Partnership Plan

March 2006

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Section I. Executive Summary

The FreedomCAR and Fuel Partnership (the Partnership)[†] began in September 2003 as an expansion of the FreedomCAR Partnership, which was originally established in January 2002 by Secretary of Energy Spencer Abraham and senior executives of DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation. The CAR in FreedomCAR stands for Cooperative Automotive Research.

The Partnership is an effort to examine and advance the pre-competitive, high-risk research needed to develop the component and infrastructure technologies necessary to enable a full range of affordable cars and light trucks, and the fueling infrastructure for them that will reduce the dependence of the nation's personal transportation system on imported oil and minimize harmful vehicle emissions, without sacrificing freedom of mobility and freedom of vehicle choice.

The partners are: the United States Department of Energy (DOE), BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, Shell Hydrogen LLC, and the United States Council for Automotive Research (USCAR)—a legal partnership among DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation.

National Benefits

The long-term vision of the Partnership is a clean and sustainable transportation energy future. While no single strategy will transform the United States from imported petroleum dependency in the near term, addressing energy source and consumption in the transportation sector is particularly critical to enable individual companies to make decisions regarding the high volume commercialization of vehicles and fuels that will enable that future. The transportation sector consumes two-thirds of the petroleum used in our nation and is virtually dependent upon it.

The Partnership strives to provide a historic opportunity to support the development of technologies that could potentially transform the U.S. personal transportation system to one that uses sustainable energy resources and produces minimal criteria or net carbon emissions on a life cycle or well-to-wheel basis. Fuel cell vehicles fueled by hydrogen, especially hydrogen derived from renewables, will make an important contribution toward achieving this vision. Success will help maintain U.S. leadership in environmental and energy technologies and will be a key to ensuring future U.S. competitiveness.

The "Freedom" principle is framed by:

- Freedom from dependence on imported oil;
- Freedom from pollutant emissions;
- Freedom for Americans to choose the kind of vehicle they want to drive, and to drive where they want, when they want; and
- Freedom to obtain fuel affordably and conveniently.

[†] The FreedomCAR and Fuel Partnership is not a legal entity and it is not intended that the "partners" have the responsibilities or rights of legal partners. Rather, everywhere that "Partnership" and "partners" are used it is used in an informal sense to denote participants working together towards the stated goals of the group.

Organization Structure

The partners jointly conduct technology roadmapping, determine technical requirements, suggest research and development (R&D) priorities, and monitor the R&D activities necessary to achieve the Partnership's Research Goals.[‡]

The Partnership functions through: the Executive Steering Group, the FreedomCAR Operations Group, the Fuel Operations Group, and the Technical Teams. Each organizational unit contains government and industry participants, an arrangement that seeks consensus on all key FreedomCAR and Fuel goals, activities and decisions. No proprietary information is introduced into the Partnership process.

Technical Scope

A major thrust of the Partnership is to examine and advance precompetitive research and development of technologies to enable high volume production of affordable hydrogen fuel cell vehicles, and the national hydrogen infrastructure necessary to support them. The Partnership also examines and advances precompetitive R&D for other advanced automotive technologies through the continuation of key enabling research on advanced internal combustion engines and emission control systems, lightweight materials, power electronics and motor development, high-power/energy battery development, and alternative fuels. Each of these advanced technologies also has the potential to dramatically reduce oil consumption and environmental impacts in conventional, hybrid and/or hydrogen fuel cell vehicles.

All the partners independently undertake their own research activities on advanced light-duty vehicle and/or fuel technologies relevant to achievement of the vision or through separate legal arrangements. The USCAR partners jointly conduct related collaborative precompetitive R&D. Companies will make independent decisions on commercialization depending upon establishment of viable business cases.

Milestones and Timing

The partners have adopted aggressive technology-specific Research Goals for 2010 and 2015, listed in Figure 3, to promote R&D innovation. Technical progress is evaluated by the achievement of technical milestones for individual technologies and by hardware-in-the-loop simulated full-system validation.[§] Also, an independent party such as the National Academy of Sciences/National Academy of Engineering will conduct a biennial review of the Partnership to evaluate progress and program direction.

[‡] Research Goals are the technology specific goals listed in Figure 3 determined by the methodology outlined on page 4. These goals form the criteria against which the Partnership will assess specific research directions and overall progress of the Partnership's efforts.

[§] Hardware-in-the-Loop is considered to be "a full computer simulation (computer model) where one or more components of the model are replaced with actual hardware before a simulation is run."

