OPPORTUNITIES FOR CANADIAN RESEARCH AND DEVELOPMENT DIRECTED TOWARD THE NEEDS OF THE NORTH AMERICAN AUTO MARKET

prepared for

THE CANADIAN MINISTRY OF STATE FOR SCIENCE AND TECHNOLOGY

DECEMBER 1979

Arthur D. Little OF CANADA LTD.

FINAL REPORT

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By

Donald A. Hurter
Jeffrey L. Staley

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Arthur D. Little OF CANADA LIMITED

DEFINITIONS OF RESEARCH AND DEVELOPMENT USED DURING THIS STUDY

Research and Development

Basic and applied research in the sciences and engineering and the design and development of prototypes and processes. This definition excludes quality control, routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, and other nontechnological activities or technical services.

Basic Research

Original investigations for the advancement of scientific knowledge not having specific commercial objectives, although such investigations may be in fields of present or potential interest to the reporting company.

Applied Research

Investigations directed to the discovery of new scientific knowledge having specific commercial objectives with respect to products or processes. This definition differs from that of basic research chiefly in terms of the objectives of the reporting company.

Development

Technical activities of a nonroutine nature concerned with translating research findings or other scientific knowledge into products or processes. Does not include routine technical services to customers or other activities excluded from the above definition of research and development.

Source: "Research and Development in Industry, 1976," National Science Foundation, Washington, D. C., 1977.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(cont'd)

LIST OF TABLES
(Cont'd)

LIST OF TABLES
(cont'd)

LIST OF FIGURES

I. INTRODUCTION

A. Background

Arthur D. Little of Canada Limited was retained by the Canadian Ministry of State for Science and Technology to undertake a study of North American automotive regulations and technology trends and their implications for Canadian auto industry development in the 1985 to 2000 time frame. It was requested that special attention be given to identifying the types of automotive related research and development (R&D) Canada should become involved in to improve Canadian employment, balance of trade, industrial investment, production levels and competitiveness.

The Canadian automotive industry has been described as generally efficient, profitable, and price competitive, and it has enjoyed considerable growth during the last ten years. The industry is composed of a group of vehicle manufacturers including General Motors, Ford, Chrysler, American Motors and several truck manufacturing firms as well as a large group of independent parts manufacturers. Unlike the vehicle manufacturers, many of the parts manufacturing companies are Canadian owned. Much background information on the Canadian automotive industry is available and will not be reviewed here.[(1-4)*]

A major factor that has contributed to the good health of the current Canadian auto industry is the Automotive Products Trade Agreement of 1965. The Agreement provides for conditional duty free trade between Canada and the United States in original equipment parts and all but certain specialized types of newly manufactured vehicles. It excludes trade in replacement parts and accessories as well as used vehicles. Largely, as a result of the Agreement, the Canadian auto industry has evolved from low volume production of many different products mainly for the Canadian market to high volume production of a smaller variety of parts for an integrated North American market. The Agreement initially led to substantial new investment in Canada by the major vehicle manufacturers primarily in vehicle assembly operations because of certain requirements in the Agreement and Canada's historical labor cost advantage. This has reinforced the historic pattern of limited autonomy of U.S. subsidiaries

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*References are listed at end of chapter.

in Canada. Research, development and engineering functions have become increasingly concentrated in the United States while Canadian subsidiaries have devoted their principal efforts to production.

In light of the very rapid changes occurring in the U.S. auto industry resulting from fuel economy, emission and safety standards, the Canadian government is concerned that Canadian owned suppliers will not have the technology required to remain competitive. Therefore, the government is interested in identifying opportunities for increasing the amount of research and development in Canada.

Canada also had a total automotive related trade deficit of more than $1.2 billion in 1977. This has stimulated government interest in searching for ways to help strengthen Canadian industry by identifying opportunities for increasing production of parts and components, and for perhaps producing a unique new line of Canadian vehicles. In addition, the government is concerned with ensuring auto industry viability through this period of rapid technological change because of the 117,000 Canadians that are employed by it and because of its 6.5% contribution to the Canadian Gross National Product.

B. Purpose

The purpose of this study is to identify opportunities for increasing Canadian R&D activities that would help improve Canadian autonomy and long term participation in the North American on-road vehicle industry.

C. Scope

We have identified opportunities for Canadian participation in both product and process R&D to the best of our ability out to the year 2000. The accomplishment of this relied upon our assessment of a variety of factors which will work in consort to determine the direction of the North American auto industry.

1. We reviewed existing U.S. and Canadian fuel economy, emission, and safety standards and developed positions on their probable directions.

2. We reviewed technological changes expected to occur in automobiles and trucks in both a summary way and a detailed component way to understand the multitude of opportunities which are potentially available to suppliers to the auto industry.

3. We used our knowledge of expected technological changes to assess which components currently being produced by Canada's largest 130 automotive suppliers will be affected by design, material or demand changes.

4. We gathered information on the manufacturing process improvements which will be required to achieve expected changes in product design and material composition.

5. We analyzed existing data on Canadian R&D capabilities related to the auto industry and gathered first hand information on capabilities and needs from a group of 20 manufacturers, industry associations, government research organizations and universities.

6. We matched opportunities available to automotive suppliers against representative Canadian manufacturers identified as being capable of capitalizing on them.

7. Barriers to achievement of identified R&D opportunities were outlined.

8. Potential for technology transfer between Canadian industrial sectors was identified to the extent we discovered it during our interviews.

D. Approach

In general, our approach to this program was to gather all pertinent reports from the Canadian government, meet personally with Canadian government representatives, manufacturers, industry associations, government research organizations and a university, and use Arthur D. Little experts to provide needed information and analyze the available data. The total number of visits possible during this program was restricted by available funds and the visits that were made were mutually agreed upon by the Ministry of State for Science and Technology and Arthur D. Little of Canada, Ltd. Our work with U.S. vehicle regulations and expected technological changes benefited from our extensive past experience in these areas.

E. Report Organization

Chapter II of this report provides a summary of the study's findings. U.S. and Canadian vehicle regulations are reviewed in Chapter III and major technological changes expected in vehicles are presented in Chapter IV. Chapter V describes design, material and market penetration changes expected in current Canadian automotive products and Chapter VI presents some of the process improvements that are needed to achieve expected design and material changes. Canadian auto industry companies capable of performing R&D in Canada are tabulated in Chapter VII and matched with product and process R&D topics in Chapter VIII. Chapter IX deals with barriers to achievement of increased auto industry R&D in Canada and Chapter X briefly discusses the potential for Canadian technology transfer to improve the auto industry.

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1. "The Automotive Industry in Canada: Sector Profile," Industry, Trade and Commerce, Ottawa, Ontario, 1976.

2. "A Report by the Task Force on the Canadian Automotive Industry," Chairman Norman H. Bell, 1978.

3. "Review of the North American Automotive Industry," Automotive Task Force, Canada, April 1977.

4. "The Canadian Automotive Industry: Performance and Proposals for Progress," Simon Reisman, Commissioner, October, 1978.

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II. SUMMARY OF OPPORTUNITIES FOR AUTO INDUSTRY R&D IN CANADA AND RELATED ISSUES

A. Key Findings

The key findings of this study regarding the identification of opportunities for auto industry related research and development in Canada are given below.

1. Directed Basic Research Opportunities

- There are several areas of basic research that could be pursued effectively in Canada because of the existence of Canadian companies who could potentially commercialize the results.
- Examples of these areas are:

  --material science and processing
  --vehicle control systems
  --tire friction and wear
  --battery electrochemistry
- This research would have time horizons for commercialization primarily in the 10 to 20 year range.

2. Industry Specific R&D Opportunities

- There appears to be a need in Canada for R&D that focuses on the problems and needs of a specific industry such as plastics processing, as opposed to the problems of producing a specific component.
- This kind of research can be effectively performed by an institute jointly funded by industry and government and able to efficiently disseminate the results of its R&D to the manufacturers in need.
- This research would generally have a time horizon to commercialization of three to ten years.
- Because of the existing combination of raw materials, energy and industry capabilities, Canada is in an excellent position to provide many of the raw materials required by the auto industry.

3. Company Specific R&D Opportunities

- Some 32 attractive auto component opportunities available to suppliers in general as well as eleven attractive truck opportunities were identified. A variety of materials related opportunities were also discovered.

- The characteristics of Canadian companies which we used to judge their attractiveness for government funding of R&D include domestic or foreign ownership, R&D capabilities, total sales, number of employees, automotive supplier status, and auto industry involvement.
- We found good matching between the attractive opportunities and the attractive manufacturers identified and we are optimistic about additional matches being available in Canada.
- The ability of Canadian auto industry manufacturers to keep up with and possibly lead the way with superior new manufacturing processes will be a critical factor in determining their future role in the North American auto industry.

4. <u>Canadian Auto Industry Issues</u>

- The costs and risks associated with the production of a special car for the Canadian market as one or two new models for the North American market are extremely high.
- We believe that the majority of new vehicles will be depending on spark ignition and diesel engines in the year 2000 because of the lack of any really competitive alternatives.
- We strongly velieve that a synthetic liquid fuel supply system should be developed to satisfy the long-term needs of on-road vehicles.
- Canada's natural resources offer the opportunity for a major role in the development of long-term North American transportation fuel supplies and basic and applied research in this area should be strongly encouraged.
- Battery design is at the heart of the major deficiencies of electric vehicles and should be the focus of any R&D aimed at accelerating their practicality.
- While we believe electric vehicle use will be limited through 2000, there will be some use in controlled travel environments that may provide a market large enough to justify a limited amount of Canadian directed basic research in electrochemistry.

5. <u>U. S. and Canadian Vehicle Regulations</u>

- We believe it very likely that mandatory auto and light truck fuel economy standards at levels slightly higher than the standards in the United States will be established in Canada in the next year or two. The challenge will be to set them high enough to get significant fuel savings, yet not so high as to disrupt the Canadian auto market. Voluntary versus mandatory fuel economy levels are a current subject of debate in Canada.

- There will be a substantial conflict between EMR who are in favor of leaded gasoline and Environment Canada who are opposed to it. If Canadians are aware of the current energy problems, we believe leaded gasoline will continue to be used. This will increase the percentage of Canadian specific emission control systems.
- If Canadian emission standards remain at current levels and the fuel economy guidelines remain voluntary, Canadians will be paying for U.S. automobile emission control technology they won't need. It will be economically impossible for the auto makers to remove it from vehicles to be sold in Canada.
- Consumer demand for high fuel economy vehicles is overcoming the push of fuel economy regulations in the U.S.
- Particulate standards are so controversial in the U.S. and have such a large potential impact on the penetration of diesel engines in the United States that we have not attempted to forecast them for this study.
- Proposed changes in U.S. heavy duty engine emission certification test procedures are very controversial. It is impossible at this point to predict how the disagreements will be resolved and at what levels standards might be set in 1983.
- Six passenger autos sold in Canada will most likely not be equipped with air bags. This should result in substantial savings for Canadian new car buyers. Canadians may also resist using passive three point belts. Since development of improved active three point belts will essentially stop in the United States, this may be an opportunity for a Canadian safety research organization.
- However, radical Canadian departures from U.S. regulatory precedents are not expected.

6. Canadian Education

- The lack of skilled trades people in Canada is an important barrier to industrial expansion.
- More educational programs are needed to train people in the latest manufacturing technologies available.
- Engineering graduates are leaving Canada because of a lack of job opportunities. The lack of good paying opportunities also makes it economically unattractive for technical personnel to go on for advanced technical degrees.
- Effective dissemination of technical information is an important need of small Canadian manufacturers.

7. General Findings

- Canadian directed basic research, applied research, and development should be tied together with the goal of developing new manufacturing processes and new materials that will enable the Canadian auto industry to offer the North American and world auto industries products, features, prices and quality they cannot find anywhere else.
- The Canadian auto industry should continue to develop unique new products it can offer the auto industry, but the emphasis should be on supplying components requested by auto manufacturers made with the most cost effective materials and manufacturing processes available anywhere in the world.
- Vehicle component designs will continue to be dominated by the auto companies. Therefore, it would not be advisable for Canadian companies in general to pursue component designs independently.
- The auto companies will not move splinter research facilities to Canada under traditional industry circumstances.
- Ford Motor Company has a well developed supplier research program that only a few Canadian companies have used.
- The technological changes occurring in the North American auto industry through 1990 are relatively revolutionary. After 1990 they will be more evolutionary. Revolutionary changes offer many opportunities for aggressive manufacturers. Thus, Canadian manufacturers will have lost a portion of available opportunities if they are unable to penetrate the auto industry market prior to 1990.
- Most of the Canadian auto suppliers are small companies who have more immediate needs for funds for plant expansion and solution of production problems rather than R&D assistance.
- The Automotive Products Trade Agreement is fulfilling its original purpose, but is has also hindered Canadian R&D by encouraging the auto companies to move their Canadian engineering efforts to the United States and build assembly plants in Canada.

B. Opportunities for Auto Industry Related R&D in Canada

A great variety of opportunities exist for increasing the amount of auto industry related R&D in Canada. They can be grouped into three broad categories:

- Directed Basic Research Opportunities;
- Industry Specific R&D Opportunities; and
- Company Specific R&D Opportunities.

1. Directed Basic Research Opportunities

A series of basic research areas related to automotive technology in a broad way have been identified by the U.S. Department of Transportation. The research areas that have been identified are:

- Thermal and fluid sciences;
- Structural mechanics;
- Electrochemistry;
- Aerodynamics;
- Materials science and processing;
- Control systems;
- Friction and wear;
- Acoustics and vibrations; and
- Surface sciences and catalysis.

Basic research in these areas can be funded by the government relatively independent of the Canadian auto industry. This kind of research is not directly intended to result in the design of new vehicles, engines or components; it is meant to focus on achieving a fuller understanding of the physical and chemical processes underlying vehicle technology.

While we feel that a certain amount of this kind of research should be encouraged and perhaps performed by the government in Canada, it must be realized that it will not provide short-term aid to the existing auto industry. Typically, results of basic research take many years to be translated into saleable products; and it is likely that any major breakthrough would be utilized by the largest companies. Canadian efforts in any of these areas should be coordinated directly with existing or planned U.S. government efforts.

Programs of this nature must receive adequate funding for them to be successful. There are a large number of government sponsored research programs in Canadian universities and government research centers that we believe are underfunded. For example, our visit to McMaster University to discuss government funded research in the materials area resulted in our finding that the majority of programs receive less than $30,000.

Government funded R&D programs in the United States receive between $50,000 and $1 million in funding. The point here is that the money and effort required to solve a given problem or make a new discovery is not a function of whether it is done in the U.S. or Canada. Canada should expect to fund programs at levels comparable to the U.S. levels assuming U.S. funding is appropriate for the task. However, because of the total amount of money available, Canada must be more selective about the programs it funds.

There are several examples of areas of basic research that could be pursued very effectively in Canada because of the existence of Canadian companies who could potentially commercialize the results:

- Materials Science and Processing - Research would be directed at obtaining improved understanding of the relationships between material composition, engineering properties and material processing parameters. The goals of improved manufacturing methods and more efficient materials use would be pursued for metals, plastics and ceramics. Materials will continue to be an area of rapid growth and change in the auto industry for some time and this will present many opportunities for suppliers with newly developed materials with needed properties.

- Control Systems - Research in this area would include work on control logic for powertrain optimization; work on sensor concepts for measurement of temperature, pressure, fluid flow, and exhaust flow composition; generic research on the physics of actuators required for air and fuel control, and physical system modeling needed to understand the required relationships between sensors and actuators for engine control. This area represents one of the significant growth areas in vehicles; the use of on-board sensors and diagnostic systems.

Two more somewhat less attractive areas of basic research Canada could pursue are given below.

- Friction and Wear - Tires - The three main areas of tire research are tire dynamics, materials and architecture. These areas would be investigated to improve tire safety and energy efficiency. Canada has a substantial tire industry and a need certainly exists for better tires for all types of vehicles.

- Electrochemistry - Research would be directed toward developing batteries and electric and hybrid vehicle systems. Specific areas of research would include:
  - catalytic behavior
  - corrosion phenomena in electrochemical systems
  - specific electrode evaluation
  - electrode and electroyte synthesis and evaluation
  - separator synthesis and characterization
  - ionic and electronic mobility properties
  - electrode chemistry and kinetics

  Even a relatively small North American market for electric and hybrid vehicles could result in substantial dollar sales for the Canadian companies supplying the batteries.

Programs in all of these areas could be established in Canadian universities or government research facilities.

2. Industry Specific R&D Opportunities

There appears to be a need in Canada for R&D at the industry level; that is, R&D that focuses on the problems and needs of a specific industry such as plastics processing as opposed to the problems of producing a specific type of component. This kind of research can most effectively be carried out by some sort of institute jointly funded and directed by industry and government and able to efficiently disseminate the results of its R&D to those manufacturers who need them. The spirit of this idea has been respresented in a variety of programs that have begun or been proposed to the government and the industry. Examples include:

- The National Research Council's Industrial Materials

Research Institute;

- The Society of the Plastics Industry of Canada's proposed Plastics Institute of Canada;
- McMaster University's Canadian Iron and Steel Research Organization.

A chief advantage of this brand of research is that it can be aimed at solving important materials and process problems that industry is facing without being tied to the problems associated with producing a specific component.

A materials institute could carry out research on the composition, physical properties, and production characteristics of:

- plastics (including composites);
- aluminum alloys;
- high strength steels (including dual phase);
- matrix reinforced alloys;
- ceramics; and
- glass.

Examples of related processing problems that could be addressed include:

- reduction of cycle times for plastics molding;
- improving the control of continuous annealing and cooling of dual phase steel;
- elimination of finishing, joining and handling problems of sheet aluminum components;
- improvement of production technology for stamping plastics;
- reduction of the manufacturing cost of reaction injection molded components;
- elimination of the finishing problems associated with achieving a class A surface finish with sheet molding compound;
- development of thin glass panel manufacturing techniques;

- development of reinforcement and high volume production techniques for ceramics;
- reduction of cycle times required for molding graphite fiber reinforced plastics.

The chief difference between this research and that which would be carried out under a directed basic research program is time horizon for commercialization. This research would generally have a horizon of three to ten years before commercialization. The basic research programs would have average time horizons of ten to twenty years with a few programs in the five to ten year range.

3. Company Specific R&D Opportunities

A major portion of this program was devoted to the identification of component opportunities available to suppliers to the auto industry, the identification of Canadian companies with applied research and development capabilities and the matching of the two. Some 32 attractive auto component opportunities available to suppliers were identified as well as eleven attractive truck component opportunities (Tables II-1 and II-2). These opportunities were chosen from among many others because, in our opinion, they appear to be those that are very likely to be purchased by the auto companies from outside suppliers. The opportunities will be available to all auto industry suppliers, not just those in Canada. The passenger car and light truck opportunities were further broken down into very good opportunities and good opportunities. Opportunities were ranked very good, based on our view of the strength of the need of the industry and our feeling that a supplier could achieve large sales volumes by offering a good product in the areas listed.

Characteristics of companies that were used to judge attractiveness for government funding of R&D include ownership, R&D capabilities, total sales, number of employees, automotive supplier status, and auto industry involvement (Table II-3). Company characteristics required to take advantage of available component opportunities are also a strong function of the expected time frame of introduction of the component (Figure II-1). For a company to hope to supply the auto industry with one of the products shown in Tables II-1 and II-2 in the 1980 to 1990

Table II-1

Most Probable Opportunities to be Sourced to Outside Suppliers: Passenger Cars and Light Trucks

Very Good Opportunities

- Linerless aluminum cylinder block
- Aluminum heads with powdered metal valve seats and guides
- Aluminum intake manifold
- Aluminum cores for radiators, heaters, and oil coolers (copper plated)
- Fuel injection systems for diesels
- Electromechanical injectors for diesels
- Knock sensor
- Air mass flow sensor
- Linearized air/fuel ratio sensor
- Third door gas strut
- Windshield wiper (advanced)
- Passive restraint system
- Fractional horsepower motor
- Antiskid brakes
- Advanced display components
- Electronic engine sensors (position, pressure, temperature)
- Fuel flow meter
- Spark plug-pressure probe
- Conductive plastic

Good Opportunities

- Corrosion inhibiting adhesive
- Plastic seat frames
- Fog lamps
- Plastic rearview mirror
- Plastic windows
- Heated windshields
- Cylinder liners
- Die cast aluminum piston with nickel inserts for diesels
- Plastic engine covers
- Low restriction molded plastic intake mufflers for diesels
- Improved electromechanical actuator (replace vacuum components, fuel pumps, fuel injection, EGR actuation)
- Hollow coil springs
- Hollow stabilizer bar
- MacPherson Strut for heavy cars and trucks
- Corrosion resistant brakelines
- Plastic gas tanks
- Fiberoptics (plastic)
- Molded plastic heater and radiator header tanks
- Low cost constant velocity universal joints (needed for front wheel drive)
- Solid state relays and solenoids

Source: Arthur D. Little

Table II-2

<u>Most Probable Opportunities to be Sourced</u>

<u>to Outside Suppliers: Medium and Heavy Duty Trucks</u>

- Mufflers
- Aerodynamic improvements (wind deflector, smooth trailers, vortex stabilizers)
- Bottoming cycle heat recovery
- Refrigeration power plants
- Diesel pistons
- Diesel piston rings
- Frame and wheels
- Leaf springs
- Pedestrian/cyclist underride guards
- Engine speed governor system
- Exhaust gas temperature sensors

Source: Arthur D. Little

Table II-3

Characteristics of Target Group Companies for Canadian Government R&D Assistance

1. Ownership (in order of preference)
   - Canadian-owned multinationals
   - Canadian-owned companies
   - Canadian divisions of foreign-owned multinationals

2. R&D Capability
   - Companies with existing R&D capability are considerably more attractive for funding than those with only product and process development capabilities.
   - Companies examined had from 0 to 200 scientific and technical personnel engaged in research and development.
   - Our recommended minimum number of scientific and technical personnel engaged in research and development for effective use of funding is ten. This corresponds to an average annual R&D expenditure of between $500,000 and $1 million.

3. Total Sales
   - **Companies examined had 1977 sales of from $10 million to $3 billion, not including the automotive company divisions examined which had sales over $3 billion.**
   - **Our recommended minimum level of sales for effective use of R&D funding is approximately $20 million.**

4. Number of Employees
   - Companies examined had between 200 and 61,000 employees.
   - Our recommended minimum number of employees for effective use of R&D funding is roughly 350 to 400.

5. Automotive Supplier Status

   Companies who have already qualified themselves as auto company suppliers are more attractive for funding than those who have not. There is little value in funding R&D in companies who have little chance of qualifying as automotive suppliers.

6. Automotive Industry Involvement

   Companies currently involved in some aspect of the automotive industry are more attractive for funding than those who are not.

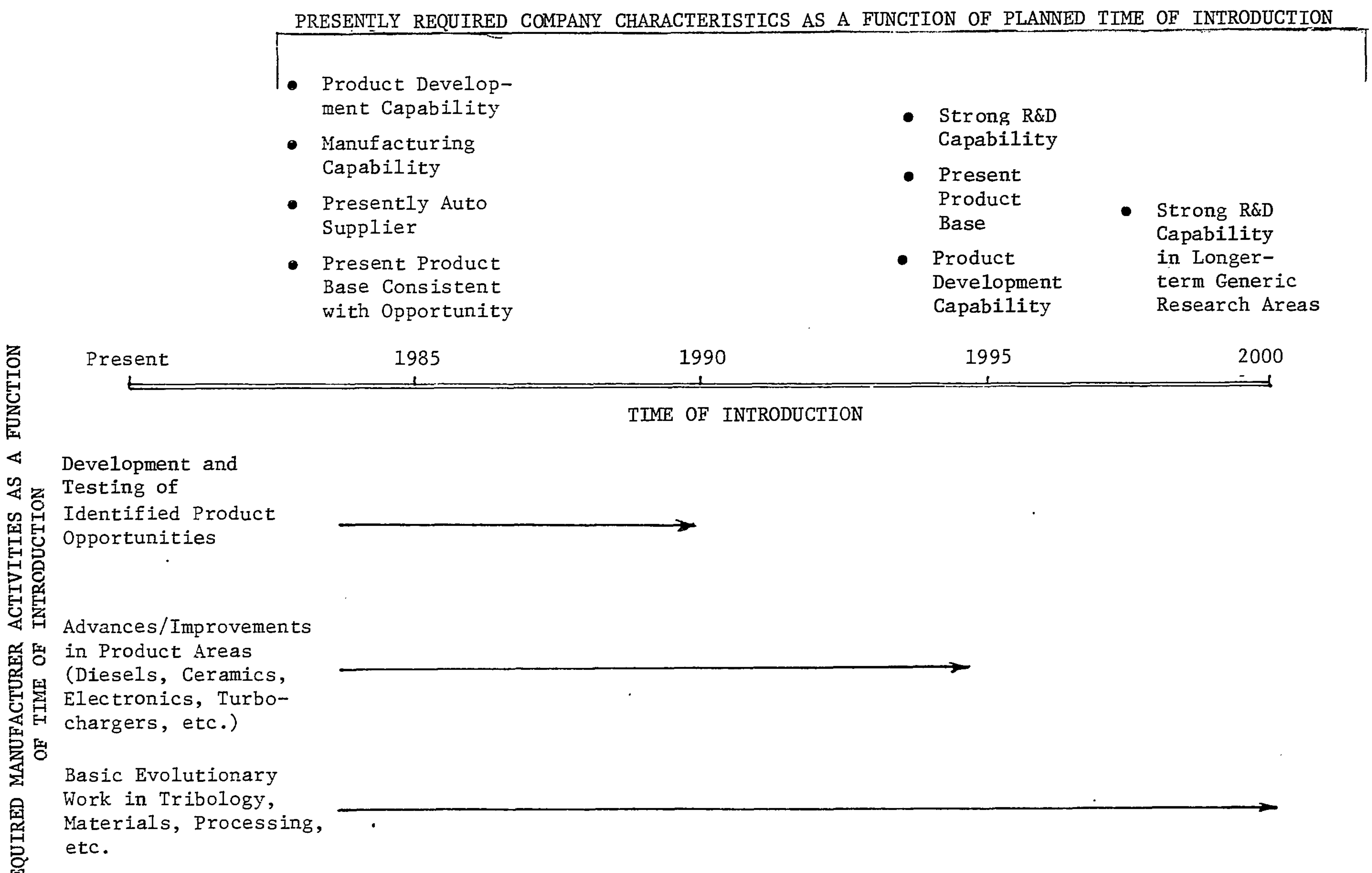

Figure II-1

Company Characteristics and Activities Needed to Take Advantage of Opportunities as a Function of Time of Introduction

Source: Arthur D. Little, Inc.

Table II-4

Examples of Matching Canadian Companies with Component Related Opportunities

Company Name	Component Development Area: Passenger Cars	Component Development Area: Trucks
Bombardier	-Plastic gas tanks -Glass reinforced plastic seat -Low restriction molded plastic intake muffler for diesel engines	
Tridon	-Advanced windshield wiper system	
Long Mfg. Div. (Borg-Warner Canada, Ltd.)	-Aluminum cores for radiators, heaters and coolers -Molded plastic heater and radiator header tanks	
CAE	-Aluminum castings -linerless cylinder blocks -heads -head with powdered metal valve seats and guides -intake manifolds -aluminum piston with cast iron inserts for diesels	-Aluminum frame and wheels -Aluminum piston with cast iron inserts for diesels
CTS	-Improved electromechanical actuators -Sensors -knock -air mass flow rate -linearized A/F ratio sensor -fuel flow	-Exhaust gas temperature sensors -Antiskid braking system
Canadian General Electric	-Fog lamps -Fractional H.P. motors	
Gabriel of Canada Ltd. (Van der Hout)	-Heavy duty MacPherson struts	-MacPherson struts for light trucks
Duplate Canada Ltd.	-Heated windshields	
Eaton Yale Ltd.		-Improved leaf springs (carbon fiber reinforced epoxy)
Kelsey Hayes Canada Ltd.		-Aluminum wheels

Table II-4
(Continued)

Company Name	Passenger Cars	Trucks
Standard Tube Canada Ltd.	-Hollow coil springs -Hollow stabilizer bars	
Philips Electronics	-Fog lamps	
Irvin Industries	-Passive restraint systems -Improved active seat belt systems	-Improved active seat belt systems
Butler Metal Products	-Plastic seat frames -Plastic windows	
OPTOTEK	-Fiber optics	

Table II-5

Matching Canadian Companies with Materials Related Opportunities

Company Name	Material Development Area
STELCO Atlas Steel Co.	-High strength steel development (dual phase and rephosphorized/renitrogenized) -formability -welding
Alcan	-Aluminum development -joining techniques -finishing -manufacturing
Polysar	-Development of conductive plastics -Plastic formulations -Corrosion inhibiting adhesive
Dunlop Plastics	-Development of conductive plastics -Polymer research -Rubber development
Canadian General Tower	-Development of improved manufacturing processes for headliners, floor coverings, seat covers -low density polyethylene -nylon fibers and fabrics -Corrosion inhibiting adhesive
Dupont	-Improved fiber for upholstery fabric, safety belts -Development of conductive plastics

Source: Arthur D. Little, Inc.

time frame, they should already be an auto industry supplier, have product development capabilities, have required manufacturing capability and have a present product base that is consistent with the opportunity. As the time frame for introduction expands to 1995 and 2000, strong R&D and product development capabilities become more important than the existing product base and current manufacturing capabilities. This happens because the manufacturers' activities shift from development of identified opportunities to applied research in product areas to basic research as the time of product introduction moves from the 1980 to 1990 time frame to 1995 and 2000. Our examination of Canadian companies was limited to approximately 150 who are already involved in the auto industry. While this did not allow us to identify attractive companies not in the auto industry or rapidly rising small companies supplying the industry currently, we believe our criteria for selecting attractive companies can be widely applied. Two additional caveats are needed. First, there are certainly companies that will be attractive for government funding because of special capabilities or other factors which make them unusual and unfairly rated by our characteristics. Second, we attempted only to identify example companies that appeared to fit our characteristics, leaving the possibility that not every attractive company among those we examined was identified. We found good matching between the attractive opportunities and manufacturers identified and we are optimistic about additional matches being available in Canada (Tables II-4 and II-5).

C. Requirements for Effective Implementation of R&D Opportunities

The success of future programs to encourage automotive related R&D will depend on the degree to which they are suited to the manufacturers who must make use of them. During our industry interviews we received a number of comments regarding the existing programs (primarily the Enterprise Development Program) and they are listed below. It must be emphasized that these comments are based on the knowledge the manufacturers have about the programs.

- The amount of money that has been spent by the government to encourage R&D is very small relative to the amounts other countries have spent.

- The government is too restrictive about the kind of programs they will fund.

- In some cases, funding must be reapplied for each year adding an additional amount of uncertainty for the manufacturer regarding his level of commitment to a program.

- The length of time required for approving a proposal for assistance is too long.

- Machinery purchased during a government funded development program must be returned to or purchased from the government after the program ends.

- The critera used to choose programs for funding are not understood by many manufacturers.

- The government should make more of an effort to inform manufacturers of the R&D funding available and then help them get it.

- The amount of effort and paperwork required to get assistance is a large burden.

- None of the existing programs provide money for process and tooling development not related to a unique new product.

- The existing programs aimed at encouraging R&D do not address the real needs of the smaller auto component manufacturers.

- The recent changes in the Enterprise Development Program effectively reduced the funding available.

- The government should try to assist manufacturers who may be reluctant to come to them for assistance for the first time.

- Presentation of proposals before the Enterprise Development Boards by an Industry, Trade and Commerce employee rather than the manufacturer places a potential barrier in the way of successful application for assistance.

- The interest rate on government guaranteed loans is prohibitive.

- Current programs concentrate only on R&D which represents only 10 to 20% of the cost of bringing an idea to commercialization.

- The current programs are not geared toward funding high risk R&D programs.

D. Canadian Auto Industry Issues

There are several issues regarding the future direction of the Canadian auto industry that should be commented upon. They include the feasibility of a "Canadian Car," the outlook for alternate engines, the outlook for alternate fuels and the future of electric vehicles.

1. The "Canadian Car"

Since Canada is the only major automotive market in the world without auto manufacturing capability, a number of people have suggested the creation of a Canadian controlled auto manufacturing facility with its own research, development, design engineering and management capabilities. We concur with the discussion of the Canadian car possibility presented by the Reisman Commission and their recommendations against it.*

The costs and risks associated with the production of a special car for the Canadian market or one or two new models for the North American market are extremely high. Factors which make this option unattractive are:

- the minimum economic volume of 200,000 vehicle sales per model;
- excessive competition from the major auto companies;
- level of risk associated with trying to sell only one model in terms of consumer acceptance;
- the high capital costs involved in setting up the required facilities;
- the trend toward concentration of the auto industry in a small group of large companies around the world;
- the infeasibility of providing a completely sheltered sales environment for the Canadian car in Canada; and
- lack of interest on the part of existing manufacturers in government takeovers or joint ventures.

*"The Canadian Automotive Industry: Performance and Proposals for Progress," Simon Reisman Commission, October 1978.

2. Alternate Engines

There are several alternate engines beyond the Otto spark ignition engine and the diesel engine that could possibly be used in vehicles. They include the gas turbine (Brayton), the steam engine (Rankine), and the Stirling engine. The steam engine has been dismissed as having inherent limitations on its efficiency that will prevent it from ever being the best engine for vehicles. Ford Motor Company's joint programs with DOE on the Stirling engine has recently been discontinued as a result of high cost and mechanical complexity. If the Stirling engine is successfully developed, it will probably not be introduced in new vehicles until the mid- to late-1990's.

The gas turbine will be used in very small numbers in heavy trucks and buses in the next five to ten years, but it will probably not be used in autos and light trucks until the late 1990's. It currently suffers from poor part load fuel economy, high manufacturing and material costs and poor transient operation response.

We believe that the majority of new vehicles will be depending on spark ignition and diesel engines in the year 2000.

