. Two meetings were scheduled and held with the Database Coordinator and selected LEDAs to test the response coding forms that were required for preparing survey information for data entry.

LEDA representatives were also included in the first meeting of the AIM Advisory Board. This dinner meeting, held at the University of Michigan's Inglis House on May 21st, included AIM Project Staff, members of the CRT, as well as LEDA representatives and Advisory Board members. This event was significant in obtaining industry support for the Project and building network contacts for the LEDAs.

Anticipated AIM I Deliverables to LEDAs

The local economic development agencies that are participating in the AIM Project are important team members. Their input and activity have helped to determine the success of the Project. While the Project has asked that the LEDAs contribute substantial effort and resources, the LEDAs all stand to gain a substantial amount of information and understanding about their manufacturing base. The deliverables that have benefited and will continue to benefit the LEDAs are:

- Direct contact with all AIM Project researchers.
- Core data on the automotive manufacturers and suppliers in the LEDA's geographical area. This was provided in hard copy and machine-readable form for LEDA's requesting it.
- A professionally-designed survey instrument to be used in obtaining additional information from the establishments in the database. This survey was printed and provided in sufficient quantity to each LEDA. The LEDAs were able to add additional questions to the survey if they wished, thus allowing them to gather additional information that might fit with specific, local activity.
- Direct identification with the Project, which was announced to State and national press. Additional, extensive press coverage will be generated with the release of the final report.

- All additional data gathered by the surveys in their respective areas will be available for the LEDAs to review and use as appropriate. The information should be added to the core data and retained by the LEDAs for future use. An electronic clipping file (explained in the database development section) has also been established, and can be accessed by each LEDA

- Meetings of the LEDAs and CRT are held to allow the LEDAs to share in plans and findings of the Project.

- One direct consultation by the AIM Project CRT with the staff of each LEDA or a presentation of the findings of the Project at an event planned and hosted by the LEDA. The findings will be reviewed, and specific attention paid to the impact of the findings not only on the State and region as a whole, but also on the specific geographic region represented by the LEDA.

- Summary findings will be prepared in printed form for use by the LEDAs and others in the State. A slide show will be used as part of the Project in its briefings with the LEDAs.

LEDAs PARTICIPATING IN THE AIM PROJECT	
City of Flint Dept. of Community Development	Kathy Stoughton Director
Detroit Economic Growth Corporation	Jack Pryor Executive Director
Downriver Community Conference	Richard Buss, Director Economic Development
Economic Development Corporation of Wayne County	Gregory E. Pitoniak Managing Director
Flint Genesee Corporation	Anthony Schifano Executive Director
Forward Bay County, Inc.	Richard R. Konicek Executive Director
Grand Valley State College Office for Economic Expansion	Douglas J. Smith Director
Greater Jackson Chamber of Commerce	Robert W. Carlton President
Jackson Alliance for Business Development	Robert T. Wolf Executive Director
Jackson Community College	Dr. Clyde E. LeTarte President
Lansing Economic Development Corporation	Tom Lipps Commercial Industrial Officer
Macomb Community College	Betty Pritchard, Director Community Research
Macomb County Planning Commission	John W. Carroll, Jr. Assistant Director
Oakland County Economic Development Group	Joseph D. Joachim Director
Saginaw Area Growth Alliance	Jerry Breen Director
Washtenaw Development Council	Michael Ammann Executive Director

THE CONFER SYSTEM

Overview

The primary interaction between the participants of the AIM project takes place electronically over a communication system known as Confer. Confer is a computer conferencing software package which allows the organization of written entries, transmission of electronic mail, broadcasting of public bulletin messages, and interfacing of participants' personal computers. This communication system provides the following benefits to the AIM project:[1]

1. There is no need to coordinate the schedules of those who want to talk with one another.

2. People can stay on the job rather than spend hours traveling to a meeting.

3. Confer provides an automatically-organized written record of the group discussion.

4. Confer allows one to collect and compose thoughts, and to contribute them at a convenient time and place.

5. Everyone in the group can contribute fully without impinging on anyone else's wishes to speak.

6. You can discuss multiple topics with all members of the group and communicate privately with particular individuals at the same time. There is no interference among these exchanges.

7. Everyone can experience rapid and multiple feedback to an idea, and can give and receive feedback on such responses.

Confer Characteristics

Confer is the "brand name" for a computer software package that allows a multitude of personal computers to be linked together through a mainframe computer to provide a structured flow of information between participants. The Confer communication software was developed by Dr. Robert Parnes at the University of Michigan for use with the Michigan Terminal System (MTS) and is available through Advertel Communication Systems, Inc. (Ann Arbor, MI). Presently, the software is being supported on the mainframes at Wayne State University, the University of Alberta, and the University of Michigan.

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[1]Dr. Robert Parnes and Dr. Edgar Taylor, "The User's Guide to Confer II," November 1983, p. 7.

The structure of Confer allows the participants to electronically supplement face-to-face meetings and other forms of communication in order to raise issues, set agendas, followup on tasks, direct and coordinate geographically dispersed persons, and distribute information. The system allows this electronic exchange easily, quickly, and inexpensively between a group that normally would have difficulty coordinating schedules for face-to-face meetings. Through a micro-computer hookup (either at the office or at home), Confer is available twenty-four hours a day for input or retrieval of information.

Although Confer itself is capable of tying 960 participants together, a conference typically ties 10 to 100 participants together. Conferences running on Confer software have facilitated three hundred participants without any serious system or software failure. In practical terms, Confer itself does not create any software constraints to the number of items, responses, or messages that can be organized within the system. These limits are a function of budget constraints concerning computer time and data storage fees. Time of operation is also not a physical constraint. Conferences may run one day or may be extended indefinitely.

Elements of an Electronic Conference

The following definitions provide the terminology used in the Confer system and the various elements that structure the input and output of information.[2]

A <u>conference</u> is the basic social structure in Confer. It is where a group of users interact with each other. There are many conferences running in parallel under Confer.

An <u>item</u> is text composed by any participant in the conference. It is immediately available to everyone who uses the conference. It becomes a permanent part of the conference and can be viewed by everyone in the conference until it is deleted.

A <u>response</u> is a short reaction to an item. Any participant is free to respond. Every response is immediately available to everyone who can use the conference. Through items and responses, Confer makes it easy for someone to present ideas to the group, to let the members give their feedback, and for all to share and comment on the feedback of other members.

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[2]Parnes and Taylor, pp. 8, 96.

A message lets any participant communicate in private with any other participant in the conference. Messages may be composed at any time. They are transmitted instantaneously to designated recipients, to be read and replied to at their convenience. The message recipient may delete the message after it has been read, or archive it for later reference.

A bulletin is a short, dated announcement. Any participant can post a bulletin which will be shown to the rest of the conference members. Bulletins can be used to announce important events, or to draw attention to a problem or an item.

A note is a reminder to the participant. The participant entering the note is the only one who can see the entry. The participant can instruct Confer to show the note on a particular day (such as a meeting reminder) or for a specific period of time (such as a timetable).

The agenda is a listing of a number of descriptive category names. Associated with each category is a list of the items that fit into the category. The conference organizer maintains the agenda.

The organizer is the person who has administrative responsibility for the conference. One of the main responsibilities of the organizer is to maintain the conference agenda. Jack Russell served as the conference organizer during the Project's first year.

AIM's Use of Confer

The operation of an electronic conference system is the only practical method of providing a continuous interaction among the participants of the AIM project. The schedules, geographic dispersion, and work habits of the members of the CRT would have inhibited the exchange of information among the members and would have made impossible the coordination of such a project.

The AIM conference has been in operation since December 18, 1984. Between the conference's beginning and August 18, 1985, the sixteen participants (Table I) have entered 173 items and 422 responses to those items, and sent 5,666 messages to each other. This equates to twenty-three messages sent per day, or two per each participant's signon.

Confer was used throughout the Project to facilitate the administrative tasks of the director and the coordinator, provide a medium for exchanging information and ideas, archive and organize approximately two hundred news article summaries, and disseminate trip reports of personal interviews.

Table I

Confer System Participants

Name	Title	Organization
David J. Andrea	AIM Project Coordinator	Central Research Team
Alan Baum	Data Resources Coordinator	Technology Deployment Service Mich. Dept. of Commerce
Kitty Bridges	Manager	Information Services Center, ITI
John Cleveland	Deputy Director	Business Information Div. Mich. Dept. of Commerce
David E. Cole	Director	Office for the Study of Auto. Transp., U-M
Michael S. Flynn	Researcher	Center for Social and Economic Issues, ITI
Lauren Hammett	Database Development Associate	AIM Project
J. Downs Herold	Director Liaison	Industrial Develop. Division, IST
Richard Hervey	President	Sigma Associates
Jerry Jurek	President	Pyrenees Consulting Corp.
Daniel Luria	Senior Researcher	Center for Social and Economic Issues, ITI
Jack Russell	Director	Technology Deployment Service Mich. Dept. of Commerce
Debra Schneider	Business Development Representative	Target Industries Section Mich. Dept. of Commerce
Donald N. Smith	Director	Industrial Develop. Division, IST

Name	Title	Organization
Patrick Sweet	Research Associate	Industrial Technology Institute
Sharon Woollard	Section Chief	Target Industries Section Mich Dept. of Commerce

MICHIGAN OEM FACILITIES AND THEIR LEADERSHIP

This section is a partial listing of the Michigan facilities of General Motors Corporation, Ford Motor Company, Chrysler Corporation, and American Motors Corporation. The directory that we have compiled is of the OEM's major manufacturing, office (corporate and divisional headquarters), and engineering facilities within the State.

The primary emphasis of this directory is the manufacturing facilities of the corporations. In this regard, the entries are as accurate and complete as possible. There was greater difficulty in compiling accurate entries for the various engineering, sales, research and development, and subsidiary establishments of the OEMs. This difficulty is in direct relation to the merger and reorganization activity taking place throughout the industry. This directory will be updated and expanded in the second year of the Project.

Each entry lists the facility or operation, its address and (where available) phone number, plus its associated UAW local, if any. Where possible, information on plant managers and union presidents is identified.

AMERICAN MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

American Motors World Headquarters
2777 Franklin Road Southfield, MI 48034

MANAGER: Jose J. Dedeurwaeder (Pres. & CEO) PHONE: 313-827-1000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

American Motors Technical Center (AMTEK)
14250 Plymouth Road Detroit, MI 48232

MANAGER: John W. Mowrey (V.P.-Product Planning) PHONE: 313-493-2000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Evart Products Co.
601 W. 7th Street Evert, MI 49631

MANAGER: Angus McGregor PHONE: 313-734-5522

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Evert Products Luman Road Plant
6251 Lauman Road Evart, MI 49631

MANAGER: Angus McGregor PHONE: 313-734-5522

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

AMERICAN MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Iron River Plant (Coleman Products)
West U.S. #2 P.O. Box 112 Iron River, MI 49935

MANAGER: Donald G. McMaster PHONE: 906-265-9965

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Mercury Plastics Co.
34501 Harper Avenue Mt. Clemens, MI 48043

MANAGER: David R. Moenssen PHONE: 313-791-8100

UAW LOCAL 155
8230 E. 8 Mile Road Detroit,

LOCAL PRESIDENT: Richard Karas PHONE:

****

Vehicle Test Facilities
12626 U.S. #12 Brooklyn, MI 48230

MANAGER: Dennis Hahnke PHONE: 517-592-8811

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

CHRYSLER CORPORATION MICHIGAN FACILITY DIRECTORY

Eldon Axle Plant
6700 Lynch Road   Detroit, MI   48234

MANAGER: Doug Cowdrey   PHONE: 313-267-3750

UAW LOCAL 961
22826 Arcadia   St. Clair Shore, MI   48082

LOCAL PRESIDENT: Francis D. McKinnon   PHONE:

****

Detroit Forge Plant
6700 Lynch Road   Detroit, MI   48234

MANAGER: Donald Santola   PHONE: 313-267-3750

UAW LOCAL 47
18725 Van Dyke   Detroit, MI   48234

LOCAL PRESIDENT: Ronald R. Gossett   PHONE: 313-464-9015

****

Detroit Trim Plant
12501 Dequindre   Detroit, MI   48212

MANAGER: R. D. Zimmerman   PHONE: 313-956-6385

UAW LOCAL 212 unit 38
12101 Mack Ave.   Detroit, MI   48215

LOCAL PRESIDENT: John R. Coyne   PHONE:

****

McGraw Glass Plant
9400 McGraw   Detroit, MI   48288

MANAGER: PHONE: 313-943-4900

UAW LOCAL 227
6790 Buhr   Detroit, MI   48212

LOCAL PRESIDENT: Wilbert Spencer   PHONE:

****

CHRYSLER CORPORATION MICHIGAN FACILITY DIRECTORY

Jefferson Assembly Plant
12200 East Jefferson   Detroit, MI   48215

MANAGER: Dennis Edwards   PHONE: 313-823-8900

UAW LOCAL 7
1551 Hart   Detroit, MI   48214

LOCAL PRESIDENT: William Lawrence   PHONE: 313-835-9245

****

Outer Drive Mfg. Tech. Center
3675 East Outer Drive   Detroit, MI   48234

MANAGER: Stan Paurazas   PHONE: 313-369-7469

UAW LOCAL 212 unit 52
12101 Mack Ave.   Detroit, MI   48215

LOCAL PRESIDENT: John R. Coyne   PHONE:

****

World Headquarters
1200 Lynn Townsend Drive   Highland Park, MI   48288

MANAGER: Lee A. Iacocca   PHONE: 313-956-5741

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Sterling Stamping Plant
35777 Van Dyke   Sterling Height, MI   48077

MANAGER: Neil Harbin   PHONE: 313-977-4700

UAW LOCAL 1264
7450 15 Mile Road   Sterling Hts., MI   48077

LOCAL PRESIDENT: Lawrence Leach   PHONE: 313-294-3926

****

CHRYSLER CORPORATION MICHIGAN FACILITY DIRECTORY

Sterling Hts. Assembly Plant
38111 Van Dyke   Sterling Height, MI   48077

MANAGER: D. W. Roller   PHONE: 313-978-6422

UAW LOCAL 1264
7450 15 Mile Road   Sterling Hts., MI   48077

LOCAL PRESIDENT: Lawrence Leach   PHONE: 313-294-3926

****

Trenton Chemical Plant
5437 West Jefferson   Trenton, MI   48183

MANAGER: Larry A. Roman   PHONE: 313-671-4741

UAW LOCAL 372 unit 1
16016 Jackson St.   Taylor, MI   48180

LOCAL PRESIDENT: P. S. Wolford   PHONE: 313-284-6535

****

Trenton Engine Plant
2000 Van Horn   Trenton, MI   48183

MANAGER: Robert Garlo   PHONE: 313-671-4129

UAW LOCAL 372 unit 2
16016 Jackson St.   Taylor, MI   48180

LOCAL PRESIDENT: P. S. Wolford   PHONE: 313-284-6535

****

Warren Stamping Plant
22800 Mound Road   Warren, MI   48091

MANAGER: Jim Unis   PHONE: 313-497--3630

UAW LOCAL 869
36059 Boyce   Mt. Clemens, MI   48043

LOCAL PRESIDENT: Tom Sondej   PHONE:

****

CHRYSLER CORPORATION MICHIGAN FACILITY DIRECTORY

Warren Truck Assembly Plant
21500 Mound Road   Warren, MI   48091

MANAGER: Harold Jones   PHONE: 313-497-2500

UAW LOCAL 140
20158 Stotter   Detroit, MI   48234

LOCAL PRESIDENT: G. E. Wojcik   PHONE: 313-891-5773

****

Mound Road Engine Plant
20300 Mound Road   Warren, MI   48091

MANAGER: Dennis Mason   PHONE: 313-369-7601

UAW LOCAL 51
11731 Mt. Elliot   Detroit, MI   48212

LOCAL PRESIDENT: Ray Bianchi   PHONE:

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Pilot Plant
17000 Oakwood Blvd.   Allen Park, MI   48121

MANAGER: E. E. Pitman   PHONE: 313-322-3000

UAW LOCAL 931
23310 Notre Dame   Dearborn, MI   48124

LOCAL PRESIDENT: C. Hamilton   PHONE: 313-582-5819

****

Dearborn Environmental Labs
19000 Oakwood Blvd.   Dearborn, MI   48121

MANAGER: G. G. Stafford   PHONE: 313-322-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Dearborn Assembly Plant (Rouge)
3001 Miller Road   Dearborn, MI   48121

MANAGER: Louis M. Callaway, Jr.   PHONE: 313-322-3000

UAW LOCAL 600 unit 2A
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

Dearborn Engine Plant (Rouge)
P.O. Box 1616   Dearborn, MI   48121

MANAGER: E. E. Wise   PHONE: 313-322-3000

UAW LOCAL 600 unit 4
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Dearborn Frame Plant (Rouge)
P.O. Box 1664   Dearborn, MI   48121

MANAGER: J. B. Hayes   PHONE: 313-322-3000

UAW LOCAL 600 unit 12
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

Dearborn Glass (Rouge)
3001 Miller Road   Dearborn, MI   48121

MANAGER: J. F. Clark   PHONE: 313-322-3000

UAW LOCAL 600 unit 14
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

Dearborn Stamping (Rouge)
P.O. Box 1694   Dearborn, MI   48121

MANAGER: M. T. Sara   PHONE: 313-322-3000

UAW LOCAL 600 unit 10
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

Dearborn Tool & Die (Rouge)
P.O. Box 1687   Dearborn, MI   48121

MANAGER: C. H. Lewis   PHONE: 313-322-3000

UAW LOCAL 600 unit 28
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Rouge Steel Company
P. O. Box 1699 Dearborn, MI 48121

MANAGER: M. P. Wojtowicz PHONE: 313-322-1068

UAW LOCAL 600 unit 24
10550 Dix Ave. Dearborn, MI 48120

LOCAL PRESIDENT: Robert T. King PHONE: 313-459-8068

****

Vulcan Forge Works
3900 Wyoming Avenue Dearborn, MI 48121

MANAGER: Bruno Larese PHONE: 313-594-0387

UAW LOCAL 174 unit 156
6495 West Warren Ave. Detroit, MI 48210

LOCAL PRESIDENT: Jim Baker PHONE: 313-485-4688

****

Research And Engineering Center
2000 Rotunda Drive Dearborn, MI 48121

MANAGER: Fred Herr (V.P.) PHONE: 313-322-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Diversified Products Technical Center
17000 Rotunda Drive Dearborn, MI 48121

MANAGER: J. G. Rivard PHONE: 313-322-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

World Headquarters
The American Road Dearborn, MI 48121

MANAGER: Donald Petersen (Chairman) PHONE: 313-322-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Renaissance Center Offices
300 Renaissance Center Detroit, MI 48243

MANAGER: Offices for various staffs PHONE: 313-568-7500

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Glass Technical Center
25500 W. Outer Drive Lincoln Park, MI 48121

MANAGER: D. E. Siddal PHONE: 313-322-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Livonia Transmission Plant
36200 Plymouth Road Livonia, MI 48150

MANAGER: Eugene E. Wise PHONE: 313-523-3000

UAW LOCAL 182
35603 Plymouth Rd. Livonia, MI 48150

LOCAL PRESIDENT: Robert Little PHONE:

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Milan Plastic Plant
800 County Street   Milan, MI   48160

MANAGER: Al P. Ver   PHONE: 313-439-8811

UAW LOCAL 600 unit 36
10550 Dix Ave.   Dearborn, MI   48120

LOCAL PRESIDENT: Robert T. King   PHONE: 313-459-8068

****

Monroe Stamping Plant
3200 E. Elm Street   Monroe, MI   48161

MANAGER: Stanley C. Cronenwett   PHONE: 313-243-4702

UAW LOCAL 723
9650 Telegraph   Taylor, MI   48180

LOCAL PRESIDENT: Daniel Brooks   PHONE: 313-964-1345

****

Chesterfield Trim Plant
26090 23 Mile Road   Mt. Clemens, MI   48045

MANAGER: William R. Brooks   PHONE: 313-466-0800

UAW LOCAL 400
20745 Catalano Dr.   Mt. Clemens, MI   48043

LOCAL PRESIDENT: Robert Tiseo   PHONE: 313-792-0689

****

Mt. Clemens Paint Plant
400 Groesbeck Highway   Mt. Clemens, MI   48043

MANAGER: Greg H. Wold   PHONE: 313-466-1700

UAW LOCAL 400 unit 4
20745 Catalano Dr.   Mt. Clemens, MI   48043

LOCAL PRESIDENT: Robert Tiseo   PHONE: 313-792-0689

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Mt. Clemens Vinyl Plant
151 Lafayette Mt. Clemens, MI 48043

MANAGER: David G. Voita PHONE: 313-466-3300

UAW LOCAL 400
20745 Catalano Dr. Mt. Clemens, MI 48043

LOCAL PRESIDENT: Robert Tiseo PHONE: 313-792-0689

****

Northville Plant
235 E. Main Street Northville, MI 48167

MANAGER: John W. Sherrick PHONE: 313-523-3803

UAW LOCAL 896
31610 Shaw Farmington, MI 48024

LOCAL PRESIDENT: Norman E. Fultz PHONE: 313-474-2199

****

Sheldon Road Plant
14425 Sheldon Road Plymouth, MI 48170

MANAGER: David H. Boerger PHONE: 313-451-8750

UAW LOCAL 845
16227 Washburn Detroit, MI 48221

LOCAL PRESIDENT: Nearlean Young PHONE: 313-861-0923

****

Manufacturing Process Laboratory
24500 Glendale Redford, MI 48239

MANAGER: Fred Bolling PHONE: 313-592-2100

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Plastics Dev. & Appl. Center
24300 Glendale Road Redford, MI 48239

MANAGER: Fred Bolling PHONE: 313-592-2100

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Michigan Proving Grounds
4305 Mack Road Romeo, MI 48065

MANAGER: John F. Conrad PHONE: 313-752-8500

UAW LOCAL 400 unit 18
20745 Catalano Dr. Mt. Clemens, MI 48043

LOCAL PRESIDENT: Robert Tiseo PHONE: 313-792-0689

****

Romeo Tractor & Equipment Plant
701 East 32 Mile Road Romeo, MI 48065

MANAGER: J. van de Kerckhof PHONE: 313-752-8000

UAW LOCAL 400 unit 8
20745 Catalano Dr. Mt. Clemens, MI 48043

LOCAL PRESIDENT: Robert Tiseo PHONE: 313-792-0689

****

Saline Instrumentation & Plastic Plan
7700 Michigan Avenue Saline, MI 48176

MANAGER: Mohindrapal (Paul) Gill PHONE: 313-429-6311

UAW LOCAL 892
211 Monroe St., Box 391 Saline, MI 48176

LOCAL PRESIDENT: Dennis Bryan PHONE: 313-423-7611

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Sterling Heights Plant
39000 Mound Road @ 17 Mile   Sterling Height, MI   48077

MANAGER: Earl C. Koops   PHONE: 313-826-5000

UAW LOCAL 228
39209 Mound Rd.   Sterling Hts., MI   48708

LOCAL PRESIDENT: E. Ralph Poszich   PHONE:

****

Van Dyke Axle Plant
41111 Van Dyke   Sterling Height, MI   48078

MANAGER: Karl Watler   PHONE: 313-826-6000

UAW LOCAL 2280
39058 Van Dyke   Sterling Hts., MI   48078

LOCAL PRESIDENT: William Stevenson   PHONE: 313-731-7113

****

Tractor Division General Offices
2500 E. Maple Road   Troy, MI   48084

MANAGER: Robert F. Moglia (VP, GM)   PHONE: 313-643-2000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

****

Utica Trim Plant
50500 Mound Road   Utica, MI   48087

MANAGER: Roger J. Storves   PHONE: 313-826-0603

UAW LOCAL 400 unit 6
20745 Catalano Dr.   Mt. Clemens, MI   48043

LOCAL PRESIDENT: Robert Tiseo   PHONE: 313-792-0689

****

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Michigan Truck Plant
38303 Michigan Avenue   Wayne, MI   48184

MANAGER: R. G. Wallace   PHONE: 313-467-0355

UAW LOCAL 900
38110 Michigan Ave., Box 227   Wayne, MI   48184

LOCAL PRESIDENT: Walter J. Washington   PHONE: 313-439-7082

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Wayne Assembly Plant
37625 Michigan Avenue   Wayne, MI   48184

MANAGER: John Latini   PHONE: 313-467-0355

UAW LOCAL 900
38110 Michigan Ave., Box 227   Wayne, MI   48184

LOCAL PRESIDENT: Walter J. Washington   PHONE: 313-439-7082

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Wixom Assembly Plant
5000 Grand River Expressway   Wixom, MI   48096

MANAGER: Paul R. Nolan   PHONE: 313-344-5000

UAW LOCAL 36
28700 Wixom Rd.   Wixom, MI   48096

LOCAL PRESIDENT: Orville Spencer   PHONE: 313-965-5545

....

Rawsonville Plant
McKean and Textile Roads   Ypsilanti, MI   48197

MANAGER: J. A. Hudson   PHONE: 313-487-8000

UAW LOCAL 898
8975 Textile Rd.   Ypsilanti, MI   48197

LOCAL PRESIDENT: Jake Smith   PHONE:

....