How to Participate

Additional information about the Partnership and ways to participate can be found at the following locations:

For More Information	**Contact Us**
http://www.uscar.org/	FreedomCAR@USCAR.org
http://www.eere.energy.gov/vehiclesandfuels/	FreedomCAR@ee.doe.gov
http://www.eere.energy.gov/hydrogenandfuelcells/	202-586-8055

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Section II. Introduction

Description

The Partnership includes participants from the United States Department of Energy (DOE), BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, Shell Hydrogen LLC and the United States Council for Automotive Research (USCAR). USCAR was formed by the major domestic automakers—DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation. The Partnership is an effort to examine and advance the pre-competitive, high-risk research needed to develop the component and infrastructure technologies necessary to enable a full range of affordable cars and light trucks, and the fueling infrastructure for them that will reduce the dependence of the nation's personal transportation system on imported oil and minimize harmful vehicle emissions, without sacrificing freedom of mobility and freedom of vehicle choice.[**]

The long-term vision for the Partnership is a clean and sustainable transportation energy future. Fuel cell vehicles running on hydrogen offer a promising pathway and could provide more than double the energy efficiency of today's vehicles while emitting only water and heat. In the nearer term, renewable fuels and clean carbon-based fuels used in advanced internal combustion engines can make a significant contribution toward reducing future petroleum consumption and vehicle emissions. Increased feedstock diversity, where hydrogen and other advanced fuels are produced from a combination of potential sources (renewables, nuclear energy, natural gas, coal and petroleum) could further reduce the dependence of the transportation sector on petroleum. Producing these fuels using clean, efficient, cost-effective new technologies (including carbon capture) may offer an affordable means of achieving environmental, energy and transportation goals.

The advanced technologies focused on by the Partnership should assist in the creation of a sustainable future in which environmental, energy security and transportation priorities are reconciled. Success will help maintain U.S. leadership in environmental and energy technologies and will be a key to ensuring future U.S. competitiveness.

A major thrust of the Partnership is to identify and address the technologies necessary to enable high volume production of affordable hydrogen fuel cell vehicles and fuels, and the national infrastructure necessary to support them. Additionally, the Partnership addresses technology needs to enable mass penetration of hybrid electric and advanced combustion vehicles that also offer the potential to significantly reduce the nation's dependence upon imported oil. To achieve this goal, the partners have developed the following strategic approach:

- Support technologies to enable high volume production of affordable and reliable hydrogen fuel cell vehicles and a hydrogen infrastructure.

- Support advanced vehicle and fuel technologies to significantly reduce oil consumption and environmental impacts in the nearer-term.

[**] The FreedomCAR and Fuel Partnership is not a legal entity and it is not intended that the "partners" have the responsibilities or rights of legal partners. Rather, everywhere that "Partnership" and "partners" are used it is used in an informal sense to denote participants working together towards the stated goals of the group.

- Support development of component technologies applicable across a wide range of passenger vehicles.

- Independently, each partner will choose how to integrate Partnership results with their technology development activities.

National Benefits

The long-term vision of the Partnership is a clean and sustainable transportation energy future. While no single strategy will transform the United States from imported petroleum dependency in the near term, addressing energy source and consumption in the transportation sector is particularly critical to enable individual companies to make decisions regarding the high volume commercialization of vehicles and fuels that will enable that future. The transportation sector consumes two-thirds of the petroleum used in our nation and is virtually dependent upon it.

The Partnership strives to provide a historic opportunity to further the development of technologies that could potentially transform the U.S. personal transportation system to one that uses sustainable energy resources and produces minimal criteria or net carbon emissions on a life cycle or well-to-wheel basis. Fuel cell vehicles fueled by hydrogen, especially hydrogen derived from renewables, will make an important contribution toward achieving this vision. Success will help maintain U.S. leadership in environmental and energy technologies and will be a key to ensuring future U.S. competitiveness.