3. Alternate Fuels

We strongly believe that a synthetic liquid fuel supply system should be developed to provide the long term fuel needs of on-road vehicles. It is our opinion that future fuels for transportation will most likely be liquids as opposed to gaseous fuels such as liquefied petroleum gas (LPG), liquefied natural gas (LNG), compressed natural gas (CNG), or hydrogen. Future liquid fuels may be produced from abundant non-renewable resources such as coal, oil shale and tar sands, or renewable resources such as biomass or waste products. There will also be pressures to adapt the available engines to accept the fuel properties that are producible in the greatest abundance at the lowest cost. Canada's natural resources offer an opportunity for a major role in the development of long term North American transportation fuel supplies and basic and applied research in this area should be strongly encouraged.

4. Electric Vehicles

Electric vehicles are expected to undergo continued development to overcome major current deficiencies such as:

- high life cycle cost,
- poor performance,
- high weight,
- poor safety characteristics, and
- short range

compared to conventional vehicles. Battery design is at the heart of all of these deficiencies and should be the focus of any R&D aimed at accelerating the practicality of electric vehicles. It should be recognized, however, that the overwhelming long-term motivation for substantial sales of electric vehicles will be the lack of conventional liquid fuels for transportation. Since we do not believe there will be a long term lack of liquid fuels of some type for transportation, we are very skeptical about large scale penetration of EV's. We do, however, think there will be some use of electric vehicles in very controlled travel environments that place a high value on the lack of energy consumption during idling, the lack of local exhaust emissions, and the lack of noise emissions. For this reason, we have suggested a limited amount of Canadian directed basic research in electrochemistry.

E. Industry Suggestions for Government Stimulation of Auto Industry R&D

A variety of suggestions were provided by the organizations we interviewed regarding possible government roles in stimulating auto industry related R&D in Canada. These suggestions are shown below.

- compile a catalogue of Canadian R&D capabilities related to the auto industry
- remove the duty on R&D test equipment, plans and spare parts that must cross the U.S./Canadian border
- the biggest returns for government dollars spent to help industry are not gotten through basic R&D

- increase funding level for materials research in government facilities and universities
- encourage cooperative R&D on new materials between government and industry
- encourage more interaction between national laboratories and industry
- keep programs in place for at least 10 years to achieve effectiveness
- leave industry R&D to the forces of the free enterprise system (this comment was made by only one of the companies interviewed).

F. Industry Suggestions for Government Assistance to the Canadian Auto Industry

Many suggestions were offered by the organizations we interviewed regarding ways the government could assist the auto industry in general. These suggestions are listed below.

- assist small manufacturers in keeping abreast of future auto company product design and material changes
- help remove union opposition to apprenticeship programs which provide needed skilled trades people
- offer partial funding for the purchase of expensive and unusual production equipment
- help manufacturers market products in Detroit
- disseminate knowledge about existing production technologies to small manufacturers
- develop programs to train required tool makers and machine repairmen
- create a coordinated Canadian industrial policy
- provide money for process and tooling development to small manufacturers
- provide a manufacturing advisory service to offer technical assistance to manufacturers (Automotive Investment Corporation, AIC)
- provide tooling recovery assurance programs to enable manufacturer investment in highly productive tooling needed to qualify as an auto supplier on a cost basis (AIC).
- provide more benefits to Canadian owned suppliers than to foreign owned suppliers

- institute a program that helps manufacturers make the final steps through production process and tooling development to commercialization
- do more to make the Canadian environment more attractive to foreign manufacturers considering new facilities
- remove trade barriers such as the duty imposed on Canadian components sold to the auto companies, shipped to a foreign company for insertion in an assembly and shipped back to the U.S. for use in a vehicle
- coordinate existing federal and provincial industry programs so they do not conflict
- revise existing pricing policies to lower petrochemical costs and aid the international competitiveness of the plastics industry
- provide funds to compensate for dislocations in small company sales resulting from technology changes or auto company integration
- carry on seminars, classes and meetings to disseminate information on technology advances to manufacturers
- establish production technology centers in Canada to carry manufacturing information to the industry
- help bring about productivity improvements
- help manufacturers find special niches to fill
- change Canadian tax laws to encourage speculative investment

G. Characteristics of Canadian Auto Industry Suppliers

Existing auto industry manufacturers have some characteristics that have contributed to their limited accomplishment of R&D and their limited role in the North American and world auto markets. These characteristics were obtained through our industry interviews and are listed briefly below.

- typically conservative toward new investments and expansion
- lack aggressive strategic planning viewpoint
- wary of instability of auto company purchasing commitments
- satisfied with present profitability
- very conservative about long-term investments in research and development
- very few auto industry suppliers have any need to do R&D

- few manufacturers aggressively market themselves in Detroit or outside North America
- uncertainty about the Canadian business climate has hindered investments
- auto company divisions and most divisions of foreign owned multinationals will continue to depend on central research facilities outside Canada
- make limited use of national research laboratories to solve problems
- not oriented toward auto company "Job 1" philosophy of meeting deadlines *
- generally unwilling to spend development money to get attention at the auto companies
- reluctant to do long term planning required by auto industry time frame of operation
- generally do not understand Detroit quality standards in the sense that the auto makers have higher quality standards than those found in many other industries
- have difficulty establishing credibility as an auto supplier if sales are under $20 million

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* "Job 1" refers to the date when production of a new model begins. Suppliers not able to meet their commitments in time for Job 1 lose credibility and probably their auto company business.

III. U. S. AND CANADIAN VEHICLE REGULATIONS: FORCES FOR CHANGE

This chapter presents a review of current and expected vehicle regulations for both the United States and Canada. Regulations have played an extremely important role in stimulating R&D and innovation throughout the transportation industry. Indeed, a recent study by Rubenstein for the U. S. Department of Transportation stated that two basic types of decisions are made in the automotive supplier's environment: "(1) the automotive customer's decision to accept, encourage development of, or adopt innovations, and (2) the government's decision to mandate changes in safety, environment or energy-related regulations or legislation."*

A. U. S. Vehicle Regulations

The importance of regulations in the United States has recently been diminished by a tremendous increase in consumer concern about gasoline price and availability. The latest round of gasoline shortages and rapid price increases that swept the country sent consumers shopping for a mix of new cars which promises to enable the manufacturers to meet Corporate Average Fuel Economy (CAFE) requirements with ease for the coming year. This demand shift has overpowered the effect of fuel economy regulations, but emissions and safety regulations are still formidable forcing factors.

1. Fuel Economy Regulations

Dependence on uncertain foreign sources for more than 40% of their new oil supply at a cost of more than $30 billion in 1977 demonstrates the need for petroleum conservation in all the U. S. energy consuming sectors. Transportation historically has accounted for roughly 25% of U. S. gross energy consumption and is nearly totally dependent on petroleum. Thus, transportation has been a focal point for petroleum conservation activities and the automobile, which consumes roughly 50% of all transportation energy, has been the object of federal fuel economy standards.

*Rubenstein, A. H., and J. E. Ettlie, "Innovation Among Suppliers to Automobile Manufacturers: An Exploratory Study of Barriers and Facilitators," R&D Management, Vol. 9, No. 2, February 1979.

Starting in 1978, each domestic automobile manufacturer must meet a sales-weighted average fuel economy goal of 18 miles per gallon (Table III-1) set by the Department of Transportation's National Highway Traffic Safety Administration (NHTSA). The mandated standard increases yearly until 1985, when it reaches 27.5 mpg.

Each year manufacturers must also certify that their cars meet the emissions standards mandated by the Environmental Protection Agency (EPA). The EPA emissions test procedure yields an average fuel economy rating that each manufacturer must use to calculate his Corporate Average Fuel Economy (CAFE). Manufacturers not meeting the mandated CAFE can be fined $5.00 per tenth of a mile per gallon over the standard times the number of cars sold in the year they fail to meet the CAFE. This economic penalty, along with the tarnished image a manufacturer would suffer from not complying with the law, will virtually guarantee that every manufacturer will meet the law or seek an exemption from it. Exemption can be granted on the basis that low production levels make it economically impossible to comply with the law.

Given the potential for substantial reductions in national energy consumption and the resulting favorable political and economic outcomes, existing fuel economy standards probably will not be relaxed. There is now some question within NHTSA about whether they will make any change in the 1984 and 1985 standards as they had planned earlier this year. In addition, no date has been announced for preparing 1986 through 1988 standards. Over the long term, we feel quite certain that fuel economy will win out over other standards when conflicts occur and that increases will continue to occur at a relatively rapid rate after 1985.

In recent years, there has been a marked increase in the use of light duty trucks and vans for personal transportation. This increase prompted the institution, starting in 1979, of fuel economy standards for these vehicles (Table III-2). The truck and van standards are expected to follow the trends for stringency anticipated for automobile fuel economy standards, although the absolute mileage figures will be lower.

The standards currently mandated for the 1980 year differ substantially

Table III-1

Present and Future Federal Passenger Automobile[1]

Fuel Economy Standards

Model Year	Average Mileage (mpg)	Percent Improvement from Precontrol
	Actual	
Precontrol	15.8	---
1968	15.4	-3
1969	15.4	-3
1970	15.5	-2
1971	15.1	-4
1972	15.0	-5
1973	14.5	-8
1974	14.4	-9
1975	15.6	-1
1976	17.7	12
1977	18.6	18
1978	19.6	24
	Mandated	
1978	18.0	14
1979	19.0	20
1980[2]	20.0	27
1981	22.0	39
1982	24.0	52
1983	26.0	65
1984	27.0	71
1985	27.5	74
	Possible	
1990	33.0	109
1995	37.5	137
2000	40.0	153

[1]Passenger automobiles are defined to be any automobile, other than an automobile capable of off-highway operation, which the Secretary of Transportation determines by rule is manufactured primarily for use in the transportation of not more than ten individuals.

[2]Captive imports may no longer be counted in corporate average fuel economy.

Sources: National Highway Traffic Safety Administration and Arthur D. Little, Inc., estimates.

Table III-2

Future Federal Light Duty Truck

Fuel Economy Standards

Model Year	Gross Vehicle Weight Rating (lb)	2-Wheel Drive	4-Wheel Drive
		Actual	
1975	0-6000	15.4	
1976	0-6000	18.0	
1977	0-6000	19.1	
1978	0-6000	18.7	
		Mandated	
1979[3]	0-6000	17.2	15.8
1980[1]	0-8500	16.0	14.0
1981	0-8500	16.7[2]	15.0[2]
		Possible	
1982	0-8500	17.4	15.6
1983	0-8500	19.0	17.0
1984	0-8500	20.0	18.0
1985	0-8500	21.0	19.0
1990	0-8500	23.5	21.5
1995	0-8500	26.0	24.0
2000	0-8500	28.0	26.0

Note: The 1980 and 1981 standards are less stringent for manufacturers using only truck-type engines instead of passenger car engines (International Harvester). For 2- and 4-wheel drive vehicles the standards are 14 mpg and 15 mpg for 1980 and 1981, respectively.

[1] Captive imports may no longer be counted in corporate average fuel economy.

[2] These standards were lowered by 0.5 mpg because EPA did not approve slippery oils by January 1, 1980.

[3] The estimated 1979 fuel economies for 0-8500 lbs. are 14.6 and 12.5 mpg for 2- and 4-wheel drive trucks.

Sources: National Highway Traffic Safety Administration and Arthur D. Little, Inc., estimates.

from the 1979 standards in that the maximum gross vehicle weight rating (GVWR) has been extended from 6000 to 8500 pounds. By precluding manufacturers from boosting the GVWR's of their vans and trucks above the 6000 pound limit to avoid regulation, DOT has helped to ensure that all vehicles being used primarily for personal travel will be regulated. In 1983, the standards may be set at 19 mpg for two-wheel drive vehicles and at 17 mpg for four-wheel drive vehicles. By 1985, these standards may rise to 21 mpg and 19 mpg for two- and four-wheel drive, respectively. Projecting these standards beyond 1985 is especially difficult because of the great amount of controversy surrounding the ultimate fuel economy capabilities of vehicles that must, on occasion, be used to carry heavy loads and provide certain minimum levels of utility.

NHTSA is devoting a large portion of their resources toward developing light truck standards and a proposal for the 1982 through 1985 model years should be issued by the end of 1979. A final rule is planned for March 1980.

2. Emission Regulations

The only change in U.S. passenger automobile emission requirements between 1975 and 1979 is a 36% reduction in the standard for nitrogen oxides (NO_x) in 1977 (Table III-3). Between 1979 and 1982, however, major reductions in all emission categories are required. Hydrocarbons must be reduced from the 1979 levels by 73%, carbon monoxide by 51% and NO_x by 50%. We expect the 1983 and 1985 standards to be set at the 1982 levels.

The low NO_x levels specified for 1981 and subsequent years will require significant changes in current U.S. emission control systems, such as the use of three-way catalytic converters with feedback electronic controls. Under current regulations, however, diesel engines may be allowed to meet a separate NO_x standard of up to 1.5 grams per mile (gpm) between 1981 and 1985. This exemption was included because of the substantial fuel saving potential of the diesel engine. General Motors has applied for this exemption and a decision should be made in the very near future.

Table III-3

Present and Future Federal
Passenger Automobile Emission Standards [1]
(grams per mile)

Model Year	HC	CO	NO_x
		Actual	
Precontrol	8.8	87.0	3.6
		Mandated	
1975	1.5	15.0	3.1
1976	1.5	15.0	3.1
1977	1.5	15.0	2.0
1978	1.5	15.0	2.0
1979	1.5	15.0	2.0
1980	0.41	7.0	2.0
1981	0.41	3.4	1.0
1982	0.41	3.4	1.0
		Possible	
1983	0.41	3.4	1.0
1985	0.41	3.4	1.0
1990	0.41	3.4	0.4

(1) CVS-75 test procedure

Sources: Environmental Protection Agency and
Arthur D. Little estimates

The Environmental Protection Agency (EPA) has proposed particulate emission standards for diesel powered automobiles and light duty trucks beginning in the 1981 model year. The 1981 and 1982 standards would be 0.6 grams per mile and the 1983 standard would be 0.2 grams per mile. These standards are very controversial because the auto companies are claiming they do not possess the technology to control particulate emissions to these levels, especially those emitted from the larger displacement diesel engines that U. S. manufacturers are now emphasizing. Particulate standards are so controversial and have such a large potential impact on the penetration of diesel engines in the United States that we have not attempted to forecast them for this study.

The EPA is currently considering separate highway and congested traffic emission standards as well as standards for vehicles operating in different temperature ranges (20°F, 50°F, 75°F, 110°F). They are also developing high altitude emission standards which will only be effective in the 1982 and 1983 model years. After 1983, the Clean Air Act Amendments of 1977 specify that all vehicles must meet the same emission standards at all altitudes.

The EPA has recently granted waivers to certain manufacturers for certain engine families from meeting 1981 and later CO and NO_x emission standards. American Motors Corporation; BL Cars, Limited; Chrysler Corporation; General Motors Corporation; and Toyota Motor Company, Limited received waivers from the 3.4 gram per mile CO standard for 1981 and 1982 for the engine families shown below.* They must instead meet 7.0 grams per mile of CO.

Manufacturer	Engine Family
American Motors Corporation	258 CID
BL Cars, Ltd.	TR 8
	XJ12
Chrysler Corporation	1.7 liter
	3.7 liter
	5.2 liter/4V
General Motors Corporation	2.8 liter/173 CID-2V
	3.8 liter/231 CID-2V
Toyota Motor Company, Ltd.	88.6 CID

*"Revised Motor Vehicle Exhaust Emission Standards for Carbon Monoxide (CO) for 1981 and 1982 Model Year Light Duty Vehicles." EPA, Federal Register, September 13, 1979, p. 53408.

American Motors Corporation was given a waiver to meet 2.0 grams per mile NO_x rather than 1.0 gram per mile in 1981 and 1982.

Paralleling NHTSA's fuel economy regulations for light duty trucks and vans, the EPA emission standards have been extended to cover vehicles with gross vehicle weight rating (GVWR) to 8500 pounds starting in 1979 (Table III-4). We expect that future standards for this group will be similar to, but lag, federal passenger car standards.

Evaporative emissions from both automobiles and light trucks are currently controlled at levels of 6.0 grams per test using the SHED (Sealed Housing Evaporative Determination) test method. The proposed standard for 1981 and later years is 2.0 grams per test, but General Motors has asked for a change to 3.0 grams per test for trucks with GVWR's over 6000 pounds.

California, because of its particularly acute smog problems, established emission control standards in 1966, two years before the first federal emission standards were put into effect. Since then, standards set by the California Air Resources Board (CARB) and approved by the EPA have generally remained more restrictive than federal standards. The California regulations have national significance in that they affect a major market for the automotive industry and also serve as a testing ground for possible future federal regulations.

The current California automobile emission regulations (Table III-5) contain three innovative features that may eventually be incorporated into the federal framework. The first consists of modifying the usual hydrocarbon standard to cover only the nonmethane component, on the theory that methane is a less harmful pollutant than other hydrocarbons present in auto exhaust. Under CARB regulations, compliance with a non-methane hydrocarbon standard of 0.39 gpm is an acceptable alternative to compliance with an overall hydrocarbon emission level of 0.41 gpm. Since methane emissions usually total no more than 0.02 gpm, the net result is to make the hydrocarbon standard somewhat easier to meet.

The CARB regulations also allow a manufacturer to certify the emission characteristics of its vehicles at one level for 50,000 miles or at

Table III-4

Present and Future Federal Light Duty Truck Emission Standards[1]

Model Year	Gross Vehicle Weight Rating (lb)	HC	CO	NO_x
		Mandated		
1975	0-6000	2.0	20.0	3.1
1976	0-6000	2.0	20.0	3.1
1977	0-6000	2.0	20.0	3.1
1978[2]	0-6000	2.0	20.0	3.1
1979[3]	0-8500	1.7	18.0	2.3
1980	0-8500	1.7	18.0	2.3
1981	0-8500	1.7	18.0	2.3
1982	0-8500	1.7	18.0	2.3
		Possible		
1983[4]	0-8500	0.8	10.0	2.3
1985	0-8500	0.6	7.0	1.5
1990	0-8500	0.6	7.0	1.5

(1) CVS-75 test procedure

(2) Standards apply to both gasoline and diesel powered vehicles for 1978 and later years

(3) Set for 1979 and later years; EPA is not planning any change until 1983

(4) Idle emission standards have been proposed to be 970 ppm HC of exhaust flow and 0.47% CO of exhaust flow at curb idle

Sources: Environmental Protection Agency and Arthur D. Little estimates slightly less stringent levels for 100,000 miles. Federal standards currently require certification for 50,000 miles. The CARB strategy is based on the notion that, under the 100,000 mile certification option, total emissions over the entire life cycle of a vehicle may be considerably lower even though initial emission levels are slightly higher. Finally, the CARB regulations allow manufacturers to choose to meet either of two schedules for emission reduction in 1981 and 1982. Option A permits postponement of tight NO_x controls in 1981, provided that very low NO_x levels are met in 1982. Option B requires compliance with an intermediate standard in both years. These options were provided so that immediate regulatory pressure need not preclude the development and use of highly effective emission control systems that require longer lead times.

Beginning with the 1980 model year, the CARB has added the additional restrictions that the maximum projected NO_x emissions measured on the federal Highway Fuel Economy Test can be no more than 1.33 times the applicable automobile NO_x standard shown in Table III-5. The test procedure used both federally and in California consists of an urban driving portion and a highway driving portion. This restriction relates the maximum rate of NO_x emission which occurs during the highway portion to the average rate for the whole test that is regulated by the standards in Table III-5.

The California standards for light truck and van emissions are slightly more complicated than the corresponding federal standards in that the 0-8500 pound GVWR category is subdivided into three inertia weight categories (Table III-6). Permissible emission levels are generally lower for lighter vehicles. Both the nonmethane option and the 100,000-mile certification option apply to the light truck and van category. The overall effect of these complexities is to make the California standards for this category more restrictive than the federal standards. Beginning with the 1981 model year, the maximum projected NO_x emission from light duty trucks on the federal Highway Fuel Economy Test are limited to 2.0 times the applicable standards shown in Table III-6.

Table III-5

Present and Future California
Passenger Automobile Emission Standards[1]

Model Year	HC	CO	NO_x
		Actual	
Precontrol	8.8	87.0	3.6
		Mandated	
1975	0.9[2]	9.0	2.0
1976	0.9	9.0	2.0
1977	0.41	9.0	1.5
1978	0.41	9.0	1.5
1979	0.41	9.0	1.5
1980[3]	0.41[4]	9.0	1.0(1.5)[5]
1981[5]			
A	0.41	3.4	1.0(1.5)
B	0.41	7.0	0.7
1982[5]			
A	0.41	7.0	0.4(1.0)
B	0.41	7.0	0.7
1983	0.41	7.0	0.4(1.0)
		Possible	
1985	0.41	3.4	0.4(1.0)
1990	0.41	3.4	0.4(1.0)

(1) CVS-75 test procedure

(2) 1.5 gpm for limited production vehicles

(3) Standards apply to both gasoline and diesel powered vehicles for 1980 and later years. Diesel powered vehicles must meet federal standards prior to 1980

(4) Compliance with a nonmethane standard of 0.39 gpm is an acceptable alternative to California's 0.41 gpm standard for 1980 and later

(5) Values in parentheses given manufacturers an option to certify their vehicles at the stricter standards for 50,000 miles or at the less stringent standards for 100,000 miles

(6) Manufacturer must choose either option A or B for the 1981 and 1982 model year

Sources: California Air Resources Board and Arthur D. Little estimates

Table III-6

Present and Future California Light Duty Truck Emission Standards[1]

Model Year	Gross Vehicle Weight Rating (lb)	Inertia Weight[2] (lb)	HC	CO	NO_x
			(grams per mile)		
		Mandated			
1975	0-6000		2.0	20.0	2.0
1976	0-6000		0.9	17.0	2.0
1977	0-6000		0.9	17.0	2.0
1978[3]	0-6000	0-6000	0.9	17.0	2.0
1979	0-8500	0-3999	0.41[4]	9.0	2.0
		4000-6000	0.50	9.0	2.0
		6001-8500	0.90	17.0	2.3
1980	0-8500	0-3999	0.41	9.0	1.5(2.0)[5]
		4000-6000	0.50	9.0	2.0(2.3)
		6001-8500	0.90	17.0	2.3
1981	0-8500	0-3999	0.41	9.0	1.0(1.5)
		4000-6000	0.50	9.0	1.5(2.0)
		6001-8500	0.60	9.0	2.0(2.3)
1982	0-8500	0-3999	0.41	9.0	1.0(1.5)
		4000-6000	0.50	9.0	1.5(2.0)
		6001-8500	0.60	9.0	2.0(2.3)
1983	0-8500	0-3999	0.41	9.0	0.4(1.0)
		4000-6000	0.50	9.0	1.0(1.5)
		6001-8500	0.60	9.0	1.5(2.0)
		Possible			
1985	0-8500	0-6000	0.41	7.0	0.4(1.0)
		6001-8500	0.50	7.0	1.0)1.5)
1990	0-8500	0-6000	0.41	7.0	0.4(1.0)
		6001-8500	0.50	7.0	1.0(1.5)

(1) CVS-75 test procedure
(2) Inertia weight - curb weight plus 300 lb and rounded off to nearest EPA inertia weight class
(3) Standards apply to both gasoline and diesel powered vehicles for 1978 and later years
(4) Compliance with a nonmethane standard of 0.39 gpm is an acceptable alternative to California's 0.41 gpm standard
(5) Values in parentheses give manufacturers the option to certify their vehicles at the stricter standard for 50,000 miles or at the less stringent standard for 100,000 miles

Sources: California Air Resources Board and Arthur D. Little estimates

The EPA has established a set of emission regulations that must be met by all engines to be used in heavy duty vehicles (above 6000 pounds gross vehicle weight).*

These regulations cover hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and smoke opacity (Table III-7). These standards are shown from their beginning in 1970 to their anticipated levels in 1983.

In 1983 EPA is planning to mandate a new heavy duty engine test procedure based on a driving cycle to replace the current steady state test. The new test will be run on an engine dynamometer as is the current test, but there will be cold start, soak and hot start portions. The test will be run automatically by sophisticated equipment that will control engine torque and rpm simultaneously. A new procedure has been developed, but baseline or precontrol levels for HC, CO and NO_x have not yet been determined using this procedure. The precontrol year for HC and CO is 1969 and 1973 is the precontrol year for NO_x. The Clean Air Act required HC and CO standards to be set in 1983 representing at least a 90% reduction from precontrol levels and a NO_x standard in 1985 representing at least a 75% reduction from precontrol levels. Since these standards will be based on precontrol levels that have not yet been established, they are impossible to predict. However, it is safe to assume they will be more difficult to meet than current standards.

The EPA is in the process of establishing 1983 HC and CO transient test and idle emission levels and is also making a number of other changes. They are establishing an assembly line testing program and nonconformance penalty system as mandated by the Clean Air Act Amendments of 1977. They are proposing a new definition of engine useful life based on the average period of use before engine rebuilding or retirement. They are mandating crankcase emission control and planning to require each manufacturer to design a test procedure to measure emissions deterioration factors for its engines. They are planning to limit the amount of maintenance that can be performed during durability testing and they are contemplating requiring a 90% pass rate during production line

*This limit was raised to 8500 pounds in 1979.

Table III-7

Past and Future Federal Heavy Duty Vehicle Engine Emission Standards

(Diesel and Gasoline, Diesel Standard Effective January 1, 1974)

Model Year		HC	CO	NO_x	HC + NO_x	Smoke Opacity[b]
1970		275 [e]	1.5[a]	NR	NR[c]	40, 20, NR
1971		275	1.5	NR	NR	40, 20, NR
1972		275	1.5	NR	NR	40, 20, NR
1973		275	1.5	NR	NR	40, 20, NR
1974		-	40 [d]	-	16[d]	20, 15, 50
1975		-	40	-	16	20, 15, 50
1976		-	40	-	16	20, 15, 50
1977		-	40	-	16	20, 15, 50
1978		-	40	-	16	20, 15, 50
1979		-	25	-	5	20, 15, 35
	or	1.5[f]	25	-	10	20, 15, 35
1980		-	25	-	5	20, 15, 35
		1.5	25	-	10	20, 15, 35
1981		-	25	-	5	20, 15, 35
		1.5	25	-	10	20, 15, 35
1982		-	25	-	5	20, 15, 35
		1.5	25	-	10	20, 15, 35
1983[g]		1.4	14.7	-	10	0, 15, 50

(a) Percent mole volume

(b) Percent opacity: acceleration, lug, peak

(c) No requirement

(d) HC and NO_x combined into a single standard and California test procedure adopted to express emissions in GM/BHP-HR

(e) Parts per million

(f) GM/BHP-HR

(g) Approximate 1983 idle emission standards are 1400 ppm of carbon for HC and 0.55% for CO

Sources: Code of Federal Regulations, Federal Register

Selective Enforcement Auditing (SEA). These proposed standards have caused a large amount of controversy in the United States and parts of the proposal have been criticized by the Motor Vehicle Manufacturers Association (MVMA), the White House Council on Wage and Price Stability, the U. S. Department of Commerce, the American Trucking Association and the Engine Manufacturers Association. It is currently impossible to predict how the disagreements will be resolved and at what levels standards might be set beyond 1983.

The EPA has also identified trucks as a major source of noise in both city and highway driving situations. They have also identified five principal sources of truck noise: the engine, fan, intake, exhaust and tires. In response to this problem the EPA has established noise emission standards for medium and heavy duty trucks (Table III-8).*

California led the United States in the establishment of heavy duty vehicle engine emission regulations. They have established regulations on HC, CO, NO_x, smoke opacity and evaporative hydrocarbons (Table III-9). These regulations are shown from their inception in 1969 to their planned levels in 1983. However, California will probably also adopt any new federal test procedure established in 1983 as well as any new types of emission regulations federally imposed.

3. Safety Regulations

The purpose of this section is to provide an overview of the safety standards that are expected to be modified and newly promulgated by the National Highway Traffic Safety Administration (NHTSA). Standards on both automobiles and light duty trucks and vans are discussed and major safety issues that currently exist are mentioned. It must be recognized that a great deal of uncertainty exists as to the types of changes to existing regulations and the adoption of new regulations that may take place in the 1985 to 1990 timeframe and beyond. In fact, the precise performance specifications corresponding to modified and new regulations expected in the early 1980's have not yet been defined. This situation has prevented even the vehicle manufacturers from confidently

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*Noise standards also exist in some states for automobiles, light trucks and heavy trucks.

Table III-8

Federal Noise Emission Standards for Heavy Duty Trucks

(over 10,000 lbs GVWR, not including buses)

Model Year	dbA
1978 (effective Jan. 1)	83
1979	83
1980	83
1981	83
1982	80
1983*	80
1984*	80
1985*	75

*Possible standards

Sources: Motor Vehicle Manufacturers Association, Federal Register

Table III-9

Past and Future California Heavy Duty Vehicle Engine Emission Standards

(Diesel and gasoline, diesel standard effective January 1, 1973)

Model Year	HC	CO	NO_x	HC + NO_x	Smoke Opacity[b]	Evaporative Hydro-Carbons (gms)
1969	275[g]	1.5[a]	NR[c]	NR	NR	NR
1970	275	1.5	NR	NR	40, 20, NR	NR
1971	275	1.5	NR	NR	40, 20, NR	NR
1972	180	1.0	NR	NR	40, 20, NR	NR
1973	-	40[d]	-	16[d]	40, 20, NR	2[e]
1974	-	40	-	16	20, 15, 50	2
1975	-	30	-	10	20, 15, 50	2
1976	-	30	-	10	20, 15, 50	2
1977	-	25	-	5	20, 15, 50	2
	1.0[h]	25	7.5[h]	-	20, 15, 50	2
1978	-	25	-	5	20, 15, 50	6[f]
	1.0	25	7.5	-	20, 15, 50	6
1979	-	25	-	5	20, 15, 35	6
	1.0 (1.5)[i]	25	7.5	-	20, 15, 35	6
1980	-	25	-	5	20, 15, 35	2
	1.0	25	-	6	20, 15, 35	2
1981	-	25	-	5	20, 15, 35	2
	1.0	25	-	6	20, 15, 35	2
1982	-	25	-	5	20, 15, 35	2
	1.0	25	-	6	20, 15, 35	2
1983	0.5	25	-	4.5	0, 15, 50	2

Table III-9 (continued)

Past and Future California Heavy Duty Vehicle Engine Emission Standards

Footnotes:

(a) % mole volume

(b) % opacity: acceleration, lug, peak. This is a federal standard applicable in California.

(c) No requirement

(d) California standards modified to express standards in GM/BHP-HR. Diesel engines added to requirements. HC and NO_x combined into a single standard.

(e) Evaporative emissions restricted, 2 grams per test, certified by design.

(f) Hardware equivalent to 6 GM per test for passenger cars tested by the Shed method.

(g) Parts per million

(h) GM/BHP-HR

(i) For 1979 only, manufacturers measuring HC with NDIR method must meet 1.0 GM/BHP-HR and those measuring HC with HFID must meet 1.5 GM/BHP-HR. Both standards are equivalent. Either method can be used to determine HC + NO_x compliance. HFID must be used after 1979.

Source: California Air Resources Board.

hypothesizing about potential design responses and the resulting impacts on material usage.

The discussion of automobile and light truck safety standards focuses on two basic types: crash avoidance and crashworthiness standards. Crash avoidance standards are meant to help in the avoidance of collisions or in the reduction of impact velocities of collisions which cannot be avoided. Crash avoidance countermeasures deal with several accident-causing factors:

- Failure or inability of the driver to see or otherwise perceive a hazardous circumstance sufficiently early;
- Inability of the driver to respond quickly enough once an impending crash circumstance is recognized; and
- Inadequate response of the vehicle to appropriate typical driver inputs.

Crashworthiness standards are meant to reduce the severity of injuries suffered by vehicle occupants when a collision occurs by encouraging improved vehicle structural performance and occupant restraint systems.

There are currently 50 Federal Motor Vehicle Safety Standards (FMVSS) in effect which are applicable to the various types of vehicles. Twenty-six of these are accident prevention standards (100 series), 22 are occupant crash protection standards (200 series), and two are post-accident protection standards (300 series). NHTSA, responsible for promulgating both fuel economy and safety standards, has released a five-year plan outlining areas where further rulemaking may bring about a reduction in traffic fatalities and injuries while continuing to conserve energy through production of fuel efficient vehicles. This further rulemaking consists of technical amendments to improve the effectiveness of existing regulations, rulemaking initiatives which embody substantial changes to existing regulations and the introduction of some new regulations, and exploratory rulemaking which identifies significant new types of regulations about which too little is known at this point to establish a firm timetable for introduction.

NHTSA identified three high priority areas for further safety rulemaking:

- Occupant protection (especially side impact);
- Pedestrian safety; and
- Braking system performance.

In the long run, the major occupant protection objective will be the development of a set of standards that will apply comprehensively to front, side, rear, and rollover crashes. These standards will be related to overall vehicle performance, as measured by injury levels to test dummies. Such an approach will represent a major change from the current practice of expressing standards in terms of the performance of specific components. It is anticipated that this approach will provide improved occupant protection, more vehicle design flexibility, and reduced aggressiveness of vehicles in multi-car collisions.

The reduction of pedestrian fatalities and injuries is a long-term priority. NHTSA plans to expand research into the causes of pedestrian injuries and methods of prevention, and to issue rulings to eliminate vehicle protrusions that contribute to pedestrian injuries.

In the area of braking system performance, rules will be issued in the near future to address such problems as differential stopping distances between various types of vehicles, variable reliability of replacement brake components, and the inspection and diagnosis of degraded brake systems. High priority is also being given to such longer-term concepts as long life automatic, and antilock braking systems.

