J. ALLEN
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CONFERENCE ON BASIC RESEARCH DIRECTIONS FOR ADVANCED AUTOMOTIVE TECHNOLOGY

Sponsored by the

U.S. DEPARTMENT OF TRANSPORTATION

Transportation Systems Center

February 13 & 14, 1979

Sheraton-Boston Hotel
Prudential Center
Boston, Massachusetts

CONFERENCE PURPOSE

By 1985 we will not have exhausted the potential for improvements in motor vehicle performance based on currently known technologies. However, further improvement beyond that date will be limited if we do not take steps to: (1) expand our basic knowledge and understanding of the principles behind the technologies used in motor vehicles; and (2) generate new ideas for the technology of the next generation of motor vehicles.

The central question to be addressed is: What basic research is needed to provide a foundation for a successful national policy to reduce the country's dependence on imported petroleum, consistent with our national goals of improved highway safety and air quality, and continuing freedom of personal mobility at reasonable cost?

The purpose of this meeting is to gather ideas on what basic research questions should be addressed in order to catalyze advances in existing technologies and the adoption of new technologies to improve the performance characteristics of motor vehicles beyond what is currently contemplated. In this process it will be important to recognize and assess the current, ongoing research and development programs of the Federal Government, the automobile industry, and independent research institutions, and, to identify other promising research directions.

PROGRAM ORGANIZATION AND DEVELOPMENT

The conference on Basic Research Directions for Advanced Automotive Technology was organized by the Transportation Systems Center (TSC). The technical staff of the National Highway Safety Administration, under the direction of Mr. Howard Dugoff, Deputy Administrator and Dr. Carl Nash, Policy Advisor to the Administrator, worked with the technical staff of TSC under the direction of Dr. Richard R. John, Chief of the Energy Programs Division, to develop the technical program.

AGENDA

February 13, 1979

9:00 - 10:15 AM OPENING SESSION, Grand Ballroom, Sheraton-Boston Hotel

9:00 AM WELCOME
DR. JAMES COSTANTINO, Director
Transportation Systems Center

9:10 AM INTRODUCTION OF THE SECRETARY OF TRANSPORTATION
DR. JEROME B. WIESNER, President
Massachusetts Institute of Technology

9:20 AM REMARKS
HONORABLE BROCK ADAMS, Secretary of Transportation

9:50 AM REMARKS ON SCOPE OF CONFERENCE - CHAIRPERSON
DR. RAYMOND L. BISPLINGHOFF, Chairman
National Research Council
Committee on Transportation

10:15 AM BREAK

10:45 - 12:30 PM PANEL SESSIONS CONVENE, Sheraton-Boston Hotel

PANEL A: ENGINES - Commonwealth Room (3rd Floor)

PANEL B: FUELS AND POWERTRAIN SYSTEMS - Independence Room (2nd Floor)

PANEL C: STRUCTURES AND MATERIALS - Fairfax Room (3rd Floor)

12:30 - 2:00 PM LUNCH

2:00 - 5:30 PM PANEL SESSIONS RECONVENE, same location as the morning sessions in the Sheraton-Boston Hotel

5:30 PM RECEPTION, Grand Ballroom

February 14, 1979

8:30 AM - 12:30 PM PANEL SESSIONS RECONVENE, Sack-Cheri Theater Complex (across from the Sheraton-Boston Hotel)

PANEL A: ENGINES - Cinema 1

PANEL B: FUELS AND POWERTRAIN SYSTEMS - Cinema 2

PANEL C: STRUCTURES AND MATERIALS - Cinema 3

12:30 - 2:30 PM LUNCH

2:30 - 4:00 PM SUMMARY SESSION, Grand Ballroom, Sheraton-Boston Hotel

PANEL SUMMATIONS

PANEL A: Dr. Richard L. Briceland, Chairperson

PANEL B: Dr. Maxine Savitz, Chairperson

PANEL C: Dr. R. Rhoads Stephenson, Chairperson

GENERAL SUMMATION
DR. RAYMOND L. BISPLINGHOFF, Conference Chairperson

4:00 PM CONFERENCE ADJOURNMENT

PANEL A: ENGINES

CHAIRPERSON: DR. RICHARD H. BRICELAND
Environmental Scientist
Office of Policy Analysis
U.S. Environmental Protection Agency

PANEL FOCUS: This panel will discuss basic research needs for heat engines. The scope of discussion will include any engine that utilizes combustible fuels to generate mechanical energy through a thermodynamic cycle, and that is suitable for use in an automobile or light truck. Research areas will include: the nature of the thermodynamic cycle; combustion processes, emissions and related factors; engine configurations; engine materials and associated manufacturing processes; diagnostic and control systems; and any other areas of research that could have direct implications for the performance of a heat engine.

PANELISTS:

MR. CHARLES A. AMANN
Department Head, Engine Research
General Motors Research Laboratories
Warren, MI

DR. WILLIAM BANKS
President
Engineering Management and Development, Inc.
San Diego, CA

MR. JOHN BROGAN
Director,
Division of Highway Systems
Office of Transportation Programs
U.S. Department of Energy
Washington, DC

MR. GEORGE E. BROWN
Executive Director,
Vehicle Emissions and Safety
American Motors Corporation
Detroit, MI

PROF. DAVID E. COLE
Associate Professor of Mechanical Engineering, and
Director, Center for the Study of Automotive Transportation
University of Michigan
Ann Arbor, MI

MR. KARL HELLMAN
Chief, Characterization and Application Branch
U.S. Environmental Protection Agency
Ann Arbor, MI

DR. PETER HOFBAUER
Advanced Automotive Power Systems
Volkswagenwerk AG
Federal Republic of Germany

MR. A. ISHIZUYA
Director
Honda Motor Co., Ltd.
Tokyo, Japan

PROF. JACK L. KERREBROCK
Head, Department of Aeronautics & Astronautics
Massachusetts Institute of Technology
Cambridge, MA

DR. HOKEN KRISTIANSEN
President
Kristiansen Cycle Engines, Ltd.
Winnipeg, Manitoba
Canada

MR. ARNOLD F. KOSSAR
Vice President, Engineering
Curtiss-Wright Corporation
Woodridge, NJ

PANEL B: FUELS AND POWERTRAIN SYSTEMS

CHAIRPERSON: DR. MAXINE SAVITZ
Deputy Assistant Secretary for
Conservation and Solar Applications
U.S. Department of Energy

PANEL FOCUS: The panel on fuels and powertrain systems will discuss the research needs relating to the motor vehicle powertrain system and the tailoring of fuels for it. The most efficient and least environmentally degrading use of available energy resources is a function of the complex relationship between the energy source, the refined fuel, and the powertrain. Many research questions therefore arise regarding how the source and refining of fuels (or generation of electricity) help to determine the most desirable technology for the vehicle powertrain. Other research questions for the panel will be concerned with on-board energy storage (of fuel or electricity), mechanical and electrical energy conversion (transmissions and motors), regenerative systems, and powertrain technology.

PANELISTS:

DR. W. DALE COMPTON
Vice President - Research
Ford Motor Company
Dearborn, MI

DR. ROGER CORTESI
Director, Criteria Development
Special Studies Division
U.S. Environmental Protection Agency
Washington, DC

MR. E. EUGENE ECKLUND
Chief, Alternative Fuels Branch
U.S. Department of Energy
Washington, DC

PROF. DR. HANS J. FOERSTER
Director of Research
Daimler-Benz AG
Federal Republic of Germany

MR. ROBERT G. JACKSON
Fuels Technology Development
Continental Oil Company
Ponca City, OK

DR. TREVOR JONES
Vice President, Engineering
TRW Automotive Worldwide
Cleveland, OH

DR. JAMES M. LAFFERTY
Manager, Power Electronics Laboratory
Corporate Research & Development
General Electric Company
Schenectady, NY

PROF. ROBERT McALEVY III
Mechanical Engineering Department
Stevens Institute of Technology
Hoboken, NJ

DR. KEITH W. McHENRY
Vice President, Research and Development
Amoco Oil Company
Naperville, IL

MR. JOHN N. NOETTL
Consultant
Washington University
St. Louis, MO

MR. RAYMOND PERRY, JR.
Manager, Fuels Research
Technical Service & Engine Test Section
Mobil Research & Development Corporation
Paulsboro, NJ

DR. BENO STERNLICHT
Chairman and Technical Director
Mechanical Technology, Inc.
Latham, NY

PANEL C: STRUCTURES AND MATERIALS

CHAIRPERSON: DR. R. RHOADS STEPHENSON
Associate Administrator for Research & Development
National Highway Traffic Safety Administration
U.S. Department of Transportation

PANEL FOCUS: This panel will discuss basic research directions affecting all aspects of motor vehicle technology other than the powertrain. This will include the basic layout or configuration of a vehicle (the placement and relationship of its components), its structure and crash energy absorption mechanisms, chassis components (wheels, tires, brakes, steering, and so on), occupant crash protection systems, and the materials used to construct the vehicle.

The research areas for this panel will include new applications of known materials, composite materials and other combined material systems, designs for structural rigidity and for crash energy management, biomechanics and occupant restraints, friction and adhesion characteristics of materials, corrosion and fatigue resistance, and the scrappage and recycling potential of vehicle components.

PANELISTS:

DR. NILS BOHLIN
Senior Engineer, Auto Safety
AB Volvo
Gothenburg, Sweden

PROFESSOR SAMUEL K. CLARK
Acting Chairman
Department of Applied Mechanics
and Engineering Science
University of Michigan
Ann Arbor, MI

MR. CLARENCE M. DITLOW III
Executive Director
Center for Auto Safety
Washington, DC

DR. DONALD FRIEDMAN
President
Minicars, Inc.
Goleta, GA

DR. WILLIAM HADDON
President
Insurance Institute for Highway
Safety
Washington, DC

MR. CHARLES M. HEINEN
Director, Research & Materials
Engineering
Engineering Office
Chrysler Corporation
Detroit, MI

MR HERBERT A JAHNLE
Manager, Advanced Materials
The Budd Company
Fort Washington, PA

DR. STEPHEN J. MATAS
Director of Research
Republic Steel Corporation
Independence, OH

MR. ROBERT F. McLEAN
Director, Automotive Research
The John Z. DeLorean Corporation
Bloomfield Hills, MI

MR. WILLIAM F. MILLIKEN, JR.
President
Milliken Research Associates, Inc.
Williamsville, NY

MR. DONALD W. PENNINGTON
Laboratory Director, Resins Research
Texas Research Group
The Dow Chemical Company
Freeport, TX

DR. ALLEN S. RUSSELL
Vice President, Science and Technology
Aluminum Company of America
Pittsburg, PA

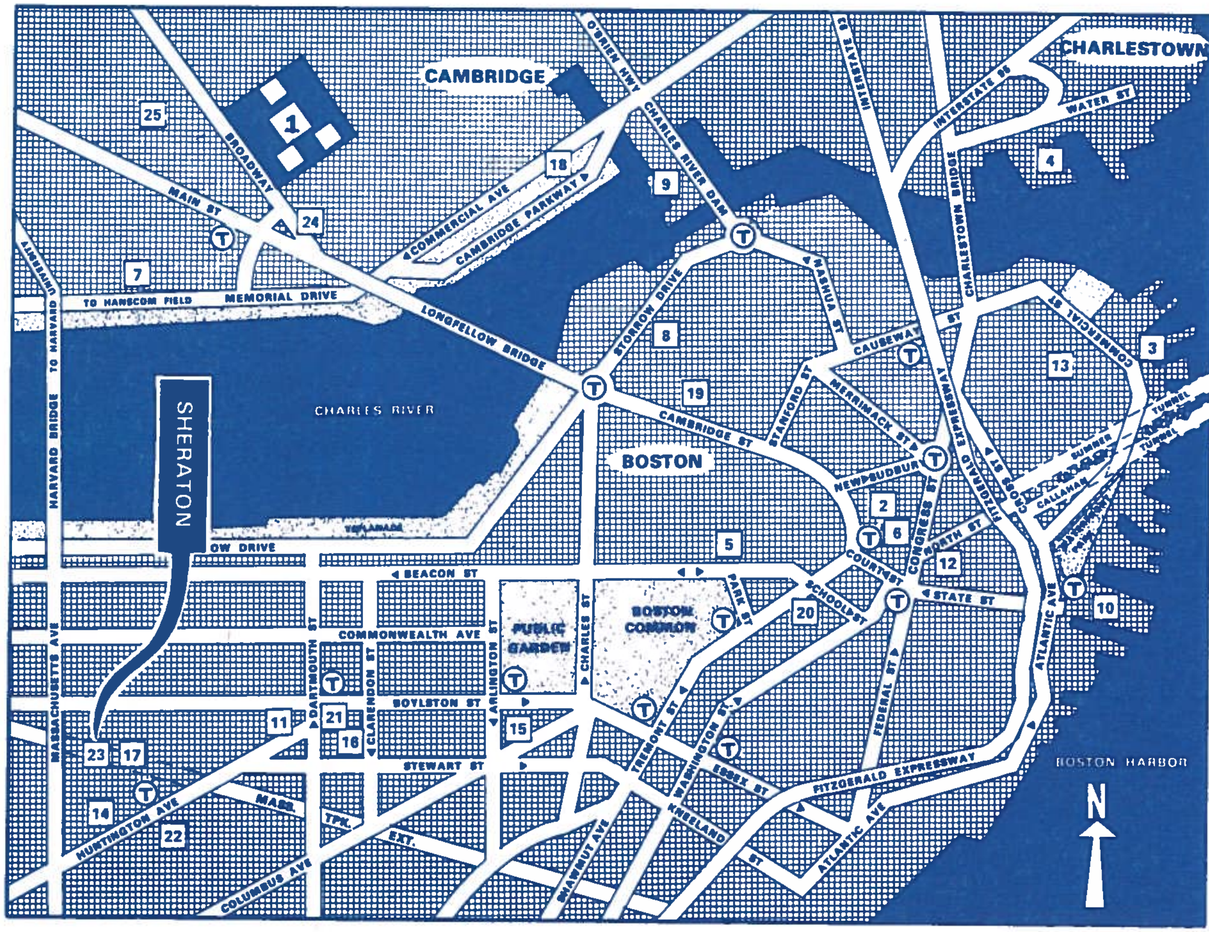
DR. O.C. TRULSON
Director, Carbon Fiber Development
Union Carbide Corporation
Parma, OH

INFORMATION SERVICES

An information desk will be operated each day to receive and post your calls. Incoming calls should be made to (617)236-2000, noting that you are attending the Conference on Basic Research Directions for Advanced Automotive Technology sponsored by the U.S. Department of Transportation.

TRANSPORTATION SERVICES

Assistance in reconfirming or changing your travel arrangements will be provided upon request at the conference information desk. Convenient local transportation is available by taxi or via the Green-Line of the Massachusetts Bay Transportation Authority (MBTA-Prudential Station). Subway maps are available at the conference literature table. In addition, bus service will be provided to Logan International Airport following completion of the Summary Session on Wednesday, 14 February 1979. Bus departure information is available on separate schedule, or can be obtained at the conference information desk.



1 TRANSPORTATION SYSTEMS CENTER
2 J.F.K.BUILDING
3 U.S.C.G.CONSTITUTION WHARF
4 U.S.S.CONSTITUTION
5 MASSACHUSETTS STATE HOUSE
6 CITY HALL
7 MASSACHUSETTS INSTITUTE OF TECHNOLOGY
8 MASSACHUSETTS GENERAL HOSPITAL
9 MUSEUM OF SCIENCE
10 AQUARIUM
11 BOSTON PUBLIC LIBRARY
12 QUINCY MARKET & FANEUIL HALL
13 OLD NORTH CHURCH
14 CHRISTIAN SCIENCE MOTHER CHURCH
15 BOSTON PARK PLAZA
16 HANCOCK TOWER
17 PRUDENTIAL TOWER
18 HOTEL SONESTA
19 HOLIDAY INN
20 PARKER HOUSE HOTEL
21 COPLEY PLAZA HOTEL
22 COLONNADE HOTEL
23 SHERATON BOSTON
24 KENDALL SQUARE
25 TECHNOLOGY SQUARE
Ⓣ SUBWAY STATIONS

Technical Report Documentation Page

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15. Supplementary Notes

16. Abstract

These proceedings contain the results of a two-day Conference on Basic Research Directions for Advanced Automotive Technology held at the Sheraton-Boston Hotel on February 13 & 14, 1979. The Conference, which was open to the public, was attended by several hunderd leaders from industry, academic institutions, and independent research and consumer groups. The Conference was organized by the U.S. Department of Transportation's Transportation Systems Center. The Conference was convened to discuss basic research activities which could provide a pool of technological options for automobile manufacturers in the areas of engines, fuels and powertrains and structures and materials. The results of the Conference will be used to develop a technology agenda which will establish the direction taken to reach the fuel economy standard of 27 mph by 1985 and the 40-50 mph goal by the year 2000.

This report contains the proceedings of the Conference. The report is presented in four volumes:

Volume I: Conference Report
Volume II: Panel Deliberations
Volume III: Conference Docket Submissions, Parts I & II
Volume IV: Conference Transcripts

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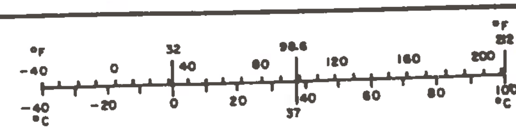
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

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

Approximate Conversions from Metric Measures

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



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BACKGROUND

Introduction

INTRODUCTION

On December 5, 1978, the Secretary of Transportation, Brock Adams, issued a challenge to those in the motor vehicle industry during his talk to The Economic Club of Detroit, Michigan.

The challenge was..."to create a car that is new from the inside out -- a car that represents a commitment, not a concession, to a world short on energy and concerned about the future." In short, Secretary Adams called upon the motor vehicle industry to "re-invent" the automobile.

Secretary Adams was aware of the dimensions of the challenge he proposed. In essence, he asked the industry to work with appropriate government officials and associates in the technical community to assess the possibilities of developing a cleaner, safer, and more significantly efficient car.

The response thus far is highlighted by the "Conference on Basic Research Directions for Advanced Automotive Technology," held in Boston, Massachusetts on February 13-14, 1979.

This conference afforded the Secretary of Transportation the opportunity to invite members of the industry, academia, the technical community, consumer groups and government to work together to develop answers for him as to what was economically and technically feasible.

This "Conference Report" presents the proceedings and results of the February conference. These results are being used as the basis for a "Research Agenda" which Conference Chairman, Dr. Raymond L. Bisplinghoff, will present to the Secretary of Transportation.

The "Research Agenda" will be used to continue the dialog between the Department of Transportation and all other concerned groups. The results of the Conference are contained in four volumes:

Volume I is entitled Conference Report and is divided into four sections:

- o Background
- o Opening Plenary Session
- o Panel Reports
- o Closing Plenary Session.

Volume I summarizes the highlights of the opening and closing sessions and presents three summary panel reports which have been reviewed and approved by the Panel chairmen. The summary panel reports are:

Panel A: Engines
Panel B: Fuels and Powertrain Systems
Panel C: Structures and Materials

Volume II contains the panel deliberations and is divided into three specific panel sections:

- o Panel A: Engines
- o Panel B: Fuels and Powertrain Systems
- o Panel C: Structures and Materials.

This volume also contains reports submitted by the respective panel members as well as submissions from conference attendees.

Volume III is entitled Conference Docket Submissions. This volume contains data and information submitted in response to requests for comments in the Federal Register 44FR7047, Feb. 5, 1979.

Volume IV contains the conference transcripts. This is a transcript of the entire conference proceedings taken from tape and stenographic recordings. (Because of the volume and detail of the transcripts, only limited duplication is planned. However, the transcripts will be available for reference at the Transportation Systems Center.)

Secretary Adams' Speech
December 5, 1978

SECRETARY ADAMS' SPEECH

December 5, 1978

U.S. Department of Transportation

news:

Office of Public and Consumer Affairs

Washington, D.C. 20590

REMARKS PREPARED FOR DELIVERY BY SECRETARY OF TRANSPORTATION BROCK ADAMS, TO THE ECONOMIC CLUB, DETROIT, MICHIGAN, DECEMBER 5, 1978.

I want to deliver a challenge to those in the industry who determine what we will be driving tomorrow, and what our children will be driving two decades from now.

I bring you a challenge because I think it is time to create a car that is new from the inside out -- a car that represents a commitment, not a concession, to a world short on energy and concerned about the future.

Let's not be deceived about the energy situation. We are skating on thin ice. The motor vehicle is the prime mover of our society, and our mobility as well as much of our economy depend on a fragile alliance with the OPEC countries.

We are using well over 100 billion gallons of motor fuel a year in our cars and trucks, and both the supply and the price of about half of that are subject to substantial uncertainties.

Events in Iran and the announcement of rationing by American oil companies reinforce my belief that the curtain is quickly dropping on the age of the internal combustion engine as we know it -- and the fact is we have no replacement.

It's time for industry and government to stop butting heads and to start working together. All of the trench warfare between government and industry over fuel economy has resulted in a 1979 car that gets about as many miles per gallon as did the "Model A" of 50 years ago.

We all know our oil imports have helped fuel the inflation President Carter is fighting so hard against. The full cost of this dependence shows up in other ways as well:

1. In a chronically negative balance of trade.
Presidential advisers estimate that the decline of the dollar on foreign exchange markets adds one percent to the U.S. inflation rate. Our weakness for oil is weakening our currency.

2. In foreign acquisitions of U.S. property.
To offset the dollar drain for imported oil, we are tolerating -- even encouraging -- foreign investments in U.S. property. There is growing concern, in the Corn Belt, along Maryland's Eastern Shore and in the financial capitals of our country as the ownership of land, buildings and companies passes into foreign hands.

3. In the danger to our defense and the efficacy of our foreign policy.
Our international relations could be constrained and our defense posture compromised by our dependency on foreign oil.

I bring these matters before you, because regardless of what other directions present and future national energy policies take, motor vehicle fuel consumption must be reduced.

There are, of course, two ways to do that: by shifting to other forms of transportation, or by making a quantum jump forward in auto technologies.

I have learned that we can divert people from their cars only to a limited degree. People do not want to give up their personal mobility. They may be persuaded to take transit where it is convenient -- and we <u>are</u> trying to make public transit more attractive and accessible, here in Detroit and elsewhere throughout the country. People will fly to save time, and they are doing that today in record numbers. Under certain circumstances people will even travel by train or bus.

But the car is still the people's choice -- far and away the preferred mode of travel. And little wonder. We have built an impressive network of roads. We have made the car a virtually indispensable element of our economy and our culture.

So, except in urban areas where a real alternative is made available, the American people will not give up their automobiles. We had better accept this fact.

For the past two years we have been caught up in the problems of how to preserve the motor vehicle in forms acceptable to the public and still live within our energy means.

Many of you here are, and have been, involved in that debate. Some of you are telling me that if the rules set in Washington remain -- that if fuel economy standards, in particular, are not relaxed -- the cost to some components of the industry may be severe; that sales, and jobs, will be lost.