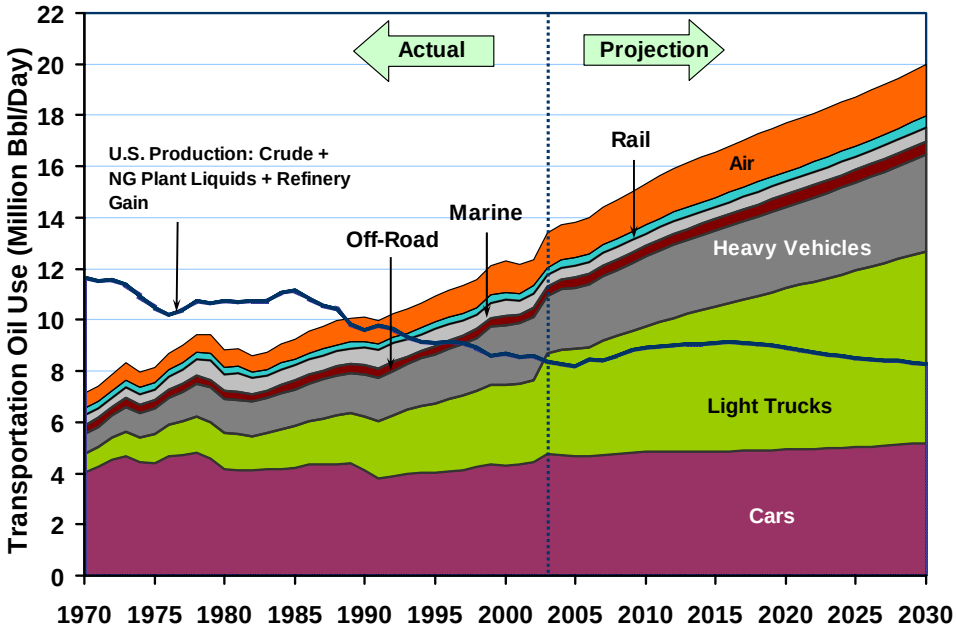
The “Freedom” principle is framed by:

- Freedom from dependence on imported oil;
- Freedom from pollutant emissions;
- Freedom for Americans to choose the kind of vehicle they want to drive, and to drive where they want, when they want; and
- Freedom to obtain fuel affordably and conveniently

The government and industry partners recognize that steadily increasing reliance on imports needed to meet the U.S. demand for energy presents energy security concerns. In 2003, the United States consumed nearly 20 million barrels of crude oil per day, of which over 11 million barrels were net imports. America’s transportation system is over 95 percent dependent on petroleum as an energy source and accounts for more than two-thirds of total U.S. petroleum consumption. Personal transportation (including cars, minivans, pick ups and SUVs) accounts for 60 percent of transportation oil consumption.

Figure 1 illustrates the expanding gap between projected domestic oil production and projected U.S. transportation oil demand. The future oil gap is based on DOE’s Energy Information Administration’s current projections of oil prices, vehicle miles driven, and the U.S. fleet vehicle fuel economy. Significant changes in these factors would have corresponding influences on the size of the gap, greater or smaller. For example, a large increase in the price of oil could be expected to reduce the gap because it would likely spur reactions such as reduced driving and greater domestic production from otherwise marginal wells and, potentially, employment of policy options that could increase domestic exploration and production.

Figure 1
Projected Transportation Oil Use



Source: Transportation Energy Data Book: Edition 24, ORNL-6973, December 2004, and EIA Annual Energy Outlook 2006, February 2006.

Reducing U.S. dependence on imported petroleum will require a multi-tiered approach, including policy initiatives and research programs, across multiple sectors of our economy. The transportation sector has a significant role to play in addressing this challenge, and successful research on advanced technologies will help accomplish the broader national goals and objectives that are being pursued. Success will maintain the United States as a global leader in environmental, energy and transportation technologies and will contribute to future U.S. competitiveness.

Responsibilities

The Partnership is a collaborative effort among DOE, energy companies -- BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, and Shell Hydrogen LLC, and the USCAR partners (DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation). The partners jointly conduct technology roadmapping, determine technical requirements, suggest research and development (R&D) priorities, and monitor the R&D activities necessary to achieve the goals of the Partnership. Technology roadmapping includes identification of existing barriers and challenges, technology-specific R&D goals and milestones needed to progress toward the overall Partnership goals.

DOE has a responsibility to promote the development and validation of hydrogen infrastructure technologies through R&D programs, government procurements, and cooperative demonstrations of hydrogen vehicle fleets and refueling station systems. The USCAR member companies will accelerate the migration of energy-efficient technologies to the marketplace and independently demonstrate progress toward real-world reduction of the petroleum consumption of passenger vehicles. The energy partners seek to accelerate the migration of energy-efficient technologies to the marketplace and independently demonstrate technology that may be relevant to a hydrogen-fueling infrastructure. Dr. Phyllis Yoshida, the DOE coordinator for the FreedomCAR and Fuel Partnership, serves as the central point of contact for all Federal Partnership activities. USCAR serves as the vehicle industry's

administrative arm. The chairperson of the Fuel Operations Group similarly coordinates administrative activities for the energy industry. The organization and operation of the Partnership provide for shared leadership and technical guidance.

The Research Goals are used as the criteria against which the Partnership will assess specific research directions and the overall progress of its efforts. DOE, or DOE and USCAR, are responsible for determining the methodology and other assumptions that will be input into the methodology from which the Partnership's Research Goals will be derived. The projected prices of energy feedstock, energy products and other alternative energy sources, used to assess pathways for production of energy carriers such as hydrogen, are not provided by the Partnership but come from DOE and DOE identified third party sources.