In addition to these high priority areas, NHTSA has recently released a set of 14 implementation plans which describe their major safety improvement program:

- Emergency Medical Services
- Motorcycle and Moped Program
- Young Driver Program
- National Driver Register
- Driver Licensing Program
- State Program Management
- Traffic Law Ajudication
- Pedestrian/Bicyclist/Pupil Transportation Program
- Occupant Restraints

- Alcohol and Drugs
- Police Traffic Services
- State Traffic Records
- 55 MPH Noncompliance and Other Unsafe Driving Acts
- Motor Vehicle Registration, Titling, and Antitheft

As increasingly stringent fuel economy regulations come into effect in the course of the next decade and the proportion of small cars in the new car fleet increases, small car safety will present significant technical and marketing problems to the auto industry. The probability of involvement in an accident is essentially independent of vehicle size, but with current designs the probability of serious injury, given an accident, is significantly higher for occupants of smaller cars. The key factor does not seem to be vehicle weight, but that small cars have shorter distances over which to dissipate the energy of impact. The result is that occupants experience greater decelerations during a crash, and the passenger compartment is more likely to undergo severe deformation. Even if small car design is improved markedly to alleviate this problem, it may be difficult to convince the consumer that small car safety is not an issue in purchasing a car, since automobile advertising has maintained in the past that large cars are not only better but inherently safer.

Many of the changes that will be required by future automobile crashworthiness standards (Table III-10) will be in component design such as the organization, shape, and identification of vehicle controls and instrument displays. Some totally new components may be used to meet upgraded theft protection standards and to provide a low pressure tire warning system.

A standard requiring an advanced passenger car braking system could potentially cause a large change in brake system components and materials. Because of the major role the brake system has in preventing accident, NHTSA will be investigating the feasibility and practicality of requiring shorter stopping distances, improved braking in turns or on low or split friction coefficient surfaces, and long-life brake systems. A number of possible design responses to this type of requirement have been identified including:

Table III-10

Crash Avoidance Federal Motor Vehicle Safety Standards on Passenger Automobiles Beyond Current Standards

FMVSS	Effective Date	Description
114	1981	Theft protection (upgrade)
115	1980-1981	Standardized vehicle identification number (VIN) system
New	1981	Low pressure tire warning indicator
New	1980-1981	Speedometers and odometers (upgrade)
Part 567	1979-1980	Uniform tire quality grading system (upgrade to include radial tires)
101	1979-1981	Controls and displays (upgrade)
108	1978	Headlight candlepower (upgrade intensity and aiming)
101	1982	Controls and displays (standardize locations)
108	1983	Rear lighting and signaling (upgrade)
109	1982	Passenger car tire traction
111	1981-1982	Rear view mirror systems (upgrade)
New	1981-1982	Direct fields of view
New	1982-1983	Brake system inspectability
New	1981-1982	Road wheel identification and selection
New	---	Aftermarket brakes (quality control)
New	---	Advanced passenger car braking system
New	---	Electric and hybrid vehicles
New	---	Electric, hybrid and lightweight restricted performance vehicles
New	---	Electromagnetic interference/compatibility
New	---	Handling and stability performance
New	---	Controls for the handicapped

Source: National Highway Traffic Safety Administration, Five-Year Plan.

- Radar devices which would warn the driver and/or apply the brakes automatically;
- Optical sensing devices to determine range and closing speed for use in providing a driver warning; and
- Devices for reducing or preventing wheel lockup (e.g., anti-skid braking systems).

Future automobile crashworthiness standards have the potential to significantly impact vehicle design (Table III-11). At present, considerable uncertainty surrounds what NHTSA may develop in the way of performance requirements and testing methods, and how the automobile manufacturers might respond. NHTSA's Research Safety Vehicle Program appears to be demonstrating state-of-the-art methods in occupant and pedestrian protection. The techniques demonstrated will probably not be adopted until the 1985 to 1990 timeframe.

FMVSS 208 has been modified to require that all new automobiles with wheelbases over 114 inches be fitted with passive restraint systems for the front seat passenger as of September 1, 1981 (1982 model year); automobiles with wheelbases over 100 inches must be fitted as of September 1, 1982 (1983 model year); and all automobiles must have passive restraint systems by September 1, 1983 (1984 model year). Automobiles will have to provide occupant protection to specified levels of injury as measured by test dummies in frontal, side, and rollover crashes. Regulations currently in effect for passive restraint system performance specify a 30-mph frontal impact, a 20-mph side impact, and rollover at 30 mph. These performance requirements may be toughened in the 1985-1990 period.

Trucks are divided into two gross vehicle weight rating (GVWR) classes for the purpose of safety regulations. Some regulations are applicable to all trucks, some are applicable to those above 10,000 pounds GVWR, and some are applicable only to those below 10,000 pounds GVWR.

Future light duty truck and van safety standards (below 10,000 pounds GVWR) are expected to lag behind but follow closely the standards instituted for automobiles. NHTSA intends to extend passenger car safety standards directly to light trucks, or modify them to take into account the unique characteristics of these vehicles. NHTSA's highest rulemaking

Table III-11

Crashworthiness Federal Motor Vehicle Safety Standards on Passenger Automobiles Beyond Current Standards

FMVSS	Effective Date	Description
208	1981	Seat belt assemblies (upgrade)
206	1980-1981	Door locks and door retention components
203	1981-1983	Impact protection for the driver from the steering control system (consider upgrading)
204	1981-1983	Steering control rearward displacement (consider upgrading)
208	1982-1984	Occupant crash protection (passive restraints)
214	1984-1985	Side impact protection (upgrade)
302	---	Flammability/toxicity of interior materials
New	---	Occupant protection - frontal/side impact
New	---	Occupant protection - rear impact
New	---	Occupant protection - rollover
New	---	Pedestrian protection
New	---	Electric and hybrid vehicles
New	---	Electric, hybrid and lightweight restricted performance vehicles

Source: National Highway Traffic Safety Administration, Five-Year Plan.

priority is improvement of side impact protection in passenger cars, light trucks, vans, and multi-purpose passenger vehicles. They intend to extend passive occupant protection to light trucks. In general, the priorities and issues discussed for automobiles also apply to light trucks.

Light trucks and van crash avoidance (Table III-12) and crashworthiness (Table III-13) standards for the future are very similar to those previously shown for automobiles. The most significant changes in terms of impact on vehicle design will be caused by the modifications to FMVSS 201, 203, 204 and 208. Changes to 201 will cause light truck interiors to be designed even more like the interiors of automobiles with padded instrument clusters and door panels. FMVSS's 203 and 204 will cause marked changes in steering column design in vans to provide the required protection. FMVSS 208 will require the use of passive restraints in light trucks by the 1984 model year.

In general, it can be said that NHTSA has placed a lower priority on improving the safety of trucks above 10,000 pounds GVWR than it has placed on autos and light duty trucks. This lower priority is the result of the relatively small contribution these vehicles make to the total number of vehicle related deaths and injuries. However, it can be expected that as the safety afforded by light duty vehicles improves, more stringent safety standards will be applied to heavier vehicles. Crash avoidance and crashworthiness standards that currently apply to vehicles with GVWR's over 10,000 pounds are listed in Tables III-14 and III-15.

Table III-12

Crash Avoidance Federal Motor Vehicle Safety Standards on Light Trucks and Vans Beyond Current Standards

FMVSS	Effective Date	Description
114	1981	Theft protection (upgrade and extend applicability)
115	1980-1981	Standardized vehicle identification number (VIN) systems (extend applicability)
New	1981	Low pressure tire warning indicator
New	1980-1981	Speedometers and odometers (upgrade)
Part 567	1979-1980	Uniform tire quality grading system (upgrade to include radial tires)
101	1979-1981	Controls and displays (upgrade)
108	1978	Headlight candle power (upgrade intensity and aiming)
108	1978-1981	Clearance and identification lamps (establish uniform mounting height on vehicles over 80 inches wide)
111	1980	Rearview mirrors (allow convex mirrors)
101	1982	Controls and displays (standardize locations)
105-75	1983	Hydraulic brake systems (extend applicability)
108	1983	Rear lighting and signaling (upgrade)
109	1982	Passenger car tire traction (passenger car tires only)
New	1981-1982	Direct fields of view (performance requirements)
111	1981-1982	Rearview mirror systems (upgrade)
New	1982-1983	Brake system inspectability
New	1981-1982	Road wheel identification and selection
105-75 and 121	---	Truck brakes (upgrade)
119	---	New pneumatic tires (traction amendment)
New	---	Aftermarket brakes (quality control)
New	---	Electric and hybrid vehicles

Table III-12 (Cont.)

FMVSS	Effective Date	Description
New	---	Electric, hybrid and lightweight restricted performance vehicles
New	---	Electromagnetic interference/compatibility
New	---	Handling and stability (improve)
New	---	Controls for the handicapped

Source: National Highway Traffic Safety Administration, Five-Year Plan.

Table III-13

Crashworthiness Federal Motor Vehicle Safety Standards on Light Trucks and Vans Beyond Current Standards

FMVSS	Effective Date	Description
208	1981	Seat belt assemblies (upgrade)
206	1980-1981	Door locks and door retention components (clarify test procedure and extend requirements to transverse rear doors)
201	1981-1983	Occupant protection in interior impact (extend applicability)
203	1981-1983	Impact protection for the driver from steering control system (extend applicability and consider upgrading)
204	1981-1983	Steering control rearward displacement (extend applicability and consider upgrading)
208	1984	Occupant crash protection (extend applicability of passive restraint requirement)
214	1984-1985	Side impact protection (extend applicability)
New	---	Occupant protection - frontal/side impact
New	---	Occupant protection - rear impact
New	---	Occupant protection - rollover
New	---	Electric and hybrid vehicles
New	---	Electric, hybrid and lightweight restricted performance vehicles
302	---	Flammability/toxicity of interior materials (upgrade)

Source: National Highway Traffic Safety Administration, Five-Year Plan.

Table III-14

Crash Avoidance Federal Motor Vehicle Safety Standards on Vehicles Over 10,000 Pounds GVWR*

FMVSS	Description
101	Control, location, identification and illumination
102	Transmission shift lever sequence, starter interlock and transmission braking effect
103	Windshield defrosting and defogging systems
104	Windshield wiping and washing systems
106	Hydraulic brake hoses
107	Reflecting surfaces
108	Lamps, reflective devices, and associated equipment
111	Rearview mirrors
112	Headlamp concealment devices
113	Hood latch systems
116	Hydraulic brake fluids
119	New pneumatic tires
120	Tire selection and rims
121	Air brake systems
124	Accelerator control systems
125	Warning devices
126	Truck - camper loading

*Gross Vehicle Weight Rating

Source: National Highway Traffic Safety Administration.

Table III-15

Crashworthiness Federal Motor Vehicle Safety Standards on Vehicles Over 10,000 Pounds GVWR*

FMVSS	Description
205	Glazing materials
206	Door locks and door retention components
207	Seating systems
208	Occupant crash protection
209	Seat belt assemblies
210	Seat belt assembly anchorages
213	Child seating systems
217	Bus window retention and release
220	School bus rollover protection
221	School bus body joint strength
222	School bus passenger seating and crash protection
301-75	Fuel system integrity
302	Flammability of interior materials

*Gross Vehicle Weight Rating

Source: National Highway Traffic Safety Administration

B. Canadian Vehicle Regulations

A series of personal interviews were conducted with Canadian government regulatory experts to gather information regarding existing and potential vehicle regulations. Key personnel from the following agencies were contacted.

- Ministry of State for Science and Technology (MOSST)
- Transport Canada
- Energy, Mines and Resources Canada (EMR)
- Environment Canada
- Department of Consumer and Corporate Affairs
- Economic Council of Canada

The purpose of these interviews was not to gather extremely detailed information regarding Canadian regulations, but to understand the major regulatory issues that exist. These issues were then related to the issues which exist in the United States and a total picture of the vehicle regulatory environment in North America was assembled. This picture enabled us to identify the major technological changes which could be expected in the North American on-road vehicle market.

1. Major Issues Related to Canadian Vehicle Regulations

The major issues we identified related to existing and future Canadian vehicle regulations are summarized below.

- We believe it very likely that mandatory auto and light fuel economy standards at levels slightly higher than the standards in the U.S. will be established in Canada in the next year or two. The challenge will be to set them high enough to get significant fuel savings, yet not so high as to disrupt the Canadian auto market. Voluntary versus mandatory fuel economy levels are a current subject of debate in Canada.

- There will be a substantial conflict between EMR who are in favor of leaded gasoline and Environment Canada who are opposed to it. If Canadians are aware of the current energy problems, we believe leaded gasoline will continue to be used. This will increase the percentage of Canadian specific emission control systems.

- If Canadian emission standards remain at current levels and the fuel economy guidelines remain voluntary, Canadians will be paying for U. S. automobile emission control technology they won't need. It will be economically impossible for the auto makers to remove it from vehicles to be sold in Canada.
- The lack of emissions and fuel economy testing facilities accessible to Canadian parts manufacturers will hinder development of new components that impact emissions and fuel economy performance.
- Six passenger autos sold in Canada will most likely not be equipped with air bags. This should result in substantial savings for Canadian consumers. Canadians may also resist using passive three point belts. Since development of improved active three point belts will essentially stop in the United States, this may be an opportunity for a Canadian safety research organization.
- Transport Canada may develop new safety regulations to cover the performance of defrosters, heaters, windshield washers, windshield wipers, and tires in the Canadian environment.

2. General Statements Regarding Canadian Vehicle Standards

Transport Canada is not interested in setting vehicle standards that will disrupt the Canadian market by preventing large numbers of U. S. made vehicles from being sold in Canada. The selection of vehicles that would become available to consumers would probably become very limited if Canada were to impose standards requiring significant vehicle changes for the Canadian market. The regulators we spoke with seemed most interested in setting standards that provided the best benefits in return for the costs for the Canadian people. Their approach to regulations is certainly more conservative than that used in the United States, but they seemed willing to break new ground when necessary. The Canadian political environment may work to stifle their creativity, however. It should also be noted that Canada has an agreement with the Economic Commission for Europe (ECE) that states they will not use regulations as trade barriers.

3. Fuel Economy Guidelines

Canada currently has voluntary fuel economy guidelines which apply only to automobiles. They have been set at the same levels as U. S. fuel economy standards and will probably keep pace with U. S. standards through 1985. Transport Canada stated that it has been politically decided that no real need currently exists for mandatory fuel economy standards, but both EMR and Environment Canada are in favor of them. They would like to see mandatory standards set at levels higher than those in the United States to compensate for less stringent emission standards. Mandatory standards for automobiles would probably result in mandatory standards for light trucks and vans up to 8500 pounds GVWR.

4. Emissions Regulations

Environment Canada is responsible for air quality in Canada, but only Transport Canada has the authority to impose vehicle emission standards (Table III-16). Canada currently has less stringent emission regulations on automobiles than the United States (Table III-17) but Environment Canada believes there is very little benefit from this. The auto manufacturers have greater flexibility in what they sell in Canada and it is doubtful consumers are benefiting from it. Less stringent emission standards without compensating mandatory fuel economy standards will probably result in Canadian consumers receiving:

- Poorer fuel economy due to engine calibration changes required when cars are not equipped with sophisticated emission controls;

Table III-16

Current Canadian Motor Vehicle Emission Requirements

		BUS	CHASSIS CAB	COMPETITION MOTORCYCLE	COMPETITION SNOWMOBILE	MINIBIKE	MOTORCYCLES, MOTOR DRIVEN CYCLES AND MOPEDS	MULTIPURPOSE PASSENGER VEHICLE	PASSENGER CAR	SNOWMOBILE	SNOWMOBILE CUTTER	TRAILER	TRAILER CONVERTER DOLLY	TRUCK
Emission Device	1101	X	X					X	X					X
Crankcase Emission	1102	X	X					X	X					X
Hydrocarbon and CO	1103	X	X					X	X					X
Diesel Opacity	1104	X	X					X						X
Evaporative Emission	1105	X	X					X	X					X

Source: Canada Gazette

Table III-17

Canadian New Car Standards for HC, CO and NO_x by Model Year

(grams per mile)

Model Year	HC	CO	NO_x
1971	3.4	39.0	3.0
1974	3.4	39.0	3.0
1974 (1)	3.0	25.0	3.1
1975	2.0	25.0	3.1
1980	2.0 (2)	25.0	3.1
1984	2.0	25.0	3.1
1984 (3)	0.9	9.0	2.0

Source: Environment Canada

(1) 1975 EPA FTP for this and later years

(2) This might rise to 2.5 grams per mile to allow for lead burning engines according to EMR

(3) This standard is effectively 50% higher than the U.S. standard of 0.41/3.4/1.0 and might become effective January 1, 1984

- Less sophisticated vehicles in terms of driveability, altitude compensation capability, and adaptability to fuel property variations possible with the air/fuel ratio feedback control systems; and
- Poorer cold weather performance and emission levels.

Canadian vehicle emission standards will have to be tightened after 1985 to prevent an increase in pollutant levels resulting from more vehicles and more travel. They are not expected to be as stringent as the standards that will exist in the United States at that time.

Canada does not have a lead phasedown program like the United States. EMR is working to promote the use of leaded gasoline because of the refinery energy saved when leaded rather than unleaded gasoline is made. A 2% credit toward meeting the fuel economy guidelines currently exists for autos using leaded gasoline, and it may be increased to 7% to offer more motivation to develop higher compression engines that use leaded fuel. Higher compression ratios will result in increased engine efficiency in addition to the refinery savings. As a result of the less stringent emission standards and the encouragement to use leaded fuel, 60% of all cars sold in Canada in 1979 had Canadian specific emission control systems and 75% are expected to be so by 1981. However, Canadian specificity generally arises from the omission of components, not the addition of Canadian made components.

Environment Canada is opposed to leaded fuel because of the health effects of lead emissions and they are working to phase it out. EMR does not believe they will win, though, because they perceive that environmental concerns in Canada have not been argued effectively enough to win out over energy concerns when conflicts arise.

In addition to meeting exhaust emission standards, automobiles must not emit any crankcase emissions or more than 2 grams per test of evaporative emissions using the carbon trap test. An evaporative emission standard of 6 grams per SHED test is likely in 1982. Light duty vehicles must not emit more than 80 dbA of noise during a standard test.

There are heavy duty vehicle emission regulations on hydrocarbons, carbon monoxide and oxides of nitrogen emissions as well as smoke opacity, noise and crankcase emissions. Heavy duty vehicles must not emit more than:

- 16 grams per brake horsepower-hour of HC and NO_x; and,
- 40 grams per brake horsepower-hour of CO

when tested on the current U. S. test procedure. The opacity of exhaust emissions from a diesel powered heavy duty vehicle must not exceed:

- 20% during acceleration;
- 15% during lugging; and
- 50% during peak condition of engine acceleration and lugging.

Exterior noise levels of heavy duty vehicles must not exceed 83 dbA and interior noise levels must not exceed 90 dbA when tested using current U.S. procedures. Crankcase emissions are also not allowed from heavy duty gasoline fueled engines.

5. Safety Regulations

All of the safety testing and standards development for Canada is done within Transport Canada. Traditionally, Canadian safety standards have been patterned very closely after U.S. standards with a time lag of a year or more. In general, future safety standards will follow the priorities that have been established in the NHTSA five-year plan.

Existing standards and their applicability by vehicle type are shown in Table III-18 and a variety of near term changes are expected in both crash avoidance and crashworthiness standards (Tables III-19 and III-20).

Air bags are a major area of interest and study for Transport Canada. However, their current position is that they will continue to require active restraint systems until more information is available. They are not willing to sacrifice protection to get air bags because some 75 to 80% of the population is covered by a mandatory seat belt law. It has been estimated that 50% of all Canadians are currently using seat belts and that the usage rate will rise to 80%.

Table III-18

Current Canadian Motor Vehicle Safety Standards

		Bus	Chassis - cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles and Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Control Location	101	x	x					x	x					x
Shift Sequence	102	x	x					x	x					x
Defrosting Defoging	103	x	x					x	x					x
Wiping and Washing	104	x	x					x	x					x
Hydraulic Brakes	105	x							x					
Hydraulic Hoses	106	x	x				x			x			x	x
Reflecting Surfaces	107	x	x					x	x					x
Lighting	108	x	x			x	x	x	x			x		x
Headlamps	108a	x	x					x	x					x
Tires and Rims	110								x					
Rearview Mirrors	111	x					x							x
Rearview Mirrors	111a								x					
Headlamp Concealment	112	x	x				x	x	x					x
Hood Latches	113	x	x					x	x					x
Locking Systems	114								x					

Table III-18
(cont'd)

		Bus	Chassis - cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles and Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Vehicle Number	115			x			x		x					
Hydraulic Fluids	116	x	x				x	x	x			x	x	x
Power Windows	118							x	x					
Tire Selection & Rims	120	x	x				x	x				x	x	x
Air Brake Systems	121	x	x									x	x	x
Motor Cycle Controls and Displays	123						x							
Accelerator Control Systems	124	x	x					x	x					x
Occupant Protection	201								x					
Head Restraints	202								x					
Impact Protection	203								x					
Steering Wheel	204								x					
Glazing Materials	205	x	x				x	x	x			x		x
Door Latches	206		x					x	x					x
Seat Anchorages	207	x	x					x	x					x
Seat Belts	208	x						x	x					x
Belt Assemblies	209	x	x					x	x			x		x
Belt Anchorages	210	x	x					x	x					x

Table III-18
(cont'd)

		Bus	Chassis - cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles and Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Nuts Discs Hub Caps	211							x	x					
Windshield Mounting	212								x					
Child Seating and Restraint Systems	213	x						x	x					x
Side Door Strength	214								x					
Bumpers	215								x					
Roof Intrusion Protection	216								x					
Bus Window Retention, Release & Emergency Exits	217	x												
Rollover Protection	220	x												
Fuel System	301	x						x	x					x
Flammability	302	x	x					x	x					x
Axles	901											x		

Source: Canada Gazette

Table III-19

Changes Expected in Crash Avoidance Canadian Motor Vehicle Safety Standards

Control Location - 101

Speedometers must be labeled in kilometers per hour in Canada. They are doing a lot of work on the development of symbols for vehicle controls.

Defrosting and Defogging - 103

They are working to develop a new standard that will cover side window defrosting. They hope the United States will adopt this standard since side window vision is a real problem.

Wiping and Washing - 104

They will be trying to sell the ECE and the United States on using a different test method and test dirt mix.

Hydraulic Brakes - 105

They are extending the applicability of this standard to trucks. Changes in rear wheel loadings during braking can cause rear wheels to lock.

Tires and Rims - 110

Radial tires are rated according to top speed capability in Europe. Canada may impose a speed rating on tires so that tire capabilities match vehicle capabilities.

Air Brake Systems - 121

They did not adopt the U. S. anti-lock standard because they felt it was unjustified and that the hardware was unreliable. They are working to remove exemptions for trailers and heavy duty haulers by the end of this year.

Headlamp Washing - New

A standard which would require headlamp washing equipment is possible.

Source: Transport Canada

Table III-20

Changes Expected in Crashworthiness Canadian Motor Vehicle Safety Standards

Occupant Protection - 201

Impact Protection - 203

Steering Wheel - 204

They anticipate applying these standards to light trucks, vans and MPV's perhaps six months after September 1980.

Head Restraints - 202

Application of this standard to light trucks currently has a lower priority than the changes to 201, 203, and 204.

Seat Belts - 208

Belt Assemblies - 209

Belt Anchorages - 210

Development of new versions of these standards is taking top priority. They are not convinced that air bags are the best solution to the safety problem so they are committed to setting standards which will continue to allow the use of active belts.

Windshield Mounting - 212

This standard will soon apply to light trucks and MPV's.

Child Seating and Restraint Systems - 213

Consumer and Corporate Affairs have jurisdiction over this standard.

Bumpers - 215

There is some doubt about the Canadian publics' willingness to pay for the 5 mph bumper. Part 581 covering allowable damage to bumpers does not apply in Canada as it does in the United States.

Source: Transport Canada

During our interviews it was emphasized that defrosters, heaters, windshield washers, windshield wipers and tires are important safety related components in the Canadian environment. Because of the importance of safety related components in Canada, Transport Canada is constructing a new safety test center that will be equipped with a laboratory, dynamometer, cold chamber, crash barriers and high and low speed test tracks. This facility should be an important asset to Canadian manufacturers hoping to develop safety related components.

6. Canadian Anti-Corrosion Code

The Department of Consumer and Corporate Affairs and the Federal Provincial Task Force on Motor Vehicle Corrosion and Durability were responsible for developing a voluntary anti-corrosion code for auto manufacturers. The existing code specifies that vehicles must last one year without surface rust, three years without perforation and six years without structural damage to components such as transmission mounts, door hinges, headlight mountings, door handles, etc. As of 1978, all manufacturers selling automobiles in Canada have either accepted the provisions of the Code or have offered anti-corrosion warranties which provide consumer protection generally similar to that specified by the Code. The Code is expected to be upgraded in 1981 to specify 1-1/2 years without surface rust, five years without perforation and six years without structural damage. There are no plans beyond 1981 at this point. The Task Force has not yet decided what to do regarding the problem of overall vehicle durability. They are looking at improvements in materials which would reduce vehicle repair costs (exhaust systems, brake tubing).

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IV. MAJOR TECHNOLOGICAL CHANGES EXPECTED TO RESULT FROM VEHICLE REGULATIONS AND OTHER FORCING FACTORS

A. Overview of Technological Changes

As a result of future regulatory, market and societal demands made upon the automotive industry, various technological changes are expected to occur in passenger cars and over-the-road trucks. An overview was prepared to provide the background against which changes in individual parts could be considered (Tables IV-1 and IV-2). These charts show the major technological changes expected between now and 2000 in six, five and four passenger automobiles and light, medium and heavy duty trucks. The length of each bar represents the expected penetration of each change from 0 to 100 percent.

1. Lockup Torque Converter

Conventional torque converters transmit power from the engine to the automatic transmission through a fluid. A "lockup" torque converter mechanically bypasses the fluid under certain predetermined driving conditions in order to avoid slippage inherent in fluid power transmitting devices. The mechanical coupling is accomplished by a mechanical clutch built into the torque converter or transmission.

While Packard produced such a torque converter in the early 1950's, Chrysler was the first of the present passenger car manufacturers to offer it. Chrysler's version was introduced in 1978. Lockup torque converters have been used on some heavy duty truck automatic transmissions for a number of years.

2. Multi-Speed (4 speeds or more) Automatic Transmission

Most conventional automatic transmissions have 3 forward speeds or gears. Each gear establishes a finite ratio between the rotational speed of the engine and the rotational speed of the driven wheels. The greater the number of speeds available in a transmission, the greater the selection of relative engine and wheel speeds. A greater selection of relative speeds allows an engine to be operated closer to its most efficient operating point for a given driving condition. Thus, multi-speed automatics allow the engine to operate at or close to its

TABLE IV–1

OVERVIEW OF EXPECTED PASSENGER AUTOMOBILE TECHNOLOGICAL CHANGES BY PASSENGER CAPACITY AND TIME FRAME AND DEGREE OF PENETRATION

TECHNOLOGICAL CHANGE	1981			1985			1990			2000		
No. Passengers	6	5	4	6	5	4	6	5	4	6	5	4
Drivetrain												
Conventional 3-Speed Automatic												
Lock-up Torque Converter												
4-Speed Automatic with Lockup Torque Converter												
Continuously Variable Transmission												
Improved Rear Axle Lubricants												
High Pressure Recompounded Radial Tires												
Front Wheel Drive												
Engine												
OTTO S.I. Engine												
Closed Loop A/F Ratio Control												
Closed Loop Spark Control												
Improved Crankcase Lubricants												
Turbocharging												
Electronically Controlled Carburetor												
Electronic Fuel Metering												
Electronic Fuel Injection												
Diesel Engine												
Substitute for S.I. Engine												
Electronic Fuel Control												
Improved Crankcase Lubricants												
Turbocharging												
Engine Configuration V–8												
L–6												
V–6												
L–4												
Total Drivetrain Electronic Control												
Accessories												
Electric Fuel Pump and/or Fan Drives												
Constant Speed Accessory Drives												
Frame												
– Separate												
– Unitized												

TABLE IV–1
(Continued)

TECHNOLOGICAL CHANGE	1981			1985			1990			2000		
No. Passengers	6	5	4	6	5	4	6	5	4	6	5	4
Suspension												
Front Double A-Arm	—	—		—								
MacPherson Strut		—	—	—	—	—	—	—	—	—	—	—
Rear Solid Axle	—	—	—	—	—	—	—	—	—	—	—	—
Steering Recirculating Ball — Power	—	—		—								
Rack and Pinion — Manual		—	—		—	—			—			—
Rack and Pinion — Power		—		—	—	—	—	—	—	—	—	—
Brakes Front — Disc	—	—	—	—	—	—	—	—	—	—	—	—
Rear — Drum	—	—	—	—	—	—	—	—	—	—	—	—
Emission Control — OTTO S.I. Engine												
3-Way/2-Way Series Converter	—	—	—	—	—	—						
A/F Ratio Sensor												
Control System												
Air Pump												
Proportional EGR												
Noble Metal 3-Way Catalyst							—	—	—	—	—	—
(or Base Metal Catalyst)												
A/F Ratio Sensor												
Control System												

Source: Arthur D. Little, Inc.

TABLE IV–2

OVERVIEW OF EXPECTED TECHNOLOGICAL CHANGES IN LIGHT, MEDIUM AND HEAVY TRUCKS BY TIME FRAME AND DEGREE OF PENETRATION

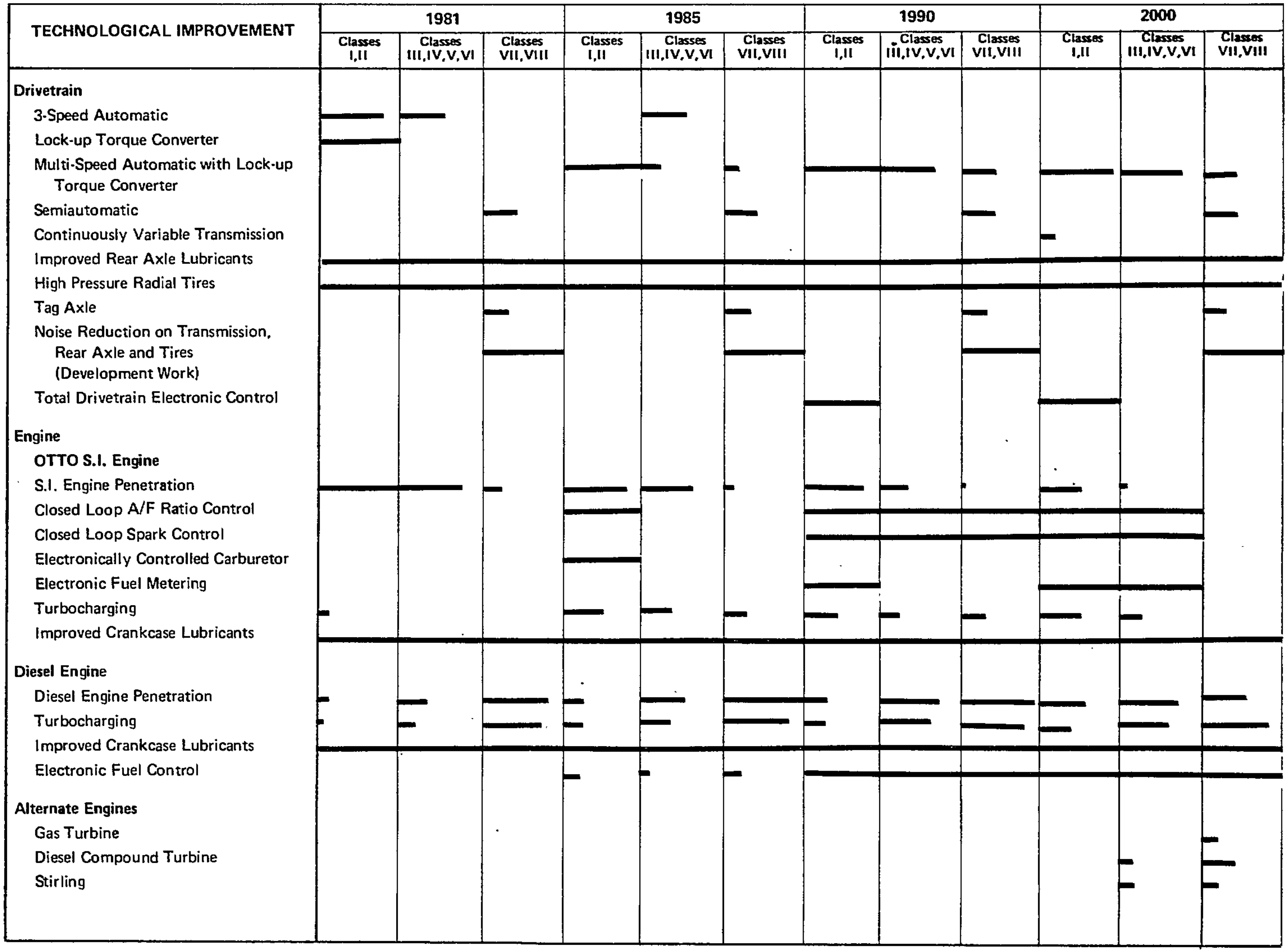

TABLE IV–2

(Continued)

TECHNOLOGICAL IMPROVEMENT	1981			1985			1990			2000		
	Classes I,II	Classes III,IV,V,VI	Classes VII,VIII	Classes I,II	Classes III,IV,V,VI	Classes VII,VIII	Classes I,II	Classes III,IV,V,VI	Classes VII,VIII	Classes I,II	Classes III,IV,V,VI	Classes VII,VIII
Accessories												
Modulated Fan (Fan Clutch)		—	—		—	—		—	—		—	—
Electric Fuel Pump				—			—			—		
Constant Speed Accessory Drives	—			—	—	—	—	—	—	—	—	—
Frame												
– Separate	—	—	—	—	—	—	—	—	—	—	—	—
– Unitized				—			—			—		
Aerodynamics												
Air Deflectors			—			—			—			—
Vortex Stabilizer			—			—			—			—

Source: Arthur D. Little, Inc.

most efficient operating point for a greater percentage of the time than a 3-speed automatic.

Ford Motor Company was the first U.S. manufacturer to offer 4-speed automatic transmissions on passenger cars when it introduced one for the 1980 model year. Multi-speed automatics have been available for heavy duty trucks for some time, although their acceptance by truck operators has been marginal.