I'm concerned about that. I'm listening to what you're saying. But I'm also concerned about the alternatives -- cars without gasoline, and trains and buses, planes and subways that can't handle the demand; which is why I believe the only practical course of action is a daring one. I believe we must do nothing less than re-invent the car -- create a new, superior vehicle within a decade.

I propose this challenge for two reasons:

1. Despite the fuel economy standards now mandated, consumption is not dropping and shows signs that it will begin to rise again by 1985; and

2. We are coming close to exhausting the possibilities for further fuel economies using existing commercial technologies. With the more efficient cars that will be common in the 1980's, we will have used up much of the potential for our present technologies. Further incremental improvements will still be possible. But if the next generation of cars is to meet the conditions of the 1990's we will have to begin to develop advanced automotive technologies now so they will be ready for commercialization.

The fuel economy standards now posted, as difficult as they may be to meet, will not suffice. Beginning in the mid 80's energy demand will spurt again and I, for one, am not prepared to guarantee the industry or the American public that sufficient supplies of affordable fuel will be available.

I am aware of the school of thought that says energy supplies will be adequate for as long into the future as we can see. I do not have that confidence. And as Secretary of Transportation I can't take that chance -- nor, in my opinion, can our society.

What I am saying is that we are engaged now in a holding action. We are not <u>solving</u> our basic energy problem; we are only <u>deferring</u> it. It is not how much fuel we save this year, or the next, or in 1985 that matters in the long run. What concerns me, and must concern you, is what the auto industry will be able to <u>build</u> and what people can <u>buy</u> in a decade.

Beyond 1985 even a one mile per gallon improvement in fuel economy per year for new cars will not be sufficient to offset increases in total demand for motor fuel. Instead we must focus on the necessity to again double the fleet fuel economy average to something like 50 miles per gallon, or its equivalent, before the new century.

I am not suggesting we set regulatory standards at that level but that industry and government together establish performance goals for ourselves, as the nation and its aviation industries did in the space program. Frankly, I am not at all sure that legislation written in Washington is the best way to inspire the building of better cars in Detroit. But the only alternative I see is for the auto industry and government together to take the leap forward in technology that focuses on long-range goals, not just short-term objectives.

When we get right down to it, the last major technological break-throughs of fundamental significance occurred about 60 or 70 years ago. I'm talking about the development of a practical, lightweight heat engine, the pneumatic tire and -- perhaps -- the self-starter. Developments since then have been important but incremental refinements of the basic technologies.

We enjoy finer, more comfortable, better performing, substantially more durable cars today, but we are still tied to the internal combustion engine. Moreover, many of the significant technological advancements that have occurred in recent years were first commercialized in Europe and Japan.

In recent years the American automobile industry, I regret to say, has acquired a reputation for imitation, not innovation. The companies have become collaborators rather than competitors. The government, in setting minimum performance standards, has found that the industry thinks of them as absolute targets and seems to feel little or no incentive to try to gain an edge by exceeding those requirements.

The time, and the opportunity, to change that perception are at hand. And the potential rewards are substantial. For example:

Never before has the American automobile industry been in a better position to compete in the world market.

1. U.S. labor costs are now competitive.

2. Motor fuel, which will almost certainly increase in price in the domestic market, has already reached the $2 level in most foreign markets. Technologies that we don't even consider are already competitive in that kind of market.

3. The import share of the U.S. market is probably going to shrink because foreign cars are losing their price and performance advantages. Europe and much of the rest of the world will become a "growth market" for U.S. cars if the industry is aggressive and our government firm in its trade policies.

4. In percentage terms, the growth prospects are greater abroad over the next 10 years than they are in the United States. The European market, where 9 million cars were sold in 1976, is projected to absorb 11 1/2 million vehicles in 1983 and 14 million by 1990. The demand in Africa will quadruple.

5. The industry's projected \$50-\$80 billion investment in the production of more efficient, less polluting and safer cars will modernize the plant and guarantee jobs at home.

If we can pull it off -- if we can build a cleaner, safer, significantly more efficient car, one the world will love, envy and buy -- the U.S. auto industry will insure its own prosperity and the continued mobility of millions.

With the right product we can erase the \$7 billion motor vehicle trade advantage Japan holds over us. The United States can become a net exporter rather than a net importer of cars and light trucks.

I do not for a minute believe that what I am suggesting is easy. It may not even be possible.

But it is an Everest that faces us -- and must be climbed.

I believe that we have, within the public and private resources of this country, the means to produce cars free of the social, environmental and energy sins that trouble us today and cloud the future.

I ask the auto industry today for a commitment to that cause -- the second genesis of the automobile.

I ask you to join with me, and with every government agency concerned with our energy, environmental and safety needs, in an intellectual consortium dedicated to a giant step for mankind's surface transportation needs.

I shall ask the leaders of the automotive industry to meet together early next year, with the appropriate officials from government, to determine what we can do together to hasten the development of an energy-stretching, life-saving, people-pleasing car.

What I am suggesting is a "summit conference" of the best brains in the auto industry together with the government agencies that support and regulate this industry. Our first priority must be a propulsion system that combines acceptable performance with exceptional fuel economy.

I extend this invitation in the full realization that the kind of commitment I am talking about exceeds the commercial capabilities of the industry alone. The Federal government can and must play a key role in fostering and, to the extent possible, assisting in such a development program. Substantial sums of tax dollars are already being invested in automotive-related research and development.

I see no reason why this Federally-supported research and development program should not be the catalyst for a concerted, cooperative government-industry effort toward a lofty goal that serves our national, industrial and personal interests. I see no reason why we cannot take a united stand against the common technical problems that confront us. I see no reason why we should not dedicate ourselves to the development of a new generation of automotive technology, not to warming over what we have now. And I see every reason why we should join together in this venture.

So, I shall expect the participation and the dedication of the private sector.

We do not begin empty-handed. An assortment of experimental safety vehicles, with improved crash protection and fuel economy, have been built and tested.

The industry has carried out, and is presently conducting with the support of the Department of Energy, a variety of alternative engine programs -- the Stirling, the turbine, electric and hybrids.

New plastics, carbon fibers and exotic metals have been used in prototype vehicles. Other advances -- turbo charged gasoline and diesel engines, lightweight structures and techniques to reduce drag -- are available or soon will be.

We need other more exciting prospects -- advances that depend on significant developments in materials, heat transfer technologies and energy storage systems.

I can't tell you whether the auto of tomorrow will be electric or powered by some other fuel, but the marketplace is waiting -- not only in America but worldwide. We must move from the distant and the dreamy to the real and the reachable; from the implausible to the possible. And we must do it now.

That's why I'm here today. I realize the dimensions of the challenge I am proposing. I am aware, too, of the industry's substantial investment in down-sizing technologies and its capital obligations through the mid-1980's.

But our greater need is to engage in a partnership effort aimed directly and unmistakenly at the development of new-born, not re-born automotive technology. We cannot build the car of tomorrow unless we first invent the engine of the future.

The prospect, I believe, can be exciting as well as productive. As Phil Caldwell of Ford said recently: "How many times do you have the opportunity to start with a clean sheet of paper?"

That's what we must do. Start with a clean slate. Go back to "cut-and-try" engineering. Revive Henry Ford the First's tactic of pitting one engineering team against another.

In 75 years the car has gone through a remarkable evolution. In the next 20 it must be the soul and center of a revolution.

I am sounding the call today. This next year let us fire the first volley.

Conference
Announcement Letter

DR. JAMES COSTANTINO'S CONFERENCE ANNOUNCEMENT LETTER

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA 02142

REPLY TO ATTENTION OF:

On December 5, 1978, Secretary of Transportation Brock Adams delivered a challenge to the U.S. motor vehicle industry to create new superior vehicles. He noted that further incremental increases in fuel economy beyond 1985 may be insufficient to offset increases in consumption in the 1990's, and that holding the use of motor fuels to tolerable levels may require a virtual redoubling of the fleet fuel economy average before the turn of the century.

The Secretary has asked the Transportation Systems Center (TSC) to hold a conference on basic research directions for advanced automotive technology. The objectives of the TSC conference will be to obtain views from a variety of knowledgeable interested people from many fields and institutions on the basic research objectives and priorities that would address automotive transportation needs for the 1990's and beyond.

The conference agenda will include three panel discussion areas: engines, fuel and powertrain systems, and vehicle structures and materials. It is planned to stimulate participant discussion on the basic research requirements for developing and expanding automotive technology for the long-term future. All discussions and meetings will be open to the public.

The meeting will be held at the Sheraton-Boston Hotel on February 13 and 14, 1979. Registration will take place on the evening of February 12 and the following morning. You are invited to join us for this important meeting. Questions about the meeting may be directed to Miss Susan Swain at (617) 494-2392.

Sincerely,

James Costantino
Director

5 Enclosures

Conference Follow-up Letter

CONFERENCE FOLLOW-UP LETTER

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE, CAMBRIDGE, MA 02142

February 3, 1979

REPLY TO ATTENTION OF:

Dear Invitee:

This letter is a follow-up to the invitation you received earlier this month to attend a conference on Basic Research Directions for Advanced Automotive Technology at the Sheraton-Boston Hotel on February 13-14, 1979. A discussion paper is enclosed which is intended to stimulate and focus discussion by the conference panelists and participants. You are invited to submit written statements of up to five pages in length and send them to Miss Susan Swain at the Transportation Systems Center, by Monday, February 12, or at the conference before 9:00 a.m. on Tuesday, February 13. These comments will be summarized and read orally at the end of the day in the appropriate panel sessions. Attachments, regardless of length, to the five-page comments will be accepted. However, the major points must be made within the five-page limit. To ensure the accuracy of the summaries of the written statements, commenters are urged to submit an abstract of their statement of 200 words or less. All of the comments that are received will be made a part of the proceedings and will be made available.

If you have not already registered for the conference or have questions about the meetings or about your role in them, please contact Miss Susan Swain (617) 494-2392.

Sincerely,

James Costantino
Director

Enclosures:

1) Agenda
2) Discussion paper

Conference
Discussion Paper

CONFERENCE DISCUSSION PAPER

BASIC RESEARCH DIRECTIONS FOR ADVANCED AUTOMOTIVE TECHNOLOGY

Introduction

On December 5, 1978, Secretary of Transportation Brock Adams called for a major program to develop a new generation of automotive technology to meet the challenging conditions we will face in the 1990's and beyond. Noting that automobiles will continue to be the major mode of personal transportation for the forseeable future, he called for a conference of government and industry leaders, members of the research community, consumers, and others to discuss what form this program should take, and how it can be implemented.

As one step toward the conference called for by the Secretary, the Department of Transportation has organized a technical meeting in Boston, Massachusetts on February 13 and 14 to discuss basic research directions for advanced automotive technology. The purpose of the conference is to obtain views from knowledgeable and interested people from various fields and institutions on the basic research objectives and priorities that would lead to commercialization of vehicles meeting the automotive transportation needs and conditions in the 1985-2000 time frame.

Plans of the automobile manufacturers for automobile and light truck design and technology, and of the Federal Government for automotive regulatory requirements are essentially set through model year 1985. Although there will be major changes in them, the 1985 motor vehicles will not be particularly unfamiliar:

- They will be powered by conventional gasoline or Diesel engines driving through multi-speed transmissions, and will use today's fuels;
- Nearly all structural parts of the body and chassis will still be made of steel, although there will be increased use of aluminum and plastics for nonstructural components; and,
- Front-wheel drive vehicles will become more prevalent but this concept is not unfamiliar at present.

For the purposes of the Boston meeting, the 1985 resized motor vehicle, with an electronically controlled internal combustion engine, perhaps turbocharged, will be taken to represent the baseline state-of-the-art.

Looking beyond 1985, some obvious general areas where further improvement in the motor vehicle system may be needed include:

- energy requirements,
- safety to users and others,
- environmental effects,
- reliability and durability,
- the cost of manufacture, ownership, and use.

By 1985 we will not have exhausted the potential for improvements in motor vehicle performance based on currently known technologies. However, further improvement beyond that date will be far more limited than it is today if we do not take steps to: (1) expand our basic knowledge and understanding of the principles behind the technologies used in motor vehicles; and (2) generate new ideas for the technology of the next generation of motor vehicles.

The central question to be addressed at the Boston meeting is: What basic research is needed to provide a foundation for a successful national policy to reduce the country's dependence on imported petroleum, consistent with our national goals of improved highway safety and air quality, and continuing freedom of personal mobility at reasonable cost?

Beyond defining the vehicle performance characteristics that may be important in the 1990's, we must be sensitive to the practical constraints involved in automotive transportation. Automobiles and light trucks are popular consumer products, and as such must be low cost, durable units that can be serviced in the field. Large numbers of automobiles are built each year and they are used by people of all levels of skill and concern for them.

There are many systems in a motor vehicle and a number of technology choices for virtually all of them. The Boston meeting is designed to gather ideas on what research questions must be addressed in order to catalyze advances in existing technologies and the adoption of new technologies to improve the performance characteristics of motor vehicles beyond what is currently contemplated. In this process it will be important to recognize and assess the current, ongoing research and development programs of the Federal Government, the automobile industry, and independent research institutions and to identify other promising research directions.

When this has been done, more specific research programs can be defined. Priorities among these programs can then be established on the basis of their scope, their likelihood of success, the potential contribution of each program to the success of a technology that would enhance motor vehicle performance, and the value given such performance by society.

At the Boston meeting, we would like to have participants provide and discuss their ideas on research projects and priorities. Three panels have been formed at the meeting, and the remainder of this paper will discuss each of them.

Panel A: Engines

- Scope.

This panel will discuss basic research needs for heat engines. The scope of discussion will include any engine that utilizes combustible fuels to generate mechanical energy through a thermodynamic cycle, and that is suitable for use in an automobile or light truck. Research areas will include: the nature of the thermodynamic cycle; combustion processes, emissions and related factors; engine configurations; engine materials and associated manufacturing processes; diagnostic and control systems; and any other areas of research that could have direct implications for the performance of a heat engine.

- Research Goals.

Heat engine technology affects a number of motor vehicle performance attributes: fuel economy; emissions; driveability; cost of production and maintenance; and vehicle size and weight, to name some of the more important ones. The engine characteristics that affect these vehicle performance characteristics include thermal efficiency, combustion completeness, susceptibility to after-treatment of emissions, internal friction and other parasitic losses, flexibility and transient responses, external size, and weight.

Research goals to be addressed by this panel are for the conception and development of practical technologies to improve these characteristics.

- Current Research Directions

In the late 1960's, continuous combustion engines such as the Rankine (steam engine), Stirling, and gas turbine engines were under active investigation because of their low exhaust emission potential. In the mid-1970's, the goals were changed to emphasize fuel economy and multi-fuel capabilities. These programs were initiated to provide potential alternatives to the conventional spark ignition and Diesel engines that were then in production. In parallel with this activity, numerous development programs were undertaken on internal combustion engines that have resulted in substantial improvements in their fuel economy and exhaust emissions characteristics.

The fuel economy potential of the Stirling and gas turbine engines is directly dependent on the availability of materials that can withstand prolonged exposure to high temperature gases. In the case of the Stirling engine, materials that can contain hydrogen gas while transferring heat rapidly are needed. Material requirements for some key engine components are quite severe, and research is currently underway on high temperature super alloys and ceramics to advance continuous heat engine technology.

The attainable fuel economy and emission limits of vehicles powered by internal combustion engines are dependent on the state of knowledge and development in thermodynamics, engine configuration, gas heat transfer, liquid atomization, and chemical kinetics. Materials do not limit the efficiency of internal combustion engines because they are not subject to continuous high heat loads. During the past ten years, advances in internal combustion engine technology, including catalytic converters, precision fuel metering, turbocharging, electronic engine controls, alternative configurations (such as the rotary engine), and systems to vary the basic engine parameters (such as valve timing, compression, and even the number of cylinders that are in operation) have been based on a pre-existing research base. Few resources have been expended on long-term research. Current research and development on internal combustion engines is directed toward near-term technological improvements to meet statutory performance requirements.

- Illustrative Heat Engine Related Research

A number of studies have identified key research needs for the advancement of automotive propulsion technology including the following:

<u>Combustion Related Research</u>

- To provide a basic understanding and insight into the chemical and physical processes that control combustion and formation of pollutants in heat engines.

Fluid Mechanics

- To provide a basic understanding of heat, mass and momentum transfer and their effects on thermodynamic processes within heat engines.

Materials Research

- To provide a basic understanding and insights into metallurgy, ceramics and chemistry in order to identify improved materials with high temperature and other important characteristics needed for heat engines.

Tribology Research

- To provide a basic understanding of friction mechanisms under various material, surface and lubrication conditions so as to be able to reduce engine/drivetrain friction losses.

Panel B: Fuels and Powertrain Systems

- Scope.

The panel on fuels and powertrain systems will discuss the research needs relating to the motor vehicle powertrain system and the tailoring of fuels for it. The most efficient and least environmentally degrading use of available energy resources is a function of the complex relationship between the energy source, the refined fuel, and the powertrain. Many research questions therefore arise regarding how the source and refining of fuels (or generation of electricity) help to determine the most desirable technology for the vehicle powertrain. Other research questions for the panel will be concerned with on-board energy storage (of fuel or electricity), mechanical and electrical energy conversion (transmissions and motors), regenerative systems, and powertrain technology.

- Research Goals.

A fuel/powertrain system for a vehicle will obviously affect the fuel or energy economy of the vehicle. That choice can also have an important effect on the acquisition or developmental costs for the energy resources and environmental costs, and can affect trade balances.

Thus, the specific research goals to be addressed by this panel include improving the matching of energy resource and powertrain technology for greater overall efficiency, better tailoring of fuels to engine characteristics, improving on-board energy storage systems such as batteries and hydrogen storage mechanisms, raising the efficiency of conversion of mechanical and electrical energy, and control and other systems for electric and hybrid vehicles.

- Current Research Directions.

During the past several years, major research and development efforts have been undertaken to tailor lead-free and low-sulfur petroleum derived fuels for use in internal combustion engines equipped with catalytic converters for emission control. Additional research and development programs are underway on wide range and continuously variable transmissions, and electric and hybrid-electric vehicles. The latter work includes extensive research and development on batteries, electric motors, and electric motor controls. With the exception of the work on electric and hybrid vehicles and the continuously variable transmission, the great majority of these programs have been planned for relatively near-term commercialization.

There have also been many studies of energy sources, refinement, and conversion for use in transportation.

- Illustrative Fuel/Powertrain Related Research

A number of studies have identified key research needs for advancement and optimization of the fuel/powertrain system. These include:

<u>Fuel Composition and Combustion Studies</u>

- To develop a fundamental understanding and insight into the chemical and physical processes that control combustion behavior over a broad range of operational conditions to identify problems associated with combustion, fuel composition and fuel quality.

<u>Fuel Synthesis</u>

- To provide insight into the fundamental thermodynamic, kinetic and processing aspects of the conversion paths in the extraction and refinement of transportation fuel from its source.

<u>Electrochemical Studies</u>

- To develop a basic understanding of the energy loss mechanisms involved in charge/discharge cycles of appropriate electrochemical couples to identify the potential for optimization of high energy/power density batteries.

Panel C: Vehicle Structures and Materials

- Scope.

This panel will discuss basic research directions affecting all aspects of motor vehicle technology other than the powertrain. This will include the basic layout or configuration of a vehicle (the placement and relationship of its components), its structure and crash energy absorption mechanisms, chassis components (wheels, tires, brakes, steering, and so on), occupant crash protection systems, and the materials used to construct the vehicle.

The research areas for this panel will include new applications of known materials, composite materials and other combined material systems, designs for structural rigidity and for crash energy management, biomechanics and occupant restraints, friction and adhesion characteristics of materials, corrosion and fatigue resistance, and the scrappage and recycling potential of vehicle components.

- Research Goals.

The central research challenge in the areas of vehicle structures and materials is to facilitate further resizing and weight reduction without compromising vehicle function, convenience, comfort, durability or reliability while improving occupant safety and reducing hazards to impacted pedestrians.

To achieve these objectives, the research goals are to find lightweight materials or material systems that are derived from plentiful resources and that can be used for rigid and durable structures and for energy absorbing components in the vehicle. Research into fastening methods could enhance the applicability of certain materials to vehicle use.

Other types of basic research on material properties may also be able to help meet the objectives for vehicle systems. These could include materials for tire construction to improve strength, traction, and rolling resistance without sacrificing treadlife. Research may also go into the reduction of parasitic losses such as from friction and aerodynamic drag.

New materials provide new challenges for manufacturing technologies. Basic research in this area may help to make commercialization of vehicles utilizing these materials feasible.

- Current Research Directions

The current programs of vehicle resizing to meet Federal fuel economy requirements have resulted in a substantial amount of material development work in plastics and high strength low alloy steels. There is also some basic research into composite materials. Composite plastics such as fiberglass have been used in new prototype and production applications for such things as wheels, engine supports, and side door beams.

New concepts for energy absorption have also been developed for both low speed impact damage and high speed crash energy management. One of the most promising for both is foam filled structures where the material containing the foam is either a plastic or sheet metal.

There have been several interesting recent developments in tire technology. The beadless, geodesic tire is probably one of the most advanced tire concepts available today to achieve high levels of performance with low weight. Other concepts for run-flat performance and bead retention have been developed, and new materials for tire cord have been introduced into production in recent years.

Some other major research and development initiatives at present are in the area of vehicle design and test methods, and manufacturing techniques for new materials.

- Illustrative Vehicle Structures and Materials Related Research

A number of studies have identified various multidisciplinary research needs for advances in structures and materials including the following:

<u>Structural Mechanics Research</u>

- To provide an understanding of the loads sustained by new vehicles, components, and occupants during normal operation(as well as collisions) so that greater design efficiency and safety can be achieved.
- To provide an understanding of the consequences imposed by the manufacturing process on parts and materials performance.

<u>Materials Science and Engineering</u>

- To provide an understanding of the relationship between composition, microstructure and engineering properties of materials that may be used in vehicles and how these properties vary under loads incurred during processing and in service.

- To provide improved experimental techniques that would reduce uncertainties in material and system behavior.

Biomechanics Research

- To provide insight into the biomechanical stresses imposed on occupants of vehicles involved in accidents to establish relationships among injuries, test specification, vehicle design and the crash environment.

References

PANEL A:

(1) Research Plan for Achieving Reduced Automotive Energy Consumption, National Science Foundation, Washington, DC, NSF Resport No. RA 760008, October 1975.

(2) Should We Have a New Engine?, Jet Propulsion Laboratory, Pasadena, California, JPL Report No. SP43-17, August 1975.

(3) Diesel Engine Research and Development Status and Needs, prepared by Aerospace Corp., El Segundo, California for U.S. Department of Energy, Aerospace Report No. ATR-78 (7753)-1, September 1978.

PANEL B:

(1) Composition of Transportation Synfuels: R and D Needs, Strategies and Actions, Conference sponsored by U.S. Department of Energy, Executive Summary of Conference Report published January 1979.

(2) Future Automotive Fuels, Colucci, J.M. and Gallopoulos, N.E., Eds., published by Plenum Press, New York, 1977.

(3) Automotive Fuels-Outlook for the Future, Bidwell, J.B., General Motors Research Laboratories, Warren, Michigan, June 15, 1978.