Furthermore, the original members of the FreedomCAR Partnership determined the following basic assumptions in 2002, prior to the inclusion of energy providers in the expanded FreedomCAR and Fuel Partnership:

1. All new vehicle and fuels options, including hydrogen, have to be cost-competitive with current vehicle and fuels options, including gasoline and diesel.

2. The performance goals determined from the above assumptions have to be pathway independent.

Technical Scope

The partners have jointly identified the technology breakthroughs that could facilitate the development of fuel cell powered vehicles and the creation of the hydrogen fuel infrastructure to support them. The significant barriers that must be overcome include fuel cell stack costs, satisfactory performance in all types of weather, durability, electric drive performance, hydrogen storage practicality, hydrogen production issues including primary energy sources, environmental effects and hydrogen distribution, and refueling infrastructure. Partners also identify data gaps related to vehicular and hydrogen infrastructure codes and standards.

There are many shared components between an advanced hybrid electric vehicle and a fuel cell vehicle, and the Partnership supports research in areas that pertain to both types of vehicles, such as lightweight materials, power electronics, electric motors, and batteries. The Partnership also supports precompetitive R&D in advanced combustion engines (including emissions controls and alternative fuels) that is needed to support the development of advanced vehicles. Such technologies also have the potential to significantly reduce petroleum consumption either alone or in hybrid vehicles.

Milestones and Timing

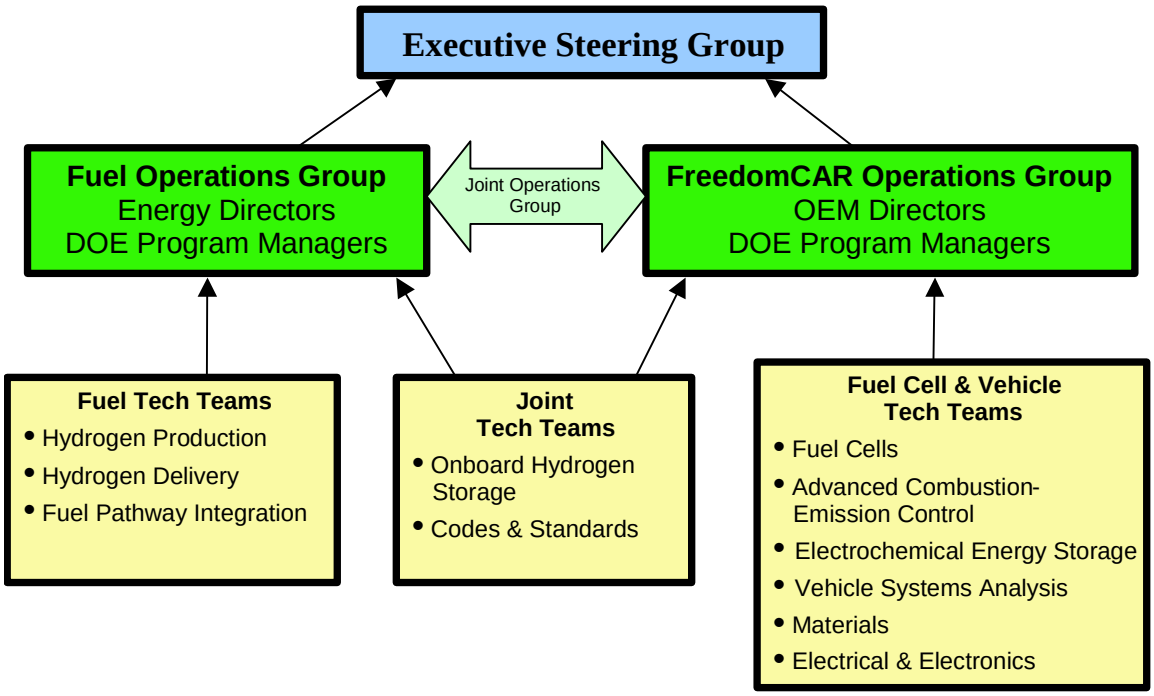
To measure progress toward the long-term vision, the partners have identified a number of technology-specific goals for the years 2010 and 2015. As business cases for the technologies can be established, industry partner companies will make independent decisions concerning commercialization. In the case of hydrogen fuel cell vehicles, commercialization will depend jointly on the economic viability of the fuel cell system as well as the widespread availability of affordable hydrogen fuel. In the case of a hydrogen infrastructure, commercialization will depend jointly on technical and economic viability of production, storage, delivery and dispensing technology as well as the clear development of a market for fuel cell vehicles.