It is expected that electronic controls will be needed to operate an engine and transmission package at the most efficient operating conditions. Total drivetrain electronic control is therefore expected to become a reality by 1990.

3. Continuously Variable Transmissions

Continuously variable transmissions provide an infinite selection of relative engine and driven wheel speeds. As such, the engine can be operated at its most efficient operating point for virtually any driving condition.

Continuously variable transmissions have been used for low power industrial machinery drives for several decades. Their application to high powered, modern highway vehicles has been hampered by problems of noise, vibration, durability, and control. However, several firms, including VanDoorne's Transmissie of Holland are making positive progress toward overcoming these problems. The use of these transmissions in mass produced U.S. passenger cars will most likely be a reality in the mid- to late-1980's.

4. Improved Lubricants

Lubricants consume power because of the energy required to pump and/or shear them. Their composition and viscosity affect their pumping and shearing energy requirements. New formulations of synthetic as well as petroleum based lubricants are capable of providing adequate lubrication while reducing the energy used in pumping and/or shearing.

5. High Pressure Recompounded Radial Tires

The energy consumed by tires is primarily a function of their flexing. The amount of flex in a tire is a function of its design, rubber compounds and operating pressure. The tire companies are working on the development of tires which run at higher pressures and are re-compounded with rubber compounds which consume less energy during flexing.

6. Front Wheel Drive

Conventional front engine, rear wheel drive vehicle configurations require a significant percentage of total available vehicle package volume to house their various components. Location of all the necessary pieces in one location within the vehicle minimizes the space they occupy and reduces the weight of the drivetrain. These reductions in turn allow a net reduction in total vehicle size and weight.

Location of the powertrain entirely in the front of the car appears more advantageous than in the rear. Front wheel drive is known to provide excellent traction and directional stability under slippery driving conditions. Its primary advantage lies in its maximization of interior volume for a given exterior volume and thus, we believe most passenger cars will be front wheel drive by 1990.

7. Closed Loop Electronic Controls

Closed loop electronic controls with 3-way catalytic converters to minimize emissions of carbon monoxide, unburned hydrocarbons, and nitrogen oxides will be required to meet the 1981 U.S. emission standards on all but the very smallest passenger cars. These controls usually maintain spark timing, exhaust gas recirculation, air pump flow rate, and air fuel ratio at precisely correct set points for each engine operating condition.

These controls influence air/fuel ratio through either an electronically controllable carburetor or other fuel metering device such as fuel injection. Either the carburetor or injection type system is adequate to meet the emission standards. It is expected that the fuel injection system will be ultimately more durable and able to maintain tighter operating tolerances. The "margin of safety" within which the vehicle must operate below the maximum allowable emission levels for 50,000 miles is therefore smaller with electronically controlled fuel metering than with electronically controlled carburetion. Thus, we expect that electronic fuel metering will replace electronically controlled carburetors.

8. Turbocharging

Turbocharging provides a means of increasing the quantity of fuel burned by a gasoline engine per unit time. A turbocharged small displacement engine can burn as much fuel as a non-turbocharged large displacement engine in the same time and produce the same amount of power. Therefore the acceleration of a car with a small turbocharged engine can equal that of a car with a larger non-turbocharged engine.

If the turbocharger is controlled such that it is only used when full power is required, a turbocharged small displacement engine can provide small engine fuel economy and large engine performance. It is expected that some portion of the passenger cars and light trucks will be turbocharged.

When applied to a diesel, a turbocharger provides improved power output and lower emissions of particulates. The power output of a turbocharged diesel is approximately equal to that of a non-turbocharged gasoline engine of the same displacement. It is expected that turbochargers will be a standard component on most diesel powered passenger cars and light trucks. Turbochargers are already used on most diesel powered heavy duty trucks.

9. Engine Configuration

Engine configuration governs the space required to package an engine. As the need to make more efficient use of vehicle space becomes more and more critical, smaller engine packages are desired. Therefore, V-6's are expected to replace in-line ("L") six cylinder engines.

As engine displacements are reduced because of the lower power requirements of light weight cars, fewer cylinders are needed to provide the desired power output. Therefore, 4 and 6 cylinder engines will replace 8 cylinder units.

The fewer the number of cylinders per engine, the more of a problem vibration can be. Fewer cylinders for a given power output result in stronger power pulses at lower frequencies. A smoother engine can result from many small cylinders providing closely spaced pulses. Thus, it is expected that small displacement V-8 engines will be used in luxury oriented vehicles until 1990. However, a large number of cylinders increases engine cost and reduces potential efficiency by creating a large wall quenching and heat transfer area. In 1990 and beyond we do not expect any significant number of V-8 engines to be used.

10. Diesel Engines

Diesel engines offer up to a 25% improvement in fuel economy over a gasoline engine providing similar performance. It is expected that the diesel will play an ever increasing role in the auto industry's strategy to improve fuel economy and meet mandated fuel economy standards in the United States.

11. Electronic Control of Diesel Engines

Electronic control of diesel engines to optimize injection timing, injection rate, turbocharger boost, and exhaust gas recirculation rate will be needed as diesels for all vehicles are required to meet increasingly stringent emission standards. Mechanical controls do not offer the flexibility required to optimize engine operation under all operating conditions.

12. Electric Fuel Pump, Electric Fan Drive and Constant Speed Accessory Drive

Electric fuel pumps, electric fan drives, and constant speed accessory drives are all methods of reducing power losses from the engine. Electric fuel pumps and fan drives operate only when needed rather than at full capacity all the time. Constant speed drives reduce or eliminate the inertial loading on the engine due to speed fluctuations and allow accessories like water pumps, alternators, and power steering pumps to operate at their most efficient speed. All of these devices are either in use now or are being developed and will be in common usage by 1985.

With the advent of front wheel drive, radiators will be placed at locations other than at the end of the engine crankshaft. Electric fan drives will be required with front wheel drive since engine shaft power will not be available.

13. Front Suspension

Front suspension components compete for vehicle space with the drivetrain. The conventional double A-arm suspension used on most U.S. built front engine, rear wheel drive cars occupies a significant portion of vehicle width. When a car is designed with front wheel drive, the double A-arm suspension occupies space which must be used to accommodate an engine, transmission and final drive unit. MacPherson Strut type front suspension does not occupy as much of the engine compartment space as double A-arm suspension. Therefore, it is expected that the trend toward MacPherson Strut suspension will continue for front wheel drive vehicles.

14. Rear Suspension

There are numerous rear suspension designs which could be employed on future cars. Of them all, the solid (beam) axle type is the most cost effective, durable, and easily massed produced system. Therefore, we believe that the solid axle will continue to be used on most domestically produced passenger cars and trucks.

15. Steering

There are two basic types of steering systems which can be employed in highway vehicles: the worm and sector type (updated versions are known as recirculating ball) or the rack and pinion type. Most rear wheel drive, domestically produced passenger cars and trucks use recirculating ball steering.

Rack and pinion steering is becoming popular because it eliminates many of the links and joints required in recirculating ball steering. This makes it easier to accommodate in the limited spaces available in small and front wheel drive cars.

It is expected that the present trend toward rack and pinion steering in new front wheel drive designs will continue. Because of the in-place capability to produce recirculating ball steering, however, it is anticipated that it will continue to be used in rear wheel drive trucks.

16. Vehicle Structure

There are two distinct methods of vehicle construction: frame and unitized construction. Frame construction utilizes a structural platform upon which the vehicle is built. Unitized construction requires the body of the vehicle to be capable of sustaining all loads to which the vehicle is subjected and to support the engine, payload, and all other vehicle components. Frame construction offers very flexible, modular construction which lends itself to the mass production of vehicles whose owners may want special features. Hence, frames are expected to be the dominant construction method for commercial trucks and specialty or luxury automobiles. Unitized construction eliminates much of the structural redundance inherent in a frame vehicle, and hence is usually lighter. Thus, unitized construction is expected to be used in most all passenger cars and passenger car based trucks.

17. Brakes

There is no anticipated change in the demand for passenger cars and light trucks with front disc brakes. Disc brakes could also be used on the rear of cars and would have good market appeal except for the expense and lack of durability of handbrakes integral with rear disc brakes. Drum brakes are easily compatible with emergency or handbrake functions and are expected to be used on the rear of most all passenger cars and light trucks.

18. Alternative Truck Engines

Presently there is a great deal of interest in Stirling, gas turbine, and diesel compound engines for use in both passenger cars and trucks. By the mid 1990's it is expected that fuel economy improvements offered by such engines would justify their purchase cost penalty for commercial truck usage. To provide fuel economy better than conventional engines, the gas turbine and the Stirling will have to use yet to be developed ceramic components. The cost of producing and inspecting these components is expected to result in an engine cost which can only be justified by high annual mileage in commercial vehicles. The same will be true of the compound diesel engine.

19. Truck Aerodynamic Devices

Cab roof mounted air deflectors reduce the turbulence created as air flows up and over a heavy duty tractor trailer rig. Vortex stabilizers reduce or eliminate the turbulence between the tractor cab and the trailer. These two devices reduce aerodynamic drag and it is predicted that they will become standard features on all long haul trucks by the mid 1980's.

B. Review of Detailed Design and Material Changes

After preparing the overview of major changes in automobile and truck technology, we assembled a detailed listing of design and material changes expected to occur between now and 2000 (Tables IV-3 and IV-4). Many of the expected changes can be seen to occur prior to 1985. This is a result of two factors: (1) a revolution in vehicle design is taking place between now and 1985, and (2) changes that will occur after 1985 are more difficult to identify. We do expect that all vehicle components will continue to go through an evolutionary process of refinement from one time period to the next. However, it is not reasonable to attempt to project detailed changes out to 2000.

TABLE IV-3

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985 CHANGE Material	1985 CHANGE Design	1985 DESCRIPTION OF CHANGE	1990 CHANGE Material	1990 CHANGE Design	1990 DESCRIPTION OF CHANGE	2000 CHANGE Material	2000 CHANGE Design	2000 DESCRIPTION OF CHANGE
Third Door Gas Strut	High pressure gas in piston and cylinder arrangment		X	Needed: A lower cost method of holding rear door open			Same as 1985			Same as 1990
Headlining System	Held in place with adhesive, clips, or stressed steel rod	X	X	Needed: A one piece, snap in place headliner for improved sound proofing			Same as 1985			Same as 1990
Floor Insulators	Fibrous foam mats held down with asphalt	X		Needed: A corrosion inhibiting glue in place of asphalt			Same as 1985			Same as 1990
Seat Frame	Steel			Same as 1978-1980	X		Plastic/steel composites blow molded polyethylene			Same as 1990
Seat Tracks	Manual		X	Seat with an automatic position adjustment memory for each person who uses seat			Same as 1985			Same as 1990
Window Mechanism	Stamped steel gears and cables	X	X	Lighter weight rack and pinion (plastic)or nylon filament tape			Same as 1985			Same as 1990
Instrument Panel/Interior Trim	Molded plastic	X		Molded plastic filled with wood flour for more wood-like appearance (e.g., Fiat)			Same as 1985			Same as 1990
Windshield Wipers	Rubber and/or plastic and/or steel			Needed: A wiper which will evenly distribute de-icing material along entire edge of blade,lower weight and cost mechanism			Same as 1985			Same as 1990
Safety Belts	Active lap and shoulder		X	Passive 3-point belts or active lap belts plus airbag or passive shoulder belt and knee bar		X	Needed: Passive belt restraint for center seat passenger and generally better restraint systems			Same as 1990
Bumpers	Steel/aluminum face and back-up bars mounted on steel/rubber shock absorbers	X	X	Molded plastic-same color as bodywork			Same as 1985			Same as 1990
Headlamps	Tungsten filament	X	X	Halogen or quartz/iodine bulbs with plastic lenses			Same as 1985			Same as 1990
Fog Lamps	None offered by OEM		X	Needed(also good in snow)			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-3
VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985 CHANGE		1985	1990 CHANGE		1990	2000 CHANGE		2000
		Material	Design	DESCRIPTION OF CHANGE	Material	Design	DESCRIPTION OF CHANGE	Material	Design	DESCRIPTION OF CHANGE
Tail Lamps	Red when brakes applied		X	Amber for engine braking-red for active braking			Same as 1985			Same as 1990
Rear View Mirrors	Glass			Optional-Conventional interior rear veiw mirrors	X		Plastic			Same as 1990
Windows	Glass		X	Reduce thickness	X		Plastic			Same as 1990
Windshield	Unheated		X	Needed: Electrically heated windshield without vision restriction present in heated rear windows	X		Plastic	X		Plastic
Cylinder Block	Cast iron	X		Aluminum with steel or cast iron liners			All aluminum block			Same as 1990
Cylinder Liners	None (U.S. cars)	X	X	Centrifugally cast iron			None			Same as 1990
Cylinder Head	Mostly cast iron	X		Aluminum with valve seat inserts			Same as 1985			Same as 1990
Valve Seat Inserts	Stellite or steel or none	X		Phosphor bronze, iron, steel, or powdered metal			Same as 1985			Same as 1990
Pistons	Die cast aluminum		X	Die cast aluminum with cast nickel inserts for diesels			Same as 1985			Same as 1990
Engine Covers and Oil Pans	Stamped steel	X	X	Double wall stamped steel (noise reduction)molded plastic or stamped plastic			Same as 1985			Same as 1990
Fuel Pump	Mechanical	X	X	Electrical			Same as 1985			Same as 1990
Carburetor	Mostly fixed venturi, zinc body	X	X	Plastic body, variable venturi, electronically controlled or replaced by single point injection			Same as 1985			Same as 1990
Air Cleaner Housing	Mostly stamped steel	X		Aluminum or molded plastic			Same as 1985			Same as 1990
Intake Manifold	Mostly cast iron	X		Aluminum, stamped steel			Same as 1985			Same as 1990
Exhaust Manifold	Cast iron	X		Stamped steel/bent tubing			Same as 1985			Same as 1990
Gaskets (other than head or manifold gaskets)	Mostly paper/fiber	X		Silicon RTV or anaerobic			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-3

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE Material	CHANGE Design	DESCRIPTION OF CHANGE	CHANGE Material	CHANGE Design	DESCRIPTION OF CHANGE	CHANGE Material	CHANGE Design	DESCRIPTION OF CHANGE
Camshaft	Cast iron			Same as 1978-1980	X	X	Needed: Electric, variable valve timing device			Same as 1990
Camshaft Drive for V Engines	Gears and or silent chains	X	X	Rubber toothed belt			Same as 1985			Same as 1990
Tappets	Hardened steel			Same as 1978-1980	X		Ceramic			Same as 1990
Fan	Stamped/sheet steel, plastic	X		Molded rigid plastic			Same as 1985			Same as 1990
Fan Drive	Belt and pulley		X	Electric motor			Same as 1985			Same as 1990
Distributor	Mechanical spark distribution			Same as 1978-1980		X	Electrical switching for spark distribution as developed by Citroen			Same as 1990
Wheels	Stamped/rolled steel	X	X	Needed: Lightweight wheel technology			Same as 1985			Same as 1990
Tires	Conventional tubeless			HSS, plastic, aluminum - same as 1978-1980	X	X	Run flat capability			Same as 1990
Spare Tire	Conventional		X	Mini spare			Spare tire optional only			Same as 1990
Coil Springs	Solid steel		X	Hollow steel tubing			Same as 1985			Same as 1990
Leaf Springs	Solid steel		X	Eliminated			Same as 1985			Same as 1990
Stabilizer Bars	Solid steel bar, convolute shape		X	Stamped solid bars		X	Hollow bar replacing solid bar			Same as 1990
MacPherson Struts	Limited load capability		X	Need: To develop MacPherson Strut which will work on heavy cars or trucks			Same as 1985			Same as 1990
Load Leveling Shock Absorber	Manual or photoelectric level control		X	Automatic, sealed electronic load leveling system			Same as 1985			Same as 1990
Wheel Bearings	Tapered roller bearings		X	Lubricated for life, sealed ball bearings preassembled in hub (GM style) will have good share of market			Same as 1985			Same as 1990
Wheel Bearings	Tapered roller bearings		X	Lubricated for life, sealed ball bearings preassembled in hub (GM style) will have good share of market			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-3

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE
		Material	Design		Material	Design		Material	Design	
Hydraulic Brake Tubing	Steel lines		X	Needed: Low cost non-corroding brake lines			Same as 1990			Same as 1990
Transmission/Transaxle	3 or 4 discrete steps, manual or automatic		X	4 or 5 speed manual						
				3 or 4 speed automatic and some continuously variable transmissions		X	Mostly continuously variable automatic		X	Mostly continuously variable automatic
Ring and Pinion	Ductile iron or forged steel, hypoid or spiral bevel		X	Helical cut spur gears cast steel, forged steel (transverse FWD)			Same as 1985			Same as 1990
Catalytic Converter	Oxidizing catalyst	X	X	Reducing and oxidizing catalyst		X	Needed: Base metal 3-way catalyst with 50,000 mile durability			Same as 1990
Fuel Tanks	Stamped steel	X	X	Molded plastic			Same as 1985			Same as 1990
Steering Gear	Recirculating ball	X	X	Rack and pinion			Same as 1985			Same as 1990
Vehicle Wiring	Copper wire			Same as 1978-1980		X	Copper foil			Same as 1990
Radiator Core	Copper	X		Aluminum, copper			Same as 1985			Same as 1990
Radiator Heater Header Tanks	Stamped copper	X		Molded plastic			Same as 1985			Same as 1990
Heater Control Valves	Copper	X		Molded plastic			Same as 1985			Same as 1990
HVAC Controls	Vacuum diaphragm operated		X	Needed: Non-vacuum controls for diesel powered cars			Same as 1985			Same as 1990
Speedometer Drive	Cable and Gears		X	Electronic speedometers			Same as 1985			Same as 1990
Body Trim	Stainless steel, vinyl plastic, aluminum, chrome plated steel			Same as 1978-1980	X		Also: plateable plastic and black chrome steel			Same as 1990
Paint	Conventional solvent based	X		Water based exterior paint, lower baking oven temperature			Same as 1985			Colors molded into exterior plastic parts
Body and Trim Fasteners	Nuts, bolts, screws, tinnerman nuts, adhesives	X		Improved adhesives for body assembly	X	X	Replaced by adhesives			Further penetration of adhesives
Anti-Skid Brakes	Pressure proportioning valve		X	Needed: Low cost intelligent speed and load sensing system			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-3

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE
		Material	Design		Material	Design		Material	Design	
Front Suspension	Predominantly double A-arm		X	Predominantly MacPherson Strut			Same as 1985			Same as 1990
Rear Differential Carrier	Cast iron		X	Nearly eliminated		X	Eliminated			Same as 1990
Drivetrain	Rear wheel drive		X	Mostly front wheel drive		X	All front wheel drive			Same as 1990
Engine Oil Cooler	None		X	Needed to compensate for higher engine temperatures			Same as 1985			Same as 1990
Power Steering Oil Cooler	None		X	Needed because of higher temperatures			Same as 1985			Same as 1990
Universal Joints	Cross and trunnion		X	Constant velocity joints at low cost and high quantity			Same as 1985			Same as 1990
Turbocharger	Conventional			Increased penetration	X	X	Variable geometry turbo-charger, ceramic components			Same as 1990
Turbocharger Ducting	Stainless steel tubing			Increased demand			Increased demand			Increased demand
Turbocharger Parts	Replacement seals and wheels			Increased demand			Increased demand			Increased demand
Rear Springs	Leaf or coil		X	Coil or torsion bar, hollow for weight reduction			Same as 1985			Same as 1990
Oils and Lubricants	Fossil based, conventional	X		Synthetic, "slippery" oils and lubricants			Same as 1985			Same as 1990
Fuel	Petroleum based gasoline and diesel fuel			Same as 1978-1980	X		Limited penetration of synthetic fuels			Significant penetration of synthetic fuels
Fuel Injection Systems (Diesel)	Indirect injection (Bosch, CAV)	X	X	Provide better operation for less money, alternate source of supply to cover growth in demand			Same as 1985			Same as 1990
Knock Sensors	Present sensor from AC Spark Plug not reliable		X	Need compensation for lean limit, marginal spark calibration, manufacturing tolerances and fuels variability			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-3

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (PASSENGER CARS AND LIGHT TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE			CHANGE			CHANGE		
		Material	Design	DESCRIPTION OF CHANGE	Material	Design	DESCRIPTION OF CHANGE	Material	Design	DESCRIPTION OF CHANGE
Programmable EGR for Diesels	None		X	As tradeoff of NO_x and particulate emissions becomes complex-an intelligent EGR system will be required			Same as 1985			Same as 1990
Air Mass Flow Sensor	Presently only the vane meter as part of the Bosch L-jetronic system is in production		X	Improved accuracy for electronic fuel metering over present speed density techniques			Same as 1985			Same as 1990
Linearized Air/Fuel Ratio Sensor	Not presently available		X	Required for stable closed loop control during non-stochiometric operation			Same as 1985			Same as 1990
Electromagnetic Injectors for Diesels	Not presently available		X	As diesel controls become more complex, EFI for diesels will be a requirement			Same as 1985			Same as 1990
Linear Displacement Actuator for Diesels	None offered by OEM		X	High precision low cost actuator for metering diesel fuel at the injection pump		X	Replace with electromechanical diesel fuel injector			Replace with electromechanical diesel fuel injector
Solid State Relays and Solenoids	Electromechanical relays and solenoids offered presently	X	X	Need for solid state switching technology with lower EMI characteristics			Same as 1985			Same as 1990
Smaller Thinner Gauges for Instrument Panel	Larger gauges presently offered (fuel, speedometer, tachometer, oil, battery clock, etc.)		X	As dashboards are downsized instrument panel real estate becomes critical. Smaller thinner gauges become major requirements			Same as 1985			Same as 1990
Advanced Display Components	Presently analog (meter) readouts and indicator lights		X	Liquid crystal and light emitting diode displays for advanced instrumentation			Same as 1985			Same as 1990
Electronic Engine Sensors (Aftermarket Demand)	Throttle position, temperature, pressure, magnetic pickups speed sensors, fuel flow rate		X	Lower cost sensors for OEM's and aftermarket needs			Same as 1985			Same as 1990
Cruise Control (Diesel)	Present systems depend on engine pumping losses to control speed downhill		X	Provide effective cruise control for diesel autos to hold speed constant downhill			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-4

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (MEDIUM AND HEAVY TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985 CHANGE Material	1985 CHANGE Design	1985 DESCRIPTION OF CHANGE	1990 CHANGE Material	1990 CHANGE Design	1990 DESCRIPTION OF CHANGE	2000 CHANGE Material	2000 CHANGE Design	2000 DESCRIPTION OF CHANGE
Engine	Gasoline in medium duty		X	Diesel for medium duty trucks Quieter engine design	X		Ceramic diesel components	X	X	Gas turbine for long haul trucks (heavy duty)
Turbocharger	Conventional			Increased production	X	X	Variable geometry turbo-charger, ceramic components			Same as 1990
Mufflers	Conventional		X	Less back pressure			Same as 1985			Same as 1990
Transmission	Manual, multi-speed		X	Increased penetration of stepped automatic with lock-up torque converter		X	Continuously variable transmission			Same as 1990
Constant Speed Accessory Drive	Not yet produced		X	Needed for short haul trucks operated in urban areas			Same as 1985			Same as 1990
Tag Axle	Non-driven rear axle now in use			Increased penetration			Same as 1985			Same as 1990
Aerodynamic Improvements	Wind deflectors Smooth trailers Vortex stabilizer			Increased penetration Increased penetration Introduced			Same as 1985 Same as 1985 Increased penetration			Same as 1990 Same as 1990 Same as 1990
Trailers	Length limit Axle loads limited Full trailers limited		X	Longer length allowed by law Higher loads allowed by law Allowed by law			Same as 1985			Same as 1990
Tires	Limited load capacity		X	Higher load capacity			Same as 1985			Same as 1990
Bottoming Cycle Heat Recovery	Experimental development funded by U.S. D.O.E.		X	Introduced			Increased penetration			Same as 1990
Tires	Conventional radial construction			Increased penetration			Same as 1985			Same as 1990
Tires	Conventional tread			Quiet trend designs			Same as 1985			Same as 1990
"Reefer" Refrigeration Power Plants	Diesel engines (10-15 HP)			Needed: multi-fuel capacity			Same as 1985			Same as 1990
Diesel Pistons	Cast iron	X	X	Aluminum with cast nickel inserts	X	X	Ceramic insert in crown			All ceramic pistons introduced
Diesel Piston Rings	Cast iron or steel	X	X	Ceramic rings introduced			Increased penetration			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-4

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (MEDIUM AND HEAVY TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE
		Material	Design		Material	Design		Material	Design	
Frame and Wheels	Steel, aluminum	X		Increased use of aluminum			Same as 1985			Same as 1990
Leaf Springs	Steel			Same as 1978-1980	X		Carbon fiber reinforced epoxy			Same as 1990
Drive Shaft	Steel tubing			Same as 1978-1980	X		Carbon fiber reinforced epoxy			
Lubricants	Based on petroleum	X		Synthetic, "slippery" oils and lubricants			Same as 1985			Same as 1990
Fan Clutches	Conventional			Increased penetration, especially on medium trucks			Same as 1985			Same as 1990
Brakes	Drum		X	Higher capacity disc brakes			Same as 1985			Same as 1990
Antiskid Brake System	Not in use			Introduce in full production			Same as 1985			Same as 1990
Pedestrian/Cyclist Underride Guards	Nonexistent		X	Required by law			Same as 1985			Same as 1990
Electronic Engine Controls Gas Engines	None		X	Gas engine controls required by Federal regulations			Same as 1985			Same as 1990
Engine Speed Governor System	Mechanical governors		X	Compensation for accessory load variations, cold engine idle performance. Full load control.			Same as 1985			Same as 1990
Variable Speed Drive for Air Pumps	Conventional air pumps	X	X	Required for improved fuel economy			Same as 1985			Same as 1990
Viscous Fan Drives	Presently being experimented with by OEM	X	X	Required for improved fuel economy, reduced noise, and temperature control.			Same as 1985			Same as 1990
Digital Display and Power-train Monitoring Systems	None		X	Improved indication of vehicle status of engine variables.			Same as 1985			Same as 1990
Electronic Control for Diesel Engines	None	X	X	More precise control of fuel to improve smoke emissions and fuel consumption.			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

TABLE IV-4

VEHICLE COMPONENT DESIGN AND MATERIAL CHANGES WHICH PRESENT OPPORTUNITIES FOR CANADIAN MANUFACTURERS (MEDIUM AND HEAVY TRUCKS)

COMPONENT	PRESENT FORM 1978 – 1980	1985			1990			2000		
		CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE	CHANGE		DESCRIPTION OF CHANGE
		Material	Design		Material	Design		Material	Design	
Exhaust Gas Temperature Sensors	Some high cost units presently available		X	Monitors performance of intercoolers and allows for engine operation at best fuel consumption			Same as 1985			Same as 1990

Source: Arthur D. Little, Inc.

C. Product Opportunities Available to Outside Suppliers

The expected technological changes for the automotive industrial sector over the next 20 years as outlined in the previous section will yield outstanding opportunities for outside suppliers provided they can satisfy qualification criteria and can respond to the automobile OEM's needs within the specified time frame. This section identifies those expected technological changes which are most likely to be sourced to outside suppliers and describes the issues related to supplier qualifications, automotive OEM timeframe needs and OEM/supplier relationships. This information is critical to an intelligent matching of the most probable opportunities with those Canadian companies who, based on their present product line and their research, development, engineering, and manufacturing capabilities, are most likely to qualify as suppliers of these new products.

1. Sorting Opportunities for Outside Suppliers

The expected technological changes resulting in new product opportunities defined in Tables IV-3 and IV-4 were sorted into components that will most probably be sourced to outside suppliers. The results of this analysis are presented in Tables IV-5 and IV-6. These tables were used to match the most probable opportunities with the Canadian companies most capable of developing these opportunities in Chapter VIII. The opportunities presented in this section are available to all suppliers.

The opportunities related to passenger cars and light trucks (Table IV-5) were divided into two categories: very good opportunities and good opportunities. This was done because of the relatively large number of opportunities available and our desire to give some indication as to those that appeared to us to be slightly more attractive than the rest. Those in the "very good" column were judged to represent important needs of the industry which, if met, would prove to be very profitable products for the manufacturer.

Criteria and characteristics of components that qualify them as most probable opportunities to be sourced to outside suppliers

Table IV-5

Most Probable Opportunities to be Sourced
to Outside Suppliers: Passenger Cars and Light Trucks

Very Good Opportunities

- Linerless aluminum cylinder block
- Aluminum heads with powdered metal valve seats and guides
- Aluminum intake manifold
- Aluminum cores for radiators, heaters, and oil coolers (copper plated)
- Fuel injection systems for diesels
- Electromechanical injectors for diesels
- Knock sensor
- Air mass flow sensor
- Linearized air/fuel ratio sensor
- Third door gas strut
- Windshield wiper (advanced)
- Passive restraint system
- Fractional horsepower motor
- Antiskid brakes
- Advanced display components
- Electronic engine sensors (position, pressure, temperature)
- Fuel flow meter
- Spark plug-pressure probe
- Conductive plastic

Good Opportunities

- Corrosion inhibiting adhesive
- Plastic seat frames
- Fog lamps
- Plastic rearview mirror
- Plastic windows
- Heated windshields
- Cylinder liners
- Die cast aluminum piston cast from inserts for diesels
- Plastic engine covers
- Low restriction molded plastic intake mufflers for diesels
- Improved electromechanical actuator (replace vacuum components, fuel pumps, fuel injection, EGR actuation)
- Hollow coil springs
- Hollow stabilizer bars
- MacPherson Struts for heavy cars and trucks
- Corrosive resistant brakelines
- Plastic gas tanks
- Fiberoptics (plastic)
- Molded plastic heater and radiator header tanks
- Low cost constant velocity universal joints (needed for front wheel drive)
- Solid state relays and solenoids

Source: Arthur D. Little, Inc.

Table IV-6

Most Probable Opportunities to be Sourced to Outside Suppliers: Medium and Heavy Duty Trucks

- Mufflers
- Aerodynamic Improvements (Wind deflector, smooth trailers, vortex stabilizers)
- Bottoming Cycle Heat Recovery
- Refrigeration Power Plants
- Diesel Pistons
- Diesel Piston Rings
- Frame and Wheels
- Leaf Springs
- Pedestrian/Cyclist Underride Guards
- Engine Speed Governor System
- Exhaust Gas Temperature Sensors

Source: Arthur D. Little, Inc.

are as given below:

- Technology required is not available inside the OEM's
- Low volumes required (options or specialty items)
- Short product life
- Products not fully tested in the marketplace
- Technology already well developed in outside supplier companies
- Low value added parts
- Low automotive volume requirement as compared to total volume potential in all markets
- Highly labor intensive components
- Hang-on components for specialty models
- Total systems are rarely supplied to auto OEM's - they prefer to maintain systems integration
- Production capability requirements inconsistent with auto industry capability (fuel injection, lifters, plating, ceramics).
- High precision components which are not usually made by high production volume auto OEM's
- Unquantifiable knowledge or accumulated experience about processing
- Component availability is capacity limited
- Proprietariness of component design, material or processing
- Price/markup strategies - OEM's can not make it cheaper

Characteristics of components that the auto companies are likely to manufacture themselves are given below.

- Safety related components
- Appearance related components such as instrument clusters that are quality "image" related
- Proprietary designs
- Very high volume components that lend themselves to automation
- High value added components
- Very high capital investment for dedicated equipment required
- Large inventory requirements to supply various combinations so that it is uneconomical for an outside supplier, e.g., variety of colors for seat fabrics

2. Automotive OEM Time Frame Needs

It is important to realize that the results of future market, regulatory, environmental and societal forcing factors will have the most significant impact upon the evolution of the automotive industry in the relatively near term time frame. Most of the potential for increased automotive end-use efficiency and lower emissions capability will be squeezed out of automotive heat engine and materials technology by 1990. This statement is not meant to imply that innovation will cease after 1990, but instead is made to emphasize that the revolution in the automobile industry is taking place today with the presently increasing cost in petroleum justifying the use of more costly yet presently available alternative technology. Eventually, the best alternatives will be sorted out and implemented, with the post 1990's automotive RD&E returning to more evolutionary long-term directed research efforts rather than revolutionary product modifications. The message of this scenario is that OEM's are presently engaged in future product developments and improvements through the 1985-1990 time frame and that the timing for decision and action on the part of present and potential suppliers is immediate. OEM's have stated that it takes from 3 to 6 years for a component or system to penetrate across the total product line from initial introduction on a production model and that this time period is preceded by 3 to 4 years of product development and prototype testing. This defines quite strongly that the automobiles of the 1980's and early 1990's will be conceptually designed during the next 3 to 4 years. It is relatively clear from these observations that in order to take full advantage of the opportunities identified for outside suppliers in Tables IV-5 and IV-6 the Canadian government should focus its attention on issues related to required supplier qualifications and capabilities, in order to promote R&D in those companies with the greatest chance for success in responding to these critical timing factors.

3. Required Supplier Qualifications and Capabilities

Automobile manufacturers have clearly stated that they would seriously consider only credible suppliers who have demonstrated capabilities that go beyond conceptualized models or engineering prototype hardware.

The characteristics which reflect this credibility include 1) a manufacturing facility capable of servicing the high volume production range of the automotive industry; 2) a present product base that demonstrates technical know-how and experience and would complement and support the new product opportunities; 3) strong engineering and R&D support groups; and 4) a record of demonstrated success at supplying components on time that meet their high quality assurance requirements.

4. Time to Qualify a Supplier

Another issue that emphasizes the critical aspects of the time horizon of the near and mid-term opportunities is the time to qualify a supplier. Table IV-7 presents data on lead times for testing phases that must precede the introduction of new products for mass productions. From this data and the knowledge that one to three years of R&D time is required before prototype laboratory testing can begin, it becomes clear that the auto of the 1980's and the early 1990's will be designed in the early 1980's and that suppliers must be prepared to move aggressively now in demonstrating their capabilities in order to capture the opportunities defined.