(4) Highway Vehicle Alternative Fuels Utilization Program, U.S. Department of Energy Program Planning Document DOE/CS-0029, April 1978.

(5) Alternative Fuels and Combustion Problems, Longwell, J.P., in Project Squid Workshop on Alternative Hydrocarbon Fuels for Engines: Combustion and Chemical Kinetics, 1977, Bowman, C.T. and Birkeland, J., Eds. (Vol. 62 in Progress in Astronautics and Aeronautics), published 1978.

PANEL C:

(1) Materials and Man's Needs - Material Science and Engineering, Report of the Committee on the Survey of Materials Science and Engineering; National Academy of Sciences, Washington, DC, 1974.

(2) Problems and Prospects of Fundamental Research in Multi-Disciplinary Fields - Materials, Organization for Economic Co-Operation and Development, Paris, 1972.

(3) The Williamsburg Conference on Highway Safety Research, Society of Automotive Engineers, Inc., Vehicle Research Institute, New York, 1972. (Special Publication SP-377.)

Conference Agenda

CONFERENCE ON
BASIC RESEARCH DIRECTIONS
FOR
ADVANCED AUTOMOTIVE TECHNOLOGY

Sponsored by the

U.S. DEPARTMENT OF TRANSPORTATION

Transportation Systems Center

February 13 & 14, 1979

Sheraton-Boston Hotel
Prudential Center
Boston, Massachusetts

CONFERENCE PURPOSE

By 1985 we will not have exhausted the potential for improvements in motor vehicle performance based on currently known technologies. However, further improvement beyond that date will be limited if we do not take steps to: (1) expand our basic knowledge and understanding of the principles behind the technologies used in motor vehicles; and (2) generate new ideas for the technology of the next generation of motor vehicles.

The central question to be addressed is: What basic research is needed to provide a foundation for a successful national policy to reduce the country's dependence on imported petroleum, consistent with our national goals of improved highway safety and air quality, and continuing freedom of personal mobility at reasonable cost?

The purpose of this meeting is to gather ideas on what basic research questions should be addressed in order to catalyze advances in existing technologies and the adoption of new technologies to improve the performance characteristics of motor vehicles beyond what is currently contemplated. In this process it will be important to recognize and assess the current, ongoing research and development programs of the Federal Government, the automobile industry, and independent research institutions, and, to identify other promising research directions.

PROGRAM ORGANIZATION AND DEVELOPMENT

The conference on Basic Research Directions for Advanced Automotive Technology was organized by the Transportation Systems Center (TSC). The technical staff of the National Highway Safety Administration, under the direction of Mr. Howard Dugoff, Deputy Administrator and Dr. Carl Nash, Policy Advisor to the Administrator, worked with the technical staff of TSC under the direction of Dr. Richard R. John, Chief of the Energy Programs Division, to develop the technical program.

AGENDA

February 13, 1979

9:00 - 10:15 AM OPENING SESSION, Grand Ballroom, Sheraton-Boston Hotel

9:00 AM WELCOME
DR. JAMES COSTANTINO, Director
Transportation Systems Center

9:10 AM INTRODUCTION OF THE SECRETARY OF TRANSPORTATION
DR. JEROME B. WIESNER, President
Massachusetts Institute of Technology

9:20 AM REMARKS
HONORABLE BROCK ADAMS, Secretary of Transportation

9:50 AM REMARKS ON SCOPE OF CONFERENCE - CHAIRPERSON
DR. RAYMOND L. BISPLINGHOFF, Chairman
National Research Council
Committee on Transportation

10:15 AM BREAK

10:45 - 12:30 PM PANEL SESSIONS CONVENE, Sheraton-Boston Hotel

PANEL A: ENGINES - Commonwealth Room (3rd Floor)

PANEL B: FUELS AND POWERTRAIN SYSTEMS - Independence Room (2nd Floor)

PANEL C: STRUCTURES AND MATERIALS - Fairfax Room (3rd Floor)

12:30 - 2:00 PM LUNCH

2:00 - 5:30 PM PANEL SESSIONS RECONVENE, same location as the morning sessions in the Sheraton-Boston Hotel

5:30 PM RECEPTION, Grand Ballroom

February 14, 1979

8:30 AM - 12:30 PM PANEL SESSIONS RECONVENE, Sack-Cheri Theater Complex (across from the Sheraton-Boston Hotel)

PANEL A: ENGINES - Cinema 1

PANEL B: FUELS AND POWERTRAIN SYSTEMS - Cinema 2

PANEL C: STRUCTURES AND MATERIALS - Cinema 3

12:30 - 2:30 PM LUNCH

2:30 - 4:00 PM SUMMARY SESSION, Grand Ballroom, Sheraton-Boston Hotel

PANEL SUMMATIONS

PANEL A: Dr. Richard H. Briceland, Chairperson

PANEL B: Dr. Maxine Savitz, Chairperson

PANEL C: Dr. R. Rhoads Stephenson, Chairperson

GENERAL SUMMATION
DR. RAYMOND L. BISPLINGHOFF, Conference Chairperson

4:00 PM CONFERENCE ADJOURNMENT

PANEL A: ENGINES

CHAIRPERSON: DR. RICHARD H. BRICELAND
Environmental Scientist
Office of Policy Analysis
U.S. Environmental Protection Agency

PANEL FOCUS: This panel will discuss basic research needs for heat engines. The scope of discussion will include any engine that utilizes combustible fuels to generate mechanical energy through a thermodynamic cycle, and that is suitable for use in an automobile or light truck. Research areas will include: the nature of the thermodynamic cycle; combustion processes, emissions and related factors; engine configurations; engine materials and associated manufacturing processes; diagnostic and control systems; and any other areas of research that could have direct implications for the performance of a heat engine.

PANELISTS:

MR. CHARLES A. AMANN
Department Head, Engine Research
General Motors Research Laboratories
Warren, MI

DR. WILLIAM BANKS
President
Engineering Management and Development, Inc.
San Diego, CA

MR. JOHN BROGAN
Director,
Division of Highway Systems
Office of Transportation Programs
U.S. Department of Energy
Washington, DC

MR. GEORGE E. BROWN
Executive Director,
Vehicle Emissions and Safety
American Motors Corporation
Detroit, MI

PROF. DAVID E. COLE
Associate Professor of Mechanical Engineering and
Director, Center for the Study of Automotive Transportation
University of Michigan
Ann Arbor, MI

MR. KARL HELLMAN
Chief, Characterization and Application Branch
U.S. Environmental Protection Agency
Ann Arbor, MI

DR. PETER HOFBAUER
Advanced Automotive Power Systems
Volkswagenwerk AG
Federal Republic of Germany

MR. A. ISHIZUYA
Director
Honda Motor Co., Ltd.
Tokyo, Japan

PROF. JACK L. KERREBROCK
Head, Department of Aeronautics & Astronautics
Massachusetts Institute of Technology
Cambridge, MA

DR. HOKEN KRISTIANSEN
President
Kristiansen Cycle Engines, Ltd.
Winnipeg, Manitoba
Canada

MR. ARNOLD F. KOSSAR
Vice President, Engineering
Curtiss-Wright Corporation
Wood-Ridge, NJ

PANEL B: FUELS AND POWERTRAIN SYSTEMS

CHAIRPERSON: DR. MAXINE SAVITZ
Deputy Assistant Secretary for
Conservation and Solar Applications
U.S. Department of Energy

PANEL FOCUS: The panel on fuels and powertrain systems will discuss the research needs relating to the motor vehicle powertrain system and the tailoring of fuels for it. The most efficient and least environmentally degrading use of available energy resources is a function of the complex relationship between the energy source, the refined fuel, and the powertrain. Many research questions therefore arise regarding how the source and refining of fuels (or generation of electricity) help to determine the most desirable technology for the vehicle powertrain. Other research questions for the panel will be concerned with on-board energy storage (of fuel or electricity), mechanical and electrical energy conversion (transmissions and motors), regenerative systems, and powertrain technology.

PANELISTS:

DR. W. DALE COMPTON
Vice President - Research
Ford Motor Company
Dearborn, MI

DR. ROGER CORTESI
Director, Criteria Development
Special Studies Division
U.S. Environmental Protection Agency
Washington, DC

MR. E. EUGENE ECKLUND
Chief, Alternative Fuels
Branch
U.S. Department of Energy
Washington, DC

PROF. DR. HANS J. FOERSTER
Director of Research
Daimler-Benz AG
Federal Republic of Germany

MR. ROBERT G. JACKSON
Fuels Technology Development
Continental Oil Company
Ponca City, OK

DR. TREVOR JONES
Vice President, Engineering
TRW Automotive Worldwide
Cleveland, OH

DR. JAMES M. LAFFERTY
Manager, Power Electronics Laboratory
Corporate Research & Development
General Electric Company
Schenectady, NY

PROF. ROBERT McALEVY III
Mechanical Engineering Department
Stevens Institute of Technology
Hoboken, NJ

DR. KEITH W. McHENRY
Vice President, Research and Development
Amoco Oil Company
Naperville, IL

MR. JOHN N. NOETTL
Consultant
Washington University
St. Louis, MO

MR. RAYMOND PERRY, JR.
Manager, Fuels Research
Technical Service & Engine Test Section
Mobil Research & Development Corporation
Paulsboro, NJ

DR. BENO STERNLICHT
Chairman and Technical Director
Mechanical Technology, Inc.
Latham, NY

PANEL C: STRUCTURES AND MATERIALS

CHAIRPERSON: DR. R. RHOADS STEPHENSON
Associate Administrator for Research & Development
National Highway Traffic Safety Administration
U.S. Department of Transportation

PANEL FOCUS: This panel will discuss basic research directions affecting all aspects of motor vehicle technology other than the powertrain. This will include the basic layout or configuration of a vehicle (the placement and relationship of its components), its structure and crash energy absorption mechanisms, chassis components (wheels, tires, brakes, steering, and so on), occupant crash protection systems, and the materials used to construct the vehicle.

The research areas for this panel will include new applications of known materials, composite materials and other combined material systems, designs for structural rigidity and for crash energy management, biomechanics and occupant restraints, friction and adhesion characteristics of materials, corrosion and fatigue resistance, and the scrappage and recycling potential of vehicle components.

PANELISTS:

MR. NILS BOHLIN
Senior Engineer, Auto Safety
AB Volvo
Gothenburg, Sweden

PROFESSOR SAMUEL K. CLARK
Acting Chairman
Department of Applied Mechanics and Engineering Science
University of Michigan
Ann Arbor, MI

MR. CLARENCE M. DITLOW III
Executive Director
Center for Auto Safety
Washington, DC

DR. DONALD FRIEDMAN
President
Minicars, Inc.
Goleta, CA

DR. WILLIAM HADDON
President
Insurance Institute for Highway Safety
Washington, DC

MR. CHARLES M. HEINEN
Director, Research & Materials Engineering
Engineering Office
Chrysler Corporation
Detroit, MI

MR. HERBERT A. JAHNLE
Manager, Advanced Materials
The Budd Company
Fort Washington, PA

DR. STEPHEN J. MATAS
Director of Research
Republic Steel Corporation
Independence, OH

MR. ROBERT F. McLEAN
Director, Automotive Research
The John Z. DeLorean Corporation
Bloomfield Hills, MI

MR. WILLIAM F. MILLIKEN, JR.
President
Milliken Research Associates, Inc.
Williamsville, NY

MR. DONALD W. PENNINGTON
Laboratory Director, Resins Research
Texas Division Research
The Dow Chemical Company
Freeport, TX

DR. ALLEN S. RUSSELL
Vice President, Science and Technology
Aluminum Company of America
Pittsburgh, PA

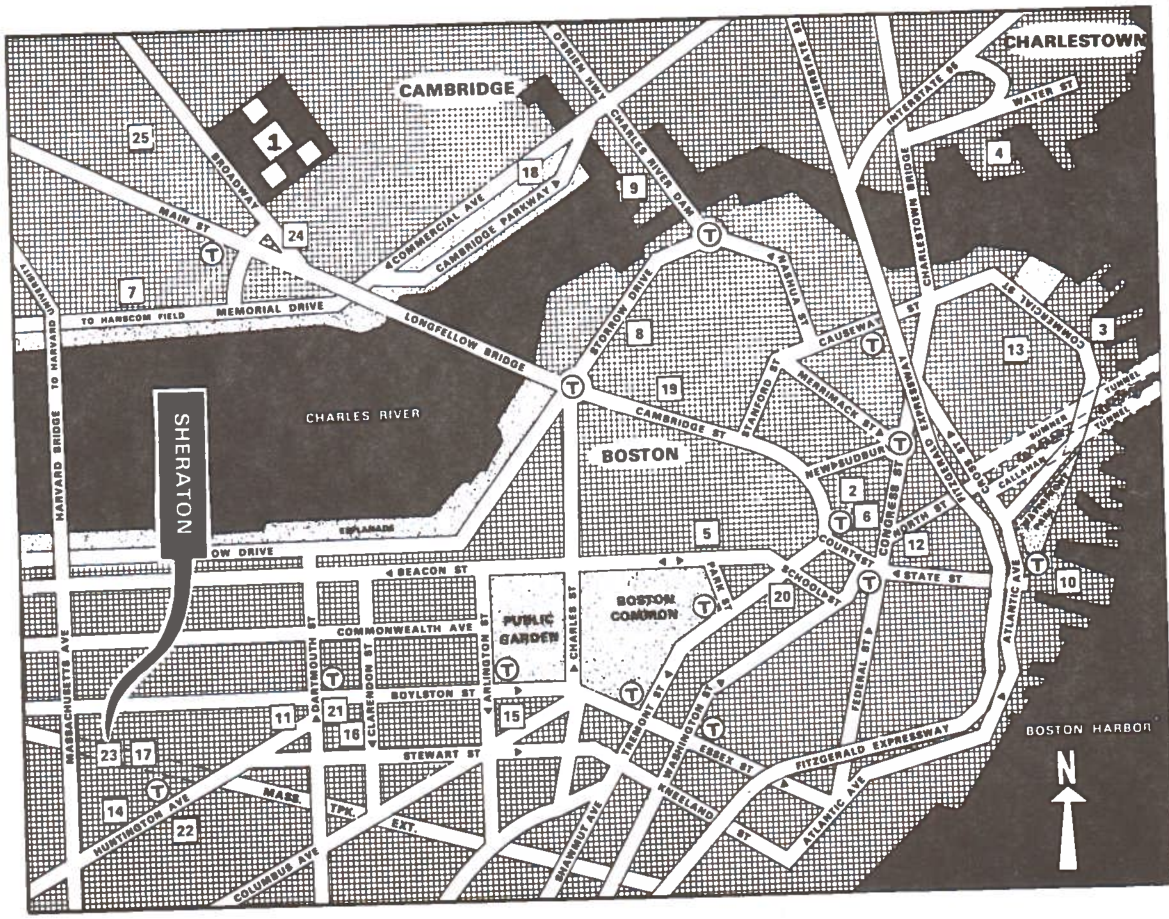
DR. O.C. TRULSON
Director, Carbon Fiber Development
Union Carbide Corporation
Parma, OH

INFORMATION SERVICES

An information desk will be operated each day to receive and post your calls. Incoming calls should be made to (617)236-2000, noting that you are attending the Conference on Basic Research Directions for Advanced Automotive Technology sponsored by the U.S. Department of Transportation.

TRANSPORTATION SERVICES

Assistance in reconfirming or changing your travel arrangements will be provided upon request at the conference information desk. Convenient local transportation is available by taxi or via the Green-Line of the Massachusetts Bay Transportation Authority (MBTA-Prudential Station). Subway maps are available at the conference literature table. In addition, bus service will be provided to Logan International Airport following completion of the Summary Session on Wednesday, 14 February 1979. Bus departure information is available on separate schedule, or can be obtained at the conference information desk.



1 TRANSPORTATION SYSTEMS CENTER
2 J.F.K.BUILDING
3 U.S.C.G.CONSTITUTION WHARF
4 U.S.S.CONSTITUTION
5 MASSACHUSETTS STATE HOUSE
6 CITY HALL
7 MASSACHUSETTS INSTITUTE OF TECHNOLOGY
8 MASSACHUSETTS GENERAL HOSPITAL
9 MUSEUM OF SCIENCE
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11 BOSTON PUBLIC LIBRARY
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15 BOSTON PARK PLAZA
16 HANCOCK TOWER
17 PRUDENTIAL TOWER
18 HOTEL SONESTA
19 HOLIDAY INN
20 PARKER HOUSE HOTEL
21 COPLEY PLAZA HOTEL
22 COLONNADE HOTEL
23 SHERATON-BOSTON
24 KENDALL SQUARE
25 TECHNOLOGY SQUARE
(T) SUBWAY STATIONS

PLENARY SESSION
OPENING REMARKS

WELCOME

DR. JAMES COSTANTINO
Director
Transportation Systems Center
Department of Transportation
Cambridge, MA

WELCOME

DR. JAMES COSTANTINO
Director, Transportation Systems Center

Gentlemen, I guess we are all lucky to be in Boston today because most of the other parts of the country are snowed in. I am Jim Costantino, Director of the Transportation Systems Center, and I want to welcome you to this conference on Basic Research Directions for Advanced Automotive Technology. This two-day meeting, sponsored by the Secretary of Transportation, is designed to obtain views from a variety of knowledgeable people from many fields and institutions on the basic research and priorities that would address automotive transportation needs for the late 1980s and 1990s. The Transportation Systems Center, the Secretary's multi-modal research arm, is under the executive direction of Dr. James Palmer, Administrator, Research and Special Programs Administration. Much of the automotive technology and assessment work at the Center is sponsored by the National Highway Traffic Safety Administration, Joan Claybrook, Administrator. The Federal Interagency Group who brought us together is chaired by Terry Bracy, Assistant Secretary for Governmental Affairs.

This meeting brings together at one location automotive technology researchers and energy specialists in engines, fuels, and power train systems, vehicle structures and materials, from government, industry, public interest groups, academia. A number of the attendees are from the international community and also engineering students from local universities, and we extend a special welcome to you. The topics under discussion today instill a sense of urgency underscored by world events. What we will be dealing with is not merely engine and vehicle research, but the larger questions of continued mobility of the American public, energy conservation, air pollution, and motor vehicle safety. Therefore, it is appropriate that the highest levels of government be here with us today as well as the private sector to carry on this conversation and discussion.

I would like to bring to your attention the automobiles that are on display in the adjoining Constitution Room. There are a six cylinder turbocharged diesel and a four cylinder naturally aspirated diesel, with an oxidation catalyst. Both of these vehicles are being assessed under technical programs at the Transportation Systems Center. The research safety vehicle and the airbag demonstration vehicle are also on exhibit. The research safety vehicle is an integrated test vehicle which utilizes complimentary technological advancements in safety, fuel economy, and emissions. In addition, three cars have been provided by the Department of Energy which are representative of some advanced power propulsion systems.

I am most pleased now to introduce our next speaker, who exemplifies perfectly the trite phrase, "He needs no introduction." Dr. Jerome B. Wiesner is President of the Massachusetts Institute of Technology. Dr. Wiesner has had a most distinguished career in research, academia, and government. In the early 1940s, as a staff member of the M.I.T. Radiation Laboratory, where many scientists of note put in their time during the war years, Dr. Wiesner made significant contributions to the nation's defense in the area of airborne radar warning systems. In 1946, he began his academic career at M.I.T. as a professor of Communications Engineering. Since that time, he has held positions of Dean of Science, and Provost, and in 1971, was elected president of that institution. From 1961 to 1964, he served as President Johnson's and President Kennedy's science advisor. Today, he still serves on numerous Presidential, Congressional, and scientific advisory boards and committees. He is a forceful and articulate spokesman for this nation's research and technological policy directions. Please join me in welcoming the distinguished president of the Massachusetts Institute of Technology, Dr. Jerome B. Wiesner.

INTRODUCTION OF THE SECRETARY OF TRANSPORTATION

DR. JEROME B. WIESNER
President, M.I.T.
Cambridge, MA

INTRODUCTION OF THE SECRETARY OF TRANSPORTATION

DR. JEROME B. WIESNER
President, Massachusetts Institute of Technology

With that introduction, I should make a long speech, I think. I am very pleased to have this opportunity to introduce this country's fifth Secretary of Transportation, Mr. Brock Adams. I did not know Mr. Adams when I was asked to introduce him, but have admired him for a long time. So I gladly accepted this opportunity to introduce him to you and to me; and we have had a very pleasant opportunity to talk this morning.

Mr. Adams was chosen by President Carter for his position following a distinguished sixth term in Congress for the state of Washington's seventh district. In his 12 years in Congress, he became an outstanding leader and expert on transportation and budget issues. He guided through Congress, as chairman of the House Budget Committee, the first budget resolution which set national spending priorities, expenditure ceilings, tax revenues, and debt levels. Though I doubt that he would like to be called the father of Proposition 13, he played the major role in Interstate and Foreign Commerce Committee in developing and having signed into law legislation that had a significant impact on this nation's transportation system, namely, the Airport Airways Development Act, the Rail Passenger Service Act, and the Regional Rail Reorganization Act. Thus, Brock Adams came to DOT two years ago with a formidable knowledge of our transportation programs and needs.

In trying to set our transportation policy, he has given equal consideration to energy conservation, environmental protection, safety, improved surface transportation systems, and fiscal responsibilities--a mighty formidable juggling act for any human being to undertake. He has also pledged to create an economic environment for the industry that will enable all modes of transportation to compete freely and equitably in the marketplace. And if he pulls that one off, we will really admire him. Anyone who travels as much as I do by air, can say without equivocation that under Brock Adams' leadership, the Department of Transportation has made considerable progress in the last case--that is, attempting to deregulate. He has secured passage of the historic Airlines Regulatory Reform Act, which deregulated air industry, and has provided the public with lower cost air travel and some of us with crowded airports. He has also successfully pushed through Congress the Surface Transportation Assistance Act, which for the first time combines the nation's highway and public transit programs and allows DOT to place surface transportation funding where it is most needed. I only wish he had that money to put where it was most needed.

He had the courage to resolve several controversial and long-pending issues when he took over--the automobile passive restraints issue, the Concorde landing rights, the safety standards for oil tankers, and many others. I am not certain that everyone in this room would be in agreement on anyone of these issues, but it seems to me that it was a matter of importance that these issues be resolved one way or another; and where we have mistakes, the nation can correct them. I have always believed that the worst crime that people can commit are crimes of omission, crimes for which they are never punished and, therefore, crimes that they frequently commit. So I would like to commend the Secretary on his forceful actions in dealing with these problems.

With all of these accomplishments in aviation, rail, public transit, and freight transportation, perhaps the most valuable of his attempts is Brock Adams' efforts to stimulate motor vehicle energy conservation, fuel efficiency, safety, and exhaust emission control. Nothing less than our continued personal mobility and the continued growth of our nation actually, possibly it is survival as a free nation, may be at stake in these issues of automobiles and energy. He is pushing the energy issue, he is pushing the industry, he is pushing all of us for more automotive research, which will lessen fuel consumption, lessen U.S. dependence on foreign oil, reduce federal deficits, and slow inflation.