FORD MOTOR COMPANY MICHIGAN FACILITY DIRECTORY

Ypsilanti Plant
128 Factory Street   Ypsilanti, MI   48197

MANAGER: Frank J. Croskey   PHONE: 313-484-8000

UAW LOCAL 849
454 Chidester St.   Ypsilanti, MI   48197

LOCAL PRESIDENT: B. J. Bowen   PHONE: 313-483-9748

****

GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

CPC Adrian Manufacturing Div.
1450 East Beecher Street   Adrian, MI   49221

MANAGER: Fred Meissinger   PHONE: 517-265-4222

UAW LOCAL 2031
11480 Shepherd Road   Onsted, MI   49265

LOCAL PRESIDENT: Mike Budwit   PHONE: 517-467-4567

****

CPC Bay City
100 Fitgerald Street   Bay City, MI   48706

MANAGER: Patricia M. Carrigan   PHONE: 517-894-7210

UAW LOCAL 362
232 Lagoon Beach   Bay City, MI   48706

LOCAL PRESIDENT: Edward Huizar   PHONE: 517-684-2311

****

Rochester Products Division
999 Randall Street   Coopersville, MI   49504

MANAGER: David F. Stepanovich   PHONE: 616-837-7476

UAW LOCAL 2151
12201 Rich Avenue   Grant, MI   49327

LOCAL PRESIDENT: Michael Bieber   PHONE:

****

BOC Cadillac Motor Division
2860 Clark Avenue   Detroit, MI   48232

MANAGER: John O. Grettenberger   PHONE: 313-554-5066

UAW LOCAL 15
1020 Springwells   Detroit, MI   48209

LOCAL PRESIDENT: J. M. Wilson   PHONE:

****

GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Detroit Forge Division
8435 St. Aubin Detroit, MI 48212

MANAGER: Clifford J. Smith PHONE: 313-556-1717

UAW LOCAL 262
9050 Warwick Detroit, MI 48228

LOCAL PRESIDENT: Thomas C. Marsh PHONE:

****

Saginaw Detroit Plant
1840 Holbrook Detroit, MI 48212

MANAGER: Jerome W. Zimmer PHONE: 313-556-6550

UAW LOCAL 235
4784 Baldwin Detroit, MI 48214

LOCAL PRESIDENT: Rufus C. Fluker PHONE: 313-921-0831

****

Truck & Bus Detroit Assembly
1840 Piquette Detroit, MI 48202

MANAGER: R. L. Thornton PHONE: 313-356-6305

UAW LOCAL 157
29841 Van Born Road Romulus, MI 48174

LOCAL PRESIDENT: William R. Robinson PHONE: 313-728-7600

****

Detroit Diesel Allison
13400 West Outer Drive Detroit, MI 48228

MANAGER: Ludvik Koci PHONE: 313-592-5000

UAW LOCAL 163
22635 Plymouth Road Detroit, MI 48239

LOCAL PRESIDENT: Earnest L. Williams PHONE:

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Fisher-Guide Division
6307 West Fort Street Detroit, MI 48216

MANAGER: John W. Powser PHONE: 313-554-6700

UAW LOCAL 329
14154 Colpaert Warren, MI 48093

LOCAL PRESIDENT: Robert Miodonski PHONE:

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General Motors Headquarters
3044 West Grand Blvd. Detroit, MI 48202

MANAGER: Roger B. Smith PHONE: 313-556-5000

UAW LOCAL 572
3044 West Grand Blvd. Detroit, MI 48202

LOCAL PRESIDENT: Conrad Kozlinski PHONE:

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AC Spark Plug Division
1601 Averill Avenue Flint, MI 48506

MANAGER: John R. Wilson PHONE: 313-766-5000

UAW LOCAL 651
5431 Antionette Drive Flint, MI 48507

LOCAL PRESIDENT: Robert Shaw PHONE:

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BOC Flint Plant
4300 South Saginaw Flint, MI 48507

MANAGER: Robert A. Hameister PHONE: 313-766-3911

UAW LOCAL 581
4425 South Saginaw St. Flint, MI 48507

LOCAL PRESIDENT: Bill D. Reno PHONE: 313-743-6600

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

BOC Buick Motor Division
902 East Hamilton Flint, MI 48505

MANAGER: Don E. Hackworth PHONE: 313-766-1828

UAW LOCAL 599
812 Leith Street Flint, MI 48505

LOCAL PRESIDENT: Fred Myers PHONE: 313-686-0119

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Truck & Bus Group
G-2238 West Bristol Road Flint, MI 48507

MANAGER: Donald E. Mueller PHONE: 313-766-5000

UAW LOCAL 598
3106 West Reid Road Swartz Creek, MI 48473

LOCAL PRESIDENT: Earl L. Henry PHONE: 313-655-4323

****

CPC Flint Engine
G-3248 Van Slyke Road Flint, MI 48507

MANAGER: Phil J. Pierce PHONE: 313-766-5000

UAW LOCAL 659 unit 4
11115 East Bristol Rd. Davison, MI 48423

LOCAL PRESIDENT: Herschel Nix PHONE:

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CPC Flint Manufacturing
300 North Chevrolet Avenue Flint, MI 48555

MANAGER: Robert E. Boruff PHONE: 313-766-5000

UAW LOCAL 659 unit 6
11115 East Bristol Rd. Davison, MI 48423

LOCAL PRESIDENT: Herschel Nix PHONE:

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Fisher-Guide Division
48559 East Coldwater Road   Flint, MI   48559

MANAGER: Al S. Herold   PHONE: 313-234-4636

UAW LOCAL 326
1272 Coldwater Rd.   Flint, MI   48505

LOCAL PRESIDENT: Michael E. Bennett   PHONE: 313-736-7084

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BOC Grand Blanc Manufacturing
10800 South Saginaw   Grand Blanc, MI   48439

MANAGER: Donald Burkhold   PHONE: 313-234-1144

UAW LOCAL 1292
G-6153 South Dort Highway   Grand Blanc, MI   48439

LOCAL PRESIDENT: Jimmy J. Osborne   PHONE: 517-743-3782

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CPC Grand Rapids Metal,Plant 1
300 36th Street, S.W.   Grand Rapids, MI   49508

MANAGER: Harold W. Kruse   PHONE: 616-247-5494

UAW LOCAL 730
3852 Buchanan Ave. S.W.   Grand Rapids, MI   49508

LOCAL PRESIDENT: Donald Byle   PHONE:

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Rochester Products Division
2100 Burlingame S.W.   Grand Rapids, MI   49509

MANAGER: Ronald T. Korte   PHONE: 616-247-5397

UAW LOCAL 167
8078 20th Ave.   Jenison, MI   49428

LOCAL PRESIDENT: P. A. Hilla   PHONE: 616-457-4281

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Inland Division
2150 Alpine Avenue N.W. Grand Rapids, MI 49504

MANAGER: Robert K. Schuler PHONE: 616-747-5830

UAW LOCAL 1231
4269 Alpine N.W. Comstock Park, MI 49321

LOCAL PRESIDENT: Ronald McMichael PHONE: 616-931-5205

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BOC Metfab Plant
5200 East Cork Street Kalamazoo, MI 49001

MANAGER: Michael J. Hanley PHONE: 616-385-1201

UAW LOCAL 488
3731 Covington Rd. Kalamazoo, MI 49002

LOCAL PRESIDENT: Robert E. Ailstock PHONE: 616-381-2703

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BOC Lansing
401 North Verlinden Lansing, MI 48915

MANAGER: Frank Schotters PHONE: 517-377-5210

UAW LOCAL 652
426 Clare St. Lansing, MI 48917

LOCAL PRESIDENT: Gary Watson PHONE: 517-372-7581

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BOC Oldsmobile Division
920 Townsend Street Lansing, MI 48921

MANAGER: W. W. Lane PHONE: 517-377-5000

UAW LOCAL 1618
R1 11740 State Rd. Eagle, MI 48822

LOCAL PRESIDENT: Ross F. Sherman PHONE: 517-627-7916

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

BOC Cadillac Engine
12200 Middlebelt Road Livonia, MI 48150

MANAGER: Robert W. Ferrari PHONE: 313-523-0316

UAW LOCAL 22
4300 Michigan Ave. Detroit, MI 48210

LOCAL PRESIDENT: M. L. Douglas PHONE: 313-861-0873

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Fisher-Inland Division
28400 Plymouth Road Livonia, MI 48150

MANAGER: Ana-Marie Vegas PHONE: 313-523-8200

UAW LOCAL 174
6495 West Warren Ave. Detroit, MI 48210

LOCAL PRESIDENT: Jim Baker PHONE: 313-485-4688

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CPC Livonia Spring And Bumper
13000 Eckles Road Livonia, MI 48190

MANAGER: Helmuth H. Majer PHONE: 313-464-5000

UAW LOCAL 262
9050 Warwick Detroit, MI 48228

LOCAL PRESIDENT: Thomas C. Marsh PHONE:

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GM Proving Grounds
Hickory/General Motors Rd. Milford, MI 48042

MANAGER: F. D. Smithsom PHONE: 313-685-5000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Central Foundry Division
701 North Glenwood   Pontiac, MI   48506

MANAGER: C. Michael Taylor   PHONE: 313-857-1007

UAW LOCAL

LOCAL PRESIDENT: PHONE:

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BOC Orion Assembly Plant
4555 Giddings Road   Pontiac, MI   48055

MANAGER: Leslie (Les) D. Richards   PHONE: 313-377-5100

UAW LOCAL 5960
821 Baldwin   Pontiac, MI   48055

LOCAL PRESIDENT: W. H. Spencer   PHONE:

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CPC Pontiac Motors
900 Baldwin Avenue   Pontiac, MI   48055

MANAGER: J. Michael Losh   PHONE: 313-857-0303

UAW LOCAL 653
2535 Normadele   Pontiac, MI   48055

LOCAL PRESIDENT: Harold D. Cox   PHONE: 313-673-1339

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CPC Pontiac Motors
One Pontiac Plaza   Pontiac, MI   48053

MANAGER: J. Michael Losh   PHONE: 313-857-5000

UAW LOCAL 417 unit 120
1640 Stephenson Hwy.   Troy, MI   48083

LOCAL PRESIDENT: Bernice Adams   PHONE:

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

Truck And Bus Div.
660 South Blvd. E.   Pontiac, MI   58053

MANAGER: Patrick J. Coletta   PHONE: 313-456-3311

UAW LOCAL 594
525 East Blvd. S.   Pontiac, MI   48053

LOCAL PRESIDENT: Don Douglas   PHONE: 313-334-2459

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Detroit Diesel Allison
36880 Ecorse   Romulus, MI   48174

MANAGER: Robert Ranka   PHONE: 313-595-5387

UAW LOCAL 483
24411 Union   Dearborn, MI   48126

LOCAL PRESIDENT: James J. Kowalik   PHONE: 313-561-4372

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Central Foundry Div.
77 West Center   Saginaw, MI   48601

MANAGER: George G. Johnston   PHONE: 517-776-3364

UAW LOCAL 455
110 Florence   Saginaw, MI   48602

LOCAL PRESIDENT: Rudy Rueda   PHONE: 517-752-6362

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Delco Moraine Saginaw Mfg. Div
2328 East Genesee   Saginaw, MI   48601

MANAGER: C. E. White   PHONE: 517-776-2801

UAW LOCAL 467
2104 Farmer   Saginaw, MI   48601

LOCAL PRESIDENT: Frederick Ziehl   PHONE:

****

GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

CFD Nodular Iron Casting
2100 Veterans Memorial PKwy Saginaw, MI 48601

MANAGER: Michael B. Hamilton PHONE: 517-776-2063

UAW LOCAL 668
1601 North 6th St. Saginaw, MI 48601

LOCAL PRESIDENT: Clayton N. Moll PHONE:

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CFD Saginaw Grey Iron Casting
1629 North Washington Saginaw, MI 48601

MANAGER: Gordon J. Marinoff PHONE: 517-776-5000

UAW LOCAL 699
1911 Bagley Saginaw, MI 48601

LOCAL PRESIDENT: Norman Myer PHONE: 517-755-0569

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Saginaw Products
628 North Hamilton Saginaw, MI 48602

MANAGER: Al Mooney PHONE: 517-776-5101

UAW LOCAL 699
1911 Bagley Saginaw, MI 48601

LOCAL PRESIDENT: Norman Myer PHONE: 517-755-0569

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Saginaw Products
3900 Holland Road Saginaw, MI 48601

MANAGER: Mark R. McCabe PHONE: 517-776-3900

UAW LOCAL 467
2104 Farmer Saginaw, MI 48601

LOCAL PRESIDENT: Fredrick Ziehl PHONE:

GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

EDS Headquarters Building
23077 Greenfield Road   Southfield, MI   48075

MANAGER: Roy Reidlinger   PHONE: 313-443-3000

UAW LOCAL

LOCAL PRESIDENT: PHONE:

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Fisher-Inland Div. Tecumseh
5550 Occidental Hwy.   Tecumseh, MI   49286

MANAGER: Richard Norton   PHONE: 517-423-0300

UAW LOCAL 1341
2756 Bent Oak   Adrian, MI   49221

LOCAL PRESIDENT: Thomas Laughlin   PHONE: 517-265-4002

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Hydra-Matic Division
1 Hydra-Matic Drive   Three Rivers, MI   49093

MANAGER: Gary C. Armstrong   PHONE: 616-278-0211

UAW LOCAL 2093
15802 Hoffman Rd.   Three Rivers, MI   49093

LOCAL PRESIDENT: Ernest Bain   PHONE: 517-683-6555

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Balance Engineering Division
6490 E. 12 Mile Road   Warren, MI   48090