The required present characteristics of potential suppliers and the types of product related activities that must be performed are functions of the planned time of product introduction. These concepts are illustrated graphically in more detail in Figure IV-1.

5. Automotive OEM Attitude Toward Outside Suppliers

It has long been recognized that the automotive industry is a unique environment in terms of OEM/supplier relations. An understanding of how to do business with "Detroit" and an insight as to OEM attitudes and policies is crucial to the development of a successful business strategy aimed at supplying original equipment. The following series of statements represent generic characteristics of the automotive OEM supplier environment which would be helpful to Canadian companies presently supplying or potentially supplying components and systems to the automobile manufacturer.

Table IV-7

Estimated Lead Time and Testing to Qualify New Components After Achieving Prototype Stage

Type of Testing	Number of Prototype Components Required	Time Required for Acceptance Testing (months)	Total Project Time Frame Requirements (years)
Laboratory Tests	2-15	2-4	3 prior to production
Life Cycle Tests	5-25	6-8	2 prior to production
Pre-Production Durability Testing and Certification Testing if Required	25-50	10-12	1 prior to production
Totals	32-90 units	18-24	3 for introduction of new product

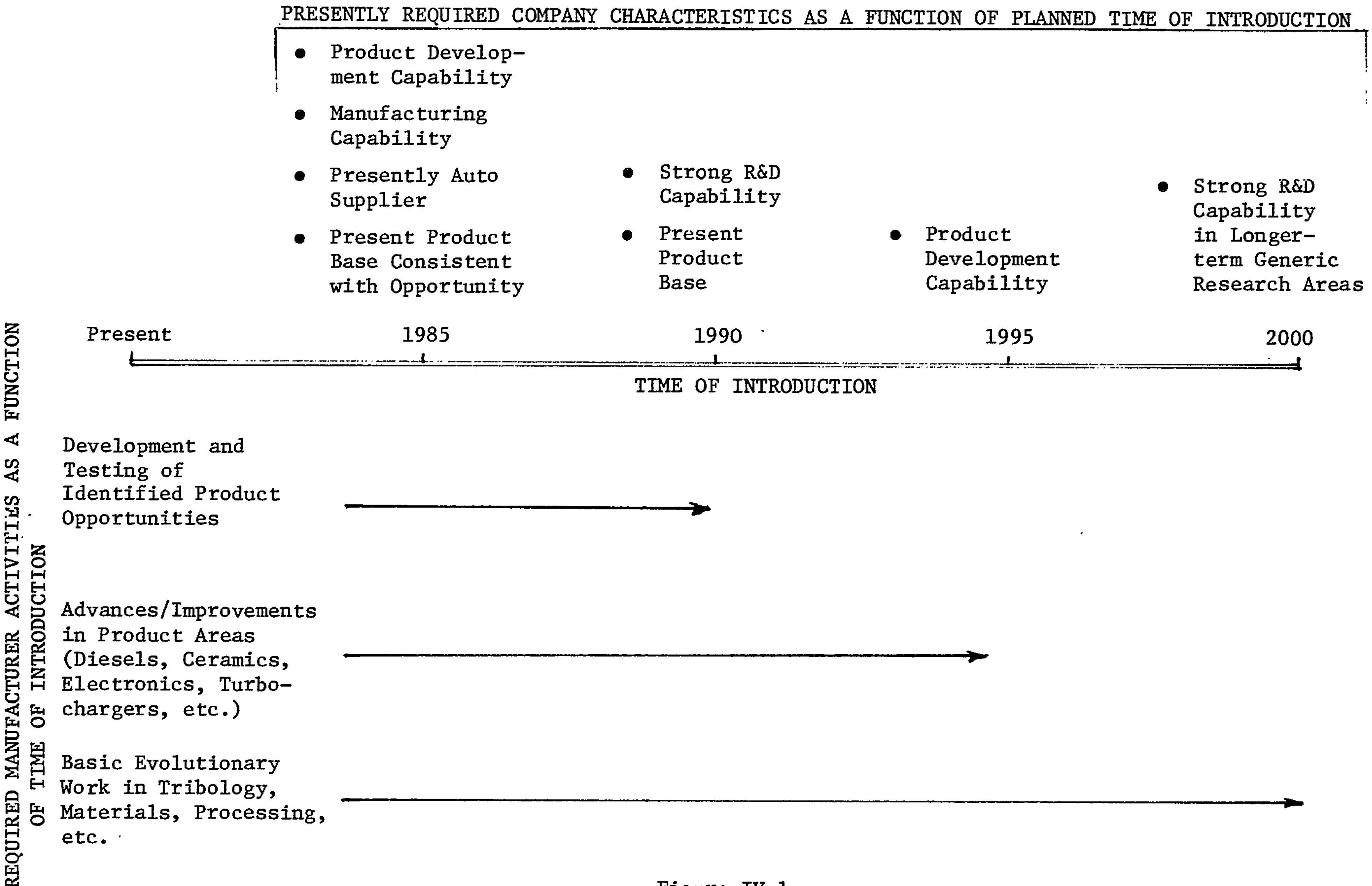

Figure IV-1

Company Characteristics and Activities Needed to Take Advantage of Opportunities as a Function of Time of Introduction

Source: Arthur D. Little, Inc.

- OEM's are strong in their policy of having two or more suppliers per component and would avoid being locked in by one supplier.
- OEM's have indicated that to gain the highest level of attention, the supplier should be prepared to present prototypes for OEM evaluation, have a cost strategy and have demonstrated manufacturing capability.
- As a general rule, the OEM's are always looking for new suppliers who can provide improved products on the basis of cost effectiveness, quality, reliability, better packaging, weight reduction, improved manufacturability, and multifunctionality. Ford Motor Company, in fact, publishes a yearly "Supplier Research Want List" to inform suppliers of product development opportunities of strong interest to the company (Appendix B).
- The experienced suppliers are prepared to turn over 67% of business eventually to the OEM through vertical integration and adjust their price strategy accordingly. The less experienced suppliers want all or nothing and usually receive nothing.
- Suppliers must be prepared to release all designs or concepts to the OEM and understand that corporate policies protect the supplier.
- Suppliers are usually tested with less critical components before being considered for larger portions of the business.
- The OEM's prefer captive suppliers with regard to most components but will relinquish this requirement on low volume specialty items or non-proprietary components.
- Suppliers must never miss "Job 1", the date when production of a new model begins, or their credibility will be lost.
- Auto OEM's are very specific in functional and environmental specifications but will leave the choice of technology to the supplier.
- The OEM's want low prices and price protection, particularly through a model year.
- Suppliers must have good raw materials supply position.
- Suppliers must have the technological capability needed to insure quality and reduce costs.
- Suppliers must be closely attuned to the needs of the OEM's.
- Suppliers must have delivery reliability.
- Suppliers must demonstrate that they are committed to financial investments needed to support new products.

V. DESIGN, MATERIAL AND MARKET PENETRATION CHANGES EXPECTED IN PRODUCTS CURRENTLY MANUFACTURED IN CANADA

A summary of the outlook for design, material composition and market penetration changes by time frame for components produced by Canada's 130 largest employers producing auto related products was prepared. The purpose of this summary is to present some indication of the degree to which Canadian products are being threatened by various types of change.

A list of components was compiled and grouped into 25 modules for ease of handling (Table V-1). Design changes and material changes were noted for each component with a simple yes or no. Each change could have been explained in detail, but it was not within the scope of this program to carefully study changes in components currently being produced by Canadian manufacturers. The probable direction of market penetration changes was also noted. A market penetration change refers to a change in the expected usage rate of a component on the new vehicle fleet.

The changes for each component are noted in Table V-2. In 1985, 33% of the components are expected to experience a design change, 51% a material change, and 44% an increase or decrease in market penetration (Table V-3). In 1990, 24% of the components are expected to have a design change, 23% a material change, and 23% a change in market penetration. In the year 2000, 10% of the components may have a design change, 24% a material change, and 25% a change in market penetration.

In summary, Canadian manufacturers will have to act aggressively to keep up with anticipated changes. Between 20% and 50% of the components examined will be changing their design, material or market penetration during the 1985, 1990 and 2000 time frames. It must be remembered that the changes or lack of changes noted in 2000 are much less certain than those noted in 1985.

Table V-I

Vehicle Modules Used to Classify Parts
Produced by Canadian Manufacturers

Module Number	Description
1	Body shell and frame
2	Interior trim and insulation
3	Seating
4	Windows and mirrors (frames, runners, mechanisms and glass)
5	Instrument panel
6	Exterior trim
7	Windshield wipers and washer
8	Safety restraints
9	Bumpers
10	Lamp systems
11	Seals, weatherstripping
12	Engine
13	Engine accessories
14	Emission controls
15	Tools
16	Wheels and tires
17	Suspension and driveline
18	Brake system
19	Transmission
20	Exhaust system
21	Fuel system
22	Steering
23	Heating and ventilation systems
24	Instruments and electrical components
25	Hardware

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
<u>BODY SHELL AND FRAME</u>									
Frames									
Passenger Cars	No	No	Down	No	Down	No	No	No	Down
All trucks	No	No	Same	No	No	Down	No	No	Same
Zinc Castings	NA	NA	Down	NA	NA	Down	NA	NA	Same
Cross Members	No	Yes (HSS/FRP/ Aluminum)	Up	No	No	Up	No	No	Up
Fiberglass Body Parts	NA	Yes (New Resins)	Up	NA	Yes (New Resins)	Up	NA	Yes (New Resins)	Up
<u>INTERIOR TRIM</u>									
Fabric/Textiles	NA	Yes	Down	NA	Yes	Same	NA	Yes	Same
Plastic Trim (rigid)	NA	Yes (PVC/ABS)	Down	NA	No	Same	NA	No	Same
Cotton Padding	NA	NA	Down	NA	NA	Same	NA	NA	Up
Glass Fiber Insulation	NA	Yes	Same	NA	NA	Same	NA	NA	Same
Door Panels	Yes	Yes	Same	No	Yes	Same	No	Yes	Same
Carpeting and Edging	No	Yes	Down	No	No	Same	No	Yes	Same
Floor Mats (rubber)	Yes	No	Same	No	No	Same	No	No	Same
Plastic Injection Molded Parts	NA	Yes	Same	NA	No	Same	NA	Yes	Same
Fiberboard Parts	NA	NA	Down	NA	NA	Same	NA	NA	Up
PVC Film	NA	NA	Up	NA	NA	Same	NA	NA	Down
Pressure Sensitive Trim	NA	Yes	Same	NA	Yes	Same	NA	Yes	Same
<u>SEATING</u>									
Springs	Yes	No	Down	No	No	Same	No	No	Down
Polyurethane Foam	NA	New Formulations	Up	NA	NA	Same	NA	NA	Up
PVC Coated Fabric	NA	Yes	Same	NA	Yes	Same	NA	Yes	Same
Head Rests	Yes	Yes	Same	Yes	Yes	Same	Yes	Yes	Same
Seat Tracks	Yes	Yes	Same	Yes	Yes	Same	Yes	Yes	Same
<u>WINDOWS AND MIRRORS</u>									
Safety Glass	No	No	Same	Yes	Yes (Plastic/Glass Laminates)	Same	No	Yes (Coated Plastic)	Same
Window Assemblies	No	Yes	Same	No	Yes (Plastic Runners)	Same	No	No	Same
Runner Channels	Yes	Yes	Same	Yes	Yes	Same	Yes	Yes	Same
Tempered Glass	No	NA	Same	No	NA	Down	No	NA	Down
Mirrors	No	Yes (Coated Plastic)	Same	No	No	Same	No	No	Same

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
INSTRUMENT PANEL	Yes	Yes (Polypropylene, Lexan, or PPO Polymers)	Same	No	No	Same	No	No	Same
EXTERIOR ORNAMENTATION									
Hubcaps and Trim Rings	No	Yes (Plastic)	Down	No	No	Same	No	No	Same
WINDSHIELD WIPERS									
Wiper Blade	No	Yes (Synthetic Rubbers)	Same	No	No	Same	No	No	Same
Wiper Holder	Yes	Yes	Same	No	No	Same	No	No	Same
SAFETY RESTRAINTS									
Seat Belt Webbing	No	No	Down	No	No	Up	No	No	Same
Three Point Belt	Yes	No	Down	Yes	No	Up	No	No	Same
Lap Belt	No	No	Up	No	No	Down	No	No	Down
BUMPERS									
Plastic Bumper Fascia (Rim)	Yes	NA	Up	No	NA	Same	No	NA	Down
Bumper Guard Assemblies	Yes	Yes	Down	No	No	Same	Yes	Yes	Up
Bumpers	Yes	Yes	Same	Yes	No	Same	Yes	Yes	Same
Bumper Support Bars	Yes	Yes	Same	Yes	No	Same	Yes	Yes	Same
LAMPS									
Miniature Lamps	No	No	Up	No	No	Up	No	No	Same
Headlights	Yes	Yes	Same	No	No	Same	No	No	Same
Injection Molded Parts	Yes	Yes	Same	Yes	Yes	Same	Yes	Yes	Down
RUBBER WEATHER STRIPPING	No	Yes	Same	No	Yes	Same	No	Yes	Same
ENGINE - BASIC									
Air Filter Housing	No	Aluminum/ Plastic/Black Plate Steel	Same	No	No	Same	No	Yes	Same
Filters: Air, Gas and Water	No	No	Same	No	No	Same	No	No	Same
Filters: Oil	Yes (Diesel, longer life)	Yes	Same	No	No	Same	No	No	Same

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
ENGINE - BASIC (cont'd)									
Radiator	Yes	Yes (Plastic Tank Aluminum Core)	Same	No	No	Same	No	No	Same
Engines (Reciprocating, Otto and Diesel)	Yes	Yes	Same	No	No	Same	No	No	Down
Spark Plugs	Yes	No	Down	No	No	Down	No	No	Down
Water Pumps	No	Yes (Aluminum Housing)	Same	No	No	Same	Yes	No	Same
Rubber Hose	No	No	Up (FWD)	No	No	Same	No	No	Same
Vee Belts	Yes	No	Down	No	No	Same	No	No	Same
Cooling Fans	Yes	Plastic	Same	No	No	Same	No	No	Same
Emission Control Valves	No	No	Same	No	No	Same	No	No	Down
Thermostats	No	No	Same	No	No	Same	Yes	No	Same
Radiator Caps	No	No	Same	No	No	Same	No	No	Same
Gaskets	Yes	Yes (Anaerobic/ RTV Rubber)	Same	No	No	Same	No	No	Same
Pulleys	Yes	Yes	Same	No	No	Same	No	No	Same
Oil Seals and Packing	No	No	Same	No	No	Same	No	No	Same
Valves and Valve Springs	No	No	Down	No	No	Same	No	No	Down
Timing Chain Sprockets	No	No	Down	No	No	Down	No	No	Down
Oil Strainer Assemblies	No	No	Same	No	No	Same	No	No	Same
Hose Clamps	Yes	Yes	Same	No	No	Same	No	No	Same
Carburetors and Chokes (Throttle Bodies)	Yes	Yes	Same	Yes	No	Same	No	No	Down
Ignition Parts	Yes	No	Down	Yes	No	Same	Yes	No	Down
ENGINE ACCESSORIES									
Alternators and Regulators	No	No	Same	No	No	Same	No	No	Same
Generators	No	No	Down		NO LONGER USED				
Starter Motors	No	Less Cast Iron	Same	No	No	Same	No	No	Same
Power Steering Hose	No	No	Down	No	No	Same	No	No	Same
Engine Heaters	No	No	Up	No	No	Same	No	No	Down
Starting Aids	Yes	Yes	Up	Yes	Yes	Same	Yes	Yes	Down
Battery Holder	Yes	Yes (Azdel)	Down	No	No	Same	No	No	Same
Engine Mounts	Yes (FWD)	No	Same	No	No	Same	No	No	Same

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
TOOLS									
Jacks and Lug Wrenches	No	No	Down	No	No	Same	No	No	Same
TIRES AND WHEELS									
Wheels	No	Some Aluminum	Down	No	No	Same	No	No	Same
Tires and Components	Yes	Yes	Down	No	No	Same	No	No	Same
Tubes	No	No	Same	No	No	Same	No	No	Same
SUSPENSION AND DRIVELINE									
Ball Bearings	No	No	Up	No	No	Up	No	No	Same
Roller Bearings (Taper and Straight)	No	No	Down	No	No	Down	No	No	Same
Leaf Springs	No	No	Down	Yes	Yes (GrFRP)	Down	No	No	Same
Axle Shafts (Conventional Rear Drive)	No	No	Down	No	No	Down	No	No	Same
Shock Absorbers	Yes	No	Down	No	No	Same	No	No	Same
Coil Springs	Yes	No	Up	No	No	Up	No	No	Same
Rubber Parts	No	Yes	Down	No	Yes	Same	No	No	Same
Torsion Bars	No	No	Down	No	No	Same	No	No	Same
Stabilizer Bars	Yes	No	Down	No	No	Same	No	No	Same
Universal Joints	Yes	Yes	Up	No	No	Same	No	No	Same
Driveshafts	No	No	Down	Yes	Yes (GrFRP)	Same	No	No	Same
Trailer Axle Parts	No	Yes (Aluminum)	Up (Increased Weights)	No	No	Same	No	No	Same
BRAKE SYSTEM									
Cable	No	No	Same	No	No	Same	No	No	Same
Hydraulic Hose	No	No	Same	No	No	Same	No	No	Same
Brake Linings	No	Yes (No Asbestos)	Same	No	No	Same	No	No	Same
Brake Rotors	No	Yes	Same	No	No	Same	No	No	Same
Brake Drums	No	Yes	Same	No	No	Same	No	No	Same
Brake Shoes	No	No	Same	No	No	Same	No	No	Same
Wheel Cylinders	No	Yes	Same	No	No	Same	No	No	Same
Boosters	Yes	No	Same	Yes	No	Same	No	No	Same
Disc Brake Braking Plates	No	Yes	Smae	No	No	Same	No	No	Same
Auto Brakes Assemblies	Yes	No	Same	Yes	No	Same	No	No	Same
Truck Brake Assemblies	Yes	No	Same	Yes	No	Same	No	No	Same
Air Brakes Devices	Yes	No	Same	Yes	No	Same	No	No	Same
Brake Pedals	No	No	Same	No	No	Same	No	No	Same

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
TRANSMISSION									
Ball Bearings	No	No	Same	No	No	Down	No	No	Down
Roller Bearings	No	No	Same	No	No	Down	No	No	Down
Taper Roller Bearings	No	No	Same	No	No	Down	No	No	Down
Clutch Linings (Manual Transmission)	No	Yes (No Asbestos)	Same	No	No	Same	No	No	Same
Clutches	No	Yes	Same	No	No	Same	No	No	Same
Transmission Assemblies (conventional auto or manual)	Yes	No	Same	No	No	Down	No	No	Down (CVT)
EXHAUST SYSTEM									
Muffler Clamps	No	No	Down	No	No	Same	No	No	Same
Mufflers	No	Yes	Down	No	No	Same	No	No	Same
Pipes	No	Yes	Down	No	No	Same	No	No	Same
FUEL SYSTEM									
Fuel Tank Caps	No	No	Same	No	No	Same	No	No	Same
STEERING SYSTEM									
Steering Arms	No	Yes	Same	No	No	Same	No	No	Same
HEATING AND VENTILATION									
Heater Cores	No	Yes	Same	No	No	Same	No	No	Same
Cab Heaters	No	Aluminum	Same	No	No	Same	No	No	Same
Defrosters	No	No	Same	No	No	Same	No	No	Same
Air Conditioner Motors	No	No	Up	No	No	Up	No	No	Same
INSTRUMENTS AND ELECTRICAL COMPONENTS									
Wire and Cable	No	No	Same	Yes	Yes	Up	Yes	Yes	Up
Speakers	No	No	Same	Yes	Yes	Same	Yes	Yes	Same
Radios	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Up
Batteries	Yes	Yes	OEM-Same/After Market-Down	Yes	Yes	OEM-Same/After Market-Down	Yes	Yes	OEM-Same/After Market-Down
Battery Chargers	Yes	Yes	Down	Yes	Yes	Down	Yes	Yes	Down
Booster Cables	No	No	Same	No	No	Same	No	No	Same
Electrical Contacts	No	No	Same	Yes	Yes	Up	Yes	Yes	Up
Capacitors	No	No	Up	Yes	Yes	Up	Yes	Yes	Up
Volume Controls	No	No	Up	Yes	Yes	Up	Yes	Yes	Up
Switches	Yes	Yes	Same	Yes	Yes	Same	Yes	Yes	Same
Wiring Harnesses	No	No		Yes	Yes		Yes	Yes	
Fractional Horsepower Motors	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Up

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

TABLE V-2

OUTLOOK FOR DESIGN, MATERIAL AND DEMAND CHANGES BY TIME FRAME FOR COMPONENTS PRODUCED BY CANADA'S 130 LARGEST AUTO INDUSTRY RELATED MANUFACTURERS

COMPONENT	1985			1990			2000		
	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?	DESIGN CHANGE ?	MATERIAL CHANGE ?	MARKET PENETRATION CHANGE?
INSTRUMENTS AND ELECTRICAL COMPONENTS (cont'd)									
Automotive Relays	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Up
Timers	Yes	Yes	Up	Yes	Yes	Same	Yes	Yes	Same
Dimmer Switches	No	No	Same	Yes	Yes	Same	Yes	Yes	Same
Terminal Boards	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Up
Automotive Electronics (Digial/Semiconduct.)	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Up
Sensors/Actuators	Yes	Yes	Up	Yes	Yes	Up	Yes	Yes	Same
HARDWARE*									
Nuts	No	No	Down	No	No	Same	No	No	Same
Bolts	No	No	Down	No	No	Same	No	No	Same
Screws	No	No	Down	No	No	Same	No	No	Same
Cold-Headed Fasteners	No	No	Same	No	No	Same	No	No	Same
Studs	No	No	Same	No	No	Same	No	No	Same
Washers	No	No	Down	No	No	Same	No	No	Same
Cable	No	No	Same	No	No	Same	No	No	Same
Hose Fittings and Couplings	No	No	Same	No	No	Same	No	No	Same
Fasteners	No	No	Down	No	No	Same	No	No	Same
Small Diameter Tubings	No	No	Same	No	No	Same	No	No	Same
Fabricated Tubing Parts	No	No	Same	No	No	Same	No	No	Same
Hinges	No	No	Same	Yes	Yes (GrFRP)	Same	No	No	Same
Gears	No	No	Same	No	No	Down	No	No	Down
Clamps	No	No	Same	No	No	Same	No	No	Same
Clips	No	No	Same	No	No	Same	No	No	Same

Source: Arthur D. Little, Inc., Corthorn H., "Automotive Parts Manufacturers Ranked by Employment Levels", Industry, Trade and Commerce Canada, March, 1979.

*Increased Use of Adhesive Assembly and Molded-in Components Could Reduce Amount of Hardware Used

Table V-3

Summary of Design, Material and Market Penetration Changes

(Percent of Components)

Year	Design Change Yes	Design Change No	Material Change Yes	Material Change No	Market Penetration Change Up	Market Penetration Change Same	Market Penetration Change Down
1985	33	67	51	59	16	56	28
1990	24	76	23	77	12	77	11
2000	19	81	24	76	10	75	15

Source: Arthur D. Little, Inc.

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VI. PROCESS IMPROVEMENTS REQUIRED TO ACHIEVE EXPECTED DESIGN AND MATERIAL CHANGES

The ability of Canadian auto industry manufacturers to keep up with and possibly lead the way to superior new manufacturing processes will be a critical factor in determining their future role in the North American auto industry. Existing manufacturers have capabilities in a wide variety of areas. Therefore, we have focused on identifying those new material and component combinations which will demand process improvements before they can become realities.

High strength steels, aluminum, plastics, carbon fiber composites, glass and ceramics applied to a variety of automotive parts are in need of process improvements (Table VI-1). In addition, there are a number of important future developments in automotive plastics technology in which Canadian manufacturers might participate (Table VI-2).

Table VI-1

Materials and Components Requiring Major Manufacturing Process Development

Material	Process Improvement Required	Example Component
High Strength Steel		
Dual Phase	- Improve control of continuous annealing and cooling	- Frames, body requirements
Rephosphorized/ Renitrogenized	- Formability problems - Welding problems - Corrosion resistance problems	
Aluminum	- Achieve faster stamping rates - Solve finishing problems - Better adhesive joining techniques needed - Solve weldability problems - Improve part handling techniques during manufacturing	- Body panels - Bumpers - Radiators
	- Improve manufacturing techniques - Develop high volume design parameters - Handle thermal process problems	- Engine block - Cylinder head
Plastics		
Polypropylene, Glass Reinforced (GR)	- Improve stamping technology - Increase room temperature notched impact strength	- Seat frames
Polypropylene, Unreinforced	- Improve stamping times to compete with injection molding	
Low Density Polyethylene	- Improve manufacturing process	- Carpet underlay headliner
Polyurethane Foam	- Improve manufacturing process	- Carpet underlay headliner
Polyurethane (RIM-Reaction Injection Molded)	- Manufacturing cost reduction	- Bumper/energy absorption
R-RIM (Reinforced Reaction Injected Molded)	- Develop formulation - Reduce paint oven temperatures - Gain greater control over mold release and fiber orientation	- Body panels - Semi-structural - Exterior components

Table VI-1 (cont'd)

Materials and Components Requiring Major Manufacturing Process Development

Material	Process Improvement Required	Example Component
Plastics		
Glass Reinforced	- Make stamping technology improvements	- Engine covers
Nylon Sheet	- Achieve shorter cycle times	
Nylon Fibers & Fabric	- Manufacturing cost reductions needed	- Seat cushion covers - Headliners - Floor covering
SMC (Sheet Molding Compound)	- Develop suitable finish capability - Improve automation of SMC production (feeding, de-molding) - Develop carousel mold stations for small systems, moderate run length SMC parts - Achieve cycle times of 80-90 seconds or faster - Develop in-mold coatings to achieve Class A surfaces	- Hood - Doors - Bumper system
Phenolics	- Improve injection moldable phenolic formulations	- Ignition - Wiring system
Carbon Fiber Composites	- Development of formulations with short cycle time necessary for high speed production	- Hinges, brackets, supports, springs
Polycarbonates	- Development of abrasion resistant coatings	- Fixed glass applications (side window backlite)
Glass	- Thin panel manufacturing techniques	- Movable side windows
Ceramics	- Development of high volume production techniques - Handling of brittle material - Development of fiber reinforcement and glass reinforcement techniques	- Piston crowns

Source: Arthur D. Little, Inc.

Table VI-2

Important Future Developments In Automotive Plastics Technology

1. Sheet Molding Compound (SMC)
   - Develop SMC's with specific gravities of 1.3-1.5
   - Increased use of injection molding of BMC (Bulk Molding Compound) to compete with some current SMC applications

2. Reaction Injection Molding (RIM)
   - Rapid development of non-methane RIM systems
   - Potential challenge to some injection molded thermoplastics

3. Stampable Plastics
   - Wider automotive use of stamped GR thermoplastics
   - Use of graphite fibers for reinforcement of stampable thermoplastic sheet

4. Resin Developments
   - Broader use of improved resin alloying techniques to achieve better properties balance
   - Platable polypropylene to compete with ABS for some external applications
   - Polypropylene having heat distortion, moldability, and dimensional stability to offer substantial competition for ABS for interior trim and exterior applications
   - Use of new improved fabric coating systems to compete with current PVC coated fabrics
   - Resins suitable for generator/motor housings

5. Systems Development
   - Systems for auto interiors which provide a factor of two to three reduction in interior noise levels
   - Simpler, substantially different bumper systems (possibly using FRP components) if 2-1/2 MPH bumper regulation is passed in U.S.
   - Broader use of integrated "snap-in" components in interiors
   - Decrease in paint oven temperatures
   - Automotive paint systems which perform equally well on metal and plastic
   - Broader use of blow molding for large interior components

Source: Arthur D. Little, Inc.

VII. CANADIAN AUTO INDUSTRY COMPANIES CAPABLE OF PERFORMING R&D IN CANADA

This section presents the company data and characteristics used to sort out attractive manufacturers for R&D funding.

A. Identification of Canadian Companies with R&D Capability

Tables VII-1 through VII-6 represent an identification and classification of companies located in Canada that are involved in some phase of the Canadian automotive industry and exhibit potential for research and development activities. These companies have been identified through several different sources: (1) Industry, Trade and Commerce (ITC) listing of automotive parts manufacturers; (2) ITC book Automotive Parts from Canada; (3) Ministry of State for Science and Technology Directory of Scientific and Technological Capabilities in Canadian Industry (1977); and (4) "Parts, Material and Machinery Manufacturers in Canada Having Capability for Research and/or Development" prepared by the Motor Vehicle Division of Industry, Trade and Commerce. Complete references are provided at the end of this chapter.

The common format in Tables VII-1 through VII-6 consists of the following headings:

- Company name
- Rank - as ranked by number of employees for the 130 largest Canadian Automotive Parts Manufacturers
- Number of Canadian Employees - as listed in Ref. (1) and Ref. (2)
- Employees in R&D or Engineering, Ref. (3), identification of technical activities - R-Research, D-Development, Ref. (4)
- Indication of OEM and/or aftermarket participation, Ref. (2)
- Classification of company relative to foreign or Canadian ownership and location of R&D facilities as explained below, Ref. (1) and (3)
- Indication of percent of employees identified in areas that are involved in R&D, Ref. (3)
- Technical area or product of company (VII-3 through VII-6).

Classification Code. The companies evaluated were classified where possible by the variables A/B which have the following key:

A: 1 = Division of United States Automobile Manufacturer.
   2 = Foreign Ownership-Multinational Company.
   3 = Canadian Ownership of Company.

B: 1 = Research and Development Performed in Foreign Country.
   2 = Research and/or Development Performed at a Single Location in Canada.
   3 = Research and/or Development Performed at Several Company Facilities in Canada.
   4 = No Research or Development Capability Identified.

Where explicit data relative to the classification was not available, the following assumptions were applied:

- If a company is either an automobile manufacturer division or foreign owned (A=1 or 2) and no R&D has been identified in Ref. 2 or 4, it was assumed that R&D is performed in a foreign country (B=1).
- If a company is Canadian owned (A=3) and Ref. 3 and 4 do not indicate any R and/or D activities, B=4 has been assumed.

Six different tables have been prepared to identify and classify particular R&D capabilities and potentials. Table VII-1 is the classification of Canada's 130 largest parts manufacturers, Table VII-2 is a summary table of scientific or technological activities for 32 companies of the 130 largest as identified by Ref. 3, Ministry of State document. Table VII-3 is an additional summary chart which lists research or development activities identified by the Motor Vehicle Division of Industry Trade and Commerce but which were not listed in the Ministry of State document. Tables VII-4, VII-5, and VII-6 are classifications of additional companies; parts manufacturers, material suppliers and machinery manufacturers respectively.