From comments I have heard from many of you, I know that the steps taken in the past two years relating to oil consumption and improved safety while trying to maintain passenger comfort and acceptance, are issues of some controversy, and I suspect they will continue to be. But I can tell you where we stand now represents extraordinary progress from the days when I was the science advisor. I can give you two examples. I was invited by the Association of Automobile Engineers to talk about research, and I said I had not seen very much research in automobile laboratories. And I got--there were two letters as a result of these--one to the President saying I had come out there and insulted the industry, and a second from a very good friend of mine who was director of research at one of the companies, who said, "You must have missed the very exciting work we're doing in our laboratory." And I wrote back saying, "I guess I did; what was it?" And he sent me a paper on magneto hydrodynamics. And I did not then or now understand how that applied to making better automobiles.

In any event, I also, while I was science advisor, tried to get, I think it was HEW that was beginning to insist that the industry put pollution control devices on automobiles, and they were setting a time scale. And I tried to find out what the time scale was related to, what scientific knowledge or developments. And they said, "Oh, we haven't any." And what is more, when I pushed them, they said, "We're not going to have a program to do research. We have a different philosophy." And I said, "What is it?" And they said, "It's a hammer and anvil philosophy. We have a big anvil with the automobile industry put on it, and we slug them with a hammer and they'll meet those standards." Well, it is very clear that that is not a way to encourage development.

As we look at the automobile industry today, we see that their research laboratories are very strong and very effective compared to the laboratories that I saw 16 or 18 years ago. It is also very clear, speaking of the work of DOT, that they recognize that it is important to have information and knowledge as part of your regulatory process. And I am very pleased that we are, in fact, making progress. I always think that 15 years for great social change is not very long, and while a lot of people despair of where we stand, I think the country has made very great strides.

Mr. Adams is very concerned that the present governmental regulations for fuel standards and safety and exhaust emissions for new car fleets will not have adequate impact on total oil consumption as the number of vehicles and miles traveled also increase. Therefore, he believes that a quantum jump forward in the auto technology and a vastly increased amount of automotive research is required to keep pace with our growing transportation needs and to come up with a truly superior motor vehicle. He has also said that whatever research is ultimately implemented, will require the full participation and dedication of the private industry. In my view, it requires more than that. I know that he appreciates--but I want to remind him that one cannot schedule genius--that technological breakthroughs are very difficult to find and particularly in the traditional places, when you look for them. But by means of this conference, Secretary Adams is seeking your advice and guidance on what research directions this nation should take to meet our growing automotive transportation needs which are threatened now by foreign, political, and economic instabilities.

I have said before that I believe that this nation is in danger of losing its scientific and technological leadership and certain ideas. I know that at least some of you will agree. There has been a noticeable shift away from long-term basic research to short-term applied research and away from risk-taking research to safe and predictable research. Given his views, I do not need to say to the Secretary that there is a conflict between creativity and regulation, between limiting of markets and profits, that inflation, taxes, and regulations lead to short-term research. He is aware of these things and he is aware of the reasons why some of these things are also required. Your views on research directions for engines, fuels, power trains, and structural materials are vital to this nation's effort to cope with an impending dangerous period of time when limitations of oil supply and exorbitant costs of oil are real possibilities. Though I must say I do not believe they are necessary scenarios. I said before that I believe that if we were foresighted and took adequate steps and preparation with regard to synthetic fuels as well as the conservation policies that are being advocated, there need not arise a shortage of liquid fuels for this country.

I commend Mr. Adams for convening this meeting on research directions for advanced auto technology, and for bringing together research executives from all major U.S. and foreign auto manufacturing and oil companies, from steel, aluminum, electronic firms, from national consumer and environmental organizations, members of Congress and congressional staffs, the White House Council of Economic Advisers, the Department of Energy, the Environmental Protection Agency, and of course, the Department of Transportation. I know that he will get plenty of advice from you ladies and gentlemen. I only wish he were in a position to implement it all because I suspect he would. Thank you. And I would now like to introduce the Secretary.

OPENING REMARKS

HON. BROCK ADAMS
Secretary of Transportation
Department of Transportation
Washington, DC

OPENING REMARKS

HONORABLE BROCK ADAMS
Secretary of Transportation

Thank you Dr. Wiesner. I particularly appreciate Dr. Wiesner being here this morning because he not only has had great experience in this, but he also has indicated, just by his presence, the difficulty we all face this morning. That difficulty is that I also entered the government at the time of President Kennedy. And Dr. Wiesner has created one of the great social dilemmas of our generation which was, he pursuaded President Kennedy that we should go to the moon. Even since then, we have always heard that if we can send a man to the moon why can't we do this, or do that.

That is what we are all about, today, and it is one of the thousands of things in this society about which I am deeply concerned--that we do not have anymore, "Why Can't We?"

Now when you talk about nuclear reactors, perhaps a hundred people are intimately involved in that subject. But when you talk about the automobile, you begin to talk about something that everybody has in their garage--or maybe two, or maybe three, or maybe four, and in some cases, depending upon the number of children, five or six. And it is overwhelming our society, and we must deal with it.

Now, I am not going to invite a comparison of going to the moon. But as I look out this morning on that sea of cynical faces, which I anticipated, maybe I ought to say that we are not asking for the moon. We are trying to get a safe, clean fuel-efficient car within the means of the consumer.

In fact, we have had such a car in America. It was a four-passenger, five-speed model, weighed about two thousand pounds, cost about $2500, had a one-year guarantee, was electric-powered, non-polluting, used no gasoline, and went 95 miles between battery charges. It even had a great name. I introduce you to the Broc car. There it is--1912. My, what a long way we have come since then.

The Broc, I have learned, was only on the market for five years--1909 to 1914. It could not compete with the gasoline-powered vehicle, but I brought it this morning, not just because of my name, which I enjoyed, but because I thought we should have some comparisons.

In 1979, we have about arrived at the mileage capacity, through five years of government regulation, of the Model A. Another way of putting it is that the downsized car we are now asking everybody to produce, and is coming off the line, has about the mileage, weight, and carrying capacity of the 1956 Chevy. Simply to put it in context, we are not asking Dr. Wiesner this morning to go to the moon, but we sure as hell would like to go to Boston in it and not use quite as much oil.

I have also come to this conclusion: In over 15 years of dealing with transportation problems in the United States, the American people will give up almost anything before their automobile--wives, children, food, houses--just about anything you might think of.

That is why we are here this morning. It is because we found last year that families spend more on their personal mobility, the automobile, than they do on food. The farmers and others have tried very hard in the last few weeks to reverse that trend, but it is still there. And I, therefore, as Secretary of Transportation, cannot avoid the problem. I cannot avoid the fact that people are going to do this.

When I asked Detroit to re-invent the car, I was not trying to dictate, and I was not trying to invoke a miricle, as the Detroit paper indicated the next morning as I stood in their caricature with a spark plug in one hand, and a tire over one shoulder, and a pair of rather bedraggled wings. The title across the top was "Annunciation" and underneath was a little statement, "Don't just stand there, invent something."

I am trying to say that I am not devoid of my senses, but that I am in this position. We have over a hundred million cars (and more coming in various stages of repair and disrepair) throughout the United States.

I am asking for a new commitment from the manufacturers. I am asking for some innovation. As Dr. Wiesner so well put it, "Some innovation, not imitation." And I want a little revolutionary and evolutionary thinking. I want automobile makers of all kinds to reach beyond their grasp. I want them to go to technologies that they do not know about. I want them to think about things they are not doing now.

Let us put our objectives in front of us. I want to state as briefly as I can why we are all gathered here and what it is we are trying to produce; where I fit into it; where you fit into it; where the American people fit into it.

We have to have an energy-stretching, life-saving and people-pleasing car. We want to preserve competition and we want to keep prices within a range consumers can afford. We are not going to solve all these problems at this meeting, or maybe even at our conference in April or maybe within the next ten years. But time is running out for us.

So, I propose a national motor vehicle policy that I can take to the President next year. And it is not a policy to impress something on industry, but one that respects our joint objectives. Our purpose today is to lay a foundation for this kind of program so that it is not done in a small room in Washington or with someone vanishing into a corner and coming forth with something dumb.

What it is is to take, in the period after 1985 (because we are frozen in position up to that time), to expand our basic knowledge, and generate some new ideas. So you understand these things. Let me add that it is not new and startling and I am not crazy. I will quote from Henery Ford, II, 15 years ago, not five, not ten, --- 15 years ago):

> ... when you think of the enormous progress of science for the last two generations, it's astonishing there is very little about basic automotive principles today that would seem strange to the pioneers of our industry. What we need more than a refinement of old ideas is the ability to develop new ideas and put them to work.

That is why we are here. We are here to generate ideas; to stimulate thinking; to assess where we are so we can say this is where we are going.

We must know what is possible. I have a stack of letters (about that high) in my office now (weighs about 200 lbs.) from people who have proposed a number of solutions to the automobile problem which our scientific people say violate all the principles of physics and are, therefore, perpetual motion machines. But we have not ignored any of them. We are going through them. We need from you the possible. Second, we need to know what is reasonable so we can avoid the unreasonable. And, third, we must know what has been tried so we can focus on the untried.

While I believe in being practical, I hope there is enough scientific curiosity that will come from this conference to inspire a few exerciese in imagination--just a few. I am not asking for a lot, just a few. I kind of am in a position of the people in this room, who are my age, who grew up with the science fiction writers and found that they predicted a great many things more accurately than our scientists of that time.

And to those of you who are here who are more the dollar and cents people, I have a little message also. I will again go to the automobile industry, to the late Charles Kettering, on comments of what do we do about tomorrow. We remember him for the self-starter and a multititude of other inventions. Twenty-seven years ago he said to a Detroit audience, "Research is good insurance for an auto company." He said also, "We have to be thinking five, 10, 15 or 20 years from where we are now or we won't have anything new." The money General Motors spends for research, he explained, "is an insurance premium--insuring against surprise."

Ladies and gentlemen, I can assure that if this is not done, you will see some surprises. You will see some production models coming into this country with new types of body materials; new types of engines; and new types of fuel sources that will mean that American industry will have to scramble to catch up.

So our job is threefold: 1) To work out a motor vehicle development policy that the public and private sector can pursue together which is based upon what I call (for lack of better words) a socially-responsible automobile; 2) To consider what is being done now, and can be done, for application after 1985.

We started this once before in the Jet Propulsion Laboratory. It ran for a couple of years. It really determined that out of six possible engines, we could discard the steam engine. Then the oil embargo stopped and everybody went away and forgot it. So much has been done. We are aware of it. We want to come back to that. Some of the panelists who are here this morning were involved in that. And, I hope they will say, why did we stop five years ago?

Three, we have to look beyond the 1980s and into the 1990s to see where technologies will take us. The distinguished panel members this morning will focus on basic research in three areas. First, engines; second, fuel and power train systems; and third, vehicle structures and materials.

Since each of these systems offers a number of technological choices, the prospects for further, more clearly defined basic research projects are encouraged.

Once you can tell us what the avenues are, then we can begin to allocate our national resources. This comes not simply from an idea that somebody had someplace, but from things such as highway deaths now averaging up to 50,000 a year. With experimental cars such as you can see here, we can reduce that.

The economic cost of that many deaths, that many accidents, to this country is staggering.

It has been nearly 40 years since the first smog cloud began over Los Angeles, and despite efforts to control emissions, the motor vehicle still is polluting the air. The car of the future cannot wear the badge of social acceptance unless it passes the clean air test.

Now, with what has happened in the last month as the most compelling motive, there is the quest for a better car that would be able to run on what we can obtain, and obtain at a reasonable price so that our people have mobility. Because the stark fact is that we are running out of the ability to control the quantity and price of the basic fuel on which our transportation system moves.

No matter how you measure it, and how many years you want to spend, oil is finite. We are now using a 100 billion gallons a year in our 145 million cars and trucks and despite all of our efforts, consumption is increasing, not leveling off, not decreasing, even with meeting 27.5 miles per gallon in 1985. And if we cannot better that 27.5 mpg after 1985, our consumption level will go on almost an absolute upward curve or there will be a limitation of mobility of the American people.

I just do not believe that the automobile industry, the academic people in the United States, those in government are going to be baffled, intimidated, or frustrated by that kind of challenge. I cannot believe that we will gamble our mobility on the shaky assumption that we will always be able to find and buy fuel someplace and somehow in the quantities that we have been accustomed to using. I will not believe that with a coordinated national program, we cannot build a new foundation in auto technologies, one that assures a continuing ability of the industry to produce cars and our freedom to drive them.

When the Civil War was imminent, Lincoln sent a terse telegram to one of his military commanders which said, "The necessity to be prepared increases. Look to it!"

What I suggest is that with the price of gasoline increasing and contingency plans for dealing with scarcity being formulated, the energy shortage is a near-term as well as long-range possibility. The importance of our purpose here grows more urgent, and as Lincoln said, I'm asking you, "Look to it."

Thank you.

INTRODUCTION OF THE CONFERENCE CHAIRMAN

DR. JAMES COSTANTINO
Director
Transportation Systems Center
Department of Transportation
Cambridge, MA

INTRODUCTION OF CONFERENCE CHAIRMAN

DR. JAMES COSTANTINO
Director, Transportation Systems Center

The Conference Chairman for the next two days is Dr. Raymond L. Bisplinghoff. Dr. Bisplinghoff is an aeronautical engineer and a physicist, and I am sure that many of us in this room have labored over his textbooks. He received his doctorate from the Swiss Federal Institute of Technology in Zurich. He has held top level engineering, scientific, and managerial positions in industry, academia and government. In the early years of the space program, he was with the National Aeronatuics and Space Administration as Associate Administrator for Advanced Research and Technology. He returned to academia as head of the Aeronautics and Astronautics Department of the Massachusetts Institute of Technology and later served as Dean of the School of Engineering of that institution.

In the early 1970s, he served as Deputy Director of the National Science Foundation, and after that he became chancellor of the University of Missouri at Rolla. Two years ago he joined Tyco Laboratories as Vice President for Research and Development and also as a member of the board of directors of that firm. He has held numerous government and industry-wide advisory positions. He is a fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science. He is the Chairman of the National Research Council Committee on Transportation. Let us welcome our chairman for the next two days, Dr. Raymond L. Bisplinghoff.

REMARKS ON SCOPE OF CONFERENCE

DR. RAYMOND L. BISPLINGHOFF
Chairman
National Research Council
Committee on Transportation
Washington, DC

REMARKS ON SCOPE OF CONFERENCE

DR. RAYMOND L. BISPLINGHOFF
Chairman, National Research Council
Committee on Transportation

Thank you very much, Jim, Secretary Adams, Dr. Wiesner. Now we are approaching the time when we must go to work. Secretary Adams has described to you the job that we have to do over the next two days, and it is up to us to try to carry out his instructions and ideas. I am delighted to be asked to serve as chairman of this conference and to work again with Secretary Adams and with the Transportation Systems Center in Cambridge. Our association through the Academies of Science and Engineering and the National Research Council, and the Department of Transportation has been a long one and has provided, I think, over the years an added dimension to the nation's transportation research. As chairman of the Committee on Transportation for the National Academy of Engineering, I know well the contributions that have been made by DOT and by the Center here in Cambridge.

We have just heard Secretary Adams call for a major program to develop a new generation of automotive technology to meet the conditions which we all foresee in the 1990s and beyond. The automobile is at the center of our lives. Ninety percent of our domestic travel is by automobile. In order to preserve the mobility of the American public, we need to determine the research needs and priorities in order to contribute more quickly to the continued development of what the Secretary has called an energy-stretching, life-saving, people-pleasing car. As he has noted, the purpose of this conference is to obtain the views on basic research directions. And I emphasize that. Basic research directions, not the design of an automobile, but what we must begin to do now in basic research to provide the knowledge that we believe will be needed in the 1990s.

We are here to identify scientific and technological opportunities and areas of missing knowledge to focus on research paths to significantly improve automotive products. The Secretary has asked me to help him work with you and listen to you, the representatives of the automotive and energy research communities, as you identify what research should be planned now as insurance for the future. The questions we ask are, where are we now, where can we hope to be by the year 2000, what are alternative technological paths to get there, what are the scientific and technological barriers along the way, and what research must be initiated now to overcome these barriers. And we have only two days to do all of this: to assess the current research and development programs in progress in the automobile industry, Federal Government and universities, and in independent research institutions. We hope to do this in a constructive and stimulating way. Research directions are to be identified on the basis of these generally accepted findings: (1) the automobile will remain as the major means of personal transportation and will have to provide similar capabilities in the future as today's motor vehicles; (2) petroleum-based fuels will be in increasingly short supply and increasingly expensive; and (3) the motor vehicle population will continue to increase with resulting impacts on environmental quality and highway safety.

It seems to me that these predicted conditions imply several characteristics for the post 1985 vehicle. First, motor vehicle fuel economy will have to be much better than at present and motor vehicles may have to have the capability of operating on blends of petroleum and synthetic fuels or even on nonpetroleum derived fuels. Secondly, increase in motor vehicle population will require continuing and even increased concern with the motor vehicle safety and the control of currently regulated and unregulated exhaust emissions. And thirdly, preservation of the nation's current level of national mobility requires that motor vehicle ownership and operating cost remain relatively constant with respect to personal income. With this perspective, we have designed the conference in terms of three panels, and Secretary Adams has already mentioned these to you. The first is engines, the second fuels and power train systems, and thirdly, vehicle structures and materials.

I would like to spend, now, just a few moments discussing very briefly the conference scope for each of these three panel discussions. Your panel chairman will elaborate more on this later. Additional details concerning the scope, the particular research goals, and current research directions in these areas have been provided you in the discussion paper entitled, Basic Research Directions for Advanced Automotive Technology. This discussion paper was sent to most of you earlier; if you do not have it, you can find it at the registration desk. I suggest that if you have not read this very illuminating paper, you might want to pick it up at the registration desk.

Panel A on engines will be chaired by Dr. Richard Briceland. Dick is here on the platform. Dick is an environmental scientist, Office of Policy Analysis of the Environmental Protection Agency. Panel A on engines will consider basic research needs and priorities for heat engines. The scope of the discussion will include any engine that employs combustible fuels to generate mechanical energy through a thermodynamic cycle and that is suitable for use in an automobile or light truck. Research areas to be addressed in Panel A are the nature of the thermodynamic cycle, combustion processes, emissions, and related factors, engine configurations, engine materials, and associated manufacturing processes, diagnostic and control systems, and any similar areas of research that could have direct implications for the performance of heat engines.

Panel B, on fuels and power train systems, will be chaired by Dr. Maxine Savitz, Deputy Assistant Secretary for Conservation and Solar Applications in the Department of Energy. Maxine is not here on the podium, but I understand that she is in the audience having just arrived from Washington. So Maxine will be with you as your chairman in Panel B. The most efficient and least environmentally degrading use of available energy resources is the function of the relationship between energy source, refined fuel, and the power train. Many research questions, therefore, arise regarding how the source and refining of fuels, or generation of electricity, help determine the most desirable technology for the vehicle power train. Other research questions for the panel will be concerned with onboard energy storage of fuel or electricity, mechanical and electrical energy conversion, transmissions and motors, regenerative systems, and power train technology.

And finally, Panel C, on vehicle structures and materials, will be chaired by Dr. Rhoads Stephenson, Associate Administrator for Research and Development of the National Highway Traffic Safety Administration. Rhoads also just arrived from Washington. I understand he is in the audience here, but not in front of you. So Rhoads will be the chairman of Panel C. Panel C is designed to discuss basic research directions affecting all aspects of motor vehicle technology other than the power train. This will include the basic layout or configuration of the vehicle, the placement and relationship of its components, its structure and crash energy absorption mechanisms, chassis components, wheels, tires, brakes, steering, occupant crash protection systems, and weight reduction potential. Research areas for this panel will include also new applications of known materials, composite materials, and other combined material systems, designs for structural rigidity, and for crash energy management as well as biomechanics and occupant restraints.

We have a format that we would like to use in running the panels. It consists first of an opening statement by the panel chairman to set the tone and scope of the session, which will be followed by brief remarks by each panel member. These panelist remarks have been prepared in reference to the discussion paper that I mentioned previously that was received by all participants prior to the convening of the meeting. As the agenda indicates, these prepared comments will take us through this morning. After lunch today, our panels will reconvene, and the remainder of the prepared panelist statements will be presented. Following the presentations from the panelists, there will be an opportunity for audience participation. I would like to emphasize that this will provide an opportunity for each of you to make a contribution to this meeting. We do suggest that complex questions from the audience be submitted in writing to the chairman during the sessions. I would like to encourage all of you to participate. Make your comments and contribute to the discussion in the panel, because only in this way will all the varied viewpoints of the universities, government, industry, public interest groups, consumers, labor, and all other interested parties be heard. Finally, I would like to mention that following today's activities, we will have a reception in this room, the Grand Ballroom, at 5:30 p.m. This evening, there will be no formal conference activities. That is to say, we do not plan to have any extensions of the panel meetings. However, I have been told that elves will be working through the night to prepare, under the general guidance of each chairman, a review of the panel's activities during the day. This review will summarize comments by all conference participants. A preliminary summary of today's activities will be submitted by the chairman for discussion among the panelists and conference participants on Wednesday morning. Finally, Wednesday afternoon at 2:30, we will hold a plenary session at which the panel chairman will present their respective panel summaries. And I, as your conference chairman, will, at the conclusion of that session, summarize the results of the two-day meeting. I plan later to submit the conference proceedings to Secretary Adams, and he has informed me that he will make them available to the public at that time. I would like also to mention that in order to facilitate the preparation of conference proceedings, all panel and plenary sessions will be recorded. Ladies and gentlemen, that is the plan that we hope to follow. I am very pleased that so many of you have come to take part in this important activity and I wish you the very best.

PANEL REPORTS

PANEL A: ENGINES

Panel Report

HEAT ENGINE RESEARCH NEEDS FOR IMPROVED AUTOMOTIVE FUEL ECONOMY

A report by the Engines Panel of the Conference on Basic Research Directions for Advanced Automotive Technology.

PANEL A: ENGINES

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PANEL FOCUS: This panel will discuss basic research needs for heat engines. The scope of discussion will include any engine that utilizes combustible fuels to generate mechanical energy through a thermodynamic cycle, and that is suitable for the use in an automobile or light truck. Research areas will include: the nature of the thermodynamic cycle; combustion processes, emissions and related factors; engine configurations; engine materials and associated manufacturing processes; diagnostic and control systems; and any other areas of research that could have direct implications for the performance of a heat engine.

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CONTENTS

1. INTRODUCTION

The objective of the Engines Panel discussion was to identify research activities which need to be conducted to support commercialization of heat engine technology for automobiles in the 1985-2000 time period. Discussions were focused on specific technology areas which reasonably might be expected to contribute to major fuel savings in the post-1985 period.

The Panel has identified two categories of engines as a basis for formulating its research recommendations:

- <u>In-use Engines</u>. Three types of in-use engines are discussed: (1) the conventional spark ignition engine used in most of our cars today; (2) the diesel engine which now is available in some autos; and (3) the prechamber stratified charge engine available from Honda.
- <u>Alternate Concept Engines</u>. Various proposed engine concepts not currently in production are included in this category; for example: direct injection stratified charge; gas turbine; Stirling; and combined cycle engines.