Section III. Structure, Responsibilities, and Management Process

ORGANIZATION STRUCTURE

The Partnership consists of the Executive Steering Group, the FreedomCAR Operations Group, the Fuel Operations Group, and the Technical Teams. Each of these units has government and industry participants, an arrangement that seeks consensus on all key Partnership activities. Each of these groups operates in a transparent manner. No proprietary information is introduced into the Partnership process.

Figure 2
FreedomCAR and Fuel Partnership Organization



The **Executive Steering Group (ESG)** is responsible for the governance of the Partnership, including Partnership program direction and policy decisions. The ESG is comprised of the Department of Energy (DOE) Assistant Secretary for Energy Efficiency and Renewable Energy and a vice presidential or presidential level executive from each of the Partnership companies. ESG members participate as peers with no designation of officers.

The ESG meets as needed. The Department of Energy, USCAR, and the energy partners host the meetings in rotation. The meetings focus on overall partnership issues, automotive technology issues, and hydrogen technology issues. ESG meetings provide for an exchange of objectives, concerns, and issues by the members of the Partnership. To that end, varying opinions will be sought and addressed in order to seek a mutual understanding among members.

FreedomCAR Operations Group

Comprised of Directors from the Department of Energy and USCAR member companies, the FreedomCAR Operations Group is responsible for direction of the vehicle technical teams, and provides direction to the automotive members of the joint technical teams. The primary focus of the FreedomCAR Operations Group is to discuss and prioritize research issues important for the partners' research activities for advanced light-duty vehicle technologies relevant to achievement of the Partnership goals. The primary responsibilities of the FreedomCAR Operations Group are as follows:

- Planning, development, prioritization and evaluation of the technical R&D program.
- Assure availability of the needed technical expertise within government and industry.
- Input into preparation and scope of the biennial external technical program review.
- Endorse vehicle technical team roadmaps.

Fuel Operations Group

Comprised of Directors from the Department of Energy and the energy partner companies, the Fuel Operations Group is responsible for direction of the fuel technical teams, and provides direction to the energy members of the joint technical teams. The primary responsibilities of the Fuel Operations Group are as follows:

- Evaluate and suggest technical R&D pathways and program priorities.
- Seek to make available the necessary technical expertise from the partners.
- Input into preparation and scope of the biennial external technical review.
- Endorse fuel technical team roadmaps.

Joint Operations Group

Periodically, the FreedomCAR and Fuel Operations Groups hold Joint Operations Group meetings for an exchange of information and views on issues of mutual interest. In addition, the Joint Operations Group identifies Partnership strategic and policy issues that warrant ESG consideration and identifies opportunities for the ESG to meet to discuss these issues. The Joint Operations Group facilitates ESG meetings, including jointly developing the agenda and other meeting materials. The Joint Operations Group endorses the roadmaps for the joint technical teams' roadmaps.

Technical Teams

Technical teams—consisting of scientists and engineers with technology-specific expertise from the USCAR member companies, energy partner companies, national laboratories, and DOE technology development managers as well as other Federal agencies if approved by the appropriate Operating Group/Groups. Technical teams have non-proprietary discussions and are responsible for developing

R&D plans and roadmaps, reviewing research results, and evaluating the technical progress toward meeting the Partnership's Research Goals. The technical teams:

- Identify comprehensive technical goals related to improving the energy efficiency and cost of vehicles and/or to establishing a national hydrogen infrastructure;
- Assess overall appropriateness of technical goals on a systems and benchmarking basis;
- Identify data gaps and R&D needs;
- Identify technical expertise to undertake the technical effort;
- Establish technical milestones and timing;
- Monitor progress in the R&D programs; and
- Report progress toward goals at regular intervals to the FreedomCAR and Fuel Operations Groups and to external reviewers.

The partners have established the following technical teams:

Vehicle Technical Teams (Members from the USCAR partners and DOE)

- Fuel Cells
- Advanced Combustion and Emissions Control
- Vehicle Systems Analysis
- Electrochemical Energy Storage
- Materials
- Electrical and Electronics

Joint Technical Teams (Members from the USCAR partners, the energy partners and DOE)

- Onboard Hydrogen Storage
- Codes and Standards

Fuel Technical Teams (Members from the energy partners and DOE)

- Hydrogen Production
- Hydrogen Delivery
- Fuel Pathway Integration

The technical team structure will continue to be assessed and additional teams may be added to or removed from this list as the demands and needs of the Partnership evolve.

MANAGEMENT PROCESS

The Partnership management process follows the standard approach of planning, execution, evaluation, and reporting. The process is implemented in a cyclical and iterative sequence that constantly uses new information to modify the plans and actions of the Partnership.