MANAGER: Gerhard K. Haas   PHONE: 313-575-8743

UAW LOCAL 160
28504 Lorna   Warren, MI   48092

LOCAL PRESIDENT: Pete Kelly   PHONE: 313-575-1014

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

CPC Chevrolet Motor Division
30007 Van Dyke Warren, MI 48093

MANAGER: Robert D. Burger PHONE: 313-492-8822

UAW LOCAL 160
28504 Lorna Warren, MI 48092

LOCAL PRESIDENT: Pete Kelly PHONE: 313-575-1014

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Hydra-Matic Division
23500 Mound Road Warren, MI 48091

MANAGER: Eugene J. Rymar PHONE: 313-575-0405

UAW LOCAL 909
24249 Mound Rd. Warren, MI 48901

LOCAL PRESIDENT: Bill Apple PHONE:

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Research Laboratories
12 Mile And Mound Road Warren, MI 48090

MANAGER: Robert A. Frosch PHONE: 313-575-3127

UAW LOCAL 160
28504 Lorna Warren, MI 48092

LOCAL PRESIDENT: Pete Kelly PHONE: 313-575-1014

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Hydra-Matic Division
2623 Tyler Road Ypsilanti, MI 48198

MANAGER: Thomas R. Zimmer PHONE: 313-485-5000

UAW LOCAL 735
1422 Blossom Ypsilanti, MI 48197

LOCAL PRESIDENT: Ronald Murry PHONE: 313-485-2224

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GENERAL MOTORS CORPORATION MICHIGAN FACILITY DIRECTORY

BOC Willow Run Assembly
2625 Tyler Road Ypsilanti, MI 48198

MANAGER: Frank D. Faga PHONE: 313-485-5000

UAW LOCAL 1176
1070 Mc Cartney Rd. Ypsilanti, MI 48197

LOCAL PRESIDENT: Richard Debs PHONE:

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THE CONFER SYSTEM

Overview

The primary interaction between the participants of the AIM project takes place electronically over a communication system known as Confer. Confer is a computer conferencing software package which allows the organization of written entries, transmission of electronic mail, broadcasting of public bulletin messages, and interfacing of participants' personal computers. This communication system provides the following benefits to the AIM project:[1]

1. There is no need to coordinate the schedules of those who want to talk with one another.
2. People can stay on the job rather than spend hours traveling to a meeting.
3. Confer provides an automatically-organized written record of the group discussion.
4. Confer allows one to collect and compose thoughts, and to contribute them at a convenient time and place.
5. Everyone in the group can contribute fully without impinging on anyone else's wishes to speak.
6. You can discuss multiple topics with all members of the group and communicate privately with particular individuals at the same time. There is no interference among these exchanges.
7. Everyone can experience rapid and multiple feedback to an idea, and can give and receive feedback on such responses.

Confer Characteristics

Confer is the "brand name" for a computer software package that allows a multitude of personal computers to be linked together through a mainframe computer to provide a structured flow of information between participants. The Confer communication software was developed by Dr. Robert Parnes at the University of Michigan for use with the Michigan Terminal System (MTS) and is available through Advertel Communication Systems, Inc. (Ann Arbor, MI). Presently, the software is being supported on the mainframes at Wayne State University, the University of Alberta, and the University of Michigan.

[1]Dr. Robert Parnes and Dr. Edgar Taylor, "The User's Guide to Confer II," November 1983, p. 7.

The structure of Confer allows the participants to electronically supplement face-to-face meetings and other forms of communication in order to raise issues, set agendas, followup on tasks, direct and coordinate geographically dispersed persons, and distribute information. The system allows this electronic exchange easily, quickly, and inexpensively between a group that normally would have difficulty coordinating schedules for face-to-face meetings. Through a micro-computer hookup (either at the office or at home), Confer is available twenty-four hours a day for input or retrieval of information.

Although Confer itself is capable of tying 960 participants together, a conference typically ties 10 to 100 participants together. Conferences running on Confer software have facilitated three hundred participants without any serious system or software failure. In practical terms, Confer itself does not create any software constraints to the number of items, responses, or messages that can be organized within the system. These limits are a function of budget constraints concerning computer time and data storage fees. Time of operation is also not a physical constraint. Conferences may run one day or may be extended indefinitely.

Elements of an Electronic Conference

The following definitions provide the terminology used in the Confer system and the various elements that structure the input and output of information.[2]

A conference is the basic social structure in Confer. It is where a group of users interact with each other. There are many conferences running in parallel under Confer.

An item is text composed by any participant in the conference. It is immediately available to everyone who uses the conference. It becomes a permanent part of the conference and can be viewed by everyone in the conference until it is deleted.

A response is a short reaction to an item. Any participant is free to respond. Every response is immediately available to everyone who can use the conference. Through items and responses, Confer makes it easy for someone to present ideas to the group, to let the members give their feedback, and for all to share and comment on the feedback of other members.

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[2]Parnes and Taylor, pp. 8, 96.

A message lets any participant communicate in private with any other participant in the conference. Messages may be composed at any time. They are transmitted instantaneously to designated recipients, to be read and replied to at their convenience. The message recipient may delete the message after it has been read, or archive it for later reference.

A bulletin is a short, dated announcement. Any participant can post a bulletin which will be shown to the rest of the conference members. Bulletins can be used to announce important events, or to draw attention to a problem or an item.

A note is a reminder to the participant. The participant entering the note is the only one who can see the entry. The participant can instruct Confer to show the note on a particular day (such as a meeting reminder) or for a specific period of time (such as a timetable).

The agenda is a listing of a number of descriptive category names. Associated with each category is a list of the items that fit into the category. The conference organizer maintains the agenda.

The organizer is the person who has administrative responsibility for the conference. One of the main responsibilities of the organizer is to maintain the conference agenda. Jack Russell served as the conference organizer during the Project's first year.

AIM's Use of Confer

The operation of an electronic conference system is the only practical method of providing a continuous interaction among the participants of the AIM project. The schedules, geographic dispersion, and work habits of the members of the CRT would have inhibited the exchange of information among the members and would have made impossible the coordination of such a project.

The AIM conference has been in operation since December 18, 1984. Between the conference's beginning and August 18, 1985, the sixteen participants (Table I) have entered 173 items and 422 responses to those items, and sent 5,666 messages to each other. This equates to twenty-three messages sent per day, or two per each participant's signon.

Confer was used throughout the Project to facilitate the administrative tasks of the director and the coordinator, provide a medium for exchanging information and ideas, archive and organize approximately two hundred news article summaries, and disseminate trip reports of personal interviews.

Table I

Confer System Participants

Name	Title	Organization
David J. Andrea	AIM Project Coordinator	Central Research Team
Alan Baum	Data Resources Coordinator	Technology Deployment Service Mich. Dept. of Commerce
Kitty Bridges	Manager	Information Services Center, ITI
John Cleveland	Deputy Director	Business Information Div. Mich. Dept. of Commerce
David E. Cole	Director	Office for the Study of Auto. Transp., U-M
Michael S. Flynn	Researcher	Center for Social and Economic Issues, ITI
Lauren Hammett	Database Development Associate	AIM Project
J. Downs Herold	Director Liaison	Industrial Develop. Division, IST
Richard Hervey	President	Sigma Associates
Jerry Jurek	President	Pyrenees Consulting Corp.
Daniel Luria	Senior Researcher	Center for Social and Economic Issues, ITI
Jack Russell	Director	Technology Deployment Service Mich. Dept. of Commerce
Debra Schneider	Business Development Representative	Target Industries Section Mich. Dept. of Commerce
Donald N. Smith	Director	Industrial Develop. Division, IST

Name	Title	Organization
Patrick Sweet	Research Associate	Industrial Technology Institute
Sharon Woollard	Section Chief	Target Industries Section Mich Dept. of Commerce

THE CRT INTERVIEWS

Universal Questions

In this set of questions, we're interested in getting a broad overview of the situation in, and prospects for, the automotive industry in Michigan.

U.1. What will be the three (3) most important changes in cars and light trucks themselves between now and 1992? How will the first such change you mentioned impact facilities in Michigan?

U.2. What will be the three (3) most important changes in the way cars and light trucks are made between now and 1992? How will the first such change you mentioned affect facilities in Michigan?

U.3. Do you think that computer-based manufacturing technologies will significantly enhance the prospects of retaining automotive manufacturing activity in the U.S. in the 1985-92 period? In Michigan? In your own operations in the State?

U.4. Please indicate the three (3) Michigan automotive facilities -- OEM or independent, excluding final vehicle assembly plants -- that you believe will be the strongest, and the three that will be the weakest, performers in the 1987-1992 period.

U.5. What can the State of Michigan do to help a changing automotive industry -- both OEMs and independent suppliers -- remain strong in Michigan in the next five to seven years?

Vehicle Program Siting Questions

Now we'd like to ask you some questions that focus on vehicle programs and their siting. This area is important in itself, but also because of the implications for supplier location and investment of where cars and light trucks are assembled.

V.1. What car and light truck programs are currently sited in Michigan assembly plants, and when are they scheduled to terminate? How much "play" is there in each program's termination date? We are particularly interested in Detroit Cadillac Assembly and Flint Plant 40 (Wixom, Wayne, and Dearborn; Jefferson).

V.2. We have constructed a chart showing the current and reported future vehicle programs of Michigan assembly plants. Will you please examine it, and help us fill in gaps in our knowledge? What new vehicle programs are planned? Which are assured and which still speculative? At which market segments will each be aimed?

VEHICLE PROGRAM SITING IN MICHIGAN, 1985 - 1992

Facility	Current Program Vehicles	Ends	Future Program Vehicles	Begins
CLARK/FLEETWOOD	B	88	?	
	D: limos			
PONTIAC West	S15			
East	med	86	GMT400	87
Central	hvy, bus			
WILLOW RUN	X	85	H(GM70)	87
LANSING	N			
(BUICK) FLINT#4			H(GM70)	86
#40			?	
ORION	C			
CHEVY FLINT TRK 2	Utilities			
1	C K			
PONTIAC #1	P			
#8	G	88	GM80	89
POLETOWN			E/K(GM30)	86
			L (GM25)	87
			V (GM35)	88
LANSING 2			GM33	87
WIXOM	Mark			
	Continental			
	Town Car			
WAYNE TRUCK	Utilities			
WAYNE (Car)	Esc/Lynx	90	?	
	EXP	85		
DEARBORN	Mstng/Cpri	86	?	
JEFFERSON	K: Ar/Rel	88	A	89
	E: LeB/600			
	E/NYer		C	87
STRLG HTS	H: Lncr/GTS		P	87
WARREN (Truck)	Pickups			
	Utilities	85		
FLAT ROCK			727	87

v.1. What program if any is likely to replace the Bs when their run at Detroit Cadillac Assembly ends? When will that be?

v.2. Where is GM80, the Camaro/Firebird successor, going to be sited? If a decision has not yet been made, when will it be?

v.3. What is Wayne's future if no domestic successor to Escort/Lynx is launched? Can that plant outlive its current program?

v.4. What is Dearborn Assembly's future, if any, after Mustang? If no new vehicle program is contemplated, what are the implications for other plants and departments in the Rouge?

v.5. Is Jefferson Assembly assured of a new C in 1987 to replace E and New Yorker? If Aries and Reliant are replaced in 1988 as scheduled, is it sure that Jefferson would get the successor?

V.3. For both current and future multiplant vehicle programs, which is (are) the core plant(s)? Which, instead, would be the first to lose a shift or to be shut down if demand fell? What factors determine the order of shutdown or shift loss? Are non-core plants given less hard automation? Given your planned product array, which products and facilities do you view as safe and which at greatest risk?

v.6. Of the three U.S. plants slated for Hs (GM70), how do Willow Run and Buick City rank?

v.7. If GM30s from Poletown cut into C sales, which would lose a shift or be shut down first, Wentzville or Orion? Why?

v.8. How does Wayne rank relative to Edison in the future of Escort/Lynx if sales volumes drop off due to the non-extension of the VRA?

v.9. If there is a new program successor to Mustang/Capri, is it assured that Dearborn would get it?

v.10. What is Jefferson's rank relative to Newark for K cars and their successor program? Will that new program need two plants? Three? What's Jefferson's rank relative to St. Louis for the E body successor? Will **that** program be multiplant?

V.4. Which if any Michigan assembly plants are likely to have a future even if no firm commitment of a new vehicle program has yet been made? Which are unlikely, and why? How important in this are plant size, age, architecture, and labor climate? Do you have a system you would share with us that combines these "plant viability" factors into an overall measure that can be compared across plants?

v.11. How, if at all, do age, size, and architecture affect the chances that a new program will be sited at Clark once the B run ends in 1988 or 1989?

v.12. How, if at all, so age, size, and architecture affect the chances that a new program will be sited at Dearborn beyond Mustang?

v.13. Is Jefferson's age, size, or architecture a major risk factor, relative to Newark and/or St. Louis, in the post-K and post-E decision?

V.5. Of the new programs planned, which will require greenfield sites?

v.14. Which programs are seen as radical departures, requiring clean sheet facilitizing? Which are "semiradical" and could go either way? Which are only "incrementally new"?

v.15. Is there likely to be one or more non-domestic greenfield cluster like Nissan's in Smyrna? Will Saturn (Alpha, Concept 90) tend to make future non-domestic projects more green- and less brownfield? How would this affect Michigan's prospects for attracting additional non-domestic assembly operations?