The research programs recommended for these two engine categories are discussed in Sections II and III. In reviewing these recommendations, it is important to recognize that the objectives of these research activities are different for the two cases: research for the <u>in-use engines</u> is directed primarily toward refinement and incremental system improvements; research for the <u>alternate concept engines</u> is designed to provide a firm basis for assessing the technological and economic feasibility of alternate powerplant systems for automobile applications.

It is anticipated that the automobile fleet for the 1985-2000 time period of interest will include a vehicle mix comprised of six passenger cars, others with 3-5 passenger capability, and a final group suitable for 1-2 individuals. The Panel recognizes that a range of engine systems representing various fuel economy and performance characteristics will be required for such vehicles. However, based upon information presented, the Panel was not able to identify a specific heat engine technology which could be classified as superior for future light duty applications, e.g., superior with respect to fuel efficiency, exhaust emissions, and acceptability for meeting a range of public needs.

The Panel did not attempt to assess in detail the balance and priority of ongoing heat engine research work. However, it was concluded that research emphasis currently given to in-use engines does not adequately reflect the importance of these systems.

The information available to the Panel did not permit projections of the ultimate fuel economy potential of possible engines and thermodynamic cycles. However, it is clear that improvements in fuel efficiency can be achieved for the in-use category of engines, even for mature and widely used engine systems, and that these improvements can provide very large fuel conservation benefits to the nation.

Although questions of fuels and fuel technology were not within the scope of the Engine Panel's discussion, the Panel nevertheless wishes to emphasize that it is difficult to treat the research needs of engines and fuels separately. The Panel recognizes that conventional in-use spark ignition and compression ignition engines are significantly more sensitive to fuel type and fuel quality than are certain alternate concept engines which have been proposed for future automobile applications. The Panel understands that the future availability and cost of automobile fuels may be related directly to fuel quality; therefore, the Panel believes it is important to improve the fuel tolerance characteristics of automotive heat engines and to work toward multifuel capabilities, including the capability to utilize synthetic fuels.

Finally the Panel recognizes the importance of conducting health effects research on engine emissions for a range of powerplant concepts. However, the Panel membership did not include technical expertise which would permit it to identify and prioritize specific health effects research needs. The Panel suggests this is an area which warrants careful attention.

2. RESEARCH NEEDS FOR IN-USE ENGINES

A. HOMOGENEOUS CHARGE SPARK IGNITION ENGINES

The homogeneous charge spark-ignition engine is presently the dominant automotive powerplant. In this system, a volatile hydrocarbon fuel (gasoline) is mixed with air, ignited via a spark plug, and burns in the combustion chamber at nearly constant volume.

This engine has been very successful up to this point in time and provides the moving baseline for comparison of all future automotive powerplants. There remains, however, a need to expand our knowledge of internal engine processes and to increase fuel utilization efficiency by improving engine performance. Recommended areas for research effort are:

- Friction research--research in the area of combustion chamber seals should be emphasized. The piston ring-cylinder interface is the most important example. Emphasis should be on component design and the lubricant system.

- Throttling loss--methods to reduce loss on intake and exhaust strokes should be explored.

- Accessory losses--reductions in the losses caused by the cooling fan, the alternator, the power steering pump, the water pump, the air conditioning compressor and other parasitic losses should be the subject of research emphasis.

- Combustion/fuels--in addition to basic combustion research, research targeted toward improved octane tolerance and/or increased compression ratio, reductions in octane requirement increase (ORI), and reductions in cyclic variation in combustion should be emphasized.

- Transient effects--thermal and speed/load transient engine performance is an important research area. Examples of areas that should receive emphasis are friction reduction and air/fuel mixture preparation during cold start/warmup modes, catalysts that have good light-off characteristics and high conversion efficiency at low operating temperatures, and fuel economy/emission interrelationships.

- Effective displacement extension--varying the effective displacement (power output) of the engine through turbocharging or other means (e.g., variable valve timing) to achieve increased power only when needed is an area for research emphasis.

- Dilute combustion--combustion research should be conducted with emphasis on HC and NO_x control, thermal efficiency and engine power.

- Alternative geometries--engine configurations that offer potential for improved power density (and therefore lower engine weight and/or volume which translates into reduced vehicle weight and improved vehicle fuel economy) should be emphasized. The rotary or Wankel engine is one example.

- Critical materials--research directed toward reducing the amount of critical, strategic, costly, or foreign source dependent materials in future vehicles should be emphasized. Nickel and precious metals (Pt, Rh) are examples.

B. PRECHAMBER STRATIFIED CHARGE SPARK IGNITION ENGINES (e.g., HONDA CVCC)

Research areas for this engine are very similar to those for the homogeneous charge engine. Some limitations in the options available to other spark ignition engines may be present because in current configurations the exhaust gas is oxygen rich, precluding catalytic aftertreatment for NO_x control.

C. COMPRESSION IGNITION OR DIESEL ENGINES

The diesel engine is highly developed in its present form, is presently the premier low fuel consumption engine in mobile applications, and is receiving increasing attention as an automobile powerplant. The current prechamber diesel designs used by VW, GM, Daimler-Benz, Peugeot and others for light duty applications exhibit excellent fuel economy in comparison to gasoline engines (20-25 percent improvement) but are thermally less efficient than open chamber diesels used in commerical vehicle applications. The ultimate fuel economy potential of light duty diesels is high and may approach the best of all competitive heat engine designs. Of course, the fact that reasonably special fuels (susceptible to ready autoignition) are required may be an important factor affecting widespread use of diesel autos.

The ultimate automobile diesel may incorporate an open combustion chamber rather than the divided combustion chamber designs used currently, be insulated to reduce the energy now rejected to the cooling media, and be turbocharged possibly with turbocompounding to take advantage of exhaust energy content. This engine would have an attractive size and a good power/weight ratio.

The most fundamental problem the diesel engine faces is not how to improve even further its already good fuel economy, but rather how to reduce its NO_x and particulate emissions. Therefore, the major research thrust must be directed toward gaining a better understanding of these two factors and their impacts. Research areas include:

- Fuel injection dynamics and spray formation
- Spray combustion and interaction with fluid mechanics
- Fuel modification
- Particulate and NO_x formation
- Particulate clean-up in the combustion chamber and exhaust system.

Beyond emissions, additional research to improve thermal efficiency is warranted; some of the above research areas are pertinent in this regard. Additional areas are:

- Open chamber design with good speed range and NO_x performance
- Friction--component design and lubricant systems research
- Improved fuel tolerance
- Turbocharging
- Reduced heat losses--approach adiabatic concept; requires significant high temperature materials and lubricants improvements
- Turbocharging with turbocompounding--this area represents combined cycle work.

3. RESEARCH NEEDS FOR ALTERNATE CONCEPT ENGINES

Four alternate concept engines are discussed briefly ... direct injection stratified charge; Stirling; gas turbine; and combined cycles. Candidate research areas are identified for each of these four concepts. These research activities represent efforts which the Panel feels would need to be carried out to fully evaluate the potential of one or more of these engines. In discussing these four specific types of engines, the Panel in no way is suggesting that these particular systems warrant higher research priority than other alternate concept engines; nor is the Panel endorsing either the scope or the distribution of research effort currently associated with ongoing research programs on one or more of these four types of engines. Questions relating explicitly to establishing research priorities as a basis for allocating research resources were not considered by the Panel. These matters more properly should be considered carefully as part of the process of structuring and organizing the overall research activity.*

A. OPEN CHAMBER OR DIRECT INJECTION STRATIFIED CHARGE (DISC) ENGINE

The DISC engine, while not an "in-use" engine, typically is derived from a gasoline-fueled homogeneous charge engine. Both reciprocating and rotary configurations are being explored. There are substantial variations between different designs and each has its own special advantages and problems. These engines theoretically have higher fuel economy potential than the homogeneous charge spark ignition engine and could benefit from some of the same research tasks. However, at the present time, the more pertinent questions relate to whether the DISC engine can be manufactured cost-effectively and operated with acceptable emission levels, performance and fuel economy.

Research areas include:

- Basic research in the total combustion process is essential including work on fluid mechanics, combustible mixture formation and ignition characteristics
- Emission formation - HC, NO_x particulate formation mechanisms
- Engine and emission control.

*The reader is referred to item "C" (Criteria for Engine Concept Screening) and item "D" (Current Government Sponsored Automobile Engine Research) in the Addendum Comments section at the end of this report.

B. STIRLING ENGINE

This engine is an external combustion engine that uses a low molecular weight gas as the working fluid (typically hydrogen or helium) and is the thermodynamic engine concept that theoretically has the potential to most closely approach ideal (Carnot) cycle efficiencies if major technological breakthroughs can be achieved. Although extensive research effort has been directed toward the Stirling engine, this system today has not yet demonstrated a potential to compete with in-use automotive powerplants.

Major research areas include:

- Improved seals for high pressure hydrogen
- Materials with acceptable high temperature properties and low cost; ceramics should be highlighted, with the heater head as the single most important area
- Reduced parasitic losses of auxiliaries and accessories; such components may have to be tailored specifically for the Stirling engine in automobile applications.

Other research areas include:

- Problems of hydrogen embrittlement and permeability
- Control systems, especially those that control power output
- Combustors with acceptable emission characteristics
- Improved packaging and power density characteristics
- Developing a better understanding of heat transfer processes in two areas: (a) heat transfer to the working fluids; and (b) waste heat rejection
- Reduced flow losses.

C. GAS TURBINE ENGINE

The gas turbine engine is an internal combustion engine that employs continuous combustion and turbomachinery for compression and expansion of the working fluid. Gas turbines may have long range potential for selected motor vehicle applications; however, the Panel generally concluded that if future motor vehicle uses for gas turbines were to develop, they most likely would be in the heavy duty truck and intercity bus sectors considerably earlier than in the passenger automobile sector.

Major research areas include:

- o The aerodynamics of small turbomachinery suitable for passenger cars with power requirements less than 100 hp
- o Development of high temperature, low cost materials for the critical "hot parts" of the engine; ceramic materials should be emphasized.
- o Manufacturing technology needed to produce all parts of the engine, especially the small ceramic turbomachinery described above.

Other research areas include:

- o Improved metallurgy and materials with low cycle fatigue
- o High speed bearings
- o Improved regenerator efficiencies.

D. COMBINED CYCLES

This category, also called compound engines, includes powerplants that operate on two or more types of thermodynamic cycles. A large number of combined cycle concepts could be investigated, but the Panel did not deal with any specific types in great detail. There was limited discussion of a combined cycle approach that essentially utilizes a combination of a turbocharged insulated diesel engine and gas turbine engine, sometimes called the adiabatic turbocompound diesel engine. Although this approach thermodynamically is considered to be one of the more attractive of the combined cycles, no specific research needs are delineated, since the research needs specified elsewhere in this paper are applicable to this concept. The Panel did not address questions of feasibility based on maintenance, reliability, durability, etc., associated with combined cycle concepts.

E. OTHER CYCLES

There are a host of different and/or novel and/or relatively unexplored concepts and cycles that could have potential application to the passenger automobile. Because these other cycles are somewhat less well-defined than other concepts discussed in this paper, specific research needs were not identified. It is speculated, however, that spin off from other research efforts would provide a technology base that would benefit these concepts.

The Panel points out that the Federal Government has a mechanism to evaluate concepts for improved fuel efficiency (the NBS/DOE program) and considers that a research need in this area is the development of improved methodologies to evaluate the potential of new concepts.

4. SUMMARY

The Engines Panel has identified two distinct classes of engines -- "in-use engines" and "alternate concept engines" -- for which research should be pursued.

An intensive research program is needed for in-use engines, the objective of which should be to develop a detailed understanding of the processes which influence fuel combustion, emissions formation and engine efficiency. This detailed understanding will provide the technical basis for design refinements which can be incorporated into production engines in the post 1985 timeframe. The Panel noted that even small improvements in in-use engine performance will provide very substantial fuel savings to the nation. The Panel also concluded that research emphasis currently given to in-use engines does not adequately reflect the importance of these systems.

The most important areas of research for in-use spark ignition engines include combustion research to permit higher compression ratios and to reduce cyclic variations; research to reduce friction and improve fuel mixture during cold starts;

turbocharging and other displacement extending techniques; and means for HC and NO_x control in dilute combustion.

For in-use compression ignition engines, the most important research areas are related to NO_x and particulate formation and destruction mechanisms and how these mechanisms affect engine efficiency and pollutant emission characteristics. Other recommended research areas are fuel injection dynamics and spray formation; broader fuel tolerance; reduced heat loss; turbochargers and reduced friction.

For the second class of engines--alternate concept engines--research should be pursued on those engine concepts which realistically are judged to have the potential to improve engine efficiency, emissions, and fuel tolerance beyond what can be anticipated for in-use engines or for advanced versions of in-use engines.

The Panel did not attempt to prescribe which alternate concept engines warrant research attention. However, the Panel examined a number of alternate concept engines which may be possible candidates for future development and identified for each the areas of research which would have to be pursued to resolve recognized major problem areas. For the gas turbine, for example, critical areas for research are ceramic materials; aerodynamics and manufacturing technology for small turbomachinery; low cycle fatigue; and hot corrosion. Major scientific advances will be required in each of these areas if gas turbines are to become viable engines for automobiles.

For the stratified-charge engine with in-chamber fuel injection, a detailed understanding of the chemistry and fluid mechanics of the heterogeneous combustion process is essential to effective development and evaluation.

For the Stirling engine, sealing of high pressure hydrogen, hydrogen permeability and embrittlement, engine controls, materials for the heater head, manufacturability and cost are critical problems requiring technological breakthroughs for the

Stirling concept to become competitive with existing conventional in-use engines.

Other selected engine concepts and cycles should be evaluated systematically and thoroughly. Federal Government efforts in this area should be expanded.

Finally, the Panel recognizes the need to conduct research on the health effects of engine emissions, including particulate emissions, and suggests this is an area which deserves careful attention

5. ADDENDUM COMMENTS

After the conclusion of the Boston Conference, various members of the Engine Panel submitted comments on the draft Engine Panel Report. These comments generally serve to emphasize or to clarify positions taken at the Conference. In all cases they provide thoughtful and constructive perspective to the matter at hand. For completeness and for the convenience of the reader, a number of additional pertinent issues and findings are summarized briefly below.

A. DISSEMINATION OF RESEARCH INFORMATION

All of the findings and data derived from a cooperative and integrated national program for basic engine research should come promptly and fully into the public domain, regardless of where the research is performed or how it is funded. This is equally true whether the research relates to in-use engines or to alternate concept engines.

B. INDUSTRY ADVISORY COMMITTEE

It would be unfortunate for the Federal Government to duplicate engine research efforts underway or already completed in industry. It would be equally inappropriate to focus attention on those technological advances which can be expected to evolve through normal product development activities. For these reasons, it appears that some form of an industry advisory committee could be constructive in helping the Government structure an optimum long-range engine research agenda.

C. CRITERIA FOR ENGINE CONCEPT SCREENING

As the performance characteristics of engine systems acceptable for 1985-2000 automobile applications become more clearly defined, it should be possible to establish criteria for selecting competitive engine concepts for research attention. Although the Panel did not specifically develop a list of such criteria, considerable discussion was directed toward the importance of factors such as: manufacturability; durability; maintainability; utilization of scarce resources; engine-vehicle integration; cost; emissions, and the potential for substantially improved fuel efficiency.

D. CURRENT GOVERNMENT SPONSORED AUTOMOBILE ENGINE RESEARCH

The Federal Government has spent and is continuing to spend substantial research dollars on specific automobile heat engine concepts (currently about 40 million dollars per year). Most of these expenditures are associated with directed research on Stirling and gas turbine engines. Some of the panel members question whether either Stirling or gas turbine engines offer as much real potential for cars of the future as do other alternate concept engines, or perhaps even as much real potential as improved versions of conventional in-use engines. Conversely, other panel members feel that Stirling and gas turbine engines indeed do offer considerable promise for the future and are of the opinion that the current research committment to these systems should be continued.

The Panel did not address these differences nor did it attempt to evaluate either the scope or the relevancy of the ongoing and planned work on Stirling and gas turbine engines. However, the Panel did emphasize that a number of fundamental technologic breakthroughs would have to be achieved for either the Stirling or the gas turbine concepts to become competitive for automobile applications. Because of this finding of the Panel, a number of panel members have suggested that it would be appropriate for the Government to reexamine promptly the likely future potential of Stirling and gas turbine engines for automobile applications in light of anticipated 1985-2000 fuel economy and performance needs in the automobile sector.

E. SAFETY AND HEALTH EFFECTS RESEARCH

Automotive systems of the future may be significantly different from the conventional systems of today. It is very important, therefore, that much additional basic research be conducted aimed at defining reliably the health effects and the traffic safety risks to which the Nation would be exposed with widespread utilization of various new engine and vehicle system concepts.

PANEL B: FUELS AND POWERTRAIN SYSTEMS

Panel Report

RESEARCH NEEDS FOR FUELS AND POWERTRAIN SYSTEMS

A report by the Fuels and Powertrain Systems Panel of the Conference on Basic Research Directions for Advanced Automotive Technology.

PANEL B: FUELS AND POWERTRAIN SYSTEMS

CHAIRPERSON: DR. MAXINE SAVITZ
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PANEL FOCUS: The panel on fuels and powertrain systems will discuss the research needs relating to the motor vehicle powertrain system and the tailoring of fuels for it. The most efficient and least environmentally degrading use of available energy resources is a function of the complex relationship between the energy source, the refined fuel, and the powertrain. Many research questions therefore arise regarding how the source and refining of fuels (or generation of electricity) help to determine the most desirable technology for the vehicle powertrain. Other research questions for the panel will be concerned with on-board energy storage (of fuel or electricity), mechanical and electrical energy conversion (transmissions and motors), regenerative systems, and powertrain technology

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CONTENTS

1. INTRODUCTION

Secretary Adams called for a National Motor Vehicle Policy and asked for a new commitment to expand basic knowledge, to develop new ideas, and put them to work. He hoped in his address to "inspire a new exercise in imagination," and he called on us to develop a research agenda that will help ensure the automotive transportation sector against future energy shortages and surprises.

This panel has been charged with formulating an agenda of research needs on fuels and powertrain systems that will articulate and "put our objectives in front of us" so that we can get on with developing an automotive transportation system that we can live with in the future. This effort must involve both the private and public sectors in a common effort to provide both automotive and fuel alternatives so that people's travel options are retained, not reduced. Alternative fuels and improved energy efficiency are required to reduce or eliminate our dependence on foreign oil and to maintain our national security mobility requirements as well as those of the civil sector.

Various aspects of alternative fuels, powertrain, and electric and hybrid systems were presented in a discussion that had a very wide range. While a number of research topics were identified and defined in some detail, a number of broader issues were raised which remain unresolved. These issues, to a considerable extent, define the context within which basic research would take place and research priorities would be established.

This report is divided into three sections: Issues Identified, Tentative Research Agenda for Alternative Fuels, and Tentative Research Agenda for Powertrain Systems/Components.

2. ISSUES IDENTIFIED

There are several alternative energy sources that augment conventional petroleum supplies. Available information needs to be critically assessed in order to make rational and prompt decisions for the fuel and its uses.

- There are several alternate routes including methanol from coal or biomass, ethanol from biomass, oil shale, electricity from nuclear energy and coal, etc., as well as syncrude. We have electric vehicles, advanced heat engines, advanced Otto engines (including diesels) and hybrid options.

- How focused should the work in this area be? How specific can the goals be?

- How can the dependence on foreign oil be eliminated or reduced by alternative fuels (including heavy oils) produced in the U.S. considering various factors and by establishing:

  - The research factors/barriers,
  - The cost and time required, and
  - The impact on consumer.

- What should be the balance between long- and relatively short-term research? Are the present programs we are doing the right ones? What scale of effort is needed in what time frame?

- We have been told that automotive costs for efficiency improvements in the future may be more costly than the development of new alternative energy supplies. How do we establish a balanced program?

- We have been sensitized to the ultimate commercialization needs--the interrelatedness of powertrains and fuel systems. We need to proceed with efforts to improve the efficiency of the automobile but, no matter how successful these efforts, they will be meaningless unless there is adequate and dependable fuel supply. This issue evolves out of a structure which has generally separated consideration of fuels and powertrain system questions. There is a necessity for product testing for all the elements in such systems, and for optimizing both systems in terms of a set of characteristics including performance, cost, and energy efficiency as well as safety and environmental factors.

- There is a clear and critical absence of a common base for comparison for both fuels and powertrain systems. Without such a common base, the comparisons necessary to make rational choices are absent. The continuing use of miles per gallon as opposed to miles per Btu is a case in point.
- How do we deal with problems such as balance of payments, national security, environmental impacts, vehicle safety, and evolutionary transition to alternative fuels, whose implications for research are not easily amenable to economic measures?

3. TENTATIVE RESEARCH AGENDA FOR ALTERNATIVE FUELS

Given the short time available to the Panel and the broad scope of this subject, the Panel did not feel it was appropriate to establish priorities among the research needs identified.

A. BASIC PREMISES

- Alternative fuels utilization activity should be addressed on a fuel/engine system basis. The nature of the tasks required have been identified.
- It is assumed that the market will dictate the fuels and resources used in various end-use applications.
- Technologies and equipment are available for construction of plants to provide various automotive alternative

fuels from various indigenous resources:

- Methanol and other liquid fuels from coal and biomass.
- Syncrude from oil shale, syncrude from coal, heavy oil and enhanced recovery,
- Ethanol from agricultural crops, and
- Gasoline from alcohol.

o Technology and equipment are available for conversion of stationary combustors to nonpetroleum resource fuels, thus increasing the availability of petroleum resources, including residuals, for conversion to higher quality fuels:

- Gaseous products from various resources, and
- Clean burning, solid-fuel systems.

o Alternative fuels are required to reduce imports of petroleum and guard against supply/demand gaps. Specific optimal applications and priorities have not been established.

o It is unlikely that meaningful quantities (more than 0.5 million barrels per day) of alternative fuels will be produced in the decade immediately following the decision to start their production even with present technology and equipment.

o Until alternative fuels that are clearly representative of candidate processes are obtained on a large enough scale, meaningful engine tests and evaluations cannot be made, and until engine tests and evaluations are made on such representative fuels, no commercialization is likely.

o Fundamentally, we have all the necessary know-how in hand to produce and use alternative fuels if we set our minds to it.

B. RESEARCH NEEDS

- Panel A has discussed heat engine research.
- There continues to be a need for greater fundamental understanding of the combustion process and this must be extended to potential alternative fuels.
- Testing is needed in order to provide comparative data for the various alternative fuel options. This requires availability of fuel products representative of applicable processing. The level of trade-offs between the degree of upgrading synthetic crudes and engine adaptability needs to be established.
- There is a need to build R&D processing plants for coal liquefaction and oil shale retorting which are of sufficient size to provide vehicular test fuels and provide data on processing economics, environmental effects and other socioeconomic impacts.
- Within the necessary alternative fuels R&D, it is essential to address issues relating to the entire system of resource/conversion/fuel distribution and storage/vehicle fuel system/combustion/emissions effects and impacts.
- The following specific items were identified as research needs for the utilization of alternative fuels in automotive systems. It should be pointed out that these items are basically subsets of the above, but are not all-inclusive and may or may not represent portions of programs that are planned or underway. This listing reflects the offering of R&D ideas.
  - Investigate fuel/engine/vehicle systems for trade-offs, optimums, minimum energy, environmental effects, conservation of petroleum, etc.
  - Investigate fuel properties and compositions to characterize fuels for engine use and vehicular application including performance emissions effects.