Planning—Planning is conducted collaboratively within the Executive Steering Group, the Operations Groups, and the technical teams. The Executive Steering Group is responsible for the governance of the Partnership, including Partnership program direction and policy decisions, and monitoring overall Partnership progress. The Operations Groups assess program priorities and develop operational procedures that are required to implement guidance from the Executive Steering Group's Partnership policy and strategic decisions. The technical teams are responsible for plans that define technical targets, identify barriers, and suggest the technical approaches and program milestones necessary to achieve the

Partnership's Research Goals. These plans are called roadmaps and the technical targets within them support technology-specific 2010-2015 goals (see Figure 3).

Execution—Accomplishment of the objectives of the Partnership requires collaborative, pre-competitive, high technical-risk R&D. Research funded by DOE is conducted primarily through competitively solicited contracts, cooperative agreements, cooperative research and development agreements (CRADAs), and research grants, or through funding of the DOE national laboratories' annual operating plans. Participation in CRADAs and cooperative agreements by industry usually depends on the degree of risk associated with a project. Industry support of R&D may be in the form of direct funding or in-kind contributions (e.g., staff participation, industry laboratory efforts, or contributions of equipment).

The DOE intends to fund R&D activities at the national laboratories, traditional and non-traditional automotive suppliers, universities, small businesses, and other research institutions. It is expected that direct funding by DOE to partner companies or consortia will be limited. In general, DOE research projects will be selected competitively, and DOE R&D funding decisions are made independently.

Evaluation—Because the priorities and relevance of the research activities change, the Operations Groups regularly measure technical progress and review the potential significance of all projects. DOE conducts an annual merit review of all national laboratory research activities and will assemble a team of industry and university evaluators to provide an independent assessment of the national laboratory work. The DOE expects to arrange for an external body of experts, such as the National Academy of Sciences/National Academy of Engineering, to conduct an independent biennial review of technical progress and program direction. Based on these and other evaluations, resource availability, and other factors, the Partnership's leadership will consider new opportunities, make adjustments to program targets, and set priorities as appropriate.

Reporting—Detailed results of DOE funded R&D efforts are documented in summary reports, annual progress reports, review meetings and workshops, and technical journals. Significant results also can be found at the DOE web site at http://www.eere.doe.gov and at the USCAR web site at http://www.uscar.org. (Some detailed results, such as those resulting from CRADAs, may not be immediately available to the public because of the need to protect the intellectual property rights of the cost-sharing participants.) The Partnership leadership and participants in R&D projects take part in public meetings, workshops, symposia, and conferences in order to disseminate information about the program, its progress, and the continuing technical interests of the Partnership. These meetings include the exchange of only non-confidential, non-proprietary information.

Section IV. Technical Scope and Objectives

Consistent with U.S. government initiatives to reduce dependence on imported oil and to promote the development of hydrogen as a transportation fuel, a primary emphasis of the Partnership is on fuel cells and enabling technologies, and on hydrogen infrastructure technologies. However, recognizing that developing the necessary affordable hydrogen infrastructure and fuel cell vehicle technology is a long-term effort, the Partnership also considers high-efficiency, petroleum-based technologies that have the potential to dramatically reduce petroleum consumption and further reduce adverse environmental impacts. The Partnership focuses on component, sub-system and infrastructure technologies to achieve these goals.

The partners have adopted challenging high-level technical goals and timetables for R&D to accelerate advancements in technologies that enable reduced oil consumption and increased energy efficiency in passenger vehicles.

The Partnership addresses:

- Integrated Systems Analysis
- Fuel cell power systems
- Storage systems for hydrogen
- Technologies for the production and distribution of hydrogen necessary for the viability of hydrogen vehicles
- The technical basis for codes and standards to support hydrogen vehicles and infrastructure and the interface between them
- Electric propulsion systems applicable to both fuel cell and internal combustion/electric hybrid vehicles (e.g., power electronics, electric motors)
- Lightweight materials
- Electrical energy storage systems (e.g., batteries, power capacitors)
- Advanced combustion and emission control systems for internal combustion engines (employing a variety of fuels such as diesel, hydrogen, and renewable blends, and investigating innovative concepts such as homogeneous charge compression ignition systems, variable compression ratio, in-cylinder exhaust gas recirculation, etc.)

Technical challenges that affect significant affordability and manufacturability issues also are addressed.

The list of technologies to be addressed will be continually reevaluated as new opportunities arise. The partners have adopted the aggressive technology-specific Research Goals for 2010 and 2015 listed in Figure 3 in order to promote R&D innovation and to facilitate automotive and energy company commercialization decisions by 2015. The partners have identified interim technical requirements and milestones (see Section V). Where interim milestones exist, they will be updated as deemed appropriate by each technical team to measure progress toward accomplishing the 2010 and 2015 goals. Technical progress will be assessed by hardware demonstrations confirming the achievement of technical milestones and by hardware-in-the-loop full-system simulation. Technical progress and program direction will be assessed annually by the partners via the DOE annual program reviews, by technical team and Operations Group reviews, and biennially by an external panel of experts.