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
General Motors of Canada Ltd.	1 6,125,121	13,089		x	x	1/1	
Ford Motor Co. of Canada Ltd.	2 5,725,000	8,036		x	x	1/1	
Goodyear Canada Inc.	3 373,420	7,074	67	x	x	2/3	40
Firestone Canada Inc.	4	5,342		x	x	2/1	
Chrysler Canada Inc.	5 3,135,613	5,001		x	x	1/1	
Uniroyal Ltd.	6	4,294	147 R&D	x	x	2/3	100
Michelin Tires Canada Ltd.	7	3,600		x	x	2/1	
Budd Automotive Temro	8 187,993	3,056	D	x		2/1	
Bendix Companies Fram	9	2,879	15 9 R&D	x	x	2/3	10 25
Bombardier	10 251,162	2,873	163 R&D	x	x	3/3	60

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)(5)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Eaton Yale Ltd.	11 (2,127,370)	2,532	D	x	x	2/2	
Rockwell International	12 5,919,100	2,445	6D	x	x	2/3	
B.F. Goodrich	13	2,294	12	x	x	2/2	60
Lear Siegler Inc. Ltd.	14	2,167		x	x	2/1	
Smith & Stone			10				30
Duplate Canada,Ltd.	15	2,152	D	x	x	2/2	
Magna International, Inc.	16 80,953	2,064	30 30D	x	x	3/2	
RAM Air Mfg.Ltd.			3				10
Hayes Dana Ltd.	17 145,795	1,890	D	x	x	2/2	
TRW Canada Ltd.	18	1,872	15			2/2	10
Kelsey Hayes Canada Ltd.	19 114,462	1,513	D	x	x	2/2	
Mansfield Denman General Co. Ltd.	20	1,457	12	x	x	2/2	20
American Motors Corp.	21	1,414				2/1	
CAE Industries	22 140,172	1,302	R&D	x	x	2/3	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Standard Tube Canada Ltd.	23	1,155	D	x		2/1	
Borg Warner Ltd.	24	1,138		x	x	2/2	75
Long	50,000,000	600	45 R&D				
Livingston Indus. Ltd.	25 77,505	1,135		x	x	3/4	
Standard Products Ltd.	26	109		x	x	2/1	
Burlington Indus. Canada Ltd.	27	1,030		x	x	2/1	
Dayco Companies	28	1,011		x	x	2/1	
Van Der Hout Assoc.	29 35,201	1,010	R&D			2/2	
ITT Industries of Canada Ltd.	30	987				2/1	
Canadian General Electric	31 1,090,878	958	827 R&D	x	x	3/3	
Canada Wire & Cable Ltd. Sub. of Noranda Wires Ltd.	32 (1,395,787)	950	25	x	x	3/3	70
Fittings Ltd.	33 22,857	834		x		3/4	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Marsland Eng. Ltd. Ind. Prod. Div. Sub. of Leigh Instruments Ltd.	34 (39,162)	900	91 D	x	x	3/2	60
Eltra of Canada Ltd. Prestolite	35	844		x	x	2/1	
SKF Canada Ltd.	36	800				2/1	
Automotive Hardware Ltd.	37 34,543	791		x	x	3/4	
Dominion Chain Co. Ltd.	38	773		x		2/1	
ESB Canada Ltd.	39	773	26			2/2	15
LOF Glass of Canada Ltd. Aeroquip	40	755				2/2	10
Blackstone Indus. Products Ltd.	41	750		x	x	2/1	
Sheller Globe of Canada Ltd.	42	721		x		2/1	
Collins & Aikman Ltd.	43	715		x		2/1	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Continental Group of Canada Ltd.	44 337,880	690	D	x	x	2/2	
Galtaco Inc.	45 12,213	673				3/4	
Dominion Forge Co. Ltd. Sub. of Canadian Corp. Mgt. Co. Ltd.	46 (287,127)	653		x		3/4	
Galt Metal Indus. Ltd.	47	650	N	x	x	2/1	
Daal Specialties Ltd.	47a	646				3/4	
Procor Limited	48	618	10			2/2	
Canadian Timken Ltd.	49	600		x	x	2/1	
National Rubber Co. Ltd.	50	600		x	x	3/4	
Fahramet Ltd. Sub. of Falcon-bridge Nickel Mines Ltd.	51 (393,447)	594	24			2/2	10

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Butler Metal Products Sub. of Min-dustrial Corp. Ltd.	52 (66,302)	580	R&D	x	x	2/2	
Johnson Mattley Co.	53	547		x	x	2/1	
Houdaille Ind. of Canada Ltd.	54	544	R&D	x	x	2/2	
Ingersoll Machine & Tool Co. Ltd. Sub. of Ivaco Ind. Ltd.	55 (167,167)	535		x	x	3/4	
International Tools Ltd. Sub. of ITC Ind. Ltd.	56 (19,434)	515		x		3/4	
Bundy of Canada Ltd.	57	513	D	x	x	2/2	
Fleck Mfg. Co.	58	505		x	x	3/4	
FHG Bearings Ltd.	59	500	14	x	x	2/2	15
Somerville Belkin Ind. Ltd.	60 55,103	496		x	x	3/4	
Monarch Indus.Ltd.	61	491		x	x	3/4	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Canadian General Tower Ltd.	62	486	28	x	x	3/2	30
Monroe Auto Equip. Co. of Canada	63	480				2/1	
R.J. Stamping Co. Ltd.	64	455				3/4	
Dominion Auto Accessory Ltd.	65	450	D	x	x	3/2	
Tridon Limited	66	450	40D	x	x	3/2	
Champion Spark Plug Co. of Canada Ltd.	67	450	1	x	x	2/2	20
Gates Rubber Co. of Canada Ltd.	68	445	14	x	x	2/2	10
National Auto Radiator Mfg. Co. Ltd.	69	440		x		3/4	
A.P. Parts of Canada Ltd.	70	425				2/1	
Wallace Barnes Co. Ltd.	71	424				2/1	
Belding Corticelli	72 11,565	419		x		3/4	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Varta Batteries Ltd.	73	412	7	x	x	2/2	75
International Parts Ltd.	74	410			x	2/1	
Westeel Rosco Ltd.	75 145,975	407	22	x	x	3/2	40
Gould Mfg. of Canada, Ltd.	76	405	3	x	x	2/2	75
Kysor Indus. of Canada	77	401	8	x		2/2	60
Ebco Indus. Ltd.	78	400			x	3/4	
Donlee Mfg. Indus. Ltd.	79	400		x	x	3/4	
Amcan Casting	80	400				3/4	
Electrohome Ltd.	81 92,147	400	32	x	x	3/2	80
MTD Products Ltd.	82	390		x	x	2/1	
Stauffer Chemicals Co. of Canada	83	360		x	x	2/1	
Davidson Rubber Co. Ltd.	84	350		x		2/1	
Textron Canada Ltd.	85	350				2/1	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Rubbermaid Canada Ltd.	86	337		x	x	2/1	
Fabricated Steel Products Ltd. (Sub. of Indal Ltd.)	87 (438,326)	336		x	x	3/4	
Amerock Ltd.	88	334				2/1	
Whittaker Cable of Canada Ltd.	89	334		x	x	2/1	
Wix Corp. Ltd.	90 11,680	330	R&D		x	2/2	
North American Plastics Ltd.	91	330		x	x	2/1	
A.G. Simpson Co. Ltd.	92	320		x		3/4	
Daymond Ltd. (Sub. of Redpath Ltd.)	93 (271,319)	316		x	x	2/1	
Weatherhead Co. of Canada Ltd.	94	315	8	x	x	2/2	5
Wilson Electric Ltd.	95	305			x	3/4	
H. Paulin Co. Ltd.	96 15,220	300		x	x	3/4	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Levy Auto Parts Co. Sub. of Levy Ind. Ltd.	97 (102,157)	300		x	x	2/1	
Stewart Warner Corp. of Canada, Ltd.	98	290		x	x	2/1	
Gulf & Western Canada, Ltd.	99	280		x	x	2/1	
Toromont Indus. Ltd.	100 59,799	280				3/4	
ACF Canada Ltd.	101	270				2/1	
United Tire & Rubber Co. Ltd.	102 31,894	279		x	x	3/4	
Columbus McKinnon Ltd.	103	275				2/1	
Asbestos Corp. Ltd.	104	270		x	x	3/4	
Canadian ASE Ltd.	105	265		x		2/1	
Hafner Fabrics of Canada Ltd.	106 8,323	265		x		3/4	
Excel Metalcraft Ltd.	107	263		x		2/1	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS (Continued)

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Hoover Ball & Bearing	108	260				2/1	
Gutta-Percha Ltd.	109	250		x	x	3/4	
Bennett Ltd.	110	250		x	x	3/4	
Lacal Indus. Ltd.	111	244		x		2/1	
Purolator Ltd.	112	243		x	x	2/1	
International Malleable Iron Co. Ltd.	113	240		x	x	2/1	
Ardiem Indus. Corp.	114	230				3/4	
Essex Internatl. Canada Ltd.	115	226		x	x	2/1	
Canadian Technical Tape	116	222		x	x	3/4	
Clix Fastener Corp.	117	220		x		2/1	
Hendrickson Mfg. Canada, Ltd.	118	220		x	x	2/1	
Mactac Canada Ltd.	119	220	8			2/2	50
Lynn Macleod Metallurgy Ltd.	120	215				3/4	

Table VII-1

CLASSIFICATION OF CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Company Name	Rank/ 1977 Revenue ($ x 10^3)	Canadian Employees	Employees in R&D or Engineering	OEM	Aftermarket	Classification	Technical Personnel in R&D (%)
Associated Tube Indus. Ltd.	121	215		x	x	3/4	
Triplex Eng. Co. Ltd.	122	212		x	x	3/4	
Seeburn Metal Products Ltd.	123	210		x	x	3/4	
Linamar Machine Ltd.	124	210		x	x	2/1	
Crowe Foundry Ltd.	125	209		x		3/4	
Plaza Fiberglass Mfg. Ltd.	126	209			x	3/4	
Philips Electronics Ltd.	127	200	D		x	2/2	
Benn Iron Foundry Ltd.	128	200		x	x	2/1	
Westinghouse Canada Ltd.	129 430,962	200	179 D	x	x	2/3	70
Farr Company Ltd.	130	200		x	x	2/1	

Table VII-2

SUMMARY OF R&D TECHNICAL AREAS IDENTIFIED FOR CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Rank (R&D Emp.)	Company Name	Technical Area of R&D Engineering	No. of Employees in R&D Group	Canadian Owned
5	Goodyear Canada, Inc.	• Tire design and development • Power transmission products • Molded or extruded rubber products development • Conveyor belt & hoses	67	
3	Uniroyal Ltd.	• Rubber, chemicals • Asphalts • Auto crash pads & bumpers • Fabrics, belts and hoses • Tire development • Process equipment	147	
13	Bendix Companies	• Brake functioning	15	
22	Fram	• Filters	9	
2	Bombardier	• Fan blades • Snowmobiles, motor cycles • Rubber products	163	X
27	Rockwell International	• Brake systems for trucks and trailers	6	
18	B.F. Goodrich	• PVC polymers	12	
19	Lear Siegler Inc. Ltd. Smith & Stone	• Wiring	10	
	Magna International Inc.	• Process development stampings, molding		

Table VII-2 (Continued)

SUMMARY OF R&D TECHNICAL AREAS IDENTIFIED FOR CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Rank (R&D Emp.)	Company Name	Technical Area of R&D Engineering	No. of Employees in R&D Group	Canadian Owned
28	RAMAIR Mfg. Ltd.	• Fractional HP motors	3	X
14	TRW Canada Ltd.	• Hot and cold forging development	15	
17	Mansfield Denmen General Co. Ltd.	• Tires	12	
30	CAE Industries Webster Mfg.	• Magnesium & zinc die casting	3	
11	Borg Warner	• Heat exchangers for auto industry	22	
0	Canadian General Electric	• 7 Technical groups-electrical devices, appliances, heavy electric apparatus, communications	827	X
9	Canada Wire & Cable Ltd.	• New products-energy, materials, mfg. • Fiber optics	25	X
4	Marsland Engineering Ltd. Ind. Products Div.	• Audio systems • Other electronic components and systems	91	X
8	ESB Canada Ltd.	• Batteries	26	
20	LOF Glass of Canada Ltd. Aeroquip	• Fluid control	10	
21	Procor Ltd.	• Design of railway cars	10	

Table VII-2 (Continued)

SUMMARY OF R&D TECHNICAL AREAS IDENTIFIED FOR CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Rank (R&D Emp.)	Company Name	Technical Area of R&D Engineering	No. of Employees in R&D Group	Canadian Owned
10	Fahramet Ltd.	• Engineering and product development for steel, SS, castings, machining and welding	24	
16	FAG Bearings Ltd.	• Roller bearing design and manufacturing	14	
7	Canadian General Tower Ltd.	• Development of vinyl films, laminations and substrates	28	X
31	Champion Spark Plug Co. of Canada, Ltd.	• Spark plug application and development	1	
15	Gates Rubber Co. of Canada Ltd.	• Belts, hoses • Industrial and auto power transmission • Hydraulics	14	
26	Varta Batteries Ltd.	• Development of batteries and battery parts	7	
12	Westeel Rosco Ltd.	• Material storage system • Building design	22	X
29	Gould Mfg. of Canada Ltd.	• Industrial lead and batteries	3	
25	Kysor Industries of Canada Ltd.	• Vehicle door latches	8	

Table VII-2 (Continued)

SUMMARY OF R&D TECHNICAL AREAS IDENTIFIED FOR CANADA'S 130 LARGEST AUTOMOTIVE PARTS MANUFACTURERS

Rank (R&D Emp.)	Company Name	Technical Area of R&D Engineering	No. of Employees in R&D Group	Canadian Owned
6	Electrohome Ltd.	• Fractional HP motors • Electronic devices • TV	32	X
24	Weatherhead Co. of Canada	• Fitting • Brake parts and hose	8	
23	Mactac Canada Ltd.	• Web coating, printing • Thermoplastic extrusions	8	
1	Westinghouse Canada Ltd.	• Metallurgy • Thermodynamics • Power systems • Heat transfer • Tribology • Data systems • Warfare systems	179	

Table VII-3

ADDITIONAL COMPANIES OF THE TOP 130 IDENTIFIED AS HAVING RESEARCH AND/OR DEVELOPMENT CAPABILITIES[4]

Company Name	Technical Area
Temro	Development of heaters, defrosters, plug cords
Eaton Yale Ltd.	Development of leaf springs
Duplate Canada Ltd.	Process development in glass
Hayes Dana Ltd.	Development of axles, drivetrains, frames
Kelsey Hayes Canada Ltd.	Process development on wheels, drums
CAE Industries	R&D on manifold castings
Standard Tube Canada Ltd.	Development in tubing
Van Der Hout Associates Gabriel	R&D in shock absorbers and process
Continental Group of Canada Ltd. SKD	Process development on stampings
Butler Metal Products Company Ltd.	R&D in stamping, plastics forming
Houdaille Industries of Canada Ltd.	Bumpers-development, some research
Bundy of Canada Ltd.	Process development-tubes
Dominion Auto Accessory Ltd.	Plastic development-lamps, mirrors
Tridon Limited	R&D in clamps, wipers, and flashers
Wix Corp. Ltd.	R&D in scrubbers
Philips Electronics Ltd.	Process development-lamps

Table VII-4

CLASSIFICATION OF ADDITIONAL CANADIAN AUTOMOTIVE PARTS MANUFACTURERS IDENTIFIED BY THE MOTOR VEHICLE DIVISION OF INDUSTRY, TRADE AND COMMERCE

Company Name	Approximate Number of Employees	R&D Capabilities	OEM	Aftermarket	Classification	Technical Area
ABC Plastic Moulding	100	3 R&D	x		4/3	Plastic parts, special materials
Custom Leather Products Ltd. (Sub. of Biltmore Ind. Ltd.)	(10,895)	D			4/2	Leather instrument panel. Process development of installing roof liners.
Gidon Indus. Inc.	150	R&D		x		Mufflers, exhaust systems
Irvin Industries	140	15 R&D	x	x		80% safety systems
Rehau Plasticks of Canada Ltd.	80	R&D	x	x		Plastic formulation
Silcofab Ltd.		N				Rubber parts, hose, diaphragms
Tamco Ltd.	100	D	x	x		Shift levers metal forming
Wilco Tubular Products	175	R&D	x	x		Tubing and assemblers
Woodbridge Foam		R&D				Plastic foam
International Harvester Co. of Canada Ltd.	6,867	164 100%				Trucks, farm and forestry equipment
Deutz Diesel Ltd.		105 80%				Diesel engine components

Table VII-5

CLASSIFICATION OF MATERIAL SUPPLIERS IDENTIFIED BY
MOTOR VEHICLE DIVISION OF INDUSTRY, TRADE AND COMMERCE AS HAVING R&D CAPABILITY

Company Name	Number of Employees	R&D Potential	OEM	Aftermarket	Classification	Technical Area
The Algoma Steel Corp. Ltd.	688,353	D	x			Development of automotive materials
Atlas Steel Co. Sub. of Rio Algom Ltd.	2,600 (496,701)	31 D 40%	x			Special alloys
Dupont of Canada Ltd.	5,747	140 R&D 90%	x	x	2	Fibres, fabrics, paint
Fiberglass Canada Ltd.	1,087		x	x		R&D on automotive materials application
Glidden Company	150	D	x		2	Development of paints and chemicals for automotive application
The International Nickel Co. of Canada Ltd. Inco Ltd.	32,459 (1,988,459)		x	x		Electrolytic nickel raw materials development for S.S.
Monsanto Canada Ltd.	850	R&D	x	x	2	
Polysar Corp.	2,500	230 R&D 70%	x	x		Development plastics & synthetic rubber usage for automotive industry
Reynolds Aluminum Co. of Canada Ltd.	1,092 108,392		x		2	Aluminum
The Steel Company of Canada Ltd.	22,251 1,457,461	150 R&D 90%	x	x		Iron & steel
Alcan	61,400 3,058,208					

Table VII-5

CLASSIFICATION OF MATERIAL SUPPLIERS IDENTIFIED BY
MOTOR VEHICLE DIVISION OF INDUSTRY, TRADE AND COMMERCE AS HAVING R&D CAPABILITY (Continued)

Company Name	Number of Employees	R&D Potential	OEM	Aftermarket	Classification	Technical Area
Subsidiaries of Alcan						
Aluminum Co. of Canada Ltd.	25,780 1,862,150	345 65%	x	x		Aluminum
Alcan Canada Products	4,700					

Table VII-6

CLASSIFICATION OF MACHINERY COMPANIES WITH R&D POTENTIAL
IDENTIFIED BY MOTOR VEHICLE DIVISION OF INDUSTRY, TRADE AND COMMERCE

Company Name	No. of Employees	OEM	Aftermarket	R&D Capability	Technical Area
Barker Thorne Div. of ITT Canada Ltd.	150	x	x	D	Special purpose machinery for automotive industry
Bata Engineering Div. of Bater Industries	85,000	x	x	R&D	Shoe machinery process development
Ebco Industries	450		x	D	Aluminum wheels
Ex-Cell-O	450	x		D	Special purpose machinery for automotive industry
John T. Hepburn Ltd.	500	x	x	D	Special purpose machinery for automotive industry
F. Jos. Lamb Co. Ltd.	97	x	x	D	Special purpose machines for vehicle companies
Lasalle Machine Tool of Canada Ltd.	100	x	x	D	Special purpose machines for vehicle companies

These tables identify many of the key companies that would be potential target companies for automotive R&D assistance. However, they are not intended to be a comprehensive list of all Canadian automotive parts or material related companies which might be potential targets. Due to the extent of available published resources utilized, there is a possibility that several prime target companies have been overlooked. It appears, though, that the present R&D potential in the identified companies represents a good range of product and material expertise which verifies that there is ample opportunity for promoting automotive R&D in Canadian companies.

The classification of Canada's 130 largest automotive parts manufacturers who have more than 200 Canadian employees is given in Table VII-1 and does not include material suppliers. Using available data in the Directory of Scientific and Technological Capabilities in Canadian Industry (1977), companies with employees in a defined technical, product development, design or R&D group were identified and the number of technical or scientific personnel were indicated. We have found several examples of companies that are currently involved in automotive development work that did not appear in the Directory. This was due to either a very recent increase in development efforts, establishment of a new company, or the lack of a separate, well defined development department or group.

Table VII-2 summarizes the technical areas that were identified in Table VII-1 relative to the number of technical personnel and the related technical area. These particular technical areas are linked in the next section to promising product/technical opportunities that have been identified as possible target company/opportunity matches for potential R&D assistance.

There were a few additional companies which did not fall into the top 130 largest parts manufacturers which were identified by the Motor Vehicle Division of Industry Trade and Commerce. The technical area and level of R&D capabilities of these companies are listed on Table VII-3.

In addition there were some relatively small(<175 employee) companies identified which are classified on Table VII-4. Also included on Table VII-4 are International Harvester and Deutz Diesel which are not directly passenger car related but which however have significant R&D capabilities.

An entire class of companies that was excluded from the auto part manufacturers were the Canadian material suppliers to the automotive industry. Table VII-5 summarizes the major companies in this category and the R&D capability as defined by the Directory (Ref. 3). As can be seen by this table in contrast to Table VII-1, the materials companies like the tire companies have relatively strong R&D capabilities.

Finally Table VII-6 lists key machinery suppliers to the automotive component manufacturers. In general these companies are strictly development oriented from a machinery focus.

B. Characteristics of Target Group Companies for Canadian Government R&D Assistance

Through our company interviews and our review of Canadian company R&D capabilities, the following general characteristics were identified as being indicative of attractive companies to receive R&D assistance.

1. Ownership (in order of preference)
   - Canadian-owned multinationals
   - Canadian-owned companies
   - Canadian divisions of foreign-owned multinationals

2. R&D Capability
   - Companies with existing R&D capability are considerably more attractive for funding than those with only product and process development capabilities.
   - Companies examined had from 0 to 200 scientific and technical personnel engaged in research and development.
   - Our recommended minimum number of scientific and technical personnel engaged in research and development for effective use of funding is ten. This corresponds to an average annual R&D expenditure of between $500,000 and $1 million.

3. Total Sales

- Companies examined had 1977 sales of from $10 million to $3 billion, not including the automotive company divisions examined which had sales over $3 billion.

- Our recommended minimum level of sales for effective use of R&D funding is approximately $20 million.

4. Number of Employees

- Companies examined had between 200 and 61,000 employees.

- Our recommended minimum number of employees for effective use of R&D funding is roughly 350 to 400.

5. Automotive Supplier Status

Companies who have already qualified themselves as auto company suppliers are more attractive for funding than those who have not. There is little value in funding R&D in companies who have little chance of qualifying as automotive suppliers.

6. Automotive Industry Involvement

Companies currently involved in some aspect of the automotive industry are more attractive for funding than those who are not.

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4. "Parts, Material and Machinery Manufacturers Having Capability for Research and/or Development," Department of Industry, Trade and Commerce, data prepared for this study by Motor Vehicles Division, Transportation Industries Branch, Ottawa, Ontario, 1979.

5. The Financial Post Survey of Industries, 1978. Published by Maclean Hunter Ltd., U.S., 1978.

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VIII. MATCHING OF PRODUCT AND PROCESS R&D TOPICS WITH TARGET GROUP COMPANIES

The best component opportunities for outside suppliers described in Chapter IV and the current capabilities of Canadian companies identified as being attractive for government R&D assistance in Chapter VII were compared to find logical combinations. This process by no means identified all of the good available opportunities or all of the attractive companies, but it did demonstrate that there are a substantial number of attractive opportunity/company combinations for the government to encourage (Tables VIII-1 and VIII-2).

Table VIII-1 shows the matches we discovered between opportunities in the auto and truck areas and the Canadian companies identified as being attractive for government R&D assistance. We are optimistic that attractive Canadian companies can be found for most if not all of the best opportunities that currently exist for suppliers to the North American auto industry.

Table VIII-2 describes the matches we identified between materials related opportunities and attractive Canadian companies. Canada is in an excellent position to provide many of the new materials required by the auto industry because of the existing combinations of raw materials, energy and industry capabilities. In addition, advances made in materials for automotive applications frequently have spin-off benefits in other industrial sectors. For these reasons, we believe the Canadian government should vigorously pursue the development of Canadian R&D and manufacturing capabilities in the materials area.

Table VIII-1

Matching of Canadian Companies With Component Related Opportunities

Company Name	Component Development Area: Passenger Cars	Component Development Area: Trucks
Bombardier	-Plastic gas tanks -Glass reinforced plastic seat -Low restriction molded plastic intake muffler for diesel engines	
Tridon	-Advanced windshield wiper system	
Long Mfg. Div. (Borg-Warner Canada, Ltd.)	-Aluminum cores for radiators, heaters and coolers -Molded plastic heater and radiator header tanks	
CAE	-Aluminum castings -linerless cylinder blocks -heads -head with powdered metal valve seats and guides -intake manifolds -aluminum piston with cast iron inserts for diesels	-Aluminum frame and wheels -Aluminum piston with cast iron inserts for diesels
CTS	-Improved electromechanical actuators -Sensors -knock -air mass flow rate -linearized A/F ratio sensor -fuel flow	-Exhaust gas temperature sensors -Antiskid braking system
Canadian General Electric	-Fog lamps -Fractional H.P. motors	
Gabriel of Canada Ltd. (Van der Hout)	-Heavy duty MacPherson struts	-MacPherson struts for light trucks
Duplate Canada Ltd.	-Heated windshields	
Eaton Yale Ltd.		-Improved leaf springs (carbon fiber reinforced epoxy)
Kelsey Hayes Canada Ltd.		-Aluminum wheels

Table VIII-1 (Contd.)

Company Name	Component Development Area: Passenger Cars	Trucks
Standard Tube Canada Ltd.	-Hollow coil springs -Hollow stabilizer bars	
Philips Electronics	-Fog lamps	
Irvin Industries	-Passive restraint systems -Improved active seat belt systems	-Improved active seat belt systems
Butler Metal Products	-Plastic seat frames -Plastic windows	
OPTOTEK	-Fiber optics	

Source: Arthur D. Little, Inc.

Table VIII-2

Matching of Canadian Companies with Materials Related Opportunities

Company Name	Material Development Area
STELCO Atlas Steel Co.	-High strength steel development (dual phase and rephosphorized/renitrogenized) -formability -welding
Alcan	-Aluminum development -joining techniques -finishing -manufacturing
Polysar	-Development of conductive plastics -Plastic formulations -Corrosion inhibiting adhesive
Dunlop Plastics	-Development of conductive plastics -Polymer research -Rubber development
Canadian General Tower	-Development of improved manufacturing processes for headliners, floor coverings, seat covers -low density polyethylene -nylon fibers and fabrics -Corrosion inhibiting adhesive
Dupont	-Improved fiber for upholstery fabric, safety belts -Development of conductive plastics

Source: Arthur D. Little, Inc.

IX. BARRIERS TO ACHIEVEMENT OF INCREASED AUTO INDUSTRY R&D

The barriers to achievement of increased auto industry R&D in Canada that were discovered during our interviews can be grouped into four basic areas:

A. Structure of Existing Government Programs to Encourage R&D

B. Availability of Trained Personnel

C. Character of Canadian Auto Industry Companies

D. The Automotive Products Trade Agreement

Each of these areas will be briefly discussed below, and it must be emphasized that these comments were made by the manufacturers during our interviews and represent their perceptions of existing barriers.

A. Structure of Existing Government Programs to Encourage R&D

- The amount of money that has been spent by the government to encourage R&D is very small.
- The government is too restrictive about the kind of programs they will fund.
- Funding must be reapplied for each year adding an additional amount of uncertainty.
- The length of time required for approving a proposal for assistance is too long.
- Machinery purchased during a government funded development program must be returned to or purchased from the government after the program ends.
- The criteria used to choose programs for funding are not understood by many manufacturers.
- The government should make more of an effort to inform manufacturers of the R&D funding available and then help them get it.
- The amount of effort and paperwork required to get assistance is a large burden.
- None of the existing programs provide money for process and tooling development not related to a unique new product.
- The existing programs aimed at encouraging R&D do not address the real needs of the smaller auto component manufacturers.
- The recent changes in the Enterprise Development Program effectively reduced the funding available.

- The government should try to assist manufacturers who may be reluctant to come to them for assistance for the first time.

- Presentation of proposals before the Enterprise Development Boards by an Industry, Trade and Commerce employee rather than the manufacturer places a potential barrier in the way of successful application for assistance.

- The interest rate on government guaranteed loans is prohibitive.

- Current programs concentrate only on R&D which represents only 10 to 20% of the cost of bringing an idea to commercialization.

- The current programs are not geared toward funding high risk R&D programs.

B. Availability of Trained Personnel

Nearly every manufacturer we spoke with mentioned that an important barrier to expansion is the lack of skilled trades people. Specifically, tool and die makers and machine repair people were most often identified. More generally, it was mentioned that more educational programs are needed in Canada to train people in the latest technologies available for:

- metal forming,
- metal joining,
- process control,
- materials handling,
- robotizing (adapting robots to manufacturing operations), and
- progressive die designs.

C. Character of Canadian Auto Industry Companies

The Canadian auto industry can be grouped into at least four types of companies:

1. divisions of U. S. auto manufacturers
2. foreign-owned multinational divisions
3. Canadian-owned multinational companies
4. Canadian-owned companies

The vast majority of companies are of the fourth type.

The Canadian divisions of the auto manufacturers are unlikely to establish new Canadian research facilities because they find it economical to keep their R&D efforts in their central U. S. facilities. It is very unlikely, under traditional circumstances, that the Canadian government will be able to alter their situation.

The foreign-owned multinationals with Canadian divisions also typically have central research facilities outside Canada. However, there seems to be a subset of these Canadian divisions that perform R&D in Canada on products that are produced nowhere else within the corporation (e.g., Long Manufacturing Division of Borg Warner). These companies are reasonably attractive for government R&D assistance.

Canadian-owned multinational companies are generally the most attractive group for performing Canadian R&D because they are headquartered in Canada and are often large enough to need R&D activities. However, there are relatively few of these companies in existence and there is the possibility that research results will be shipped to a division outside Canada.

The vast majority of Canadian companies that supply the auto industry are small Canadian-owned manufacturers with no need to perform R&D. Thus, the biggest group of people that need help do not, in general, need help performing R&D. They are typically involved in product and process development work with time horizons no longer than a few years. They specialize in responding quickly to customer needs and are usually so occupied with short-term manufacturing problems that they would be unable to use R&D money if it were offered to them. There does exist, however, a small group of these companies that performs some R&D or will shortly expand to the point where some R&D is needed. This small group of companies is probably the second most attractive to provide R&D funding. This brief discussion has hopefully made it clear that one of the major barriers to expanding R&D in Canada is the lack of a large number of companies interested in and capable of doing R&D.

D. The Automotive Products Trade Agreement (APTA)

A one-day briefing was conducted with Industry, Trade and Commerce (ITC) personnel to gather information on the present and probable future state of the trade agreement. Our goal was to understand any barriers the agreement might create for conducting R&D in Canada. The aspects of the agreement important to this study are summarized in bullet form below. However, no major barriers to the performance of R&D in Canada were discovered.

- Any new components considered for Canadian manufacturers must be evaluated in light of the provisions of the APTA.
- Canadian government assistance which might be required to bring about more Canadian auto industry manufacturing may be considered export subsidization. This would allow a competitor in an importing country to instigate procedures which could result in a countervailing tariff under the General Agreement on Trade and Tariffs (GATT). This is not very likely according to ITC.
- Since all GATT members are able to enjoy the benefits of the APTA when exporting components to Canada, protection of Canadian manufacturers from foreign competition has been reduced.
- The overriding impression from our discussions is that the APTA is not in danger of being cancelled by Canada or the United States.
- Canada's location subsidies and duty remission schemes for new manufacturing operations are of current U.S. concern. Negotiations between Canada and the United States are currently underway to clarify acceptable behavior regarding programs which act as export subsidies.
- Potential investors would feel more secure if the APTA had a guaranteed duration. There may be a small amount of concern that a facility in Canada might end up isolated from its biggest potential market in the United States.
- APTA currently benefits only bona fide vehicle manufacturers who were producing above a prescribed level just prior to the beginning of the pact. However, ITC personnel indicated that the government would be generous in extending rights to any manufacturer provided they maintained an acceptable level of Canadian value added (CVA).

- The change in federal leadership, the existence of separatist sentiments, and disparities in federal and provincial policy objectives raise the risk premium on the rate of return expected from a Canadian investment.
- Technology and research results are not free to cross the border without tariffs. However, special arrangements could be made to accommodate a major U. S. company desiring to locate a facility in Canada.

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X. POTENTIAL FOR CANADIAN TECHNOLOGY TRANSFER TO IMPROVE THE AUTO INDUSTRY

A great variety of ways exist to upgrade the existing Canadian auto industry through technology transfer. In the broadest sense, technology transfer is the dissemination of technical knowledge and expertise from one group that possesses it to another group that needs it. During our industry interviews, it became very clear that there are no existing really effective ways for typical auto industry companies to take advantage of technical information that already resides in Canada or at other locations. The government has an opportunity to play a major role in selectively disseminating pertinent technical information and skills to Canadian manufacturers who will require it to prosper. A number of technology transfer linkages can be identified which the government could encourage:

- From universities to industry;
- From government research facilities to industry;
- From government contractors to industry;
- From one Canadian industry to another;
- From parent companies to divisions;
- From central research facilities of multinational companies to Canadian customers.

An example is the potential that exists for transferring the composite materials knowledge being developed by the National Research Council for the aircraft industry to some portion of the Canadian auto industry.

The Canadian educational process can be better focused on the needs of the industrial sector. Seminars should be held to give auto suppliers a forum for learning about product and process technologies they should be using or planning to use. The current educational system is not supplying the skilled trades people necessary to implement new manufacturing technologies. There is a serious shortage of tool and die makers and machine repair personnel. The Canadian auto industry is not providing enough jobs for engineering graduates, and it is not providing sufficient monetary rewards for Ph.D.'s in appropriate fields. As a result, many of the engineering personnel needed to implement new technologies are being forced to leave Canada in search of better opportunities.

Finally, Canada should not be concerned with carrying on research that has no foreseeable potential for commercial application. The U. S. has had a history of performing basic research in areas such as high energy physics, space, health care and defense. This research provided benefits to society and national well-being, but did very little to foster growth in the industrial sector. If Canada's aim is to stimulate its industrial sector in general and the auto industry in particular over the long term, directed basic research should be funded in areas that have some predictable potential for industrial applications. And, every effort should be made to disseminate as widely as possible the technical information being developed that can be commercialized.

APPENDIX A

PROFILES OF ORGANIZATIONS INTERVIEWED

INDEX OF ORGANIZATION PROFILES

NOTE: General Motors of Canada was contacted by both Arthur D. Little of Canada Limited and Industry, trade and Commerce representatives regarding our desire to interview them. They declined to cooperate with the Canadian government in this study.

COMPANY PROFILE

I. **Background Data**

Name FORD MOTOR COMPANY OF CANADA, LTD.

Address The Canadian Road
Oakville, Ontario L6J 5E4

Primary Contact Mr. Jack T. Still (Reviewed 10/30/79)

Title Director, Corporate Services and Supplier Development

Telephone Number (416) 845-2511

Additional Contacts Mr. Ron M. Bright, Executive Engineer
Mr. Jack Holman

Date of Visit August 22, 1979

Annual Gross Sales Total Ford Motor Company sales in 1978 amounted to $42.8 billion.

Number of Employees There are more than 8000 Canadian employees and total Ford employment in 1978 was 506,531.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Division of foreign-owned multinational company.

Product Areas Castings, safety glass, engines, electronics, etc., along with assembling a variety of vehicles.

Participation in Auto Industry Major original equipment manufacturer.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket products worldwide.

Existing Products Threatened by Technological Change Many of their products are going to be updated or replaced because of technological change.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Presently, Ford of Canada performs only a limited amount of process development at plants where the required facilities are available. They have no product engineering function beyond Mr. Bright. They perform no real research or development. They have embarked on a four element program to obtain Ford-related R&D in Canada: 1) encourage greater use of government-owned test facilities, 2) realize greater utilization of university-related expertise on specific programs, 3) use Windsor area tooling and machining companies for prototype building and testing, and 4) continue to encourage our major OEM suppliers to implement or expand product development capabilities.

Need for R&D Ford of Canada has a very limited need for R&D because that kind of work can be performed most economically at the Ford research facilities in Dearborn, Michigan. The results of the centrally performed research are distributed throughout the company.

Time Horizon for R&D Programs Their process development or improvement programs have a time horizon of one year or less. In most cases they are searching for very quick improvements.

Manpower Facilities Devoted to R&D They have no manpower or facilities devoted to R&D and their process improvement programs are handled by their manufacturing management personnel. Total Ford Motor Company expenditures on R&D in 1978 amounted to $1.5 billion.