- Investigate storage and distribution compatibility of new fuels with existing systems.
- Investigate nontransportation sector uses for alternative fuels where petroleum could be displaced for use in transportation.
- Investigate the practical extent to which various alternative fuels can be made in this time frame.
- The above points cover aspects related to identified alternative fuels options, namely fuels from synthetic crudes, alcohols, and hydrogen. Some of the specifics noted in the discussion are:
  - -- Repair and maintenance impact of vehicle systems operating on alternative fuels, and
  - -- Efficiency of producing fuels from land-based biomass systems.
- Almost any problem addressed has facets which involve basic research, applied research and development; therefore, little discussion was directed to details. One basic research concept was the use of solar energy in stationary facilities to provide heat or electricity or alternative fuels.

C. INSTITUTIONAL NEEDS

- o Assess options for displacement of petroleum now used for nontransportation areas by use of alternatives which are of a quality compatible with the requirements.
- o Clarify how energy use is to be quantified and compared and on what basis it is to be used for clean air certification.
- o Evaluate appropriate incentives and policy instruments to encourage the use of all fuels.
- o Assess multisector competition for fuel usage, because there is no guarantee any specific fuel will be used

only for transportation.

- o Research to assess the environmental, health and safety effects of new fuels and associated powertrains covering resource extraction through end-use influences.

4. TENTATIVE RESEARCH FOR POWERTRAIN SYSTEMS/COMPONENTS

The automobile represents a systems problem which encompasses the supply (fuel) side of the equation and the demand (engine/transmission/vehicle/fuel storage) side. Both sides are very important and offer significant opportunities for technological advances.

The underlying R&D strategy is to bring the technology to a point of commercialization readiness. Other actions (i.e., incentives, demonstrations, etc.) will be required to fully commercialize these technologies. Decisions to proceed to full commercialization must be reached with consideration of the full powertrain-fuel systems interrelationships.

Specific R&D objectives should be stated in terms of application period: 1985-2000; post 2000.

Translation of these objectives into petroleum savings require movement from the "readiness" state to the "implementation" state. The Panel identified demand-related research needs in three broad categories:

- o Powertrain systems that allow fuel switching (i.e., electricity),
- o Efficiency improvements, and
- o General systems considerations.

The following listing of R&D needs represent a summary of the panel comments; however, no conclusions should be drawn concerning overlaps, particularly in the fuel switching and efficiency categories. In some cases, there is a broad basis of support, and in other cases, diverse views were expressed concerning the research need. In still other cases, the need expresssed is that of a single investigator.

A. FUEL SWITCHING

1. Electric Vehicles

The highest priority in this area is battery R&D for higher energy and power density, longer life, lower life cycle cost, improved reliability, safety, packaging efficiency, and thermal control. Basic electrochemical studies and research should be conducted in close coordination with the drive development in order to optimize the total system. Additional items that need to be addressed include:

- o Air conditioning and heating research to eliminate need for on-board gasoline heater.
- o Define the cycle over which electric vehicles are to be evaluated and develop appropriate equivalence factors.
- o Develop lower cost and lighter weight electric motors and controls. This encompasses dc, ac, and permanent magnet motors as well as the use of small multiple motors.
- o Explore uses of electronic control systems (microprocessor, sensors, interface electronics).
- o Improve regenerative braking systems.
- o Cost-effective vehicle systems optimization.
- o Battery chargers/charging techniques/exchange.
- o Low-cost production technology.

2. Hybrid Vehicles

In addition to the battery research described above, the following items are unique to the hybrid powertrain system.

- o Investigate utilization of waste heat from internal combustion engines for air conditioning and thermal conditioning.
- o Explore microcomputer control for complex hybrid systems. Examine alternative engine control strategies.
- o Examine integrated heat engine and electric drive systems (internal combustion engine/permanent magnet disk motor, free piston/generator, reciprocating engine/linear motor).
- o Develop an optimum heat engine for hybrid application.
- o Develop reduced-cost motors for hybrid application.
- o Develop a battery system optimized for hybrid applications (high energy/low power).
- o Develop low-cost, high-power polyphase dc-ac inverters to permit use of ac motors.
- o Examine potential for other hybrid concepts (e.g., fuel cell/flywheel, fuel cell/battery, heat engine/flywheel, battery/battery).

3. Dual-Mode Inductively Coupled Highway Systems

- o Analyze and assess value of system with power source in roadway; can incorporate automatic vehicle control for safety; can be evolutionary with conventional vehicles using same roadway.

B. EFFICIENCY IMPROVEMENTS

1. Transmission

o Continuously Variable Transmissions (CVTs). Develop computer-controlled CVT to maximize fuel consumption reduction potential.

o Flywheel Transmissions. Integrate flywheel into transmission to reduce maximum power demand and reduce engine size or battery requirements.

2. Photo-Catalytic Combustion Systems

o Examine photo-catalytic combustion for diesel engines (soot reduction) and lean-burn gasoline engines for combustion enhancement and reduction in wall-quench effects.

C. GENERAL SYSTEMS CONSIDERATIONS

1. Control Systems and Modeling (not exclusive to EV/HV)

o Apply control theory and vehicle system modeling to optimize fuel economy, emission control, performance, safety, and driver operational demands.

o Research on electronic control systems and their interfaces. Includes sensors, actuators, connections, temperature controls, and cost factors.

2. System Studies (not exclusive to EV/HV)

o Research on the interaction of driver behavior and traffic controls to optimize vehicle system performance as well as traffic patterns to reduce fuel consumption.

o Analysis of systems approach to improving maintenance and repair infrastructure.

o Cross impact studies.

5. SUMMARY

Much research and development is already under way in private industry, in the universities, and in government, in the development of low emission, safe, and fuel-efficient automobiles, including alternative fuels and new powertrain systems.

Energy is the focal issue. Within the Government, in the Department of Energy there are RD&D programs dealing with the development of enhanced petroleum recovery and alternative energy supplies, ongoing programs to develop advanced heat engines, electric and hybrid vehicles, and to facilitate the end-use applications of alternative fuels. The programs are linked with EPA because it is very clear that energy and environment are interactive and that issues affecting health and safety cannot be ignored. They are also linked to the Department of Transportation's programs on automobile safety and mileage standards. There are, in addition, similar privately funded research programs in both the automotive and fuels industries. University work, funded by the Government and industry, provides both basic and applied research capability.

While improved conservation can reduce the demand for energy, it is recognized that a greatly increased availability of alternate fuels is essential if this nation's dependence upon foreign petroleum is to be diminished. Thus, the report of this panel recognizes the importance of both of these key areas.

In order to evaluate properly the overall levels of basic research that are needed and the particular areas that deserve support, it will be necessary to undertake a careful analysis of the national effort that is currently under way and the potential risk and benefit of any new research activity. Furthermore, it is essential that a continual assessment of the research programs be carried on so that we can rapidly move to the next phase in the RD&D chain to ultimate commercialization, redirection, or termination.

Because we are trying to establish a partnership between government, industry and universities and because we represent the R&D community, we would be remiss if we did not recommend that future regulation be based on adequate and timely R&D.

The panel recognizes that significant contributions by universities, industries and government can be made to the many basic research areas identified here.

PANEL C: STRUCTURES AND MATERIALS

Panel Report

RESEARCH NEEDS FOR STRUCTURES AND MATERIALS

A report by the Structures and Materials Panel of the Conference on Basic Research Directions for Advanced Automotive Technology.

PANEL C: STRUCTURES AND MATERIALS

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PANEL FOCUS: This panel will discuss basic research directions affecting all aspects of motor vehicle technology other than the powertrain. This will include the basic layout or configuration of a vehicle (the placement and relationship of its components), its structure and crash energy absorption mechanisms, chassis components (wheels, tires, brakes, steering, and so on), occupant crash protection systems, and the materials used to construct the vehicle.

The research areas for this panel will include new applications of known materials, composite materials and other combined material systems, designs for structural rigidity and for crash energy management, biomechanics and occupant restraints, friction and adhesion characteristics of materials, corrosion and fatigue resistance, and the scrappage and recycling potential of vehicle components.

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1. INTRODUCTION

The purpose of the Conference on Basic Research Directions for Advanced Automotive Technology was to gather ideas on what basic research questions should be addressed in order to advance motor vehicle technology. The fuel economy of a motor vehicle is dependent on powertrain efficiency, vehicle weight, vehicle road load and how the vehicle is used. The purpose of Panel C, Structures and Materials, was to discuss basic research directions affecting all aspects of motor vehicle technology, other than the powertrain. The goal was weight reduction at reasonable process cost with a given or enhanced level of safety and road load reduction. The scope of the Panel thus included vehicle configuration, vehicle structure and crash energy absorption, vehicle components and occupant crash protection systems, and the materials used to construct the vehicle. During the Panel's proceedings, the research areas discussed fell into the following categories: materials, structures, other subsystems, road load, vehicle systems, hardware test and evaluation, and systems analysis and program management.

Time did not allow the Panel to define a complete list of research needs in the subject areas. Also, it was not the purpose of the Panel to define either funding requirements or who should perform the research. However, the Panel did recommend the development of a more detailed research plan.

During the meetings of the Panel, panelists and conference participants made certain assumptions on the potential improvements of engines and other powertrain components (which were the purview of Panels A and B, respectively). This was done to provide a background for defining the research requirements in the areas of structures and materials consistent with the overall goal of the conference. The results of the discussion indicated that an achievable passenger car fleet fuel economy by the end of the century fell within the range of 40 to 50 miles per gallon if the nation is willing to pay the price. The corresponding average inertia weight of the fleet would have to range from 2500 down to 2000 pounds with an acceptable (near present) mix of vehicle sizes. The 2000 pound fleet average passenger car weight with an engine improvement of 20 percent above the estimated 1985 fleet average engine efficiency was estimated to yield a 50 miles per gallon fleet. Variations in projected engine efficiency and inertia weight provide the achievable fuel economy range.

The Panel was in open session for two days. The first day opened with the prepared statements by the panelists (Volume II, Panel C Panelists' Opening Remarks) followed by: (1) questions and comments from the floor; (2) the reading of the written submissions from interest parties in accordance with the requests for comment in the Federal Register 44FR7047, Feb. 5, 1979 (Volume II, Panel C Submissions); and (3) the solicitation and receipt of research program summaries from panelists and the audience (Volume II, Panel C Research Program Summaries). In the evening of the first day, the Panel reconvened informally (in open session) to structure a summary of the research topics. On the second day, the Panel clarified and expanded on the research topics, and additional questions and comments from the floor were accepted. At the end of the second day, the Panel Chairperson delivered a summary of the Panel's activities in the general summation (all panels) of the Conference (see Volume I, Plenary Session Closing Remarks).

This report is divided into the following sections which correspond to the structure developed by the Panel for categorizing the necessary research programs:

Materials
Structures
Other Subsystems

Road Load Reduction
Vehicle Systems
Hardware Test and Evaluation
Systems Analyses and Program Management

2. MATERIALS TECHNOLOGY

It was agreed that the increased use of high strength and/or low density materials in the automobile is one of the major tools available for reducing vehicle weight while maintaining packaging and safety attributes required by the consumer.

Several candidate materials proposed by the Panel are listed in Table 2.1. The estimated weight reduction potential of these materials compared to current materials such as steel, cast iron, or glass, as well as their relative costs based on current technology, are also given in this table. The values listed in the table were provided by several members of the Panel without detailed examination or discussion.

The Panel considered the following to be the most promising structural materials for appropriate applications:

1. High strength and ultra-high strength steels with improved formability (elongation)
2. Aluminum alloys
3. Fiber-reinforced plastics, including glass, organic, and graphite fiber reinforcement
4. Foam for filling large sections of thin gauge structural members and for padding
5. Scratch resistant plastics for glazing

The Panel agreed that these materials could contribute greatly to the weight reduction required to achieve the weights discussed in Section 1. However, research is required to overcome a number of obstacles that currently exist and limit their extensive use in production vehicles. The successful completion of the required research would result in mass producibility

TABLE 2-1. CANDIDATE ALTERNATIVE AUTOMOTIVE MATERIALS

MATERIAL	WEIGHT REDUCTION POTENTIAL (%)	RELATIVE MATERIAL COST PER PART BASED ON CURRENT TECHNOLOGY*
WROUGHT METAL		
Low Carbon Steel (LCS)	-	1
Dent Resistant Steels	10 to 20	0.8 to 1
High Strength/Low Alloy Steel	15 to 30	0.9 to 1.1
Ultra-high Strength Steel	40 to 50	0.7 to 0.8
Aluminum (Al)	50 to 60	1 to 3
METAL CASTINGS		
Grey Iron	-	1
Al Die Casting	50 to 60	0.9 to 1.2
Al Permanent Mold Casting	50 to 60	1.5 to 1.9
Zinc Die Casting	10 to 40	0.7 to 1.1
Magnesium Die Casting	75	2.5
PLASTICS (Relative to LCS)		
Unidirectional Fiberglass Reinforced Polyester or Epoxy Resin	50	2
Sheet Molding Compound, Random Fiberglass-Reinforced Polyester Resin	35 to 50	1.15
Unidirectional Graphite Fiber Reinforced Epoxy Resin (Hybrid Reinforcement with Fiberglass, where Possible)	60 to 70	1.5 to 4 (graphite @ $6/lb**, present cost $20/lb)
Continuous Fiberglass Reinforced Nylon "STX" Hot Stampable Sheet	35	1.5-4**
TRANSPARENT MATERIALS		
Glass	-	1
Polycarbonate	40	1.4

*Material cost only, not including direct labor or variable manufacturing burden.
**Projected values.

of parts and assemblies at minimum cost. It was pointed out that the major introduction of the above materials (and the redesign of the fleet) will entail major capital investments. Also, a research effort is required to examine issues other than costs. These include:

1. The effect of alternative materials on crash energy management
2. In-use reliability and durability
3. Environmental and health effects assessments on a life cycle basis (from raw material source, to manufacture, to use, to recycling, and ultimate disposal)

It was stated that the materials research area includes:

1. Improved properties of these materials during manufacture and end use
2. Better knowledge of materials' properties and design procedures
3. Improved manufacturing technologies and processes compatible with these materials
4. Improved inspection and quality control

The limited amount of properties and design data availalbe for some of these materials and parts made of these materials was considered a serious drawback, and research in this area was indicated. It was felt that without the establishment of a data base with which an automobile designer would feel comfortable, and without wide dissemination of this information to the designers, use of alternate materials would be greatly hindered. For all materials, it was felt that a better theoretical understanding of their mechanical behavior under repeated loads and at high strain rates (as would occur during manufacturing and in a crash environment) was required. Research on the mechanical behavior and energy management characteristics of alternate materials under impulse loads, durability, environmental resistance of materials, and material combinations, as well as the field maintainability and repairability of novel structures and components, was recommended.

It was also pointed out that the introduction of new materials in automotive structures could have numerous environmental and health effects that would have to be carefully analyzed on a "womb-to-tomb" basis, i.e., from the raw materials to the disposal of a junked automobile which contained any of these materials. Potential health hazards to workers that would be exposed to any new materials (including precursors) and recyclability were deemed to be the two major environmental research areas.

The Panel agreed that there are a number of common and high priority areas of research that are applicable to all materials and material systems. These research areas include:

1. Fastening and joining technology
2. Improved forming and shaping processes
3. Improved mechanical properties
4. Improved knowledge of properties and theoretical understanding
5. Corrosion and environmental resistance
6. Analysis of environmental and health effects
7. Material production for low cost

Table 2-2 and the following subsections represent research programs for each of the materials discussed. The Panel notes that this list should not be considered as a definitive research plan because of insufficient time for the development of a comprehensive list of research

TABLE 2-2. MATERIALS TECHNOLOGY - ILLUSTRATIVE RESEARCH AREAS (Partial List)

STEEL

- Improved Materials Properties
  - Advanced High Strength Multiphase Ferrous Based Alloys
  - Improved Materials/Processes for Corrosion Prevention
- Improved Manufacturability
  - Forming Research and Development
  - Joining

ALUMINUM

- Lower Cost of Raw Materials (Including New Refining Processes)
- Improved Materials Properties
  - Corrosion Resistance
  - Fatigue Resistance
  - Stiffness
- Improved Manufacturability to Reduce Cost
  - Formability
  - Joining
  - Finishing
- Data and Manufacturing Experience to Increase Designer's Confidence

PLASTICS AND COMPOSITES

- Lower Cost Raw Materials
  - Materials Based on Renewable Feed Stocks
  - Lower Cost Reinforcing Graphite Fibers
- Improved Materials Properties
  - Develop Materials with Overall Improvement in Properties
  - Develop High Temperature Resins
  - Develop Stronger and Stiffer Fibers
  - Develop/Design Optimized Hybrid Composites
  - Analyze Resin/Fiber Interface

TABLE 2-2. MATERIALS TECHNOLOGY - ILLUSTRATIVE RESEARCH AREAS (Partial List) (Continued)

PLASTICS AND COMPOSITES (Continued)

Improved Manufacturability to Reduce Cost

- High-Speed, Short-Cure Cycle Molding Processes
- Thermoplastic Preforms
- Joining
- Fabricate Larger Parts
- Finishing
- Non-Destructive Testing (NDT)

Increased Designer Confidence

- Fatigue Properties
- Reliability and Durability of Composite Parts
- Crashworthiness
- Engineering Properties and Design Criteria

Environmental Impacts

- Recycling
- Nontoxic Substance Emitting Materials
- Health Hazards due to Fibrous Reinforcements

FOAM FILLED AND MULTIMATERIAL COMPOSITES AND OTHER MATERIALS

- Foam Core Structural Components
- Low Cost Manufacturing Process for Magnesium
- Metal Matrix Composites
- Optimized Multimaterial Systems

IMPROVED GLAZING

- Elimination of Lacerations Upon Impact (Windshields, Side and Rear Glazing)
- Improved Strength for Structural Purposes and Weight Reduction

issues; for development of an inventory of on-going research; and for caréful definition of research projects and their associated funding requirements. The Panel recommends that this list be used for the purpose of illustration of the typical research tasks.

2.1 STEEL

Primary research objectives were identified in terms of improved material properties and improved manufacturability. In the area of improved material properties the Panel's recommendations included the following research tasks:

1. Research to determine how static strength and ductility, fatigue strength, toughness, and impact strength of multiphase steels are affected by microstructure, composition, and processing. Material systems of interest should include multiphase alloys, alloy systems strengthened through heat treatment after forming, and metal composites.

2. Research to obtain an improved understanding of the corrosion of coated metals, crevice corrosion, corrosion at the joints/juncture of dissimilar materials, the behavior of surfaces and surface contaminants, and of corrosive environments of importance to automotive structures.

In the area of improved manufacturability the Panel's research tasks included:

1. The development of an improved understanding of metal forming by examining the fundamentals of the plasticity of metals, analyzing work hardening of metals under complex loads, and examining the effects of temperature over a wide range on the forming process. Specific research would also include analysis of strain path effects and material/die interactions leading to the development of predictive die design methods.

2. The development of novel metal forming techniques and manufacturing guides which can result in thinner and/or more complex automotive stampings. For example, examine the potential of squeeze forming operations or other roll forming techniques to achieve metal sheet structures of controlled variable thicknesses.

3. The development of improved metal joining techniques to increase joint efficiency and reduce manufacturing costs. Areas of investigation should include improved cleaning procedures needed for joining, improved welding processes and controls, and adhesive bonding. Special attention should be given to the joining of dissimilar materials.

2.2 ALUMINUM

Long-term and short-term research objectives were identified in terms of lower cost of raw materials, improved material properties, improved manufacturability and increased designers' confidence. Research tasks included:

1. Development of a process to manufacture silicon - aluminum casting alloys by direct thermal reduction of aluminum ore as one approach to reducing the energy required and cost to produce aluminum.

2. Development of alloys with improved resistance to the automotive environment, with minimum sacrifice of strength, formability, joining, and finishing characteristics, and alloys with significantly enhanced fatigue strength. A novel approach would be the production of aluminum castings by ultra-fast solidification. Aluminum-lithium alloys have been found to have a significantly higher modulus than state-of-the-art aluminum alloys. Further work is required to develop commercially effective manufacturing processes for these alloys.

3. A better understanding of the fundamentals of the relation of alloy composition and thermomechanical treatment to formability. This could result in lower cost stampings and reduce the need for secondary operations.

4. Development of improved methods of joining aluminum to itself and other automotive materials (that are economic and commercially acceptable). For spot welding aluminum, approaches include the development of a method for forming a stable, low resistance surface, or alternatively the development of a simple cleaning operation.

5. Obtaining design data for using aluminum alloys in chassis, suspension, and drivetrain components, such as frames and frame parts, pivot arms, U-joints, bumpers, shock absorbers, idler arms, and driveshafts.

2.3 PLASTICS AND COMPOSITES

Research objectives were identified in terms of lower cost of raw materials, improved materials properties, improved manufacturability, increased design confidence, and reduced environmental impacts. As compared to metals technology, more emphasis was placed on development and dissemination of a reliable material properties data base and design data, inspection, and environmental and health impacts. In addition, the lowering of manufacturing costs was emphasized. Representative research tasks included the following:

1. Development of resins and high strength/high modulus fibers that use renewable resources as feed stocks

(perhaps derived from agricultural products).

2. Development of materials and methods of producing high strength, high modulus graphite filaments at a cost of less than $10/lb. with a goal of $3/lb.

3. Development of resins and fibers with improved properties.

4. Development of resins with higher operating temperatures.

5. Development of stronger and stiffer fibrous reinforcements.

6. Development of hybrid composites that make optimum use of mixtures of fibers such as glass, aramid, graphite, boron, etc.

7. Obtain better understanding of the characteristics of the fiber-resin interface so as to obtain better utilization of fiber properties and improved composite shear strength.

8. Development of high speed molding processes for continuous, oriented, fiber-reinforced thermoset resin composites, by developing faster curing resins, and obtaining a better understanding of resin-fiber-flow in the mold during cure. In addition, consideration should be given to improved materials handling before and after curing and an improved trim cycle.

9. Development of methods of preparing sheets of continuous, oriented fiber-reinforced thermoplastic resin composities that would lend themselves to inherently rapid manufacturing operations such as thermal stamping or vacuum forming.

10. Development of improved methods of cleaning surfaces to be joined. Development of improved adhesives that will

result in efficient joints that cure rapidly under plant conditions, and in-process quality controls.

11. Development of improved capability to mold significantly larger parts than is current practice.

12. Development of reduced cost methods of obtaining acceptable showroom finishes on visible automotive parts.

13. The establishment of rapid on line methods of non-destructive testing and evaluation that will allow for 100% inspection of molded composite parts.