[For V.6., V.7., v.16., and v.17. respondents:] Some industry observers predict that the U.S. new car market will be increasingly split between a "commodity market" composed of long production run vehicles in each size class, and a series of "niche markets" served by a profusion of lower volume product offerings.

V.6. Which programs are anticipated as long production run vehicles? Which are more niche-oriented, and what is the minimum acceptable niche size? How much does that minimum depend on market segment?

V.7. What is the role of segment mix and demographics? Will future upscale models tend to be assembled nearer to coastal markets where European sales are concentrated?

v.16. If captive imports and/or joint venture vehicles can be counted as domestic for CAFE purposes, what joint ventures might this prompt? Is Michigan a good U.S.-Japan joint venture site, or would the typical U.S. OEM prefer its JV partner to be on a coast near where parts and subassemblies are shipped in?

v.17. Are performance cars, e.g., GM80, likely to be assembled in the South or West because of the stronger muscle car market there?

V.8. What is the outlook for investment by foreign-based OEMs in the U.S. and especially Michigan between now and 1992? If NUMMI, Smyrna, Marysville, and Flat Rock were to be joined by a purebred Toyota facility and a Mitsubishi (or Mitsubishi-Chrysler) plant, where do you think those two new facilities would be most likely to be sited?

v.18. What are the capacity, plant age, technology, and Japanese market circumstances of each Japanese-based OEM? How might these impact the decision about whether -- and if so when and where -- to initiate or add to U.S. production?

V.9. What vehicle programs of the U.S.-based OEMs will be sited outside the U.S. and Canada? Would a profusion of niche products increase the volume of captive imports (U.S. market absorbs "extra" output in Japan and Europe), or decrease it (U.S. more competitive in niche vehicles)?

v.19. Are there likely to be more upscale niche vehicles such as Ford's Merkur imported by the Big Three? How many and when? Do you see such captive import niche cars costing sales at existing Michigan assembly plants such as Orion (Wixom, Sterling Heights)?

v.20. [For OEMs:] Do you anticipate that Canada will host a smaller, larger, or unchanging proportion of your North American assembly and engine- and transmission-building investment in 1992 as compared to 1983-85? If smaller or larger, by how much?

Vehicle and Component Characteristics Questions

We'd now like to pose some questions concerning how the product and some of its major subsystems are likely to change in the next five to seven years. Please keep in mind that we're particularly interested in how these changes might affect facilities in Michigan.

Drive Train

c.1. The table below shows the current, and the 1983 University of Michigan Delphi forecast for the 1992, distribution of U.S.-assembled passenger cars according to front or mid-engine and front or rear drive. Please indicate your expectations for 1992 in the blanks provided.

	1984	1992 Delphi	Your 1992
Front engine, rear drive	48%	15%	____%
Front engine, front drive	51	81	____
Mid-engine, rear drive	1	4	____

c.2. Which Michigan automotive facilities, OEM and independent, will be most affected if your 1992 forecast proves accurate?

c.3. List the up to five (5) components for which demand would be seriously reduced if the shift you predicted away from rear drive occurs.

c.4. The current, and 1992 Delphi forecast of, transmission mix is shown in the table below. Please indicate your expectations for 1992 in the blanks provided.

	1984	1992 Delphi	Your 1992
Manual			
Four-speed	6.4%	10%	____%
Five-speed (incl overdrive)	9.0	16	____
Total manual	15.4	26	____
Automatic			
Three-speed		19%	____%
Four-speed		41	____
Continuously Variable (CVT)	0	14	____
Five- & six-speed		0	____
Total automatic	85.6%	74	____

c.5. Most observers agree that there remains a major high-volume production problem for the belt of a CVT transmission. Do you believe this problem will be solved and, if so, when? Are there other significant problems that have to be overcome before CVTs can be brought to the mass market?

c.6. What, in your opinion, is the maximum engine displacement and curb weight for CVT-equipped vehicles? If the CVT proves successful, do you expect it to displace automatic or manual transmissions/transaxles to a different extent?

c.7. In addition to the belt, what other elements of the CVT are unique and new? If the CVT begins to make inroads in the U.S. market in the next five to seven years, which transmission components and which suppliers are most at risk? Which stand to gain, and why?

c.8. Which company or companies are likely to produce CVTs if they prove out? Where will they be produced, and where will there major components be cast and machined?

c.9. What, in your view, is the minimum annual economic production volume (2-shift operation) for a high-production module for the following transmissions, today and -- in your view -- for 1992?

	Today	1992
Automatic	___,000	___,000
Manual	___,000	___,000
CVT	___,000	___,000

c.10. What product and process technology changes do you foresee in the 1986-92 period in conventional transmissions, transaxles, and axles?

Frame/Structure/Body

c.11. The current, and 1992 Delphi forecast of, frame mix among separate body frame, integral body frame (unibody), and Fiero-type space frame are shown in the table below. Please indicate your prediction of the mix in 1992.

	1984	1992 Delphi	Your 1992
Separate Body Frame	25%	0%	____%
Integral Body Frame	74	90	____
Space Frame	1	10	____

c.12. Which major body and structural components will be most affected by the changes you predicted above?

c.13. Which Michigan automotive facilities, OEM and independent, would be most affected if your forecast proves accurate?

c.14. What is your 1992 forecast for reinforced plastic and steel body panels for the components listed below? (each row must sum to 100%)

	Steel	Reinforced Plastic
Hood outer	____%	____%
Door exterior	____	____
Roof exterior	____	____
Fender outer	____	____
Fender inner	____	____

c.15. What is your forecast for the material mix – steel, aluminum, and plastic-reinforced composites – in frame/structural members in integral body/frame and space frame designs in 1992? (each row must sum to 100%)

	Steel	Aluminum	Composites
Integral Body/Frame	____%	____%	____%
Space Frame	____	____	____

c.16. Some newer assembly plants have their own on-site stamping facility. Some niche vehicles have plastic body panels. In your view, will either of these developments intensify significantly enough by 1992 to affect any of the OEM's current stamping plants? Which one(s)? Any of the large independent stampers? Which?

Spark-Ignited Engines

c.17. The current, and the Delphi forecast of the 1992, engine mix are shown in the table below. Please indicate your forecast in the blanks provided.

	1984	1992 Delphi	Your 1992
3-Cylinder	0%	5%	____%
4-Cylinder	47	58	____
5-Cylinder	0	0	____
6-Cylinder (V6)	26	32	____
8-Cylinder (V8)	27	5	____

c.18. Many of the engines installed in U.S.-assembled light vehicles are of proven, mature design. Many of the technologies are in turn mature and long-standing. Is this about to change significantly? Specifically, what percentage of the engines that power U.S.-made cars and light trucks are likely to undergo major redesign between now and 1992? What are the implications of your answer for automotive facilities, OEM and independent, in Michigan?

c.19. The current, and the Delphi forecast for the 1992, penetration rates of aluminum engine blocks and cylinder heads are shown in the table below. Please indicate your 1992 forecast for aluminum use in heads and blocks in the blanks provided.

	1992 Delphi	Your 1992
Heads	40%	____%
Blocks	15	____

c.20. What major design changes or features do you foresee in spark-ignited car and light truck engines between now and 1992? Please indicate such changes together with your forecast of how widespread they will become by 1992, i.e., in what percentage of new car and light truck engines they will be embodied. (Prompts: 3- or 4-valve cylinder heads, roller lifters, turbochargers) How would each affect automotive facilities, OEM and independent, in Michigan?

c.21. Ceramics

c.22. What major changes do you expect in how engines are produced over the next five to seven years, and how will such changes, if any, affect Michigan facilities?

c.23. What is the minimum annual economic production volume (2-shift operation) of an engine module today, and what do you think it will be in 1992? (in 000s per year)

Electronics

c.24. The 1983 University of Michigan Delphi forecast was for electronics to constitute about 12 percent of vehicle cost in 1992, up from about 5 percent today. What is your forecast for the 1992 share of vehicle cost accounted for by electronics?

c.25. Which major components (e.g., valves), sensors and controls that now are manually-controlled will be fundamentally changed by the application of electronics between now and 1992? What implications does your answer have for Michigan facilities, OEM and independent?

c.26. Which significant factors, if any, limit the auto industry's ability to move quickly to increase the use of electronic technology in vehicles? (Prompts: cost, technical personnel, capital)

Engineering Process

c.27. What percentage of your engineering employees have a microprocessor-based workstation or computer at their desk? Alternatively, what is the ratio of microcomputers to engineers?

c.28. What percentage of product design in your engineering operation is performed with the aid of computers?

c.29. Improved structural efficiency has been termed crucial to weight and cost reduction and to improved quality. Do you have the capacity in-house to perform computer-based structural analyses such as finite element analysis? If so, are these techniques regularly employed in the design and development process?

c.30. What is the lead time in your component/system from the end of forward planning through design test and production? What steps, if any, are you taking to reduce it? What do you estimate the lead time will be in 1992?

c.31. Do you have in-house design and process capability and knowledge of potentially competitive materials? For example, can you judge what it would take to design and manufacture your part in a variety of materials?

C.1. How do Michigan universities and technical institutions compare, in your view, to those elsewhere in the U.S. and abroad in basic and applied research on automotive product technologies?

Body and Component Materials Questions

Now we'd like to ask you a set of questions that focus on changes in automotive materials. Please keep in mind that we are especially interested in how such changes, should they occur, might affect manufacturing facilities in Michigan.

M.1. To what extent by 1992 will fiber optics replace copper wiring harnesses in domestic car and light truck electrical systems? If to a significant extent, what will be the impact on Michigan suppliers of copper wiring harnesses? To what extent could those facilities adapt their technologies and skill endowments to fiber optics technology? Which of the second- and third-tier Michigan suppliers of connectors, insulation, clips, and so on for copper wiring harnesses are most at risk?

M.2. What is the likelihood -- and the likely extent -- of ceramic or other high-temperature plastic parts being used in engines and/or transmissions? In the 1985-1992 time frame, will their market penetration (if any) be limited to heavy duty applications? In which programs? Produced where?

M.3. What are the major trends in soft trim styling and manufacture? How sensitive are Michigan's trim operations to changes in product mix and market segmentation?

M.4. How much basic knowledge exists about the solidification mechanics of aluminum castings alloys, as compared to iron alloys? How much has this been translated into practical gating assistance for major automotive components?

M.5. What speeds and feeds are required to machine properly the types of aluminum castings contemplated, and are these practical with today's machine tool technology? What impact do recent cutting tool developments (e.g., practical diamond tools) have on the rate at which aluminum castings replace iron and steel?

M.6. What developments in aluminum casting and machining technologies (if any) have motivated the contemplated shift to aluminum for many more cylinder heads and engine blocks?

m.1. What will be the extent of usage of car and light truck aluminum engine blocks and cylinder heads in 1988 and in 1992?

	1988	1992
Percent of Engine Blocks		
Percent of Cylinder Heads		

m.2. What percentage of car and light truck aluminum blocks and heads will be imported in 1988 and in 1992?

	1988	1992
Engine Blocks		
Cylinder Heads		

m.3. What will be the distribution of block design among unsleeved and sleeved and, within, sleeved, of wet and dry sleeve? In light of your answer, do you think it is existing engine plants or the foundries that supply them that are more at risk over the 1985-92 period from aluminum engine blocks?

m.4. By what casting technique(s) will aluminum blocks and heads be made in the 1985-92 time period?

* Sand Casting
* Shell Molding
* Lost Foam Casting
* Gravity (Semi-) Permanent Mold Casting
*Normal Density Die Casting
* Pore-Free Density Die Casting
* Other(s) _____

m.5. What will be the distribution of alloy usage in aluminum blocks and heads in 1987? In 1992?

Engine Blocks	1987	1992
Alloy 319		
355		
356		
380		
390		
Other		

Cylinder Heads	1987	1992
Alloy 319		
355		
356		
380		
390		
Other		

m.6. What proportion of aluminum blocks and heads will be made from primary and from secondary smelting?

	Primary	Secondary
Engine Blocks		
Cylinder Heads		

m.7. To what extent may the projected aluminum scrap supply and recycling capacity of Michigan affect the State's prospects in the shift to aluminum engine castings? What are Michigan's strengths and weaknesses with regard to attracting or retaining secondary smelters needed in the shift?

M.7. What impact if any does the fact that many of the industry's engine plants are located in Michigan have on the siting decisions about new aluminum casting facilities?

M.8. What will happen to Michigan's captive and independent ferrous and nonferrous foundries now casting iron heads and blocks should there be a widespread shift to aluminum by 1992? What investment in plant and equipment would be required for them to adapt?

m.8. How amenable are OEM captive head and block machining facilities in Michigan to the change from iron to aluminum? Will they keep the machining work despite the materials change, or will much of the work be resourced to save the cost of refitting existing machining plants?

m.9. What opportunities, if any, are there for Michigan's independent machining facilities in the shift to aluminum?

M.9. Will the shift to greater aluminum usage for heads and blocks require new machining lines or will changes (how major?) to existing lines suffice? How well based are Michigan's machine tool builders, compared to their domestic and foreign competitors, in the special requirements of machining aluminum?

m.10. How well developed are shrink models for precision aluminum head and block castings? How available are these models to Michigan pattern makers?

m.11. Do the heat treatment, impregnation, and other requirements for aluminum heads and blocks present any opportunities for Michigan firms in these lines of business?