Examples of Past R&D Programs They have an on-going paint development program in a Canadian plant strictly because they have an extra paint oven. They are working on water base and urethane paints. Ford of Canada has also made use of the NRC windtunnel and the Ontario Research Foundation in the past.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) They are performing the proper amount of R&D in Canada that provides the greatest benefit to the corporation as a whole. They did mention having problems with keeping track of the R&D capabilities that exist in Canada.

Organizational Barriers The existence of a central research facility in the U.S. is a formidable barrier to expanding R&D in Canada.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

No barriers to continued successful operation of Ford of Canada were identified.

V. Canadian Government Role

Present Use of Government Programs to do R&D They mentioned no current or past use of government programs intended to stimulate R&D.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

- --They suggested that there is a need for a catalogue of Canadian R&D capabilities related to the auto industry.
- --They mentioned that the duty on R&D test equipment, plans and spare parts along with required work permits place several more roadblocks in the way of expanded R&D in Canada.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

- --Small manufacturers in Canada lack information about coming changes in product design and materials. Ford has made an effort to keep the raw material suppliers and component manufacturers cognizant of their planned changes.
- --They feel that the uncertain political climate in Canada has inhibited supplier expansion. However, in the last two years they have had 78 Canadian supplier expansions planned, underway, or completed.
- --The government could help remove union opposition to the apprenticeship programs which result in more of the much needed skilled trades personnel.

COMPANY PROFILE

I. **Background Data**

Name MAGNA INTERNATIONAL, INC.

Address 355 Wildcat Road
Downsview, Ontario M3J 2S3

Primary Contact Mr. Burton V. Pabst (Reviewed 11/5/79)

Title Vice Chairman of the Board

Telephone Number (416) 661-1485

Additional Contacts None

Date of Visit August 22, 1979

Annual Gross Sales $128 million in 1978

Number of Employees They have a total of 3000 employees distributed among 40 small plants.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned public company

Product Areas The Automotive Division contributes 70% of the company's sales. The Industrial Products Division which produces electronic components, aerospace and defense components, and steel structures contributes 30% of sales.

Participation in Auto Industry In the Automotive Division they produce pulleys, interior and exterior trim, stampings and electromechanical devices.

Market Areas (OEM, Aftermarket, Geographical Areas) They supply OEM parts in the North American auto industry.

Existing Products Threatened by Technological Change Bumper guards were identified as a product that will gradually be phased out.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They perform little, if any, R&D in the strict sense. They specialize in working with materials in unique ways through manufacturing process developments. They hire skilled and entrepreneurial tool makers to turn product designs into realities.

Need for R&D They need only do process development which will enable them to be highly productive and under cut their competitors in selected component areas. They can adapt to change quickly enough so that they have no real need for long-term R&D.

Time Horizon for R&D Programs Their development programs have a typical time to commercialization of one to two years.

Manpower Facilities Devoted to R&D Each plant is capable of taking on its own process development programs. The company has about 30 people devoted to development programs that would not be undertaken by any one plant. Their annual report for 1978 states that they spend approximately 7% of before tax profits for special projects.

Examples of Past R&D Programs They developed a new manufacturing process that enabled the production of pulleys for Chrysler's new single belt engine accessory drive system. The PAIT program provided 50% of the money required for the development work and a group of six people spent two years getting a viable product and process.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) They do not feel they need to do any real R&D. They could, of course, use financial assistance in doing more process development programs.

Organizational Barriers The company is set up to respond efficiently to a well defined product need. They could not fulfill their role more efficiently by performing R&D.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

Because the company actively markets their products and capabilities to auto company purchasing and engineering people in Detroit, they will probably continue to be successful at adapting quickly to needs they discover.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not presently making use of the government programs to stimulate R&D.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--Machinery purchased with government money used to perform R&D should be left with the manufacturer once the R&D is completed.

--The government should make more of an effort to inform companies of the R&D funding available and then help them get it.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The government should consider offering partial funding for the purchasing of expensive and unusual manufacturing equipment such as that required to produce hydraulic valve lifters.

--The government should help smaller companies actively market their products and capabilities in Detroit.

--The government should consider helping smaller companies make use of productive technologies that already exist.

--The government should consider a joint industry/government program to cost share the training of manufacturing personnel such as toolmakers and machine repairmen.

--There should be a way of helping companies move into new product areas that seem relatively mundane along with those that are exotic in nature.

COMPANY PROFILE

I. Background Data

Name AUTOMOTIVE PARTS MANUFACTURERS' ASSOCIATION (APMA)

Address 55 York Street
Toronto, Ontario

Primary Contact Mr. Patrick Lavelle (Reviewed by phone on 12/4/79)

Title President

Telephone Number (416) 366-9673

Additional Contacts Mr. Lavelle arranged for a group of representatives from six small auto suppliers to meet with us. A list of their names is attached.

Date of Visit August 23, 1979

Annual Gross Sales Not applicable.

Number of Employees Information not obtained.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Association of auto parts manufacturers with facilities in Canada.

Product Areas They are a lobbying organization.

Participation in Auto Industry They represent the interests of their members before the government and provide other member services.

Market Areas (OEM, Aftermarket, Geographical Areas) Not applicable.

Existing Products Threatened by Technological Change Not applicable.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information The APMA does not perform R&D. None of the firms represented perform R&D. They engage primarily in the process development work required to get existing designs into production.

Need for R&D The manufacturers present stated they had no need for R&D. They specialize in responding quickly to auto company needs and only need to engage in process and tooling development.

Time Horizon for R&D Programs Most of the manufacturers' programs have a time horizon of one year or less.

Manpower Facilities Devoted to R&D In general, the manufacturers present had very limited staff and facilities for carrying on development work.

Examples of Past R&D Programs Not applicable.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) None of the manufacturers represented is interested in carrying on R&D because it is not required for them to be successful. In addition, they have so many short term problems to deal with that they cannot afford the resources necessary to do R&D.

Organizational Barriers The small manufacturers are not organized in a way that would allow the efficient execution of R&D if they were given money from the government.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--Rather than creating a coordinated industrial policy, the Canadian government has established fragmented programs with so many barriers that the effort required to use them is extraordinarily high.
--Small manufacturers need money for process and tooling development.
--There is a lack of skilled tradespeople (plant maintenance, toolmakers, moldmakers, etc.) for companies in Canada.
--Small manufacturers do not seem to have difficulty identifying opportunities. They do seem to lack the financial and manpower resources needed to take advantage of them.
--Smaller manufacturers have difficulty being price competitive because they must spread their tooling costs over lower volumes.
--Uncertainty about the Canadian business climate has affected Canadian investments. Manufacturers need to see a relatively short payback period before they will be willing to invest.

V. Canadian Government Role

Present Use of Government Programs to do R&D Some of the manufactuers present have used the EDP program successfully and others have not been able to use it. There is considerable confusion about the criteria that are used to select projects to get EDP funds and the application process is very cumbersome and time consuming.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--According to the APMA, since the creation of the Enterprise Development Program, only $1.138 million has been spent to provide funding for nine R&D programs. The remaining money has been used for guaranteed loans. This funding does not seem adequate to them.

--The existing loan guarantee program is not very attractive because it requires an interest rate 1% above the commercial rate.

--Complaints related to the EDP program centered around the length of time needed for approval, the representation of manufacturers' programs by an ITC staff member before the EDP board, the low level of funding to date, and the recent change which reduced the costs which could be recovered under the program.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The APMA has proposed the establishment of an Automotive Investment Corporation to the government. The corporation would:

- provide a manufacturing advisory service that will encourage small and medium auto parts manufacturers to augment their own resources with outside technological assistance.
- provide a direct loan program to make possible investment in new plant and equipment by medium to small Canadian firms.
- offer a Tooling Recovery Assurance Program that would enable investment by Canadian auto parts manufacturers in highly efficient tooling that would qualify them as successful suppliers of auto components.

--Arthur D. Little suggested they include a system for providing needed manpower training.

--Canadian owned companies should be given more benefits than foreign owned companies.

--Existing programs do not address the problems of taking a new product through the first steps of process and tooling development to commercialization.

--The manufacturers interviewed feel the government is not awarding enough money and that they are too restrictive in selecting who they will help.

AUTOMOTIVE PARTS MANUFACTURERS' ASSOCIATION REPRESENTATIVES

David Knowles, Chief Engineer
Amcan Castings, Guelph, Ontario

Roel C. Buck, President
Dominion Auto Accessories Ltd., Toronto, Ontario

D.L. Kirsch, Chairman
Gidon Industries Inc., Rexdale, Ontario

Joe M. Cumming, Director, Business Planning Int'l
Rockwell International, Toronto, Ontario

R.A. Tripp, General Manager
Somerville-Belkin Industries, Scarborough, Ontario

Leonard Neal, President
Tamco Limited, Windsor, Ontario

V.L. Van Der Hout, Honorary Chairman
APMA

Patrick J. Lavelle, President
APMA

COMPANY PROFILE

I. **Background Data**

Name LONG MANUFACTURING DIVISION, BORG WARNER (CANADA) LIMITED

Address 3228 South Service Road, Suite 200
Burlington, Ontario L7N 3L3

Primary Contact Mr. Desmond M. Donaldson (Reviewed 11/7/79)

Title President and General Manager

Telephone Number (416) 681-1141

Additional Contacts None

Date of Visit August 23, 1979

Annual Gross Sales Approximately $50 million per year in sales are provided by Long Manufacturing Division out of total Borg Warner worldwide sales of $2 billion.

Number of Employees Long employs over 750 people. Borg Warner as a whole employs 50,000 people.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) They are a division of a foreign-owned multinational company.

Product Areas They produce radiators, oil coolers, and air conditioning heat exchangers for cars, trucks, buses, agricultural equipment, industrial and construction equipment, military vehicles and light aircraft.

Participation in Auto Industry Most of their products are used by the auto industry.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket heat exchangers worldwide. Their major market is North America.

Existing Products Threatened by Technological Change Their copper radiators may be replaced by aluminum radiators. They seem prepared for this change.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Long Manufacturing Division has an Engineering Center in Malton, Ontario. They develop most of their required technology in-house (80%) and they bring the remainder from Borg Warner's central research facility or from other agencies such as Ontario Research Corporation.

Need for R&D Manufacturing engineering is really the key type of work needed by Borg Warner in Canada.

Time Horizon for R&D Programs Approximately 50% of their programs have a planned time to commercialization of two to four years. None of their programs are planned to go beyond 10 years.

Manpower Facilities Devoted to R&D There are 45 people in their R&D group. Some 10 to 15 of these are engineers and the rest are technicians. They spend approximately 2.2% of their sales on development programs.

Examples of Past R&D Programs The Canadian government supported Borg Warner work on aluminum radiators by paying 50% of certain costs over a period of 23 years. This amounted to several hundred thousand dollars. Applied research was performed to discover the processing key required to braze aluminum radiators, a pilot production line was built at the engineering center using manufacturing engineering skills, and the pilot line was translated into full scale production equipment.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) He expressed no real desire to do more R&D than they are currently doing on products, but more development is required on manufacturing processes.

Organizational Barriers The existence of a central research facility in the U.S. will not prevent expansion of R&D efforts in Canada by Long Manufacturing Division.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

A specific barrier mentioned is the lack of Canadian people with the appropriate manufacturing skills. Europe has been supplying Canada's skilled trade needs for many years.

V. **Canadian Government Role**

Present Use of Government Programs to do R&D They are apparently still making use of government funding for the development of aluminum radiators.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--The biggest return for each government dollar spent on industry is not from basic research.

--Opportunities do exist for making the Canadian R&D environment more attractive.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--More educational programs are needed in Canada to train people in the technologies available for:

- metal forming
- metal joining
- process control
- materials handling
- robotizing
- progressive die design.

--People studying engineering in Canada who want to go into the auto industry are almost forced to leave Canada.

COMPANY PROFILE

I. Background Data

Name OPTOTEK LIMITED

Address 1283 Algoma Road
Ottawa, Ontario K1B 3W7

Primary Contact Dr. David I. Kennedy (Reviewed 11/2/79)

Title President

Telephone Number (613) 746-3100

Additional Contacts P. Grunnar Wareberg
Vice President - Operations

Date of Visit August 23, 1979

Annual Gross Sales Not given

Number of Employees 25 professional staff plus a group of highly-skilled technicians

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) OPTOTEK, LTD., is a Canadian company made up of individuals from the R&D Division of BOWMAR Canada Ltd. when BOWMAR terminated their Canadian operations.

Product Areas Light emitting diode displays for visual and photographic applications for military aircraft instrumentation and industrial use (e.g., commercial printers and copiers).

Participation in Auto Industry None at present

Market Areas (OEM, Aftermarket, Geographical Areas) Supplier to EOM's in military cockpit instrumentation.

Existing Products Threatened by Technological Change LED's may give way to two alternative technologies: Liquid Crystal Displays (LCD) and Electroluminescence.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information

--Scientists and engineers hired from universities or other research organizations.

--Technical information gained through internal seminars.

Need for R&D The nature of this product and its markets require state-of-the-art development to resolve problems and to displace conventional technology. Examples include:

--Developing LED displays for aviation where sunlight-minimizing-contrast-enhancement-filter requirements are high.

--Developing LED based electronics that allow film annotation in real-time.

Time Horizon for R&D Programs

0 - 2 years	50	% of RD&E budget
2 - 5 years	30	
5 - 10 years	18	
over 10 years	2	

Manpower Facilities Devoted to R&D 20 professionals involved in applied research, development and engineering and one individual doing basic research in process and materials for LED displays.

Examples of Past R&D Programs

--OPTOTEK has developed a flat low voltage solid state matrix military display which has allowed for the replacement of CRT's.

--While the personnel of OPTOTEK were with BOWMAR, they did try to develop LED displays for Chrysler Corporation, but higher costs, lower visibility and reliability could not compete with the present instrumentation. However, the instrumentation being made available on 1980 Lincolns changes this picture.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities)

--Monies available on a cost sharing basis from the Government tend to be heavily oriented towards engineering and development where a guaranteed customer is identified. High risk R&D capital is much more difficult to obtain.

Organizational Barriers

--None specifically. The company is only two years old and very small. There are financial and manpower limitations to doing more R&D.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

A general barrier:

--OPTOTEK must compete with companies like Bell Northern and MITEL (both of which pay higher salaries) for people with technical backgrounds consistent with OPTOTEK's product area.

A specific barrier:

--Monies available on a cost sharing basis from the government tend to be heavily oriented towards applied research and development where a guaranteed customer such as the U.S. military has been identified. Monies for R&D aimed at industrial or commercial areas is more difficult to obtain because industry (the customers) are not necessarily customers that will commit themselves prior to the research taking place. An example, OPTOTEK submitted a proposal to the Canadian Department of Supply and Services in 1977 for the "Development of a Solid State Fuel Efficiency Monitor for Automotive Applications" but in OPTOTEK's view the government thought this was a high risk venture and subsequently did not fund it. Ford Motor will introduce such a device in the early 1980's.

V. Canadian Government Role

Present Use of Government Programs to do R&D Areas of interest to OPTOTEK are the Defense Industry Productivity Program and the Applied Research Program within the Department of Industry, Trade and Commerce and the Science Contracts Program within the Ministry of State for Science and Technology. OPTOTEK stated that the Department of Supply and Services can also finance R&D programs. For OPTOTEK, the Defense Industrial Research Program was the most effective program, but it was terminated (no reason given). Government policies of allowing two year write offs for capital equipment and contributing 50% to the cost of capital equipment with a no interest payback option are helpful at introducing new technologies to manufacturing processes.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada Presently, the funding available from the government is too conservative, oriented toward applied research and development where the markets and customers are guaranteed. Effectively these programs are bid and quote support where OPTOTEK counts on Canadian government cost sharing when it writes a proposal to a U.S. company or the U.S. military in order to ensure competitiveness with other U.S. companies. If the contract is won by OPTOTEK then the Canadian government funds are made available. If the government would like to help they should reorient themselves towards higher risk R&D aimed at industrial or commercial markets where the results statistically are less guaranteed but the payoff in terms of Canadian viability in advanced technology is greater.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies
The Canadian government, however, through joint sponsorship of research and development with Canadian and U.S. companies can accomplish two significant objectives:

- --Cost sharing of R&D can stimulate the U.S. auto companies to be more involved with Canadian suppliers (the cost of the product, the cost of tooling, and therefore, the cost of doing business is reduced).
- --Cost sharing of R&D can stimulate U.S. based auto supplier companies to do more R&D in their Canadian subsidiaries.

Presently, the Canadian government has a policy requiring that if it purchases a product from a U.S. comapny a certain portion of that product must be made in Canada. Lockheed, for example, commits millions of dollars to Canadian industry in order to sell aircraft to Canada. An alternative to this policy could be the investment of R&D money in the development of new components by Canadian suppliers as well as the purchase of presently available Canadian components.

COMPANY PROFILE

I. **Background Data**

Name DEPARTMENT OF ENERGY, MINES AND RESOURCES
CANMET

Address PHYSICAL METALLURGY RESEARCH LABORATORIES (PMRL)
568 Booth Street
Ottawa, Ontario K1A 0G1

Primary Contact Dr. Alf Crawley (Reviewed by W. H. Erickson, 11/20/79)

Title Section Head, Metal Forming Section

Telephone Number 613/593-7136

Additional Contacts None

Date of Visit August 23, 1979

Annual Gross Sales N/A

Number of Employees PMRL has 130 employees of which 50 are professionals, 60 are technicians and the balance are administrative.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.)
The Physical Metallurgy Research Laboratories (PMRL) are one of four research laboratories in Canada Centre for Mineral and Energy Technology (CANMET) and CANMET is one of four branches in the Science and Technology Sector of the Department of Energy, Mines and Resources (EMR).

Product Areas Under the Resources and Technical Surveys Act, the role of CANMET and therefore PMRL is: 1) to develop technology which is too high risk and/or too long term for the Canadian private sector; 2) to develop technology which is in the national interest and in particular in technological gap areas; 3) to develop technology in areas of responsibility delegated to CANMET by Parliament; 4) to develop technology which supports other public agencies; and 5) to develop technology which supports the policy functions of EMR.

Participation in Auto Industry
PMRL, through its mission of providing longer-term, high risk, technological support for the Canadian mining and metallurgical industry, provides research support to the Canadian steel industry. Some of this effort is presently directed towards research on dual phase steels.

Market Areas (OEM, Aftermarket, Geographical Areas) Government Research Laboratory

Existing Products Threatened by Technological Change N/A

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information

Research and Development is done either in-house or by external contracts. Some contracting-in is done because of unique equipment and special expertise. Technical information is gathered by:

1) Literature surveys including computer searches;
2) Seminars and conferences; and
3) Industrial visits.

Need for R&D

PMRL does not do R&D for themselves.

Time Horizon for R&D Programs 2-10 years before commercialization

Manpower Facilities Devoted to R&D

130 man-year total in PMRL:

- 50 professional
- 60 technical
- 20 administrative and support staff

Examples of Past R&D Programs

--Galvanizing research
--Oxygen probe for steelmaking
--Various aspects of non-ferrous foundry metallurgy - at present, the focus is on cupronickel alloys
--Corrosion of high strength steels
--Fracture toughness of line pipe and in particular line pipe welds.

The preceding examples are given to show the broad range of work being done at PMRL.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities)

The resources of PMRL, both personnel and funds for capital equipment, supplies, and travel, are being cut back because of government restraint programs. Several gaps in our traditional technological expertise have now developed because of attrition.

Organizational Barriers

None

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

The main barriers to PMRL doing more research work on metallic materials for the automotive industry are:

1) personnel and financial limitations, and
2) demands for work on other projects, e.g., line pipe, pressure vessels, recycling of metal, rolling mill performance, etc.

V. Canadian Government Role

Present Use of Government Programs to do R&D

N/A - Government R&D laboratory.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

One possibility is for the government to set up a single facility on a joint basis with the steel industry to produce dual phase steels if the market is not sufficiently large enough for each company to develop their own capability. The R&D would be cost-shared with the work actually taking place at the CANMET Laboratory.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

- To increase the R&D funding level now going to materials research and production/manufacturing process research.
- Develop a laboratory for simulating press forming operations, testing edge tearing, hole flanging and forming limit rates on advanced steels.
- Conduct cooperative R&D with industry on new steels and aluminum alloys.

COMPANY PROFILE

I. Background Data

Name NATIONAL RESEARCH COUNCIL OF CANADA

Address Ottawa, Ontario K1A 0R6

Primary Contact Mr. Robert Scott (substitute for Paul Mclean) (Reviewed 11/5/79)

Title Structures and Materials Laboratory

Telephone Number 613/993-2845

Additional Contacts None

NOTE: The comments recorded here are from the point of view of the development of applications of composite materials to the Canadian automobile industry and not the NRCC as a whole.

Date of Visit August 23, 1979

Annual Gross Sales

Number of Employees

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) N/A

Product Areas Basic research in aeronautics, biology, chemistry, physics, mechanical engineering, building/construction, and electrical engineering.

Participation in Auto Industry Very low level effort

Market Areas (OEM, Aftermarket, Geographical Areas) Acts as a national resource of technical knowledge and problem-solving talent.

Existing Products Threatened by Technological Change N/A

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information

On a contracting basis NRC will perform development, research, evaluation and assessments for Canadian companies on technical matters of particular interest. Published papers, NRC reports, international conferences are primary diffusion mechanism.

Need for R&D

Time Horizon for R&D Programs

Manpower Facilities Devoted to R&D

Examples of Past R&D Programs

Matrix materials (reinforced plastics, etc.)

Composite materials (mica, plastics, fiberglass)

Alternatives to aluminum that improve stiffness, strength fatigue, and cost characteristics

NRC's expertise is in high load-high stiffness technology--could be applied to driveshafts and springs

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities)

NRC has very little money to cost-share on joint programs, but instead must receive contract money from industry or other government agencies.

Organizational Barriers

Same as above.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

Presently only a "low key" interaction among NRC personnel and industry engineers exists. There appears to be no formal arrangement for technology transfer except in the cases where industry has asked a specific question and funded the work.

Most transportation-related effort is aimed at the aircraft and railroad industries and not the auto industry.

V. Canadian Government Role

Present Use of Government Programs to do R&D

Technologically there has been good work done at NRC, but conservative industry has been reluctant to use it.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

Automotive R&D initiative should fall under the ITC (product-oriented research) and not within the NRC. NRC does some, but very little, contracting to industry.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

Canadian auto industry basically builds to specifications. Stimulating innovation in such an environment would require a large financial effort on the part of the Canadian government. Suppliers should be more in touch with OEM long-term needs and utilize national research labs and other national resources in order to develop solutions. Better overall awareness is required.

COMPANY PROFILE

I. **Background Data**

Name CAE INDUSTRIES, LTD.

Address Suite 3060
P.O. Box 30
Toronto, Ontario M5J 2J1

Primary Contact Mr. C. Douglas Reekie (Reviewed 10/29/79)

Title President and Chief Executive Officer

Telephone Number (416) 865-0070

Additional Contacts None

Date of Visit August 24, 1979

Annual Gross Sales Their total revenues were $191 million (Canadian) for the year ended March 31, 1979.

Number of Employees They have a total of 4000 employees.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned multinational company.

Product Areas Aircraft flight simulators, castings, electronics, aircraft maintenance, pulp and paper products, rail car bearings and axles, fiberglass pipe.

Participation in Auto Industry Automotive aluminum, magnesium and zinc castings.

Market Areas (OEM, Aftermarket, Geographical Areas) OEM parts are produced principally for the North American market although they sell other products worldwide.

Existing Products Threatened by Technological Change They are in a very competitive position with regard to their automotive part production capabilities.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They created or acquired all or parts of companies which had the skills needed to make aluminum and zinc diecastings for the automotive market.

Need for R&D They do not need research in the automotive area. They are carrying a process development program which will enable them to make complex aluminum castings for the auto market.

Time Horizon for R&D Programs Their development programs have time horizons of several years.

Manpower Facilities Devoted to R&D They spent approximately $10 million per year on development programs or roughly 5% of their total revenues. Most of this was not spent in the automotive area.

Examples of Past R&D Programs

--Steering column locking mechanism made from magnesium was developed for Ford. This design saved four pounds over the existing design made from zinc.

--They have formed a new company called CAE-Montupet Die Cast Ltd. to manufacture aluminum die cast automobile components (primarily cylinder heads and manifolds) for the North American auto industry. Through a worldwide search for market opportunities and some help from Ford, they were able to locate Societe Industrialle et Financiere Montupet in Naterre, France. They created CAE-Montupet and now own 80% of this company which has the skills required to make die castings for Ford, GM and others. Ford will be spending $50 million per year on castings from CAE beginning in the 1981 model year and GM will be spending about the same amount.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) The most pressing problem they have is the availability of people in highly skilled trade groups and professions. Restrictive federal government immigration policies have made it difficult to bring in the required skills from abroad.

Organizational Barriers The company has no organizational barrier to doing the development work that is required. The company does not view basic or applied research as activities it should perform.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

The lack of skilled trades people needed to design and build dies for diecasting was the only barrier identified which relates to their automotive efforts.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not making use of any government programs beyond the tax benefits available to compensate for R&D expenditures.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--The government should not hesitate to aid larger companies because they feel they will move ahead regardless of their help. If companies get aid with one program, it means they will have the money to invest in something else.

--The government only seems interested in funding R&D programs that are glamorous and will win them votes.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The key to diecasting is having personnel with the ability to produce the dies. There is a shortage of people in Canada with this skill.

--CAE has gotten more assistance from the German government than from the Canadian government.

--CAE should be a very attractive type of Canadian manufacturer to help because 70% of what they produce overall is exported.

COMPANY PROFILE

I. Background Data

Name CTS OF CANADA, LTD.

Address 80 Thomas Street
Streetsville, Ontario

Primary Contact Mr. J. W. Hanley (Reviewed 11/1/79)

Title President

Telephone Number (416) 826-1141

Additional Contacts None

Date of Visit August 24, 1979

Annual Gross Sales Total for CTS worldwide was $165 million with automotive sales portion being $21.5 million.

Number of Employees 340 at the Canadian facility

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.)

Product Areas Sensors, electromechanical actuators, tuners, variable resistors potentiometers for the automotive, audio, television and consumer electronic product areas.

Participation in Auto Industry CTS of Canada makes position sensors and electromechanical actuators for Ford and General Motor carburetors.

Market Areas (OEM, Aftermarket, Geographical Areas) Supplier to OEM's for 80% of gross sales. The remainder is from products they manufacture for direct sales to consumers.

Existing Products Threatened by Technological Change Variable resistors and potentiometers for the automotive, audio, television and consumer electronic product areas are threatened.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Engineers hired from universities and industry.

Need for R&D The company is presently product development oriented fulfilling specific needs for OEM's, thus this relationship does not call for more long-term R&D. Auto suppliers cannot determine the needs of the auto OEM's prior to the OEM's knowing the needs themselves. The auto OEM's develop and eliminate a great number of concepts before deciding which one will go to production. A supplier would go bankrupt trying to anticipate which technology will win out.

Time Horizon for R&D Programs

0 - 2 years	75	% of R&D budget
2 - 5 years	25	
5 - 10 years	0	
over 10 years	0	

Manpower Facilities Devoted to R&D 20 people including engineers, technicians and draftsmen with 300 people involved in manufacturing.

Examples of Past R&D Programs

--Developed a high frequency (10 Hz) solenoid as the closed-loop air/fuel ratio metering actuator on General Motors carburetors using GM's C4 system. Through duty cycle modulation the solenoid is used to position metering rods in the main jets of the carburetor.

--CTS developed the throttle position sensor for Ford's EEC-I system.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities)

--Competition for product development efforts with other subsidiaries of CTS.
--Length of time for approvals for grants from the Canadian government.
--Shortage of engineers, technicians and tool and die makers. CTS predicts an extreme shortage of tool and die makers.

Organizational Barriers

--R&D joint funding with the Canadian government has helped CTS of Canada to break down organizational barriers and win out over other CTS subsidiaries on bids to do product development for the obvious reason that CTS of Canada can do the job for less money. This government program has been very helpful in overcoming organizational barriers to doing more R&D in Canadian subsidiaries of U.S. based firms.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

Two barriers were cited as disruptive to expansion of automotive R&D efforts:
--Duty free entry does not apply to engineering prototype components developed for auto OEM's by Canadian suppliers. Duty of 6% on the cost of the whole value of the development contract must be paid on the prototypes.
--Canadian components shipped to the U.S. auto OEM's and then exported for assembly, for example to Singapore, do not reenter into the U.S. duty free. However, if U.S. based companies export components to Singapore for assembly, they do reenter the U.S. duty free. This policy obviously hurts Canadian companies who manufacture components such as variable resistors which are part of a printed circuit board subassembly which is exported and assembled outside the U.S. and then imported back in.

V. Canadian Government Role

Present Use of Government Programs to do R&D Programs which have had a positive effect on CTS of Canada are: 1) the R&D cost sharing program (the Enterprise Development Program sponsored by the ITC); 2) the two-year write-off on capital equipment; and 3) the favorable tax rate. CTS has an excellent relationship with the EE branch of the ITC.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada Faster response on proposals, reduction of approval time and less paperwork. Additional funding is needed as well. Japan spends $500 million, France $1 billion, U.S. $300 million and Canada only $50 million on semiconductor R&D. In other words, intensify programs already in place.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies Continue to support cost sharing R&D programs, disseminate information on programs the Government would like to finance, negotiate with the U.S. Government concerning the barriers defined in Section IV of this profile and rather than attempt to shift automotive OEM R&D to their Canadian plants, the Canadian Government should stimulate U.S. supplier companies to do more R&D in their Canadian subsidiaries' facilities.

COMPANY PROFILE

I. Background Data

Name TRIDON LIMITED

Address 201 North Service Road East
Burlington, Ontario

Primary Contact Mr. Douglas L. Sedgwick (Reviewed 11/1/79)

Title President - Tridon Canada

Telephone Number (416) 632-8900

Additional Contacts None

Date of Visit August 24, 1979

Annual Gross Sales They were not willing to divulge their annual sales.

Number of Employees They have approximately 600 Canadian employees and between 1000 and 2000 in total.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned multinational company (private).

Product Areas Windshield wipers, flasher units, hose clamps, fittings for plumbing industry.

Participation in Auto Industry They are supplying 50% of Ford's windshield wiper needs. They also sell flasher units and hose clamps to the automotive market.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell both OEM and aftermarket products worldwide.

Existing Products Threatened by Technological Change There are no serious threats to their existing products.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They have a small group of engineers and technicians devoted to product and process development work. They have made it a practice to seek out required technical information from any available source (e.g., Ford, General Electric, Canadian government, seminars, Ontario Research Foundation).

Need for R&D They have little or no need for basic or applied research. They carried out a great deal of very pragmatic product and process development during their windshield wiper programs.

Time Horizon for R&D Programs Their time horizon for development work is typically one to three years.

Manpower Facilities Devoted to R&D They currently have 30 engineers and technicians doing development on the windshield wiper program. They have roughly 40 people in total doing development work.

Examples of Past R&D Programs They went to the Canadian Government in 1974 to get aid for the development of an extruded windshield wiper squeegee. They successfully sold the product in Europe, so they tried for OEM sales with Ford. In 1975-76 Ford said they were interested and put the idea through their supplier research program. The Canadian Government has continued to assist them and as a result of the joint effort, Tridon has captured 50% of Ford's windshield wiper requirements in their second year of being a supplier.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) They have made good use of available government aid and see no reason why they could not expand their development efforts to meet their future needs.

Organizational Barriers The company does not need research in order to survive and prosper. They have no organizational problems with doing required development work.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--He did not identify any specific problems within Tridon.

--He did say that he felt Canadian manufacturers are more conservative than U.S. manufacturers. He said that they should be more aggressive and strive for top quality products.

--He feels the Canadian auto industry is in deep trouble and they should actively look to world markets rather than being limited to North America.

V. Canadian Government Role

Present Use of Government Programs to do R&D They have made use of three government aid programs in the last year. They have received a significant amount of funding from the government for their windshield wiper program.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--The government should send personnel directly to the companies that want to apply for assistance to help them prepare the required information in a timely and acceptable manner.

--The government should try to assist those manufacturers who may be reluctant to come to them for assistance for the first time.

--The government should concentrate R&D in the areas of metals, plastics, and electronics.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--There seems to be a marketing problem. Many Canadian companies are not good at dealing with buyers in Detroit or with the Canadian Government. The government might be able to help educate the Canadian manufacturers in these areas.

--Based on his experience, if a Canadian made product is presented to the auto companies in Detroit that is equal in price, quality and service to the competition, the Canadian will not get the business. The Canadian product must be better than the competition and this tough atmosphere has kept many manufacturers away from Detroit. The government can help sell Canadian made products in general.

--The government should take a more active role in helping manufacturers use the programs that are available.

--Additional benefits are needed in Canada to make the overall business environment competitive with that in the U.S., for example. These benefits could take many forms such as tax reductions or lower cost money for capital investments. Japan is an extreme example of government involvement in aiding industrial expansion.

COMPANY PROFILE

I. **Background Data**

Name FORD MOTOR COMPANY

Address The American Road
Dearborn, Michigan 48121

Primary Contact Mr. John Ogden (Reviewed 11/19/79)

Title Director, Purchasing, Policy and Planning
Purchasing and Supply Staff

Telephone Number (313) 322-8262

Additional Contacts None

Date of Visit August 28, 1977

Annual Gross Sales Total sales in 1978 were $42.8 billion.

Number of Employees Total Ford employment in 1978 was 506,531.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) U.S. owned multinational company.

Product Areas They produce a wide range of transportation related products.

Participation in Auto Industry Major original equipment manufacturer.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket products worldwide.

Existing Products Threatened by Technological Change Many of their products are going to be updated or replaced because of technological change.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Not applicable.

Need for R&D Not applicable.

Time Horizon for R&D Programs Not applicable.

Manpower Facilities Devoted to R&D Not applicable.

Examples of Past R&D Programs Not applicable.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) Not applicable.

Organizational Barriers Not applicable.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--Canadian suppliers tend to be less contributory with R&D because they are many times small companies that are divisions of multinationals or have separated by capitalizing on some unique idea in a small area. They are not usually the size of companies that carry on much R&D.