Figure 3
Technology-Specific 2010 and 2015 Research Goals[1]

This figure summarizes the key technical goals for the 2010 and 2015 time frames. The technical teams will identify the need for additional goals as appropriate for proposal to the Executive Steering Group.

- To ensure reliable systems for future fuel cell powertrains with costs comparable to conventional internal combustion engine/automatic transmission systems, the goals are:
  - Electric Propulsion System with a 15-year life capable of delivering at least 55kW for 18 seconds, and 30kW continuous at a system cost of $12/kW peak.
  - 60% peak energy-efficient, durable fuel cell power system (including hydrogen storage) that achieves a 325 W/kg power density and 220 W/L operating on hydrogen. Cost targets are at $45/kW by 2010 ($30/kW by 2015) .[2]
- To enable clean, energy-efficient vehicles operating on clean, hydrocarbon-based fuels powered by internal-combustion powertrains, the goal is:
  - Internal combustion engine powertrain systems costing $30/kW, having a peak brake engine efficiency of 45%, and that meet or exceed emissions standards.
- To enable reliable hybrid electric vehicles that are durable and affordable, the goal is:
  - Electric drivetrain energy storage with 15-year life at 300 Whr per vehicle with discharge power of 25 kW for 18 seconds and $20/kW.
- To enable the transition to a hydrogen economy, ensure widespread availability of hydrogen fuels, and retain the functional characteristics of current vehicles, the goals are:
  - Demonstrated hydrogen refueling with developed commercial codes and standards and diverse renewable and non-renewable energy sources with a cost of energy from hydrogen equivalent to gasoline at market price, assumed to be $2.00-3.00 per gallon gasoline equivalent produced and delivered to the consumer independent of pathway by 2015.[3]
  - On-board Hydrogen Storage Systems demonstrating specific energy of 2.0 kWh/kg (6 weight percent hydrogen), and energy density of 1.5 kWh/liter at a cost of $4/kWh by 2010 and specific energy of 3.0 kWh/kg (9 weight percent hydrogen), 2.7 kWh/liter, and $2.00/kWh by 2015.
  - Internal combustion engine powertrain systems operating on hydrogen with a cost target of $45/kW by 2010 and $30/kW in 2015, having a peak brake engine efficiency of 45%, and that meet or exceed emissions standards.
- To enable lightweight vehicle structures and systems, the goal is:
  - Material and manufacturing technologies for high volume production vehicles which enable/support the simultaneous attainment of:
    - 50% reduction in weight of vehicle structure and subsystems
    - affordability, and
    - increased use of recyclable/renewable materials.

1. Cost references based on CY 2001 dollar values. Where power (kW) targets are specified, those targets are to ensure that technology challenges that would occur in a range of light-duty vehicle types would have to be addressed.
2. Does not include vehicle traction electronics.
3. Based on lower heating value of hydrogen; allows over 300-mile range.

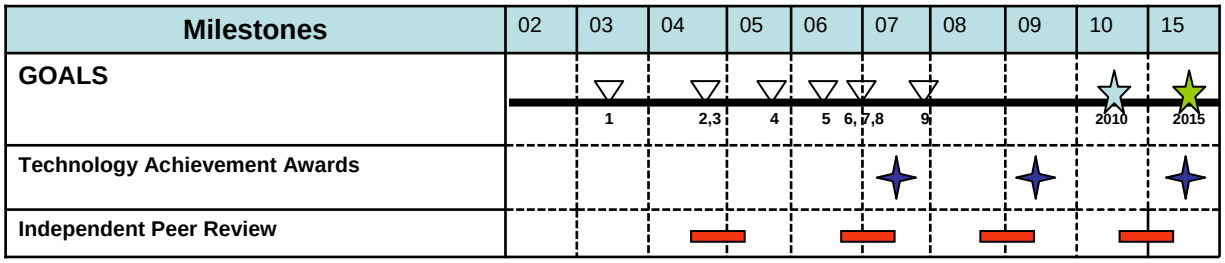
Section V. Interim Milestones and Timing

The Partnership is not designed to produce any particular vehicle or advantage any particular technology, but rather to accelerate the adoption of advanced automotive technologies targeted toward a broad range of vehicles and the technologies needed to develop the hydrogen infrastructure. Recognizing the goal of high volume production of hydrogen-fueled fuel cell vehicles is long-term, the Partnership also supports technologies such as advanced internal combustion hybrid vehicles, batteries, materials, and advanced electronics that will contribute to reduced petroleum consumption in the nearer term and are necessary for the successful commercialization of fuel cell vehicles. The partners have established aggressive technology-specific Research Goals for 2010 and 2015 (shown in Figure 3) in order to promote R&D innovation. Each technical team as appropriate will determine interim technical requirements and milestones to support progress toward accomplishing the 2010 and 2015 Research Goals. A partial list of interim milestones is shown in Figure 4. Technical progress will be assessed by the achievement of technical milestones for individual technologies and by validation.