M.10. Are there labor intensity implications of the shift from iron to aluminum casting of heads and blocks? If so, what are they? Are there different skill requirements in pattern- and mold-making, in casting, in machining, and in tooling?

M.11. What is the current state of the art in automotive applications of reinforced plastics and composites (hereafter, RPC), and what developments in the U.S. and abroad are foreseen in terms of resin cost, filler cost and amount required, material formulation consistency, and resistance to temperature? Which mechanical properties of RPCs are most important to automotive engineers, and how is the state of knowledge likely to evolve between now and 1992 with regard to modulus, tensile strength, compressive strength, and coefficient of thermal expansion? Finally, are there new RPC materials that are likely to have a significant effect on utilization rates between now and 1992?

M.12. In which automotive applications are significant increases in functional (i.e., not just decorative) uses or RPC? Please estimate the pounds per typical vehicle in the following categories/applications:

	1988	1992
Chassis Parts		
Hood Panels		
Deck Panels		
Other Body Parts		
Engine and Related Parts		
Other Power Transmission Parts		
Steering and Suspension		
Interior Structure		
Fuel Tanks		
Bumpers		
Other		

Which classes of RPCs are likely to be used in which applications, and how is the choice made? In any of the applications listed above, is there likely to be significant import competition? If so, why?

M.13. It has been estimated that the economic tradeoff point between reinforced plastic body/spaceframe and state-of-the-art steel unibody has risen from 25-50,000 a decade ago to about 100,000 today? What would you estimate to be the volume flashpoint in 1988? In 1992?

M.14. What effect if any do the following reported trends have on the probable rate of RPC usage?

* Smaller, more differentiated model runs
* Modular construction

* Shorter development and implementation leadtimes
* Part count simplification

m.12. For which models or classes (e.g., sports, luxury) will RPCs be applied in priority? Will that change between 1986 and 1992? If so, how?

m.13. Of those bodies with a space frame, what will be the materials distribution for the parts of the frame?

	1988	1992
Electro-Galvanized Steel		
Hot-Dipped Galvanized Steel		
Uncoated Steel		
RPC		
Other _____		

m.14. What will be the comparative production equipment and tooling investments, and the comparative operating (maintenance, changeover, etc.) costs, between RPCs and steels? Please estimate RPCs as a percentage of steel:

	Investments	Operating Costs
Molding Machines/Stamping Presses		
Molds/Dies		
Secondary Operations		
Quality Verification Equipment		
Other _________		

m.15. What will be typical hourly production rates for body component stamping/molding plants in 1988 and in 1992?

	1988	1992
Steel Stampings		
Molded RPCs		

If you forecast a major improvement in RPC production rate, please indicate how much of the improvement will be due to new molding equipment (___%), new plastic materials (___%), and to other factors ______ (___%)?

m.16. What will be the total paint cure/dry cycle time and maximum temperature for RPC exterior components in 1988 and in 1992?

	1988	1992
Time (minutes)		
Max. Temp. (deg. F)		

If you foresee a significant decrease in either cycle time or temperature, how much of the advance will be due to new paint materials (___%), new paint equipment (___%), new plastic materials (___%), and to other factors ______ (___%)?

M.15. How do Michigan universities and technical institutions compare, in your view, to those elsewhere in the U.S. and abroad in (a) casting technology in general, and aluminum casting technology in particular; and in (b) RPC technology?

Major Input Sourcing Questions

Now we'd like to pose a set of questions concerning which Michigan and non-Michigan facilities -- OEM and independent -- manufacture the components and subsystems that go into Michigan-assembled cars and light trucks.

I.1. First, however, please indicate what OE automotive product(s) you manufacture in your Michigan facility(ies), regardless of where the cars and light trucks they go into are assembled.

----

i.1. For each current GM car and light truck program assembled in Michigan, which facilities -- captive or independent -- supply which and how many (percent, or 000s per year) of the major components and subassemblies that appear in the tables below?

	DETROIT CADILLAC ASSEMBLY Cadillac (D)	 Delta(B)
Major body stampings (hoods,	----	----
decks, roofs, doors, floor	----	----
pans, fenders, etc.) and	----	----
stamped subassemblies	----	----
Engines		
Chev 3.8 V6 231	----	----
Olds 5.0 V8 307	----	----
Cadi 4.1 V8 249	----	----
Transmissions	----	----
	----	----
Rear axles, U-joints,	----	----
& differentials	----	----

	LAKE ORION ASSEMBLY SedanDeVille, 98, Electra (C)
Major body stampings	----
& stamping plant	----
subassemblies	----
Engines	
Buic 3.0 V6 181	----
Buic 3.8 V6 231	----
Transaxles	----

	PONTIAC PLANT 1 Fiero (P)
Major body stampings	----
& stamped/molded	----
subassemblies/panels	----
Engines	
Pont 2.5 I4 151	----
Chev 2.8 V6 173	----
Buic 3.0 V6 181	----
Transmissions	----

Rear axles, U-joints,	----
& differentials	----

	PONTIAC PLANT 8 Regal, Supreme (G)
Major body stampings	----
& stamping plant	----
subassemblies	----
Engines	
Chev 4.3 V6 262	----
Chev 5.0 V8 305	----
Transmissions	----

Rear axles, U-joints,	----
& differentials	----

	LANSING ASSEMBLY Somerset, Calais, GrandAm (N)
Major body stampings	----
& stamping plant	----
subassemblies	----
Engines	
Pont 2.5 I4 151	----
Buic 3.0 V6 181	----
Transaxles	----

	CHEVY FLINT TRUCK Utilities	C/K
Major body stampings	----	----
& stamping plant	----	----
subassemblies	----	----
Engines		
	----	----
Transmissions	----	----
	----	----
Rear axles, U-joints,	----	----
& differentials	----	----

i.2. For each current Ford car and light truck program assembled in Michigan, which facilities -- captive or independent -- supply which and how many of the major components and subassemblies that appear in the tables below?

	DEARBORN ASSEMBLY Mustang/Capri (Fox)
Major body stampings (hoods, decks, roofs, doors, floor pans, fenders, etc.) and stamped subassemblies	---- ---- ---- ----
Engines	
Ford 2.3 I4 140	----
Ford 3.8 V6 232	----
Ford 5.0 V8 302	----
Transmissions	---- ----
Rear axles, U-joints, & differentials	---- ----

	WAYNE (CAR) ASSEMBLY Escort/Lynx, EXP (Erika)
Major body stampings & stamped/molded subassemblies/panels	---- ---- ----
Engines	
Ford 1.6 I4 98	----
Transmissions	---- ----

	MICHIGAN (WAYNE) TRUCK Utilities
Major body stampings	----
& stamped/molded	----
subassemblies/panels	----
Engines	

Transmissions	----

Rear axles, U-joints,	----
& differentials	----

	WIXOM ASSEMBLY Mark, Continental, Town Car (S)
Major body stampings	----
& stamped/molded	----
subassemblies/panels	----
Engines	
Ford 5.0 V8 302	----
BMW 2.4 I6 149 T/D	----
Transmissions	----

Rear axles, U-joints,	----
& differentials	----

i.3. For each current Chrysler car and light truck program assembled in Michigan, which facilities -- captive or independent -- supply which and how many of the major components and subassemblies that appear in the tables below?

	JEFFERSON ASSEMBLY K Cars	E Cars
Major body stampings (hoods,	----	----
decks, roofs, doors, floor	----	----
pans, fenders, etc.) and	----	----
stamped subassemblies	----	----
Engines		
Chry 2.2 I4 135	----	----
Mits 2.6 I4 156	----	----
Transaxles	----	----
	----	----

	STERLING HTS ASSEMBLY Lancer/LeBaronGTS
Major body stampings	----
& stamped/molded	----
subassemblies/panels	----
Engines	
Chry 2.2 I4 135	----
Transaxles	----

	DODGE CITY (WARREN TRUCK) Pickups	Utilities
Major body stampings	----	----
& stamped/molded	----	----
subassemblies/panels	----	----
Engines		
	----	----
	----	----
Transmissions	----	----
	----	----
Rear axles, U-joints,	----	----
& differentials	----	----

i.4. For each known future GM car or light truck program with at least one expected Michigan assembly site, which captive and independent supplier plants will (could) supply the major components and subassemblies listed in the tables below?

	POLETOWN E/K (GM30)	L (GM25), V (GM35)
Major body stampings & stamped/molded subassemblies/panels	---- ---- ----	---- ---- ----
Engines	4.1-l V8 (Livonia) ----	---- ----
Transaxles	---- ----	---- ----

	PONTIAC PLANT 8 GM80
Major body stampings & stamped/molded subassemblies/panels	---- ---- ----
Engines	---- ----
Transaxles	---- ----

	BUICK CITY H (GM70)
Major body stampings & stamped/molded subassemblies/panels	---- ---- ----
Engines	---- ----
Transaxles	---- ----

	WILLOW RUN ASSEMBLY H (GM70)
Major body stampings	----
& stamped/molded	----
subassemblies/panels	----
Engines	

Transaxles	----
	----

i.5. For each known future Ford car or light truck program with at least one expected Michigan assembly site, which captive and independent supplier plants will (could) supply the major components and subassemblies listed in the tables below?

[Does not apply: as of now, no future Ford vehicle programs have been announced for Michigan assembly. CRT interviewers should explore with Ford interviewees whether and to what extent the State's supplier endowment is, or could become, an important influence in the Company's thinking about post-Escort Wayne and post-Mustang Dearborn Assembly.]

i.6. For each known future Chrysler car or light truck program with at least one expected Michigan assembly site, which captive and independent supplier plants will (could) supply the major components and subassemblies listed in the tables below?

	JEFFERSON ASSEMBLY	
	A Cars in '89	C Cars in '87
Major body stampings & stamped/molded subassemblies/panels	----	----
	----	----
	----	----
Engines		
	----	----
	----	----
Transaxles	----	----
	----	----

i.7. Which captive and independent supplier plants will (could) supply the major components and subassemblies listed in the tables below to Mazda's Flat Rock stamping/assembly complex?

	MAZDA (FLAT ROCK)
Major body stampings & stamped/molded subassemblies/panels	----
	----

Engines	

Transaxles	----
	----

i.8. For each of the major components and subassemblies that go into the cars and light trucks that GM assembles or expects to assemble in Michigan, which captive and independent facilities in Michigan (if any) supply (are likely to supply) the most important inputs?

Inputs for Major Stampings/Moldings ___________
(sheet steel, resins; presses, molds, dies, tooling)

Inputs for Engines (block, heads; transfer lines)
Chev 2.8 V6 173
Chev 3.8 V6 229
Chev 3.8 V6 231
Chev 4.3 V6 262
Chev 5.0 V8 305
Pont 2.5 I4 151
Buic 3.0 V6 181
Buic 3.8 V6 231
Olds 5.0 V8 307
Cadi 4.1 V8 249 alum block: _____
Planned new engines

Inputs for Transmissions/Transaxles __________
(casing, housing, CV joint; transfer lines)

Inputs for Rear Axles, U-joints, & Differentials _________
(major castings and forgings; transfer lines)

i.9. For each of the major components and subassemblies that go into the cars and light trucks that Ford assembles or expects to assemble in Michigan, which captive and independent facilities in Michigan (if any) supply (are likely to supply) the most important inputs?

Inputs for Major Stampings/Moldings _________
(sheet steel, resins; presses, molds, dies, tooling)

Inputs for Engines (block, heads; transfer lines)
Ford 1.6 I4 98
Ford 2.3 I4 140
Ford 3.8 V6 232
Ford 5.0 V8 302
Planned new engines

Inputs for Transmissions/Transaxles _________
(casing, housing, CV joint; transfer lines)

Inputs for Rear Axles, U-joints, & Differentials _________
(major castings and forgings; transfer lines)

i.10. For each of the major components and subassemblies that go into the cars and light trucks that Chrysler assembles or expects to assemble in Michigan, which captive and independent facilities in Michigan (if any) supply (are likely to supply) the most important inputs?

Inputs for Major Stampings/Moldings _________
(sheet steel, resins; presses, molds, dies, tooling)

Inputs for Engines (block, heads; transfer lines)
Chry 2.2 I4 135
Planned new engines

Inputs for Transmissions/Transaxles _________
(casing, housing, CV joint; transfer lines)

Inputs for Rear Axles, U-joints, & Differentials _________
(major castings and forgings; transfer lines)

i.11. For each of the major components and subassemblies that go into the car(s) (and light truck) that Mazda expects to assemble in Michigan, which captive and independent facilities in Michigan (if any) supply (are likely to supply) the most important inputs?

Inputs for Major Stampings/Moldings _________
(sheet steel, resins; presses, molds, dies, tooling)

Inputs for Engines (block, heads; transfer lines)

Inputs for Transaxles _________
(casing, housing, CV joint; transfer lines)

I.2. Which current vehicle programs -- and their successors -- are likely to be most impacted by U.S. OEM captive import plans between now and 1992? [Note that each OEM will be commenting not just on its own, but on the others', plans and their impacts]

I.3. Which captive and independent producers of frames, stampings/moldings, engines, transmissions, and transaxles are most at risk from the captive import plans announced for the 1985-1992 period?