--To meet "job 1" for 1983, they must have all the required design and development programs in place now. Thus, Canadian manufacturers who wish to supply Ford in any major way will probably not be able to do so until the 1984 model year (ADL conclusion).

--Canadian manufacturers in the transportation area generally do not have a reputation for being pacesetters. They are not terribly aggressive about coming to Detroit to look for business.

--Most of Ford's purchasing business is with large suppliers, but a supplier with $20 million or more in sales is large enough to get their attention. The size of the order Ford is willing to place with a supplier is determined somewhat by the supplier's total sales volume.

V. Canadian Government Role

Present Use of Government Programs to do R&D Not applicable.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--The government might be able to get more Canadian suppliers interested in participating in research and development.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The government can help manufacturers be aware of the qualifications they must have in order to become Ford suppliers. For example, Ford strives to choose suppliers who are the most qualified, cost competitive and favorably located. They try to go to experts who are worthy of their confidence, are flexible and are responsive to management requests.

--Overseas purchasing is much more difficult to handle than Canadian purchasing and Canadian manufacturers should capitalize on this advantage.

COMPANY PROFILE

I. **Background Data**

Name FORD MOTOR COMPANY

Address 20000 Rotunda Drive
Dearborn, Michigan 48121

Primary Contact Mr. Charles Nave (Reviewed 11/6/79)

Title Technical Planning Manager - NAAO

Telephone Number (313) 323-0270

Additional Contacts Mr. Jerry Scott, Features and Supplier Research Manager, Technical Operations

Date of Visit August 29, 1979

Annual Gross Sales Total sales in 1978 were $42.8 billion.

Number of Employees Total Ford employment in 1978 was 506,531.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) U.S. owned multinational company.

Product Areas They produce a wide range of transportation related products.

Participation in Auto Industry Major original equipment manufacturer.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket products worldwide.

Existing Products Threatened by Technological Change Many of their products are going to be updated or replaced because of technological change.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Mr. Nave manages the Supplier Research Program. This program is aimed at getting vendors in touch with the engineer who needs a particular part. A sample of the 1979 Supplier Research Want List is included in Appendix B. There are nearly 600 items on the complete list.

Need for R&D Ford has a very significant amount of research on-going in their Dearborn laboratories and a large number of projects in progress through the Supplier Research Program. During 1979 Mr. Nave has personally addressed over 70 Canadian suppliers in a continuing effort to encourage their participation in advanced engineering programs.

Time Horizon for R&D Programs The programs initiated under the Supplier Research Program are typically one or a few years in length.

Manpower Facilities Devoted to R&D

Ford has extensive in-house research capabilities. They spent approximately $1.5 billion on R&D in 1978.

Examples of Past R&D Programs

--The Tridon windshield wiper program is an example of a successful Canadian development program that began through the Supplier Research Program

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) No specific barriers were identified.

Organizational Barriers No organizational barriers were identified.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--They believe that aggressive companies that want to expand are able to get government help and able to get into the OEM's to learn how they can participate.

V. Canadian Government Role

Present Use of Government Programs to do R&D Not applicable.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--There is a need for more government research people and facilities so that small manufacturers can hire researchers on a short term basis. Mr. Nave was favorably impressed by the type of capability exhibited at the Ontario Research Foundation and at CRIQ in Quebec.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

We did not discuss the possible roles of the Canadian Government.

COMPANY PROFILE

I. Background Data

Name CHRYSLER CANADA LTD.

Address Chrysler Center
Windsor, Ontario

Primary Contact Mr. Robert F. Kiborn, Q. C. (Reviewed by phone on 12/6/79)

Title Vice President - Staff Operations

Telephone Number (519) 252-3651

Additional Contacts Mr. J. E. Elliot, Director of Engineering, Quality and Vehicle Safety

Date of Visit August 29, 1979

Annual Gross Sales Gross sales were $3.1 billion for 1977 and $2.9 billion for 1978.

Number of Employees There was a total of 15,500 Canadian employees at the end of 1978.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Chrysler Canada is a division of a foreign owned multinational company.

Product Areas They have produced the Cordoba and the Charger/Magnum recently. They also make vans, truck based station wagons, seat springs, soft trim for doors and seats, pistons, and the 360 CID V-8 engine.

Participation in Auto Industry Major original equipment manufacturer.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket equipment principally in North America.

Existing Products Threatened by Technological Change The large cars and light trucks they produce in Canada will have to be replaced before 1985. The 360 CID V-8 engine will be phased out within the next several years. Seat springs will be completely replaced by foam.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They perform no R&D in Canada. They do perform some short term process improvement projects.

Need for R&D They have no need for R&D in Canada because they depend on the central research facilities in Detroit.

Time Horizon for R&D Programs Not applicable.

Manpower Facilities Devoted to R&D Not applicable.

Examples of Past R&D Programs They have worked on several development programs such as:
--An automated aluminum pouring system for casting pistons,
--The processes required to produce foam seat cushions.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) It is not currently economically attractive for Chrysler to do R&D in Canada.

Organizational Barriers Chyrsler Canada will probably continue to depend on the R&D work being carried out in their central R&D facility in Detroit.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--They help Canadian suppliers get in touch with the proper people in Detroit if they are interested in selling to Chrysler. However, prospective suppliers must have a good marketing effort and offer good service because they cannot afford to take a chance on totally unproven suppliers.

--The auto companies always own the tools required for aftermarket parts, so this is not a burden the suppliers must bear.

V. Canadian Government Role

Present Use of Government Programs to do R&D Not applicable.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--It makes absolutely no sense to go after an all Canadian car because of the economics involved.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

There is a need to coordinate the existing federal and provincial programs so that they do not conflict with each other.

COMPANY PROFILE

I. **Background Data**

Name CANADIAN GENERAL TOWER (CGT)

Address 52 Middleton Street
Cambridge, Ontario

Primary Contact Mr. Robert Turnbull (Reviewed 11/14/79)

Title Vice President and General Manager

Telephone Number (519) 623-1630

Additional Contacts Mr. Douglas MacMillan, Technical Director

Date of Visit September 11, 1979

Annual Gross Sales Their sales are approximately $69 million. Approximately 35% of this volume results from the North American auto industry.

Number of Employees They have roughly 850 employees located in four Canadian plants.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned company.

Product Areas Custom fabrication of PVC films and PVC coated fabrics.

Participation in Auto Industry Approximately 35% of their production of PVC films and PVC coated fabrics is sold to the North American auto industry.

Market Areas (OEM, Aftermarket, Geographical Areas) They principally sell their automotive related products to the auto companies. They are seeking European business.

Existing Products Threatened by Technological Change There has been a substantial reduction in the use of PVC upholstery fabrics in automobiles in favor of other synthetic body cloth fabrics. Ford and Chrysler tend to integrate the manufacturing of PVC coated fabrics. Increased use of non-flexible interior trim could significantly affect their sales.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They have the capacity to do process development and work related to successfully applying existing materials to new uses. They do not do research on polymers.

Need for R&D They do not perceive any need to carry out more research to meet their custom fabrication requirements.

Time Horizon for R&D Programs They have no R&D programs and their development programs typically have a time horizon of one year. In some cases, such as the current program involving changes in General Motor's seating specifications, their program of applications development will extend over a three-year period.

Manpower Facilities Devoted to R&D They have no specialized facilities for research. Their manpower is limited to four individuals who carry out applications development programs.

Examples of Past R&D Programs In the past, they have made use of the IRDIA program and the PAIT program to perform modest amounts of process development work.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) They do not perform any in-house R&D because they perceive no need for it. This is because they look to suppliers of polymers, plasticizers, stablizers, etc., to carry out the materials research.

Organizational Barriers There were no organizational barriers defined. They do not have the organization in place required to perform basic research programs.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--There is a lack of skilled trades people in the plant maintenance and machinery installation areas of their operation.

--Part of the method of operation of the auto companies is to integrate their plastic parts requirements and displace suppliers.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not currently making use of any government R&D programs.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

They felt it was difficult to justify government participation in R&D efforts in their area of business because:

--Detroit dictates standards, manufacturing methods and material specifications.

--Large American resin suppliers are considerably more effective in carrying out materials research which could affect CGT's business.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--They perceive that Canada does not have an industrial development policy.

--Tax credits for new process equipment investments would be helpful.

--The government could participate in improving the education and training of skilled plastics oriented labor.

--The government could help substantially by instituting new policies or revising existing policies to lower petrochemical or raw material costs which would lower CGT's costs for PVC and plasticizers.

--Research directed toward improved coating methods would help CGT.

--The government could provide funds to help overcome dislocation in sales of small manufacturers caused by technology changes or auto company integration.

COMPANY PROFILE

I. **Background Data**

Name McMASTER UNIVERSITY

Address 1280 Main Street West
Hamilton, Ontario L8S 4L7

Primary Contact Professor G. R. Purdy

Title Department of Metallurgy and Materials Science

Telephone Number (416) 525-9140

Additional Contacts Professor J. D. Embury, Metallurgy and Materials Science

Date of Visit September 12, 1979

Annual Gross Sales Not applicable.

Number of Employees Not applicable.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian University.

Product Areas They educate students and perform research.

Participation in Auto Industry They carry on some research that produces results used by the Canadian auto industry.

Market Areas (OEM, Aftermarket, Geographical Areas) Not applicable.

Existing Products Threatened by Technological Change Not applicable.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information McMaster has a fairly large Metallurgy and Ceramics Department with about 25 graduate students and a graduating class of about 15 people per year. Approximately 75% of their research is government funded and 25% is industry funded.

Need for R&D Not applicable.

Time Horizon for R&D Programs They specialize in long-term basic research.

Manpower Facilities Devoted to R&D They have the machine shops, laboratories and experimental equipment needed to support the research carried out by professors and students.

Examples of Past R&D Programs

--They have had long-term involvement in the study of micro structural development in steels. This work has direct implications for development of HSLA and dual phase steels, and these implications are currently being pursued.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) Additional funding, facilities and graduate students would enable them to carry on more research.

Organizational Barriers None were identified.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--There is not enough economic incentive for Canadians to go on for Ph.D.'s in many areas. This problem may hurt Canadian industry over the long term.

--They proposed establishment of the Canadian Iron and Steel Research Organization to carry out research to meet the needs of the Canadian iron and steel industry. The research directors of the Canadian steel industry declined to endorse their proposal.

V. Canadian Government Role

Present Use of Government Programs to do R&D They receive government funding to carry on R&D.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--They are skeptical of whether the government can help R&D in Canada by funding R&D. They would prefer funding for industry people to attend universities and for university professors to work in industry to foster information exchange.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The government should continue to fund basic research in universities in areas which have potential for long-term payoffs in the auto and other industries in Canada.

--The government could assist in carrying on seminars, meetings and classes which serve to disseminate technology advances to the industry at large and provide an open forum for discussion of existing industrial problems.

COMPANY PROFILE

I. **Background Data**

Name STEEL COMPANY OF CANADA
Research Laboratory
Address Burlington, Ontario

Primary Contact Mr. J. C. McKay (Reviewed 11/5/79)

Title Director - Research and Development

Telephone Number (416) 528-2511

Additional Contacts Mr. George A. Chapman, Research Consultant-R&D
Mr. Peter M. Ouellette, Automotive Development Engineer

Date of Visit September 12, 1979

Annual Gross Sales Total sales for 1978 were approximately $1.8 billion.

Number of Employees They had a total of 23,712 employees in 1978.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned multinational company.

Product Areas Nineteen plants produce steel sheet, bars, pipe and tubular products, wire products, fasteners, cold drawn bars and forgings.

Participation in Auto Industry They supply sheet and prefinished steel, forgings, cold drawn bars and fasteners to the auto industry.

Market Areas (OEM, Aftermarket, Geographical Areas) STELCO sells their materials to a wide variety of manufacturers worldwide.

Existing Products Threatened by Technological Change Auto industry steel demand is being threatened by plastics and aluminum.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information The majority of the process related problems come from the operating sections. They work primarily on product and process development work. They have an experienced person providing liaison between plants and research organization. They also have a number of agreements with other firms worldwide for exchanging technical information.

Need for R&D No R&D project is undertaken without the supporting signature(s) of the ultimate user of the technology to be developed.

Time Horizon for R&D Programs The average project life is about 26 months. Small projects last two to three years and large projects last four to five years.

Manpower Facilities Devoted to R&D They have approximately 100 people in their central research facility and another 50 people distributed throughout their various plants.

Examples of Past R&D Programs

- --They received approximately $1 million in government funds that enabled the coil box development.
- --They are spending 8-9 years working on the developments needed for Arctic gas pipeline production.
- --They developed the Stelmar Process for in-line heat treatment of rods.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) No specific barriers were identified.

Organizational Barriers No barriers were identified.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--Trained automotive engineering graduates have no place to go except the U.S. if they want to work for a large company.
--Graduates are not finding it economically advantageous to go on for post-graduate degrees.

V. Canadian Government Role

Present Use of Government Programs to do R&D They received some funds from the Industrial Energy R&D Program on two occasions. They have not used the Enterprise Development Program. They also use NRL's IRAP.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--STELCO does not believe the EDP is effective because it concentrates on helping small businesses, who are in deep financial difficulty.

--They suggest that 75% of government research money should be related to industry problems and 25% should be devoted to long-term basic research.

--There never seems to be enough money for CANMET, for example, to bring their research results to industry and learn in return what the industry's real problems are.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--The government should consider bringing about a program similar to the Productive Technology Center that has been established by the Metal Trades Industry Association of Australia. This Center offers short technical courses covering many practical aspects of metal forming which serve to bring the latest technology to manufacturers interested in participating. The upgrading of skills residing in small manufacturing operations is very important.

--The NRC holds seminars to bring members of the building industry up-to-date on new technology. This same type of program could be applied to the auto industry.

--A system of aggressive government selective information dissemination is needed to get answers from the research laboratories into industrial use.

--Available information must be disseminated to the small manufacturer so he can be prepared for the future. The government can help take what is known and get it to the people who need to use it.

--Government programs must be stablized for at least 10 years after they are created for them to become effective.

COMPANY PROFILE

I. **Background Data**

Name THE SOCIETY OF THE PLASTICS INDUSTRY OF CANADA (SPI)

Address 1262 Don Mills Road
Don Mills, Ontario M3B 2W7

Primary Contact Mr. Ron Evason (Reviewed by phone on 12/4/79)

Title President

Telephone Number (416) 449-3444

Additional Contacts Dr. Frank Maine, Special Assistant to the President
Mr. John L. McNamara, Division Manager

Date of Visit September 16, 1979

Annual Gross Sales Their total revenues for 1978 were approximately $500,000

Number of Employees They had seven full time professional employees in 1978.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Society sponsored by about 300 Canadian manufacturers.

Product Areas They are an industry organization that provides a variety of information to its members and the Canadian government.

Participation in Auto Industry They work on behalf of members who participate in the auto industry as well as those who participate in other industries.

Market Areas (OEM, Aftermarket, Geographical Areas) Not applicable.

Existing Products Threatened by Technological Change Canada will probably lose out in the production of SMC and RIM parts because they are not doing the required process development work.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information Not applicable.

Need for R&D Not applicable.

Time Horizon for R&D Programs Not applicable.

Manpower Facilities Devoted to R&D Not applicable.

Examples of Past R&D Programs Not applicable.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) Not applicable.

Organizational Barriers Not applicable.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--Plastics processors in Canada are small and do not perform any R&D. Since they are small, they often do not have the manpower or the skills needed to sell to Detroit. SPI held a seminar on selling products to Detroit in response to this problem.

--SPI is currently conducting a study on the creation of a Canadian Plastics Institute.

--U.S. based buyers tend to prefer U.S. suppliers because the border adds one more problem they have to deal with.

--There is a serious information gap regarding the latest in automotive plastics processing methods.

--There is a lack of trained personnel for operating and maintaining machines and for constructing tooling.

--Canadian processors are not using the latest production technologies like their U.S. competitors.

--There is very little process development work being done in Canada. The large U.S. owned companies do their research and process development in the U.S.

V. Canadian Government Role

Present Use of Government Programs to do R&D Industry, Trade and Commerce among others is providing some of the funding for their year long study of the potential Canadian Plastics Institute.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--The custom plastics processors they represent are not big enough to make use of R&D funding. The average plastics processor has 52 employees.

--The Enterprise Development Program requires too much paper work.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

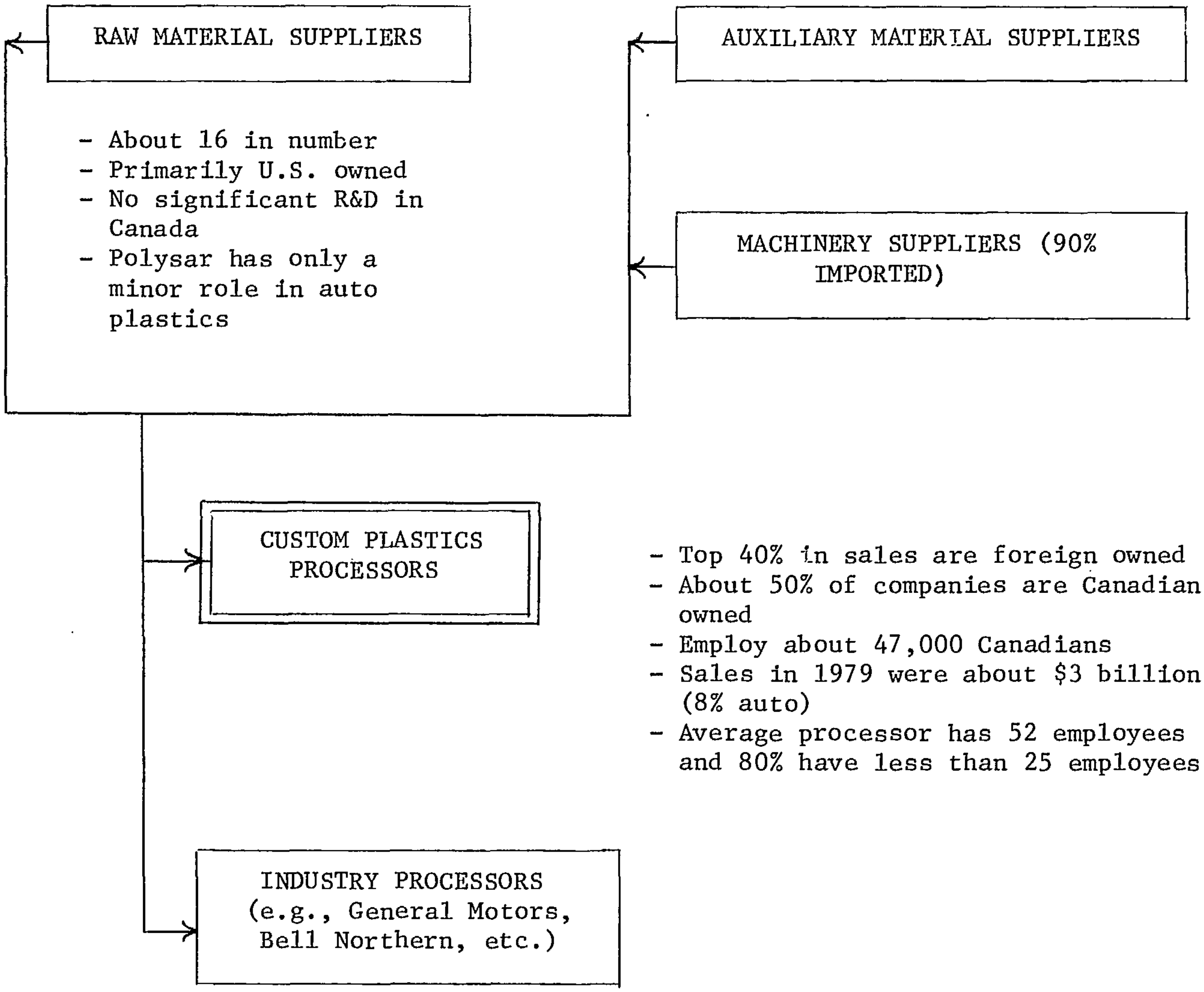
--They are actively investigating the possibility of creating a Plastics Institute of Canada that would:

- act as a technological interface between sources of new technology and the plastics industry;
- adapt new technologies to meet the needs of companies in the plastics industry;
- advise and assist firms in ways to improve upon use of existing technology;
- undertake R&D relevant to the plastics industry;
- provide testing services.

--If their study indicates this type of Institute is needed, they will approach the government for assistance.

--The government should do more toward bringing about applied research and development in the plastics technology needed by the Canadian plastics industry. There are analogies to this in other countries such as Sweden, England (RAPRA), and France (IRCHA), where various forms of aid are given to various industries.

STRUCTURE OF THE PLASTICS INDUSTRY IN CANADA



SOURCE: Mr. Ron Evason, Society of the Plastics Industry of Canada.

COMPANY PROFILE

I. **Background Data**

Name BOMBARDIER, INC.

Address 800 Dorchester Street West
Montreal, Quebec

Primary Contact Mr. L. Hollander (Reviewed 11/8/79)

Title Chief Operating Officer

Telephone Number (514) 861-9481

Additional Contacts None

Date of Visit September 19, 1979

Annual Gross Sales Their net sales for the year ended January 31, 1979 were $385 million. Their current sales in the North American auto market are less than $10 million.

Number of Employees They have approximately 6000 employees in total (two plants in Austria).

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned multinational company.

Product Areas Recreational products (snowmobiles, motorcycles, sailboats) mass transit vehicles, off-road equipment, rubber and plastic products, clothing, seating, two stroke engines, aircraft equipment, rail products and diesel products.

Participation in Auto Industry They produce plastic, rubber and metal parts related to transportation in general. For example, they produce rubber parts for truck suspension, tire recapping products, seating components for buses and trucks and distributor caps.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell OEM and aftermarket products on a worldwide basis.

Existing Products Threatened by Technological Change None were identified.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They gather product and process technology through plant visits, trade show attendance, etc. They have ability to do applied research related to the development of suspension and drive systems for rubber tracked vehicles, various processes for making fiberglass components, and various sizes of injector molded plastic parts.

Need for R&D They have no need for basic research. They have some applied research capability, but it is not directed toward automotive products.

Time Horizon for R&D Programs Their applied research and development programs have a relatively short time frame (2-3 years).

Manpower Facilities Devoted to R&D They have approximately 200 people devoted to applied research and development in the Recreational Products Division. Other Divisions have their own smaller staffs.

Examples of Past R&D Programs They are the largest snow mobile producer in the world as a result of their research in suspension and drive systems for rubber tracked vehicles. This development began prior to 1959 when the SKI-DO was developed.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) No specific barriers were identified.

Organizational Barriers They have a number of small divisions which cannot individually justify a research effort of their own. Mr. Hollander has not yet attempted to make use of his past experience with GSW and the Sheraton Park concept.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--It is very difficult for Canadian companies to stay aware of the state of technology as it applies to them.

--Auto company purchasing offices located in Detroit rather than Canada create a barrier to Canadian manufacturers.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not presently making use of any government R&D program beyond the available tax incentives.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--Ottawa's funding tends to concentrate only on research which represents only 10-20% of the cost of bringing an idea to commercialization.
--There is a big problem in getting the auto companies to acknowledge Canadian suppliers.
--The Sheraton Park concept appears to be a successful way for small divisions of companies to stay informed of technology developments.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--They could function as a technology listening post and engage in selective information dissemination to manufacturers requesting it.
--A task force could identify opportunities for getting licensing agreements to get needed technology.
--They have found it necessary to hire consultants to help them understand the government programs that exist.
--The government should help bring about productivity improvements because Canadian productivity is not adequate. There is a need for improved productivity that will lead to the development of new technology.

COMPANY PROFILE

I. **Background Data**

Name POLYSAR LIMITED

Address Vidal Street
Sarnia, Ontario N7T 7M2

Primary Contact Mr. James W. McDonough (Reviewed 11/21/79)

Title Manager, Technical Development Division

Telephone Number (519) 337-8251

Additional Contacts Dr. J. Beaton, Dr. E. J. Buckler and Mr. D. C. Edwards

Date of Visit September 19, 1979

Annual Gross Sales Sales for 1978 were $740 million. Approximately $100 million of this represents products sold in Canada.

Number of Employees They have more than 2500 employees.

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian owned multinational company.

Product Areas Rubber, latex, plastics and chemicals.

Participation in Auto Industry Emulsion rubbers, butyl rubber and poly butadiene are used by the auto industry. Their major method of auto industry participation is through sales to tire companies.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell their materials worldwide.

Existing Products Threatened by Technological Change Rising underhood temperatures could impact nitrile usage. Sales of products for tire production may be impacted by reduced travel and lower rolling resistance.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They have a central group of people that handle everything from basic research to technical support of existing product lines and manufacturing processes. They concentrate on improvements of current polymers and formulation, development of new specialty grade rubber and meeting new customer demands.

Need for R&D They have a need to perform applied research and development on future products as demonstrated by the existence of their research organization.

Time Horizon for R&D Programs Their typical programs have time frames of one to two years to commercialization. However, they have some programs with planned lives of 10 years.

Manpower Facilities Devoted to R&D They have a central facility with more than 100 people carrying out everything from basic research to technical support. This industry typically spends 1.2% of sales as R&D.

Examples of Past R&D Programs They have actively developed NBR which is used principally for oil resistant motor vehicle parts. They have had R&D programs in many other areas, such as halobutyls, plastics modification, liquid rubbers, oil extension, etc.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) No specific problems with their current R&D operations were identified.

Organizational Barriers No organizational barriers were identified other than the fact that the corporation feels they are currently performing an adequate amount of R&D.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

--Small companies must find special niches to fill rather than competing head-on with much larger companies.

--They suggested that Canadian companies must closely examine what business they are in and determine how they can offer something special.

--Canadian companies must stop thinking of Canada as their only market. Most of Polysar's markets for new ideas are everywhere except Canada. Their Canadian markets are smaller than their foreign markets.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not currently using any government programs beyond the tax provisions available.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada

--In general, the government should leave industry R&D to the forces of the free enterprise system.

--They did not identify any possible roles for the government in helping them perform required R&D.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies

--Canadian tax laws tend to inhibit speculative investment.

--The government could help focus the efforts of small companies on smaller market niches where they can hope to compete effectively.

--Ten years ago, Polysar tended to look at all opportunities for expansion on an equal basis. Today, they have narrowed their objectives as a company to specific types of business and have found specialty areas.

COMPANY PROFILE

I. Background Data

Name ALUMINUM COMPANY OF CANADA, LTD.
ALCAN ALUMINUM LIMITED (parent company)

Address Research Center
Kingston, Ontario

Primary Contact Mr. John A. Hirschfield (Reviewed 11/7/79)

Title Associate Director

Telephone Number (613) 549-4500

Additional Contacts Initially contacted Dr. Frontini, Director of Technical Development, by telephone

Date of Visit September 20, 1979

Annual REVENUES $2.3 billion in 1978 for Aluminum Company of Canada, Ltd.; $3.7 billion in 1978 for Alcan Aluminum Limited.

Number of Employees 18,900 Canadian and 63,400 worldwide employees in 1978

Ownership (Division of Foreign-Owned, Multinational, Canadian, etc.) Canadian multinational

Product Areas Bauxite, alumina, primary aluminum, semi-fabricated and finished products.

Participation in Auto Industry Supply extrusion stock, rolled products and ingot. Their automotive marketing office is in Detroit.

Market Areas (OEM, Aftermarket, Geographical Areas) They sell their products to OEM and aftermarket manufacturers around the world.

Existing Products Threatened by Technological Change While their sales of sheet aluminum to the auto industry may not grow as expected earlier, their products are not being significantly threatened by change.

II. Ability to do R&D

Present Mechanism for Performing R&D and Gathering Technical Information They have international research centers in Arvida-Jonquière, Quebec; Kingston, Ontario; and Banbury, England. They are currently building a research center in Belgaum, India. They have an automotive steering committee to give direction to automotive R&D. They do long term research (30 to 40% of budget), corporate funded development and individual company funded development.

Need for R&D They have a very substantial need for R&D as is indicated by their expenditure of $33 million in 1978 for Canadian R&D activities alone (1.4% of Canadian revenues).

Time Horizon for R&D Programs Their research programs typically have a planned life of 7 years and usually no less than 5 years. Their development programs may last from 1 to 5 years, but usually last approximately 3 years.

Manpower Facilities Devoted to R&D Approximately 600 scientists, engineers, technicians and support staff are located in their three international research centers. There are 300 people in the Kingston Center and they are organized around three basic categories: 1) ores/raw materials (30-40 people); 2) reduction processes (90 people); 3) fabricating and casting (100 people); and 4) support staff (70-80 people).

Examples of Past R&D Programs

--Improvements in formability of 2036 aluminum.
--Improvements in aluminum for bumper applications.
--Search for new aluminum alloys with unique properties.

III. Barriers to Doing More R&D

Specific Problem Areas (Money, Personnel, Facilities) No specific problem areas were mentioned. It was stated that they could, of course, investigate more areas of interest if they had additional funds.

Organizational Barriers There were no barriers identified.

IV. Barriers to Successful Operation and Expansion of Automotive Efforts

No significant barriers were identified.

V. Canadian Government Role

Present Use of Government Programs to do R&D They are not using any programs presently beyond the tax reduction provisions for R&D expenditures. They have used the old PAIT program and the current IRAP program.

Suggested Government Role in Stimulating Auto Industry Related R&D in Canada The proper role was said to be difficult to identify. It was apparent that Alcan has no real need for government assistance in order to do R&D potentially related to the auto industry in Canada.

Suggested Government Role in Assisting Canadian Auto Industry Related Companies They offered no suggestions.

APPENDIX B

1979 FORD MOTOR COMPANY SUPPLIER RESEARCH PROGRAM

WANT LIST SAMPLE

1979 SUPPLIER RESEARCH WANT LIST

Want List Number	Title	Objective
535	Plastic Parking Brake Conduit	Develop extruded plastic tubing to replace steel conduit and polyethylene/nylon/teflon liners.
536	Engine Air Cleaner	Develop a fire resistant plastic for engine air cleaner application.
537	Brake Master Cylinder Cap	Material development required for transparent cap which seals top of master cylinder reservoir.
538	Coupling Agent, Glass Fibers and RIM Materials	Develop a coating material for glass fibers with good adhesion to the fiber and to a polyurethane and non-polyurethane matrix.
539	RIM Materials	Develop High Modulus Polyurethane RIM materials for improved impact resistance, regidity, heat sag and dimensional stability for body panels.
540	RIM Technology and Processing	Develop liquid material systems (not polyurethanes) for RIM processing to to achieve improved impact resistance, rigidity, heat sag, dimensional stability and processing.
541	RIM Mold Release Agent	Develop mold release to improve the processing of high modulus to reinforced RIM materials.
542	Pigmentation for Polyurethanes	Develop pigments for dispersion in polyurethane components to mold parts in color.
543	Coatings for Rigid Plastic Substrates	Develop a resin to incorporate into enamels for ABS, polypropylene and and polycarbonate substrates.
544	Primers and/or Adhesion Promoters	A primer system is needed for polypropylene and polyethylene substrates which provide good adhesion characteristics.
545	Bumper Facia, Bright Flexible	Develop a bright plastic or elastomer facia for bumpers, similar in appearance to chrome plated steel.
546	Flexible Bright Materials	Provide a flexible, damage-resistant, bright material system for trim exterior applications on soft body components.
547	Body Parts - Painted Plastic	Develop new plastic materials for use as painted exterior body parts with impact properties not affected by paint.
548	Molding, Structural Foam, Class "A" Surface	Develop a process or technique to produce a class "A" paintable surface for an exterior body panel formed out of structural foam.
549	Paintable Polypropylene	Develop a composition of polypropylene which is paintable without primer for cost reduction purpose.
550	In-Mold Coating	Provide a coating for plastic exterior components which will provide acceptable Class "A" surface.

1979 SUPPLIER RESEARCH WANT LIST

Want List Number	Title	Objective
551	Plastic, Chrome Plateable High Heat Injection Moldable	Develop a chrome plateable, high heat injection moldable plastic for exterior application.
552	Plateable Plastic	Develop a plateable plastic material for exterior decorative applications.
553	Window Regulator Handle, Bright Finish Plastic	Develop a bright finish plastic for use in a window regulator handle.
554	High Strength, Lightweight Material	Develop a material that can be chrome plated or bright finished to replace zinc die cast for weight reduction.
555	Precision Thermoset Parts	Develop warm manifold injection molding process for precision thermoset parts to eliminate gate/runner scrap.
556	Prototype Mold Technique	Prototype molding technique is desired to better approximate the mold cycle of thermoplastic injected molded parts.
557	Post-Formable Pultrusion	Develop thermoset resin systems which may be readily liquified for fiber wet-out prior to pultrusion.
558	Plastic Glazing Material	Develop scratch-resistant glazing material, low in cost that will allow the replacement of glass.
559	Glazing, Lightweight	Design and develop a lightweight, low cost, glazing for subcompact cars.
560	Common Pre-plating System, Plastic Chrome Plating	Provide a system of pre-plating solutions which can be used interchangeably with ABS, Noryl and Mineral Filled Nylons.
561	Plastic Sheet Electrical Conductivity	Develop material to provide electrical shielding capability integral with the plastic part.
562	Conductive Plastics	Develop an electrically conductive plastic for use in place of stampings and/or die cast metal parts.
563	Control Body Material - Transmission	Develop an easily machineable housing (plastic) with coefficient of expansion close to that of steel.
564	Separator Plate and Gasket - Transmission	Develop a separator plate coating to replace current plate and gasket combination.
565	Valve Body Gasket Material	Develop a material (or material treatment) that will resist humidity related dimensional variance.
566	Gaskets, RTV Rubber	Need is to replace several preformed gaskets with form-in-place types.
567	Plastics with Improved Dimensional Stability	Develop plastic material that can maintain as-molded dimensions within .0005 in/in to replace machined aluminum parts.
568	Differential Cap and Shim Material	Plastic material is required to replace current grey iron applications in differential adjuster shim and bearing cap.

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