The term "Validation" in the context of the interim milestones listed in Figure 4 is defined as "confirmation that the technical targets defined within each milestone for a given technology are met." The confirmation may be in the form of one or a combination of the following: analysis, simulation, bench test, hardware-in-the-loop, etc. Hardware-in-the-Loop is considered to be "a full computer simulation (computer model) where one or more components of the model are replaced with actual hardware before a simulation is run." Factors to be considered in choosing the appropriate validation method include availability of resources, scale-up issues, and the extent to which the chosen methodology represents real-world applications/conditions. The validation methodology for the interim milestones will be defined by the associated technical teams and will most likely vary.

DOE and USCAR sponsor the FreedomCAR and Fuel Technology Achievement Award. It will be awarded to recognize exceptionally productive collaborations between government and industry researchers that make outstanding contributions to advancing the state of the art of automotive, and related hydrogen, technology and the success of the Partnership.

Figure 4
FreedomCAR & Fuel Partnership Interim Milestones



Milestones

1. Pre-production prototypes of the Automotive Integrated Power Modules and Electric Motor Drive completed (1Q, 2003)
2. DOE Fuel Cell Advanced Fuel Processing Go/No-Go Decision and Technology Downselect to meet 2010 targets completed (3Q, 2004)
3. Full-scale lithium-ion battery pack demonstrated via Hardware-in-the-Loop completed (4Q, 2004)
4. Validate fuel cell interim cost target of $125 per kW completed (4Q, 2005)
5. Intermediate, Integrated, Series Electric Drive Systems Technology Validated (2Q, 2006)
6. DOE Downselect advanced hydrogen storage concepts showing potential to meet 2010 targets (4Q, 2006)
7. Durable NOx and PM emission control technologies validated (4Q, 2006)
8. Hardware-in-the-Loop testing of advanced energy storage device completed (4Q, 2006)
9. Demonstrate integrated hydrogen refueling stations using advanced components to meet interim hydrogen fuel cost target (4Q, 2007)

FreedomCAR & Fuel 2010 Goals

FreedomCAR & Fuel 2015 Goals

FreedomCAR and Fuel Technology Achievement Awards

Independent Peer Reviews

Section VI. How to Participate

The USCAR member companies, energy partner companies and DOE have historically maintained a close affiliation with other developers and suppliers of technology, including the supplier community, universities, small businesses, and individuals. The Partnership seeks out non-proprietary information on technologies from any sources that can make relevant and potentially important contributions toward the attainment of its goals.

Individuals and organizations have the opportunity to participate in FreedomCAR and Fuel activities through several venues. Periodically, DOE will solicit and fund proposals for advanced automotive technology R&D in areas related to Partnership goals. In response, qualified individuals and organizations can submit proposals to receive government funds to pursue promising R&D. For additional information concerning business opportunities and periodic competitive solicitations through DOE, please visit the following website: http://e-center.doe.gov. In addition to periodic solicitations, DOE funding to support activities supportive of Partnership goals is routinely available through existing DOE programs such as these:

- **Graduate Automotive Technology Education (GATE),** managed by DOE, is a multidisciplinary automotive engineering program for graduate students (http://www.eere.energy.gov/vehiclesandfuels/).
- DOE's **Small Business Innovation Research (SBIR)** program is designed to strengthen the role of small businesses in meeting Federal R&D needs, stimulate and foster scientific and technological innovation in the private sector, and increase the commercial application of innovations derived from federally funded research (http://sbir.er.doe.gov/sbir/).
- **Small Business Technology Transfer (STTR**) is closely modeled on the SBIR, with an additional requirement of co-participation by a research institution such as a university, non-profit institute, or contractor-operated, federally funded R&D center (http://sbir.er.doe.gov/sbir/).

Dr. Phyllis Yoshida, the DOE coordinator for the FreedomCAR and Fuel Partnership, serves as the focal point for managing Partnership activities on behalf of the Federal government.

For More Information
http://www.uscar.org/
http://www.eere.energy.gov/vehiclesandfuels/
http://www.eere.energy.gov/hydrogenandfuelcells/

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