I.4. Which captive and independent component-making facilities are most at risk from OEM offshore or Mexican sourcing of engines and transaxles?

I.5. How big and how closeable, in your view, is the cost gap, if any, between the U.S. current typical and best practice, on the one hand, and our least-cost competitor, on the other?

	Current ('85) Gap		Estimated '92 Gap	
	Typical	Best	Typical	Best
Final Assembly				
Stamping/Molding				
Engine				
Transaxle/CVT				
Total Vehicle				

I.6. How will anticipated market shifts affect captive and independent component facilities in Michigan? Will an increasing share for low- and mid-volume niche vehicles help suppliers -- and, if so, which ones -- by providing a profusion of short- and medium-run length product demands? Or is it more likely that greater vehicle differentiation will coexist with greater parts standardization, permitting suppliers that depend on long runs to gain sales?

I.7. What generic factors predict danger for domestic component production, both by the OEMs and by independent suppliers? If one wanted to forecast which parts, or types of parts, were most likely to (a) be pulled in-house by the OEMs, (b) sourced out to domestic suppliers, and (c) sourced offshore or to Mexico, what variables would one want to consider? Value-to-weight ratio? Level of technology embodied in the part? Run length?

I.8. Please give us your view of whether each of the following developments is likely to be a net plus or a net minus for Michigan OEM and independent facilities between now and 1992:

New Frames
Greater Use of Plastic Body Panels
Modular vehicle assembly
Modular ("chunk") subassembly sourcing
Rising ratio of EFI to Carburetion
Rising ratio of FWD to RWD

i.12. [OEMs only] What are the product-specific economics of engine and transaxle transportation, and do you expect them to change between now and 1992? How much extra, if any, would you be willing to pay to source engines or transaxles domestically for reasons of logistics, engineering continuity, and so on?

I.9. What effect on major component sourcing do you expect from the ongoing reorganization of GM? Will the possibility of greater "entrepreneurship" by GM component plants be a major competitive factor for independent supplier facilities in Michigan? For which suppliers, making which parts?

I.10. Which original equipment automotive components and subassemblies (up to five) now typically made inside the OEMs' Michigan facilities are most likely to be sourced outside by 1992? Please indicate to what extent the outside source will be (a) Mexico or offshore; (b) U.S. or Canada but non-Michigan; or (c) Michigan.

I.11. Which original equipment automotive components and subassemblies (up to five) now typically supplied to the U.S.-based OEMs by independent suppliers are most likely to be pulled into the OEMs? Please indicate the extent to which the OEM facilities receiving -- and the suppliers losing -- the work are located in Michigan.

OEM-Supplier Relations Questions

Now we'd like to get your views on a set of issues concerning how OEMs and their suppliers -- current and prospective -- relate to each other. Please bear in mind that one of our main goals in this area is to assess which suppliers, making which parts of the vehicle, are most likely to prosper -- or most likely to need help if they are to prosper -- as participants in Michigan's automotive economy in the next five to seven years.

R.1. What effect on major component sourcing do you expect from the ongoing reorganization of GM? Will the possibility of greater "entrepreneurship" by GM component plants be a major competitive factor for independent supplier facilities in Michigan? For which suppliers, making which parts? [same as I.8., but asked of different respondents]

R.2. Which components and subassemblies are most likely to be pulled in-house by the OEMs between now and 1992? Why? Which independent supplier facilities in Michigan would be impacted?

R.3. How free are the OEMs to alter substantially their current pattern of domestic subcontracting and offshore sourcing, in light of contractual obligations with suppliers and the UAW, and in light of the "political" clout of captive component plants within the OEMs?

R.4. If the OEMs decrease their level of vertical integration between now and 1992, which parts and subassemblies are they most likely to send out to independent suppliers, both domestic and foreign? In which of these parts/subassemblies would you expect Michigan suppliers to have the best chance to gain work? Why?

R.5. What are the likely developments in OEM sourcing of parts from offshore locations? Which components are most likely to be sent offshore or to Mexico? How do cost differentials balance against JIT and other logistical concerns? For which parts does the desirability of proximity to assembly site justify paying substantially more for the component than it would cost to buy it offshore?

r.1. To what extent are current independent supplier problems rooted in dependence on long production runs? To what extent could supplier implementation of programmable technologies reduce unit cost to permit survival based on many low- and medium-run orders? In which components/subassemblies will long run lengths remain essential to low unit cost?

r.2. What contractual or gentlemen's agreements are required to get suppliers to implement JIT? What additional understandings will have to be reached to entice suppliers to locate within an OEM facility?

r.3. What proportion of your sales to the OEMs are to facilities located more than 300 miles from your plant? Is OEM emphasis on JIT causing you to undertake or consider undertaking new operations closer to the OEM facilities you supply? In Michigan? For which parts or subassemblies?

R.6. How will Mazda's Flat Rock operation affect Michigan independent suppliers? In general, when non-domestic OEMs site production in Michigan, in which cases (i.e., for which parts) are they likely to "bring their own suppliers" versus giving business to Michigan firms? For Mazda in Flat Rock, what does your answer imply about which Michigan facilities stand to gain and which to lose?

R.7. In which parts and subassemblies will modular, or "chunk," sourcing to independent suppliers become common by 1992? In the answer predictable by knowing value-to-weight ratios or relative supplier labor costs? How will the OEMs pick their "module suppliers"? What can suppliers do to improve their chances of selection?

r.4. What are your plans with regard to diversification? Are you aiming to diversify your products **within** automotive or to move away from automotive? What proportion of your current sales are in automotive this year (1985)? What do you predict the proportion will be in 1992? Do you see the automotive aftermarket playing a larger role in your business in 1992 than in 1985, a smaller role, or about the same?

r.5. Have you made -- and, if not, why not? -- recent major investments in your Michigan automotive facilities? In capital equipment? In new plants? What percentage of your sales dollar goes to R&D? How much of your R&D is automotive-related?

r.6. Is your process technology tied to specific materials? Are there indications of impending materials change in any of your automotive products? If so, which products? If such a change does occur, can your current manufacturing process adapt? Or will major new investments be required and, if so, can you afford them or will you have to cede that business?

r.7. With whom, and at what level, does your facility staff interface with the OEMs? With their purchasing people? Their engineering staffs? Both?

r.8. Are you electronically linked to one or more OEM customer(s)? If so, is that link used only for delivery scheduling, or also for exchanging engineering data? If the latter, do you have capabilities for prototype and production-level drawings and specifications?

R.8. How important is supplier engineering competence likely to be in the 1986-1992 period? Which engineering activities are likely to remain in the OEMs due to proprietary product or process and/or system integrity reasons, and which are likely to be a shared OEM and supplier responsibility?

r.9. Will process and/or product innovation capacities protect suppliers? Will shifting more engineering responsibilities to independent suppliers help Michigan firms, or will it tend to hurt them? In which products are Michigan suppliers most and least competent technically? Which Michigan firms' automotive business is most secure as a result of their perceived engineering and design competence?

R.9. Please list the three (3) parts/subassemblies in which you believe time is most likely to run out for independent suppliers doing original equipment automotive business in Michigan?

R.10. [For all independents and for OEM component makers] Do you perform regular, periodic competitive analyses of the firms in your line(s) of business? Do the analyses include offshore competitors? Who are your top three (3) automotive product line competitors -- domestic or foreign -- and where are their plants that produce parts that go head to head with those you produce in Michigan?

Labor Relations Questions

Now we'd like to turn to the area of labor relations. Our primary concern is to assess which aspects of labor-management relations are likely to have the greatest impact on manufacturing costs in Michigan, and to get your sense of how well -- or how poorly -- Michigan is likely to fare in maintaining or increasing its share of U.S. automotive employment.

L.1. What changes are new technologies -- both programmable and dedicated -- bringing with regard to skill requirements in the auto industry? Which jobs, if any, are being deskilled? Which upskilled? Are the skill requirement effects different in the skilled trades than in production work? Are they different in different kinds of skilled work or production work?

l.1. Will modular assembly of vehicles and/or components tend to upskill production jobs **and** skilled jobs, or only the former?

l.2. Do workers perceive the move toward greater use of programmable technologies as being in their interests? Do you believe that the ways in which the new technologies are implemented are inherent in the technologies, or are there a variety of options for their deployment?

L.2. Between 18 and 20 percent of the blue-collar jobs in the U.S. automotive industry today are skilled. What will the figure be in 1992? In which trades, if any, and in which parts of Michigan, if any, is there likely to be a skilled worker shortage? How can/should it be addressed?

L.3. Which are the "basic" skilled trades? By that definition, which job classifications, if any, can and cannot legitimately be combined?

l.3. Which new "megaclasssifications" is auto management trying to implement? In local negotiations over classifications, does management make the argument that programmable technologies require flexibility in job assignment and hence wider classifications?

l.4. What reaction have skilled and production workers had to the new, more streamlined classification systems now in place at NUMMI, Sterling Heights, St. Louis, and elsewhere?

l.5. Are there important differences in the area of job classifications and their combination between OEMs and suppliers? Do first tier suppliers tend to follow the "patterns" established in local bargaining at OEM plants producing similar components?

L.4. Which work rules and lines of demarcation, if any, have a substantial impact on unit production cost in Michigan OEM and independent supplier facilities? How much impact?

l.6. At which Michigan facilities, to your knowledge, are there daily output quotas beyond which employees are not required to work? To what extent have such quota systems been eliminated since 1980?

l.7. Which work rules or lines of demarcation, if any, would have to change significantly to have a material effect on the citing of small car assembly in the U.S. as opposed to offshore?

l.8. Which work rules or lines of demarcation, if any, would have to change significantly to have a material effect on the citing of 4-cylinder engines in the U.S. as opposed to offshore?

l.9. Which work rules or lines of demarcation, if any, would have to change significantly to have a material effect on the citing of manual transaxles in the U.S. as opposed to offshore?

L.5. With regard to blue-collar employee compensation, do you believe that there will be a two-tier pay system in the future? If so, will it be service- or hire-date based? How large a gap will there be between the upper and lower tiers? Will the tiering occur in actual pay or be confined to fringe benefit grow-in periods?

L.6. Will Saturn, Mazda, NUMMI, and Honda mean an end to a single Big Three-based wage-and-benefit pattern? Is Saturn-sharing, in which workers' pay is partly fixed by contract, partly based on overall Saturn profits, and partly based on the work team's productivity and quality rating, spread beyond Saturn? How far beyond? In what time frame? Will it extend beyond small cars?

l.10. Will small car assembly plants become a lower tier? Is that part of the message of the (production, not marketing) GM reorganization into a large car (BOC) and small car (CPC and Saturn) divisions? Could this occur in the 1987 bargaining round? In 1990?

L.7. Will OEM component plants become a lower tier? Will that new lower tier, if there is one, set the standard for first-level independent suppliers as well?

L.8. How will demands for job security be fashioned in the 1987 and 1990 bargaining rounds? Will the JOBS Program be a viable system beyond its expiration in 1990? [see also L.10., l.12., and l.13 below]

l.11. How will area hire and other recall and transfer provisions of the UAW national agreements operate if the industry has more than one tier of wages and benefits?

l.12. The JOBS approach does not readily apply to many supplier firms. What forms will the demand for greater job and income security take, if any, in supplier labor contracts in the 1987-1992 period?

L.9. What, if anything, are the implications for U.S. firms of the Canadian-U.S. UAW split? Will Michigan facilities benefit significantly ?

[For respondents to employment maintenance questions below:] Now we'd like to move from the area of labor-management relations to the question of employment levels. Our main concern here is with Michigan's prospects for maintaining or increasing its share of total U.S. automotive employment in the next five to seven years.]

L.10. Total U.S. employment -- blue- and white-collar combined -- in the U.S. Motor Vehicle and Equipment (i.e., vehicles and OE parts) industry -- SIC 371 -- declined from 1,005,000 in 1978 to 699,000 in 1982, recovering about half of the decline by early 1985 to stand at 867,000. What do you predict the figure will be for 1987 (_ _ _,000) and for 1992 (_ _ _,000)? Michigan hosted 35 percent of the 1978 and 1982 totals and 37 percent of the 1985 total. What share of the national total do you predict Michigan will host in 1987 (_ _%) and in 1992 (_ _%)? If you predict a change, please indicate why.

l.12. Blue-collar U.S. employment in the U.S. Motor Vehicle and Equipment (i.e., vehicles and OE parts) industry -- SIC 371 -- declined from 782,000 in 1978 to 512,000 in 1982, recovering about half of the decline by early 1985 to stand at 669,000. What do you predict the figure will be for 1987 (_ _ _,000) and for 1992 (_ _ _,000)? Do you think Michigan will maintain or gain in relative blue-collar employment share between now and 1992? Why?

l.13. White-collar U.S. employment in the U.S. Motor Vehicle and Equipment (i.e., vehicles and OE parts) industry -- SIC 371 -- declined from 223,000 in 1978 to 187,000 in 1982, recovering about one-third of the decline by early 1985 to stand at 198,000. What do you predict the figure will be for 1987 (_ _ _,000) and for 1992 (_ _ _,000)? Do you think Michigan will maintain or gain in relative white-collar employment share between now and 1992? Why?