14. To obtain failure/fatigue curves on glass/graphite fiber reinforced plastics to be able to better understand the cyclic fatigue characteristics of composites of various resins and reinforcements.

15. Determination of the effect of long-term environmental exposure on various composite materials in automotive service.

16. Examination of impact and energy absorbing properties of fiber filled composites and their applicability to crashworthy structures.

17. Establishment of a data base and analysis techniques for continuous, oriented fiber composite structures for use by design engineers. Development of a better understanding of off-directional properties (away from the principal axis), under static, fatigue and dynamic load conditions. Establishment of a more comprehensive data base with regards to two dimensional and three dimensional properties of fibrous composites.

18. Establishment of economical methods of recycling major portions of plastics that will be found in future automobiles.

19. Further work is required to develop resins which can be molded with or without ventilation, as well as

adhesives which can be applied without requiring special precautions. Toxicity levels of these improved materials have to be examined.

20. Further research to insure that the fibrous reinforcements being considered for use in composites do not result in increased health risks to workers in materials production plants, component fabrication plants, automotive maintenance and repair, and auto disposal systems.

21. Improvements in manufacturability of foam core structural components.

2.4 OTHER MATERIALS

The potential of other materials, such as magnesium, whisker reinforced metals, and optimized multimaterial composite systems were also discussed by the Panel in response to questions from the floor, and further examination was indicated.

2.5 GLAZING

The Panel recommended examination of the feasibility of replacing conventional glass with lighter plastics such as polycarbonates.

3. STRUCTURES TECHNOLOGY

This area includes the use of materials to form the structure, and handle the static, dynamic, and crash loads to which the car may be subjected. It was felt that additional weight reductions could be attained with comparable or improved crash energy management by pursuing research in:

1. Improved quantification of loads to which the structure will be subjected.
2. Improved design and analytical tools.
3. Optimal use of material properties and structural shapes.
4. Integrated design approaches whereby heretofore nonstructural parts and components are utilized as load-bearing members and the parts and components are optimized for more than one function.

It was suggested that improved quantification of loads should include projections of anticipated road quality (which may be lower than at present) in the time period under consideration; optimal use of material properties include the design of parts in a way that enhances the favorable properties of the material; and the integrated design approaches include concepts such as utilizing seats and laminated windshields as part of the load bearing structure.

A need for greater safety research was expressed and it was suggested that the minimum passenger compartment volume will be controlled not by comfort, but by the minimum survival space (based on the relevant biomechanical data). It was estimated that an improved safety capability (40 mph frontal impact against fixed barrier) would require 150 pounds of structure and other subsystems.

During the course of the proceedings the following structures-related safety research needs were expressed:

1. Research toward reduced occupant injury, including research for the protection of children and the elderly during collision.

2. Research for reduction of injuries resulting from side, rear corner, and rear impact.

3. Research for the reduction of vehicle aggressivity with respect to vehicles, pedestrians and cyclists.

4. Research on safety trade-off methodology (including safety and fuel economy design features).

Table 3.1 is a partial listing of the research areas for structures recommended by the Panel.

TABLE 3-1. STRUCTURES TECHNOLOGY — RESEARCH AREAS (Partial List)

- Quantification of Load Inputs
  - Normal Service
    - Projected Road Environment
    - Projected Speeds
  - Collision
    - Projected Vehicle Size/Weight Distribution and Distribution of Collisions by Vehicle Clock Position and Speed
- Improved Design and Analytical Tools
  - Design Optimization
    - Tools
    - Materials Data
  - Vehicle Response During Collision
    - Tools
    - Materials Data
- Vehicle Component Integration and Optimization
  - Utilization of Maximum Number of Components for Load Bearing
  - Optimization of Components for Multi-Use
- Safety Related Data
  - Biomechanical Data
  - Improved Dummies for Non-Frontal Crash Modes

4. OTHER SUBSYSTEMS

The Panel discussed the possible needs for research in subsystems technology that would yield either fuel economy or safety benefits. These technologies included tire inflation indicators, brake systems, speed control systems, improved suspension components that would facilitate the use of higher tire pressures, improved analytical techniques for suspension analyses under conditions of increased differences of loaded and unloaded vehicle weights, and electronic transmission controls. It was felt that through suitable speed control devices and reduced engine power, the car could be designed to be much more compatible with the 55 mph national speed limit with accompanying injury reductions, reduction in emissions, and materials and fuel saving benefits.

Table 4.1 is a partial listing of the research areas for other subsystems recommended by the Panel.

TABLE 4-1. OTHER SUBSYSTEMS — RESEARCH AREAS (Partial List)

Weight and Energy Consumption Reduction of Accessories and Auxiliaries (including possible integration of accessories such as air conditioning with the powerplant)

Electronic Transmission Control

Tires and Wheels

- Tire Inflation Indicators
- Lightweight Wheels

Brake Systems

- Anti-Lock
- Radar Warning (Crash Avoidance)

Driver Displays

Speed Control Systems and Cruise Controls

Suspension

- Analytical Tools and Technology

5. ROAD LOAD REDUCTION

The three major components of road load are tire resistance, aerodynamic drag, and lubricant and bearing friction. The areas of tire research identified included development of tire structures and material combinations which will result in tires with low rolling loss, which at the same time are long wearing, high traction, and resistant to road hazards. It is anticipated that tire inflation pressures will be significantly increased (perhaps to 40-45 psi) in the future to reduce rolling losses.

The research for long wearing characteristics and resistance to road hazards will have to be pursued for tires under high inflation pressures. In addition, improved test techniques for the measurement of tire rolling friction and computer design methods for tires were proposed. Also improved non-destructive testing methods for production facilities was proposed.

For the reduction of aerodynamic drag, a research plan[1] recently completed by one of the panelists was introduced and should be consulted for more detailed information. The research elements are: (1) assessment of the prior and continuing art; (2) definition of the aerodynamic operational environment; (3) aerodynamic testing methods and facilities including wind tunnel and road testing, wind tunnel to road correlation, flow visualization, and moving body testing; (4) aerodynamic

[1] William Milliken and Martin Zlotnick, "Aerodynamics of Road Vehicles". Paper presented at AIAA 15th Annual Meeting and Technical Display, Washington, D.C., February 6-8, 1979. (Paper No. 79-0531).

drag assessment of contemporary vehicles; (5) vehicle aerodynamic flow fields and generalized design data including systematically derived generalized vehicle shape data, flow field research, and internal air flows; (6) aerodynamic flow-control devices; and (7) interaction of vehicle aerodynamics and tire/road chassis characteristics.

The Panel felt that the most fruitful area for lubricant/bearing research would be to concentrate on low temperature losses.

Table 5-1 is a partial listing of the research areas for road load reduction recommended by the Panel.

TABLE 5-1. ROAD LOAD REDUCTION - RESEARCH AREAS (Partial List)

Tires

- Tire Materials and their Inter-related Composite Geometry and Properties
- Run-Flat Tires of Low Weight and Rolling Loss
- Tire Structures and Design
- Test Methodologies
  - Accurate Laboratory Measurement of Tire Rolling Loss
  - Development of Improved Non-Destructive Test Methods for Production Quality Control

Aerodynamic Drag

- Assessment of the Prior and Continuing State-of-the-Art
- Definition of the Aerodynamic Operational Environment
- Aerodynamic Testing Methods and Facilities
- Aerodynamic Drag Assessment of Contemporary Vehicles
- Vehicle Flow Field and Generalized Design Data
- Aerodynamic Flow-Control Devices
- Interaction of Aerodynamic and Tire/Road Forces

Lubricants/Bearings

- Friction Reduction at Low Temperatures

6. VEHICLE SYSTEMS

The research topics in the systems area included the design, layout and configuration of the entire vehicle; the vehicle level requirements that the vehicle must meet; and the development of methodologies for making tradeoffs between conflicting requirements. The development of criteria and tests both for overall vehicle acceptability and vehicle safety was proposed.

The enhancement of pedestrian and cyclist protection; improved maintainability and repairability; lower damage susceptibility; and the design for compatibility with other vehicles and stationary devices such as guardrails were proposed. Tradeoffs between these attributes, when in conflict, were also proposed. The need for a data base of some of the above attributes was identified. It was also suggested that training for auto mechanics and the development of optimum diagnostic systems and external interfaces in the vehicle for maintenance and repair functions are profitable areas of activity. The Panel recommended the development of a methodology to determine the benefit/cost relationships and the fuel economy payoff of various technology improvements and alternatives, and to combine it with the methodology for safety payoffs. The study of mission and use analyses for vehicles in the post-1985 time frame was also proposed.

Research was also proposed to determine the payoff of multi-function microprocessor control electronics for engine, transmission, collision avoidance and driver aids. The study of driver behavior from the fuel conservation point of view was also recommended.

7. HARDWARE TEST AND EVALUATION

The Panel pointed out the need for hardware evaluation at both the component and vehicle system levels as part of the research and development program. The development of criteria and test procedures for vehicle and component acceptability and safety (see also Section 6), testing of new technology, and the organization and dissemination of the results were proposed. The following specific recommendations were made for:

1. The construction of state-of-the-art composite vehicles, establishment of the reliability and durability of such vehicles, and the investigation of the high volume producibility potential of such vehicles.
2. The large scale field testing for improved corrosion and fatigue resistance of some materials which have already shown promise in the laboratory.
3. Scale model testing for safety research (including the development of improved methods for scaling the data).
4. Evaluation of occupant, pedestrian and cyclist protection subsystems and vehicle aggressivity.
5. The evaluation of production process technology.

In conjunction with the hardware evaluation efforts, analytical effort in support of the tests was recommended. Also, it was recommended that fuel economy test procedures be developed to better simulate real world conditions.

8. SYSTEMS ANALYSES AND PROGRAM MANAGEMENT FOR RESEARCH PROGRAM

An additional task proposed by the Panel was Systems Analyses and Program Management. This task was deemed necessary because of the envisioned complexity and magnitude of the overall research and the need for a coordination function. This activity was envisioned as paralleling the above research activities to perform requirements analyses; set requirements and targets for various research projects; develop decision making methodologies on a cost/benefit basis; and to integrate the decision making between the safety aspects, availability of materials and resources, the fuel economy goals, and vehicle life cycle cost. It was emphasized that under this task, it would be most appropriate to perform an inventory of ongoing and completed research, and to maintain and communicate research results. There also needs to be a continuing assessment of needs versus research results to change priorities and funding levels of specific research programs and projects.

9. CONCLUDING REMARKS

There was general agreement that:

1. Major vehicle weight reductions are achievable by the year 2000 while meeting acceptable injury reduction, damage susceptibility, repairability, and durability goals.

2. Achievement of this significant weight reduction can only be accomplished by (a) the near-term acceleration of ongoing research and initiation of new research to develop the technical capability, and (b) if the nation is willing to pay the price, to implement the new technical options.

3. If such a program is established an average passenger fleet fuel economy of 40-50 miles per gallon can be attained assuming reasonable improvements in powertrain efficiency, and reduction in aerodynamic drag and other losses.

4. Firm decisions on research priorities must be made soon after systems analysis and cost effectiveness studies are completed. The capital cost for translating the anticipated new technologies into mass production should be estimated and included in the national priority-setting process.

5. It was suggested that the potential of the ongoing research at universities be explored. The needs for qualified manpower should be defined.

6. This report represents a first, top level cut of research needed to reach the possible goals for the 1990's. Much more detailed planning needs to be done in each of the topical areas. It was noted that professional and scientific societies, trade associations, and other organizations could be of considerable help in this planning.

PLENARY SESSION
CLOSING REMARKS

INTRODUCTION OF THE SECRETARY OF TRANSPORTATION

DR. RAYMOND L. BISPLINGHOFF
Chairman
National Research Council
Committee on Transportation
Washington, DC

INTRODUCTION OF THE SECRETARY OF TRANSPORTATION

DR. RAYMOND L. BISPLINGHOFF
Chairman, National Research Council
Committee on Transportation

You have seen from your agenda, the purpose of our gathering this afternoon is to receive reports from the panel chairmen on the results of their panel meetings. Prior to hearing those reports, I would like to ask Secretary Adams to speak to you. He has got to return to Washington in the middle of the afternoon and he has agreed to spend a little time with us before he goes. So, without any further comments, let me introduce to you Secretary Brock Adams.

CLOSING REMARKS

HON. BROCK ADAMS
Secretary of Transportation
Department of Transportation
Washington, DC

CLOSING REMARKS

HONORABLE BROCK ADAMS
Secretary of Transportation

Thank you, Mr. Chairman. I want to personally thank the panel chairmen and all of you for your participation. I have just spent a considerable amount of time meeting with the panel chairmen and going over the preliminary results of what has occurred during the last thirty-six hours. I am looking forward to their final reports and comments which will go to all of you.

There was a specific reason for calling all of us together here during this very cold time of the year in Boston. I have to know, as a matter of public policy and as a matter of taking a position of making recommendations to the President and to the Congress, whether anything can be done. I cannot tell you how pleased I am as I move through these panels and as I have received the reports, that the results of these panels indicate clearly that we can achieve a substantial improvement in mileage, that we really are going to be able to get the kind of fundamental breakthrough in the total automobile that will enable us to have personal mobility in this country in the year 2000.

I did not come here to ask for an instant solution, but to get a research agenda, and most important of all, to get an answer whether or not it was realistic to do something about this vehicle. When we started, I saw a lot of very cynical people. I do not see that anymore. I went through a lot of panels and spent a lot of time listening to the comments that came out, and I saw a lot of old cynics begin to grin a little bit and say, "Yes, it is achievable." We can, technologically, in this country, get that mileage up in the ranges -- and there won't be a consensus, I understand that -- of forty to fifty miles a gallon.

I did not come here for a target but I came here for research information: Is it realistic to try and, second, if it is realistic to try, what are the specific areas in which we should be directing our basic research so that the dollars industry-wide and government-wide are spent at the proper places? Now that is what your panelists have been talking to me about and will start detailing to you in their reports which you will get in written form.

We are looking, as the Chairman said to me, for a research agenda. We do not want to step on one another's feet while we are doing this and we do not want to do something foolish, but we do want to know that industry, government, academia, and the people want to change. I can tell you that they do. It is incredible to me that a public policy issue of this size has been left unaddressed for this long. I guess it is because if you are comfortable you do not think about it. But the response, not only from this group but from throughout the whole United States, has been to say, "Go at it. You really can do it. Let's see something very new. Let's see the in-use engines." And you will hear a fascinating report on comparison of in-use and alternative engines and on in-use and alternative fuels and on total concept and powertrains that will indicate, I think, to you, as it has to me, that it can be done.

Now that was the first thing I needed to know. The second thing is the research agenda. Then we will meet to determine how we implement a program to move on with what I consider to be one of the most difficult things this country faces, which is how to take an economy which is oil-based and therefore, now rests on a rather fragile structure, and make it accommodate through the year 2000. Every nation in the world is trying to determine how to do that, and transportation and the automobile is a very big part of it in the United States.

There will be disagreements. There will be concerns. There is risk-taking. I suppose some of the panelists will probably say that I should not have mentioned a number at all. That is a risk that I have to take, that I have to defend. It is an assessment that I have to make out of what I am hearing from you, but I think it can happen. I am excited about it. I am very pleased about it.

I appreciate your efforts and I am going to turn the meeting back to the Chairman. I will be awaiting the results from the Chairman and the individual Panel Chairmen as I make my report and recommendations to the President which will lead to a meeting in the spring when we will talk about how we will implement and commercialize it.

Thank you for both your attention and your help. The fact that you are all still here proves the point that I guess we knew originally: Everybody in America wants to know what the hell we are going to do with the automobile.

Thank you.

CLOSING REMARKS
PANEL A: ENGINES

DR. RICHARD H. BRICELAND
Environmental Scientist
Environmental Protection Agency
Washington, DC

PANEL A: ENGINES

DR. RICHARD H. BRICELAND, CHAIRPERSON
Environmental Scientist
Office of Policy Analysis
U.S. Environmental Protection Agency

I am going to summarize for you briefly the results of the Engine Panel deliberations. I think that in doing this we sometimes forget that there are eleven panel members that worked very hard in this activity. We also have some very exceptional support from the Department of Transportation people, so I acknowledge that with great appreciation.

I would also comment that there was, during the course of our deliberations, what I might characterize as "spirited discussion" at times, and as a result, the draft report which we have prepared certainly does not represent a universal consensus about the general thrust of what I am going to report to you, but I say to you, in all fairness, that all of the points have certainly not been agreed to by all the panel participants.

The report consists basically of a twelve page document. I am going to very quickly read through the introduction. I will read through the summary and I will summarize as quickly as I can the basic elements of the recommended research activities.

The objective of the Engine Panel discussions was to identify and prioritize research activities which need to be conducted to support commercialization of heat engine technology for light duty vehicles in the 1985-2000 time period. Discussions were focused on specific technology areas which reasonably might be expected to contribute to major fuel savings in the post-1985 period.

The Panel has identified two categories of engines as a basis for formulating its research recommendations; first, in-use engines which are characterized by homogeneous charge spark ignition engines such as are used in most of our cars today, and compression ignition engines, for example, the diesel powerplant. The second category is alternate concept engines such as are characterized by gas turbines, Stirling systems and various proposed new concepts. Although the Panel has recommended research programs in both of these engine categories, it is important to recognize that the objectives of these research activities are different for the two cases. Research for the conventional in-use engine is directed primarily toward refinement and incremental system improvements, while research for alternate concepts is designed to provide a firm basis for assessing the technological and economic feasibility of these powerplant systems.

The Panel recognizes that a range of engine systems representing various fuel economy and passenger carrying capabilities will be required during the 1985-2000 time period of interest. However, based on information presented, the Panel was not able to identify a specific engine technology which could be classified as superior for future light duty applications; for example, superior with respect to fuel efficiency, exhaust emissions and acceptability for meeting a range of public needs.

The Panel did not attempt to assess in detail the balance and priority of ongoing Government funded heat engine research work. However, it was concluded that research emphasis currently given to in-use engines by Government and by industry does not adequately reflect the importance of these systems.

The information available to the Panel did not permit projections of the ultimate fuel economy potential of possible engines and thermodynamic cycles. However, it is clear that improvements in fuel efficiency can be achieved for the in-use category of engines, even for mature and widely used engine systems, and that these improvements can provide very large fuel conservation benefits to the nation.

Although questions of fuels and fuel technology were not within the scope of the Engine Panel's discussion, the Panel nevertheless wishes to emphasize that it is difficult to treat the research needs of engines and fuels separately. The Panel recognizes that in-use spark ignition and compression ignition engines are significantly more sensitive to fuel type and fuel quality than are engines such as the gas turbine and Stirling.

The Panel believes it is important to decrease the fuel sensitivity characteristics of automotive heat engines and to work towards multi-fuel capabilities, including the capability to utilize synthetic fuels in light duty applications.

Finally, the Panel recognizes the importance of conducting health effects research on engine emissions for a range of power-plant concepts. However, the Panel membership did not include technical expertise which would permit it to identify specific health effects research needs. The panel suggests this is an area which warrants careful attention.

That is the end of the introductory statements, and I am now going to summarize the recommended research activities.

In the report, we have broken them into two areas I have described for you: the in-use engine category and the alternate concepts engines. First, let me identify the research efforts needed or recommended for the in-use engines. The basic objective here is to develop a detailed understanding of processes which control fuel consumption and emissions.

In the spark ignition engine research area, there are topics such as higher compression ratios, combined combustion and fuels research, reduced cyclic variations, improved cold start performance, research leading to improved size and shape options, reduced accessory losses, turbocharging, internal NO_x control in dilute combustion systems and so forth.

In the diesel research area, the research recommendations are of a somewhat different thrust: improved fuel injection characteristics, improved fuel tolerance, reduced heat losses, turbocharger research, and research related to reduced friction.

In the advanced concepts area, the research efforts which we have recommended to receive attention are the following: first, the purpose of this research is to investigate a range of scientific problem areas that are associated essentially with innovative concepts; we have research relating to improved ceramic materials, seal and bearing technology, manufacturing technology, combustion chemistry, hot corrosion and so forth. I am going through this very quickly because to further identify specific research topics almost means that we would go into specific engine categories, highlight the problems, and say these are the kinds of things that we think have potential for dealing with the problem. That is covered in the report, and I am just summarizing some of the areas here.

There was a very strong feeling among the members of the Engine Panel and also among the members of the audience that we have very little real understanding of the basic physical phenomenon occurring in the heat engine. We should support basic research activities that would maximize the type of technology options that are available for future commercialization.

We should support work which has potential payoff in a spectrum of areas so that as some of these options develop either in the engineering sense of in other senses, the opportunity for them to go into commercialization is augmented. I am speaking specifically of basic technology areas such as friction, lubrication and wear research; systematic and intensive research on the internal engine processes such as combustion processes, combustion chamber configurations, thermodynamics, heat transfer; basic research on engine controls; materials research -- specifically, materials research related to ceramics and high temperature materials; and then also basic research on engine emissions.

It has been suggested that we should organize our recommended research programs along areas of basic research such as friction and combustion processes and so forth. We have elected to focus on a variety of engine concepts, identify problems and then make suggestions about specific areas. But we saw a cross-current all the way through that said high temperature ceramics, friction, and lubricants, were basic problems that were occuring across the board in all engine types. Basic problems require basic research activities.

Finally, let me read to you the very brief summary that is at the end of our report. The Engine Panel has identified two distinct classes of engines: in-use engines and alternate concept engines, for which research should be pursued. For engine types which are in-use at the present time, an intensive research program is needed, the objective of which should be to develop a detailed understanding of the processes which influence fuel consumption and emissions. This detailed understanding will provide the technical basis for design refinements which can be incorporated into production engines in the post-1985 time frame.

The critical areas of research for spark ignition engines include combustion research to permit higher compression ratios and to reduce cyclic variations; studies of friction and fuel mixture preparation during cold start; turbocharging; and means for hydrocarbon and NO_x control in dilute combustion. For compression ignition engines, the most important research areas are related to NO_x and particulate formation and destruction mechanisms. Other recommended research areas relate to both emissions and improved fuel consumption characteristics: fuel injection dynamics and spray formation; broader fuel tolerance; reduced heat loss, turbochargers, and reduced friction.

Research also should be pursued on alternative engine types such as the gas turbine, Stirling and stratified-charge engines with the objective of developing a technology base which will support rational future decisions on the development of these engine types. For the gas turbine, critical areas for research are ceramic materials; aerodynamics and manufacturing technology for small turbomachinery; low cycle fatigue and hot corrosion. For the stratified charge engine, with in-chamber fuel injection, a detailed understanding of the chemistry and fluid mechanics of the heterogeneous combustion process is essential to effective development and evaluation. For the Stirling engine, sealing of high pressure hydrogen, hydrogen permeability and embrittlement, controls, materials for the heater head, manufacturability and cost are key problems.

Other engine concepts and cycles should be evaluated systematically and thoroughly. The future Federal Government efforts in this area should continue and be emphasized.

Thank you.