Programmable Technology Questions

Now we'd like to get your views in the area of programmable manufacturing technologies. While we would value your assessment of the state of the art in various aspects of computerized automation, please remember that our main interest is in how the changes you expect in the 1985-92 time frame will affect automotive facilities and their workforces in the State of Michigan.

P.1. In the broad effort by the OEMs to deploy programmable automation (hereafter, PA) and computer-integrated manufacturing (CIM) practices, what is the current status report? What are the success stories? What implementation problems need priority attention?

p.1. To what extent has computer-based, JIT-driven production scheduling now been achieved in your [OEM] internal operations? In your [OEM] relations with major suppliers? Overall? Do you expect to see remaining difficulties in this area taken care of by 1992? If not, which problems will remain?

P.2. Where has computer-aided design (CAD) been installed? What percentage of the automobile is now CAD-designed? Will this ever reach 95-100% and, if so, when? What range of CAD workstations has your firm purchased, and from which vendor(s)? What is your ratio of CAD workstations to drafting personnel? What are your expectations about future purchases of CAD workstations?

P.3. What role, if any, does computer-aided engineering (CAE) play in your product development activities? In which areas, if any, do you expect CAE to become more important in the future? What range of CAE workstations has your firm purchased, and from which vendor(s)? What is your ratio of CAE workstations to design engineers? What are your expectations about future purchases of CAE workstations?

P.4. How do you view the role and potential of computer-aided process planning (CAPP)? In which applications will CAPP be most significant?

p.2. How do you view the distinction between 'variant' and 'generative' approaches to CAPP?

p.3. How might increased use of CAPP impact your relations with the facilities that supply you?

P.5. In which areas has the most progress been made in exploiting the advantages of flexible PA? In which areas of automotive manufacturing will flexibility be most significant in the next five to seven years? In which components/subassemblies and operations will volumes or design stability requirements keep hard automation preferable?

P.6. In which manufacturing operations will CIM be most important in the 1985-1992 period? Where will stand-alone tooling operations be replaced by flexible machining systems (FMS)? Where will current hard, or dedicated, automation be most widely replaced by PA systems? What are the factors that underlie decisions about the order in which to flexibly automate particular operations?

P.7. What scales of integration do you aim to achieve by 1992? How much will the answer differ from facility (or facility type) to facility? In which components is integration a more important goal, and why? Will there be some fully-integrated flexibly-automated plants, while others will have only "islands of automation"? Are older assembly plants likely to get PA beyond robotic applications and, if so, what sorts of systems are the priority? Similarly, will older Michigan engine, transmission/transaxle, and rear axle plants be getting significant investments in PA in the next seven years?

p.4. For each element of CIM, where are the leading OEM "beta sites," the first, path-breaking, problem-solving applications? Which of these sites are, or will be, in Michigan?

p.5. How will the further development and deployment of CIM influence the character of your new facilities? Will CIM push things in the direction of more fully-integrated Saturn-style complexes? If so, do you believe that by 1988 (1992) CIM will deliver enough flexibility to allow such in-complex stamping, engine, and molding operations to supply other assembly plants as well?

p.6. Which technologies -- tooling, computer hardware, software, etc. -- do you expect to produce in-house, and which will be acquired outside? What influences will shape the OEM market for CIM technology? Which vendors with a presence in Michigan are positioned for success, and for problems, in the 1985-92 period? Which of those vendors have a manufacturing presence in the State?

P.8. What, in your view, are the key labor relations issues raised by the move toward CAM and CIM?

P.9. Do you see multi-firm design and production consortia as a viable strategy for supplier base rationalization and for cost- and risk-sharing in the PA/CIM transition? How might it work? How prevalent might such arrangements become by 1992?

P.10. To what extent is Michigan likely to play host to captive and independent PA/CIM manufacturing facilities? Do the major PA/CIM vendors' location calculations vary by technology? By customer location? How important a role could the State's technological infrastructure (e.g., ITI, university engineering departments, etc.) play in increasing Michigan's share of the PA/CIM industry?

P.11. It has been alleged that PA increases the penalty associated with inflexible work practices. Do you agree? If so, could you please describe one or two such practices and the problems it (they) pose(s) for the successful deployment of PA? Can you suggest any kind of "deal" between labor and management that might address this problem, if you think a problem exists in this area?

P.12. How do Michigan universities and technical institutions compare, in your view, to those elsewhere in the U.S. and abroad in their capacities with regard to programmable manufacturing technology, both in general and specifically in its automotive applications?

Nonprogrammable Technology Questions

Now we'd like to get into some questions that focus on developments in nonprogrammable manufacturing technologies. We are particularly concerned with how advances in this area are likely to be introduced in Michigan OEM facilities, both existing ones and the greenfield complexes likely to host clean-sheet programs such as Saturn, Alpha, and Liberty.

[Virtually all respondents in this basket are from OEMs.]

N.1. With regard to plans for the 1985-92 time period, and excluding projects slated especially for Saturn (Alpha, Concept 90), what new nonprogrammable manufacturing technologies are likely to be implemented in the U.S. plants of the OEMs and major independent suppliers that produce the following vehicle subsystems? Where possible, please suggest which of these technologies are most likely to be deployed in product programs assembled in Michigan or in Michigan component facilities.

Final vehicle assembly ________
Engines ________
Transmissions/transaxles ________
Rear axles & suspensions ________
Chassis/body structure ________
Body Components ________
Other vehicle subsystems ________

n.1. What are the most important changes in manufacturing technique associated with Saturn?

Final vehicle assembly ________
Engines ________
Transmissions/transaxles ________
Rear axles & suspensions ________
Chassis/body structure ________
Body Components ________
Other vehicle subsystems ________

n.2. What are the most important changes in manufacturing technique associated with Alpha?

Final vehicle assembly ________
Engines ________
Transmissions/transaxles ________
Rear axles & suspensions ________
Chassis/body structure ________
Body Components ________
Other vehicle subsystems ________

n.3. What are the most important changes in manufacturing technique associated with Liberty?

Final vehicle assembly ________
Engines ________
Transmissions/transaxles ________
Rear axles & suspensions ________
Chassis/body structure ________
Body Components ________
Other vehicle subsystems ________

N.2.a. Putting aside manufacturing processes being considered specifically as part of the Saturn (Alpha, Liberty) Project, what are the most important technological advances likely to be manifested in OEM and major supplier plants in the 1985-1992 period? Which, if any, of these advances hold the greatest promise of reducing manufacturing cost enough to alter current make-buy decisions?

n.4. Machining (incl. grinding)
n.5. Forming
n.6. Die Casting
n.7. Near Net Shape Casting
n.8. Forging
n.9. Assembly
n.10. Joining (welding, bonding, ...)
n.11. Coating & Plating
n.12. Plastic Molding & Painting
n.13. Soft Trim

b. What priority problems are anticipated in implementing these technologies? What could help resolve those problems?

c. Which, if any, of the developments you forecast are likely to increase, and which to decrease, the importation of automotive parts and subassemblies? Why?

d. Which, if any, of the developments you forecast are most likely to affect facilities – both OEM and independent – currently involved in automotibve manufacturing in Michigan?

n.14. With regard to the Saturn Project, what are the most important technological advances likely to be manifested in your and your major suppliers' plants in the 1985-1992 period?

Machining (incl. grinding)
Forming
Die Casting
Near Net Shape Casting
Forging
Assembly
Joining (welding, bonding, ...)
Coating & Plating
Plastic Molding & Painting
Soft Trim

b. What priority problems are anticipated?

n.15. With regard to the Alpha Project, what are the most important technological advances likely to be manifested in your and your major suppliers' plants in the 1985-1992 period?

Machining (incl. grinding)
Forming
Die Casting
Near Net Shape Casting
Forging
Assembly
Joining (welding, bonding, ...)
Coating & Plating
Plastic Molding & Painting
Soft Trim

b. What priority problems are anticipated?

n.16. With regard to the Liberty Project, what are the most important technological advances likely to be manifested in your and your major suppliers' plants in the 1985-1992 period?

Machining (incl. grinding)
Forming
Die Casting
Near Net Shape Casting
Forging
Assembly
Joining (welding, bonding, ...)
Coating & Plating
Plastic Molding & Painting
Soft Trim

b. What priority problems are anticipated?

N.3. How do Michigan universities and technical institutions compare, in your view, to those elsewhere in the U.S. and abroad in regard to their capacities in the field on nonprogrammable manufacturing technology, both in general and specifically with respect to automotive applications?

Selected CRT Interviewees
Fiscal Year 1985

NAME	TITLE	CORPORATION
Donald Abelson	Plant Manager C-P-C Group Pontiac Assembly Plant	General Motors Corporation
Rudolph W. Blatt	Program Director Adv. Engineering Staff	General Motors Corporation
Fred Bolling	Director, Manufacturing Processes Laboratory	Ford Motor Company
Lauren L. Bowler	Technical Director Elec./Electronics Systems C-P-C Group	General Motors Corporation
Robert Brauburger	Chief Engineer Technical Computer and Instrument Group	Chrysler Corporation
Edmund C. Burke	Program Director Manufacturing Develop.	General Motors Corporation
Roger Caderet	Managing Director	Automotive Industry Action Group
Robert W. Carlton	President	Greater Jackson Chamber of Commerce
Burt W. Cartwright	Chief Engineer Trans. and Final Drive	Chrysler Corporation
Conrad T. Coen	Director, Worldwide Procurement Planning	Chrysler Corporation
Peggy Columbo	Just-In-Time Program Coordinator	Chrysler Corporation
Gordon D. Corrigan	Chief Engineer	General Motors Corporation
Robert Costello	Executive Director of Purchasing	General Motors Corporation
Igor Dangoor	Detroit Gear & Axle Saginaw Products	General Motors Corporation
Michael Doherty	Vice President Sales/Engineering	R. J. Tower Corporation

NAME	TITLE	CORPORATION
Robert J. Eaton	Vice President Adv. Engineering	General Motors Corporation
Norman Ehlers	Exec. Dir., Purchasing & Trans. Services	Ford Motor Company
W. Jack Eichler	Adv. Engineering Staff	General Motors Corporation
Henry E. Fradkin	Truck, Tractor, Power-train Strategy Mgr.	Ford Motor Company
Thomas B. Gage	Planning Analyst Advanced Powertrain	Chrysler Corporation
John Green	Exec. Vice President	Sackner Products
David Greeneisen	Senior Director Research & Develop.	Sheller-Globe Corp.
William J. Harahan	Director Mfg. Planning	Ford Motor Company
John W. Hassey	C-P-C Materials Mgt.	General Motors Corporation
B. J. Jurek	President	Pyrenees Consulting Corp.
Robert King	President Local 600	United Auto Workers Union
James Knister	Vice President	Donnelly Corporation
Frank Kocevar	Director, Computer Integrated Mfg.	Kelsey-Hayes Corporation
Victoria F. Kohl	Just-In-Time Coordinator Product and Scheduling	Chrysler Corporation
Odessa Komer	Vice President	United Auto Workers Union
John Konkal	Vice President Engineering	Cross Company
Jack Loeffler	Assistant Managing Director	Automotive Industry Action Group
Ralph Mandarino	President and Chief Exec. Officer	Four Star Corporation

NAME	TITLE	CORPORATION
Bud Mann	Manager, Advanced Powerplant Eng.	Chrysler Corporation
Douglas C. Owen	EDS, Account Mgr.	General Motors Corporation
Philip J. Pierce	Plant Manager C-P-C Group Flint Engine Plant	General Motors Corporation
Doug Plzak	Mfg. Engineering Sys. C-P-C Group	General Motors Corporation
Douglas Radtke	Cadillac – Detroit B-O-C Group	General Motors Corporation
Al Rasegan	Director, Product & Process Engineering Hydra-Matic Div.	General Motors Corporation
William Risk	Development Mgr. Auto Materials Center	General Electric Corp.
Richard D. Rossio	Chief Engineer, Body Electrical Engineering	Chrysler Corporation
James Roth	President Stamping & Frame Div.	The Budd Company
Kenneth E. Ruff	Adv. Engineering Staff	General Motors Corporation
G. Paul Russo	President	Industrial Advisors of America
J. Peter Schmidt	Director, Design Services, C-P-C Group	General Motors Corporation
W. Thomas Schrift	Manager Structure Engineering	Chrysler Corporation
William P. Shulhof	Technical Director Central Foundry Div.	General Motors Corporation
Robert M. Sinclair	Vice President Engineering	Chrysler Corporation
Douglas J. Smith	Director, Office for Economic Expansion	Grand Valley State College

NAME	TITLE	CORPORATION
Rick Steinhelper	Assistant Managing Director	Detroit Tooling Assc.
Charles W. White	Corporate Strategic Planning Staff	General Motors Corporation
Steven A. Weiner	Mfg. Systems and Machining	Ford Motor Company
W. R. Wilkinson	Executive Director Product Strategy Dev.	Ford Motor Company
Howard Young	Special Consultant to the President	United Auto Workers Union