CLOSING REMARKS PANEL B: FUELS AND POWERTRAINS

DR. MAXINE SAVITZ
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Conservation & Solar Applications
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PANEL B: FUELS AND POWERTRAIN SYSTEMS

DR. MAXINE SAVITZ, CHAIRPERSON
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Conservation and Solar Applications
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I want to thank the participants on our panel for the hard work that they have done in the past two days and also for the audience that participated in both the committee comments earlier and at the discussion.

We had a very broad agenda on our panel in covering the two areas of fuels and powertrain systems. We were charged with formulating the agenda for research needs for fuels and power-trains, and to articulate and put our objectives in front of us so that we get on with the development of an automotive trans-portation system that we could live with in the future. There must be a common effort by both private and public sectors to provide automotive and fuel alternatives so that people's travel options are retained, not reduced. Alternate fuels and improved energy efficiency are required to reduce or eliminate our dependence on foreign oil and maintain our national security position.

We looked at various aspects of alternative fuels, power-trains, electric and hybrid system, in a wide range of discus-sions. While a number of research topics were identified and defined in some detail, a number of broader issues were raised which remained unresolved. These issues, to a considerable extent, defined the context within which basic research would take place and research priorities established.

Our report is divided into three sections: Issues Identi-fied; A Tentative Research Agenda for Alternative Fuels; and A Tentative Research Agenda for Powertrains Systems and Components.

I will summarize a couple of the issues identified and also talk about some of the proposed agenda items for research.

There are several alternative energy sources which can augment conventional petroleum supplies. Available information however, needs to be critically assessed in order to make rational and prompt decisions for the fuel and its uses. Some of the alternative groups are methanol from coal or biomass, ethanol from biomass, oil shale, electricity from nuclear energy and coal, and syncrude. We have electric vehicles, advanced heat engines, advanced Otto engines, diesels and hybrids.

Our panel did not feel that we could identify a specific goal and we could not say even how specific that goal should or should not be, and what should be part of that goal, though there was quite a bit of discussion on that. We all became quite sensitized to the commercialization needs of getting an advanced automotive system and having to really consider the inner relationships of the engine and the fuel system. We need to proceed with efforts to improve the efficiency of the automobile, and no matter how successful these efforts they will be meaningless unless there is some alternative fuel to supply them. We really must look at both the engine and the fuel system for that.

We felt that there was a clear and critical absence of a common base for comparison for both fuels and powertrain systems. Without such a common base, comparisons necessary to make a rational choice are absent. The continuing use of miles per gallon as opposed to considering something like miles per Btu is a case in point and we need to think about what alternative fuels we are going to look at. We also need to deal with problems such as a balance of payment, national security, environmental impacts, vehicle safety, and the evolutionary transition to alternative fuels whose implications for research are not necessarily amenable to economic measures.

Now we will proceed to a tentative research agenda for alternative fuels. Given the short time available for the Panel and the broad scope of the subject, the Panel did not feel that it was appropriate to establish priorities among the research needs identified. Our report will not be able to include ones that many people thought were important, but those are not priorities.

We felt that technologies and equipment are available for construction of plants to provide various automotive alternative fuels from various resources. We do have technology for methanol and other liquid fuels from coal and biomass, syncrude from oil shale, ethanol from agriculture products and gasoline from alcohol. It does not mean these cannot be improved, but they are things that are available.

The Panel also felt that meaningful quantities, essentially more than half a million barrels of oil a day, would be available in the next decade from these alternative fuels. We felt that we have all the necessary know-how on hand to produce and use alternative fuels, but we have got to set our minds to do it and make a commitment to it. We felt engines with multi-fuel capability will definitely have to be developed, but we did not go into any discussion of what those engines might be, leaving that to Panel A.

We felt that there will be a continuous need for greater fundamental understanding of the combustion process, and this must be extended to potential alternative fuels. Testing is needed in order to provide comparative data for various alternative fuel options. This requires availability of fuel products representative of the processing, and a level of tradeoffs must be established. But we have to investigate fuel properties and the compositions that there are to characterize what fuels will be used for what engines and what type of applications, the performance parts and the emissions effects.

We need to investigate the storage and distribution compatability of new fuels with existing systems and see how we can work them in and look at the cost effectiveness of these. The non-transportation sector uses for the alternative fuels must be investigated where petroleum might be displaced in transportation. We need to look at the competition for the available fuel from all sectors of the economy.

In addition to technological research, the Panel felt the need to look at institutional and non-technological needs to assess the options for displacement of petroleum now used in non-transportation areas, and to clarify how energy used is to be quantified and compared when we look at value of one form of energy versus another and its use both in the automotive and other forms of transportation in the economy.

We felt that there needs to be research done to assess the environmental health and safety effects of new fuels and associated powertrains covering resource extraction through in-use influence.

We now come to the tentative research agenda for powertrain systems/components. Again, we stress that the automobile represents a systems problem which encompasses the supply (fuel) side of the equation and the demand (engine/transmission/vehicle/fuel storage) side. Both sides are important. In a sense our panel looked at one part of it, and the others looked at other components, but we really need a total systems look at the automobile.

The effort underlying R&D strategy for the powertrain systems components is to bring the technology to a point of commercialization readiness and we may need to look at other action incentives and the like -- to fully commercialize these technologies. We must look at our objectives in this area and the terms of the application period. Are we looking at something from 1985 to the year 2000, and are we looking for something beyond the year 2000?

The Panel identified three broad categories in this area: powertrain systems which would allow for fuel switching, for example, to electricity; efficiency improvements; and general systems consideration. I will give a couple of examples of some of the research items in each of the three.

In the fuel switching, one of the items was the electric vehicle and this was the one case where the panel did give a priority. It felt that within the electric vehicle, the highest priority in that area had to be for battery research and development for higher energy and power density, for longer life, lower life cycle cost, inproved reliability, and supply packaging efficiency. Basic electric chemical studies and research also need to be conducted. In order to make the electric vehicle happen we need battery research. Other items that need to be addressed include better vehicle systems optimization, better electronic controls, development of lower cost and lighter weight electric motors and controls, research in air conditioning and heating in order to eliminate the need for some onboard gasoline heaters.

The hybrid vehicle was another area that was discussed in the fuel switching area where we want to look at the utilization of waste heat from the engines for air conditioning and thermal conditioning; explore microcomputer control for complex systems; and examine the potential for various hybrid concepts such as fuel cell/flywheel, heat engine/flywheel, and battery/battery and wind-boosted systems. The third area was a dual mode coupled highway system.

In the efficiency improvements area we talked about specific projects in transmission and in photocatalytic combustion systems as well as other conversion systems for more efficient systems such as fuel cells.

Then there was a third area of general systems considerations in control systems and modeling, and research on electronic control systems and their interfaces. There were also some systems studies that would be applicable to all kinds of automotive transportation -- interaction of driver behavior, traffic controls, and cross impact studies. Those were basically the agenda items.

The Panel also said that we really do need to acknowledge that much research and development is under way in private industry, in the universities, and in government in the development of clean, safe and fuel efficient automobiles, as well as in the areas of alternative fuels and new powertrain systems.

While it was not possible to list all the research that is on-going in universities, in the private sector, and in government in the time available to the Panel, a word can be said about the work currently being done within the Government. The Department of Energy has research and development programs dealing with enhanced petroleum recovery and the development of alternative energy supplies. There are ongoing programs to develop advanced heat engines, electric and hybrid vehicles, and to facilitate use of alternative fuels. All these programs are linked closely with the EPA because of the importance of energy and the environment and also with DOT for vehicle safety and mileage.

While improved conservation can reduce the demand for energy, we must recognize that greatly increased availability of alternative fuels is essential if the nation's dependence upon foreign petroleum is to be diminished. The Panel wants to emphasize the importance of both of those two areas. Also, it was felt that we need to evaluate properly the overall levels of basic research that are needed (and particularly in areas that deserve support) by doing an analysis of what is currently under way and by looking at the potential risk and benefits of the new research activities in addition to the existing ones. We continually need to assess the ongoing programs to see how we could rapidly move them, if they are in the research and development chain, to ultimate commercialization, or whether the programs need to be redirected or whether even some programs just are not fruitful and need to be terminated.

Since we are trying to establish a partnership between government and industry and universities, and since we represent the research and development community in this action, we would be remiss if we did not recommend that future regulations be based on adequate and timely research and development. The Panel recognizes a significant contribution by universities, industry and government. These contributions can be made to the many basic research areas that were identified by the Panel.

Thank you.

CLOSING REMARKS
PANEL C: STRUCTURES AND MATERIALS

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PANEL C: STRUCTURES AND MATERIALS

DR. R. RHOADS STEPHENSON, CHAIRPERSON
Associate Administrator for Research & Development
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This has been the most interesting two days for me and, I think, the panel members who contributed to Panel C. We had an interesting group of experts with a great deal of combined knowledge. The audience participated actively and steadfastly stayed with us throughout the entire day and a half of proceedings. I would like to thank all of them for their participation. I would also like to thank the DOT staff for their help by working into the wee hours of the morning to put together the material from yesterday.

We had a very broad scope in Panel C with a free rein to consider anything other than the powertrain itself. We came up with a large number of research ideas which have been captured on one-page summary forms. There are in excess of 50 of these items. We did not have time to review each one of them in detail. We expect to include these summaries in an appendix to the proceedings of this conference.

I would now like to discuss some of the general conclusions that came out of our work, and then lead you through a categorization of the research and give the highlights of the research that we thought was most important.

Our panel discussed goals which would be achievable. Since we were not concerned with the powertrain, we had to make some assumptions. The key one is that the powertrain itself (that is, the transmission, the engine, and its control system) would be able to improve another 20 percent beyond a 1985 baseline. I would guess this assumption is generally consistent with the conclusions of the Engine Panel. It was observed that to meet the 27.5 miles per gallon fleet average in 1985 would result in about 3000 lbs average inertia weight vehicle fleet.

In order to go further to the 50 miles per gallon range, it will be necessary to get down to 2000 to 2250 lbs fleet average weight. Our main conclusion is that there was a fair degree of optimism among the Panel, that there were many, many approaches that could be taken, and that such a goal was probably achievable. There would be some differences of opinion as to exactly when; I think the concensus was closer to the year 2000 than 1990. There also was some question as to whether it was sensible to go that far. It was observed that there is an asymptotic effect: as you spend more and more money, you get less and less in return for each incremental dollar. Thus, there may be alternative ways of spending an equivalent amount of money to solve the problem of finding an adequate energy source for our personal mobility. However, I believe there was concensus on the Panel that if the 50 mpg range was determined to be a national goal, and everyone set their mind to it and established their priorities, and the nation and the consumers were willing to pay the bill; that this kind of a goal would be achievable.

It was also pointed out that the time is short. It was characterized as somewhat of a crash program--not something we are going to do leisurely even if we are shooting for the year 2000. Some decisions have to be made right away. Perhaps this conference and the follow-up conference can be the sparkplug to get some of those decisions made.

I would also like to add that these conclusions have been based on the assumption that we are talking about a fleet of cars with a size spectrum which is similar to what we are used to now in terms of four, five and six passenger cars and a few station wagons. It was observed that if consumer preferences would change to accept lower performance and/or smaller cars, then it would not be necessary to go as far technologically in order to achieve the same goals.

Another observation relative to consumer demands is that it may be possible in this time frame to design a car which is more compatible with the national 55 mph speed limit. That would be another example of where somewhat reduced performance would have fuel and safety benefits.

A second general conclusion is that, in the day and a half here, we merely identified research areas that the group agreed were important to pursue. In no sense should our report be viewed as a detailed research program that somebody could go off and start implementing on Monday morning. Considerable additional planning will have to be done well beyond the scope of this conference or even the follow-up conference. However, it was learned that in a number of areas there have recently been, or there will be in the near future, detailed research planning activities carried out by Government funded studies, by professional societies and by trade associations. It should be possible to use the committee structures of some of these organizations to work out much more detailed research plans in each of the topical areas.

Also, there is work going on in almost all of these areas right now. But the view is that it is necessary to put more emphasis on it, provide better coordination, and that additional funding could accelerate the rate at which the various objectives are met.

We broke down our research into six top-level categories. In my discussion, I will start with the most detailed and specific areas and end at the systems level.

The first area is materials. In this area there are a variety of questions relating to joining and fastening techniques that apply to many of the alternative and composite materials that we discussed.

There are also needs for improved formability, and molding and shaping techniques to go with these materials. There are questions as to availability and the time scales for availability where paper studies would be appropriate. For some of the more exotic materials, there are overriding cost considerations. Research needs to be done in the basic refining process in order to get the kind of cost breakthroughs that are required for large scale use.

The energy consumption throughout the life cycle of the material was discussed--everything from mining to the ultimate disposal. There was concern that the environmental and health effects of the large scale use of new materials be addressed early so that there will be no downstream surprises or adverse consequences. Again, this should start with the source of the raw materials, the manufacturing processes, the actual use of the materials on the road, the repair industry, the possible recycling of the materials, and their ultimate disposal.

There was also a general feeling that for some of the materials, the physical properties need improvement. This is basically the purview of the metallurgist and polymer chemist. For some of the materials, better knowledge and documentation of the properties are needed so that the design engineer can more effectively and confidently use them.

The second area into which we divided our research was "structures." This is a higher level of aggregation--something that is made out of materials. Here we talked about both improved crashworthiness of the structure as well as its weight reduction potential. The feeling is that you could view safety as a constraint on the weight reduction potential, but both of these goals can be achieved simultaneously and become an integral part of the design process.

The priority areas that we identified include a better quantification of the dynamic load inputs that the structure is required to withstand. Because of this uncertainty, there is now a great deal of overdesign of components. In a similar vein, the design and analysis tools are in rudimentary shape--again resulting in conservatism and more weight. Better knowledge of the response of these structures under dynamic loading conditions (both under actual road usage as well as in the crash environment) is an important advance. Computer graphics design tools and software are logical extensions here.

Other areas of payoff are improved vehicle configurations in terms of the placement of parts, the integration and the optimization of functions, and in some cases, using clever design principles to have one part serve multiple functions.

The first two areas, structures and materials, have the primary goals of weight reduction and/or safety improvement. The third area has the goal of road load reduction and thus reducing the energy required from the powerplant. We broke road load reduction into three parts: aerodynamic drag, tires, and friction and lubricants.

The first is the aerodynamic drag of the vehicle. The highlights include improved testing methods and facilities for conducting the testing; a better understanding of flow fields; and better design data and handbooks--perhaps similar to what NACA did for airplanes a few decades ago. Recognizing that the car is inherently a blunt body, it will be necessary to develop flow control devices to help reduce its drag. It was pointed out here that there is a tradeoff in vehicle configuration between the more upright "boxy" structure (which would provide more efficient packaging) and aerodynamic drag. This is a systems-level tradeoff that has to be examined.

The second area under road load reduction is tires. There was considerable concern about the test methodology for actually assessing the road losses of tires, and the comparison between various laboratory techniques and actual on-the-road, real world losses. There is a problem of low inflation pressure, and it is necessary to detect pressure loss and/or maintain the air in the tires. Another tire research area is the run-flat tire. The panel felt that problem has not been solved yet and that the payoff would be there in terms of reduced weight and increased cargo capacity.

The third area under road load reduction is "tribology," which is the study of friction, lubricants and bearings. It was pointed out that the savings in this area are small under normal temperatures, but they are much more substantial under cold weather conditions. Thus, the focus of this research should be on the low temperature problem.

Our fourth area of research we labeled "other subsystems" as a catchall for everything we haven't discussed up to this point. We have a shopping list of things here which I'll discuss very quickly. There are research topics in suspension, lightweight wheels, brake systems--including antilock and radar warning systems, and a number of things related to accessories. The latter include windshield wipers, air conditioners, and heating systems. It should be possible to reduce their weight, as well as their energy consumption, and possibly integrate some of these accessories with the powerplant.

There are also a number of operating systems that were discussed including: electronic speed control tied-in with cruise control, heads-up displays for drivers, and various kinds of radar and warning systems. The design of the front end of the car to protect pedestrians and cyclists was listed under this particular area and is certainly a design consideration for this time period. We also included an area of behavioral research under this topic which has to do with how drivers drive from an energy consumption point of view. There may be things you can do to educate the driver, or to provide him with the right kinds of displays, so that he would drive in a more energy efficient and, may I add, safe manner.

The fifth research area includes the actual test and evaluation of components and integrated vehicle systems. We highlighted the question of scale model testing and the methodology of scaling-up to full size. Better analytical techniques for assessing full-scale tests are needed as well as nondestructive testing methods. In addition, there is a need for better methods for collecting data on durability, customer acceptance, and other items that can only be demonstrated at the integrated vehicle level.

Finally, our last area is what I would call "systems analysis." It would be an ongoing activity which parallels the other research activities and would perform the needs analysis; set requirements and targets for various research projects; develop decision making methodologies on a cost/benefit basis (and integrate the design decision making between the safety and the fuel economy goals); and handle such questions as the effects of changes in the lifetime and durability of the car on the life cycle cost.

It would also be very valuable under this task to develop an inventory of ongoing research and communicate the results of this research to the entire automotive community.

These are the highlights of the six areas we discussed. As I said, we have had a very interesting time, and we will have a much more detailed statement in our final written report.

Thank you.

GENERAL SUMMATION

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GENERAL SUMMATION

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Ladies and gentlemen, we have heard now from our three panels. We have heard excellent summaries of their discussions. I listened to all three panels part of the time and I felt that in the time that was available they did a tremendous job. Now our task, the task that I have and the task that the Panel Chairmen and Dr. Costantino and his staff at TSC have, is to bring this all together into a series of coherent recommendations to the Secretary of Transportation within about thirty days. So we will be working in the meantime to take what you have given us and bring it together into a report.

I would like to emphasize that in preparing this report, we are discussing basic research opportunities, I recognize, as all of you do, that there is no sharp line between basic research and applied research, and we will not try to establish that line with any precision, but we will be looking at those research opportunities that are aimed at achieving a better understanding of the physical and chemical processes that are relevant to automotive technology, and not looking at the design of vehicles, engines, et cetera. We have to be clear on this point because it seems to me that this is the one area where intervention by the Federal Government is accepted by most of us.

The Federal Government is, by far, the largest contributor to basic research dollars in the United States, and that contribution and that role seem to be pretty well accepted. Indeed, it seems to have been accepted for many years. Perhaps the most notable early acceptance of that role was in the passage of the Morrill Act in the 1860s which created the agricultural research stations at the universities. That seems to have been a successful intervention into basic research on the part of the Government because our agricultural system has certainly been a most effective system. We, of course, have had many other examples in the past of Federal intervention in basic research. The creation of the NACA in 1915 and its expansion throughout the 1920s and 1930s as an organization which had as its sole aim, basic research to contribute to aeronautical technology is another successful example of this Federal intervention.

During World War II, the OECD, which many of you are familiar with, was later converted by President Roosevelt at the suggestion of Vannevar Bush into the National Science Foundation. That organization has gorwn over the years as a supporter of basic research; indeed, it is the principal supporter of basic research in many areas such as astronomy and mathematics, in the United States. Now that is not the kind of basic research intervention we are talking about here. Indeed Vannevar Bush's idea was research without thought of practical end. In the running of the NSF there is a funding of all kinds of research proposals which show promise of extending the area of knowledge in fields such as physics, chemistry, math and biology. It seems to me that what we are talking about here is something that would be modeled more after the ONR kind of activity, namely, basic research which is highly relevant to automotive technology.

As I listened to these panel reports (I heard them only just before you did, and, of course, I heard them in detail just as you did) it seemed to me that there were some threads that ran through them. It would not be useful for me to try to repeat anything that has been said because they have been described very fully already. One of the threads that ran through the reports of the three Panel Chairmen is the need to look at automotive systems, the need to develop methods of analysis of automotive systems, and the need to formulate our research directions after looking at the total engine, vehicle, fuel system in a cradle to grave mode. We must look at the consumption of energy, the production of environmental pollutants, the environmental and health aspects, and recycling considerations. Clearly, a portion of this basic research program ought to be devoted to this kind of total systems look, not only so that we can route our own thinking more clearly on what we are doing, but also so that we can more ably judge what is important and what is not in making these kinds of basic research investments.

Another thread that went through the reports of the three Panel Chairmen is the necessity of integrating the Federal and private sector activities in designing a program of basic research by the Federal Government. This is a special challenge to us because there is a great deal of work now going on in the private sector, and the Federal Government should take that into full account before it commences anything. It is a special challenge because in many other areas of basic research the Federal Government is almost the one hundred percent contributor, and it is quite easy to design programs on that basis.

Another thread that went through the reports of the Panel Chairmen is that we need certainly to look at a thermodynamic assessment of the opportunities for research. We have to look at what really can be done with powertrains, what really can be done with reduction of friction, in order to assess where we should put our monies in a program of basic research. I got the feeling from the panelists that they felt that the basic research which is now being conducted in their areas is insufficient in comparison with the opportunities that are available to us as a result of such research and the importance of the problem.

We all believe that what we have here today is a long way from a detailed research agenda and that much additional planning and staff work is needed before a final research program could be proposed to the Secretary of Transportation and to Congress.

I found rather interesting the suggestions that professional societies and their committees could be used in aiding the Department of Transportation and Dr. Costantino and his staff in designing a Federal research program. That seems to me to be a splendid idea and it is one that came from several of the panels. Indeed, in thinking about how these professional societies might be employed to aid in this activity, it was also suggested that better documentation of basic information and data is required. That certainly is another place where the societies can contribute Better communication of research results is another thing that is needed, and professional societies would also be very helpful in that respect.

In planning a basic research program, from the reports of the chairmen, one can identify threads of disciplines--and I am sure that when Dr. Costantino looks at this he will identify a lot of what he does in terms of disciplines--such as friction, combustion, materials, lubrication, heat transfer, fluid mechanics et cetera.

It was also suggested that we have a way, a very positive way, of assessing risks and benefits of such a program by frequent reviews and by identification of areas that may be emerging through basic research that merit hot pursuit on the part of the private sector.

Those are a few of the threads that I identified as I went through all of this. I did get the feeling that all of you felt that there were significant improvements achievable in systems that are now in use through a better understanding of the internal physical processes of those systems, and that understanding can be gotten by basic research.

You will be hearing from us. At least Secretary Adams will be hearing from us in about thirty days. He has told me that he intends to make this report public soon thereafter and all of you will be receiving copies of it. It is also planned to have another similar conference in mid-April to deal with the second part of the question: Once you have a research agenda how should it be implemented? What process should the Federal Government use to stimulate that kind of research agenda? There are lots of ways it can be done. All of you have ideas, I know, that are perhaps much more controversial than the research agenda itself. That is the second step in the process, and although the date has not been set for this conference, it will be some time around mid-April.

I would like to compliment the Department of Transportation on originating and creating this conference and especially, Secretary Adams, Dr. Palmer and Dr. Costantino who has had the job of putting it together in a very short length of time. They have done a splendid job. The kind of interchange that we have had among industry, universities, and government is, as far as I can see, unique in terms of basic research in automotive technology. I believe that is was badly needed and that it has been helpful to everyone who came.

I would like to thank the panelists and the Panel Chairmen for a splendid job, and I would like to thank all of you for coming and taking part, and especially for staying until the bitter end.

This conference is adjourned.

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