Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena California 91109-8099
(818) 354-432'

September 14, 2005

Refer to: 82-10777.TRN

Universal Power Vehicles Corp.
Attention: Mr. Howard A. Foote, Chairman
53975 Avenida Coretz
La Quinta, CA 92253

Subject: JPL Task Plan No. 82-10777, entitled "Mechanically-Fed Metal-Air Fuel Cell as a High Energy Power Source"

Dear Mr. Foote:

The California Institute of Technology, Jet Propulsion Laboratory, a Federally Funded Research and Development Center (FFRDC) for the National Aeronautics and Space Administration (NASA), is pleased to submit one copy of the subject Task Plan, including the original Intellectual Property Agreement (IPA).

As an FFRDC, all work performed under this effort by the Jet Propulsion Laboratory must be conducted solely under the terms and conditions of NASA Prime Contract No. NAS7-03001, as detailed in the section of the Task Plan entitled "Contractual Arrangements" and the enclosed NASA letter entitled "NASA Information for Reimbursable Sponsors."

To expedite processing and acceptance of your check, please follow the instructions as detailed in the section of the Task Plan, entitled "Funding" under Contractual Arrangements.

Your cover letter and/or check should state: "**All work will be performed in accordance with NASA Prime Contract NAS7-03001, under Task Plan No. 82-10777." Include the executed copy of the Intellectual Property Agreement with the cover letter and check.**

Please direct all questions pertaining to technical aspects of this Task Plan to the Task Manager, Mr. Andrew Kindler at (818) 354-4511. For programmatic concerns, contact Dr. James K. Wolfenbarger at (818) 354-3821. For contractual or funding questions, contact the undersigned at (818) 354-2487.

This Task Plan is unsolicited and JPL will not, to the best of its knowledge, be in competition with any private, industrial, or profit-making organization.

Sincerely,

Helen L. Tanabe
Senior Contract Administrator
Reimbursable Task Order Administration

Enclosures

cc: NASA Management Office

National Aeronautics and
Space Administration
Science Mission Directorate

NASA Management Office

180-802
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099

Reply to Attn of: DD000/NMO

August 18, 2005

Subject: **NASA INFORMATION FOR REIMBURSABLE SPONSORS**

The Jet Propulsion Laboratory (JPL) is a government-owned contractor operated Federally Funded Research and Development Center (FFRDC) that conducts programs in Space Science and other scientific areas approved by its sponsor, NASA. JPL is operated for NASA by the California Institute of Technology (Caltech), which is a private educational institution.

Neither JPL nor Caltech is an arm of the Federal Government nor are any of their employee's agents of the Federal Government empowered to bind NASA to agreements with reimbursable sponsors.

Caltech operates JPL under NASA Contract NAS7-03001, which is administered by Federal employees of the NASA Management Office, located on-site at JPL. While Caltech is responsible for preparation of reimbursable proposals and performance of assigned tasks under the contract, agreements sending work to JPL are executed between Contracting Officers of the NASA Management Office, and the sponsor. Please be advised that Federal law places strict constraints on the types of work that an FFRDC, such as JPL, may perform for NASA or other sponsors.

All reimbursable work that NASA agrees to accept under NAS7-03001 must be consistent with its terms and conditions and JPL's mission as an FFRDC as determined by the NASA Contracting Officer.

Details on the reimbursable task order process are available from JPL. Inquiries may be directed to the JPL individuals identified in the Task Plan's cover letter or to the NASA Contracting Officer, Ms. Theresa A. Moulse at (818) 354-4529.

Jeff Lupis
Procurement Officer

MECHANICALLY-FED METAL-AIR FUEL CELL AS A HIGH ENERGY POWER SOURCE

to

Universal Power Vehicles Corp.
53975 Avenida Cortez
La Quinta, CA 92253

JPL Task Plan No. 82-10777

Prepared by:

Andrew Kindler
Task Manager

Prepared by:

Helen L. Tanabe
Senior Contract Administrator

Approved by:

Robert S. Cox, Assistant Director for
National Space Technology Applications

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California 91109

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I. TECHNICAL SECTION

A. INTRODUCTION

1. BACKGROUND

Universal Power Vehicles Corp., is interested in developing a high-energy power source based on metal-air batteries for extending the range of all-electric fleet vehicles. Metal-air batteries can store about three to four times more energy than state of art rechargeable lithium-ion batteries. However, metal air batteries have generally poor electrical rechargeability and thus the metal has to be replenished in order to charge the battery. Therefore, Universal Power Vehicles is specifically interested developing in a unique mechanically rechargeable metal-air battery system that resembles a fuel cell. In such a device the anode is supplied continuously with metal by mechanical means and the cathode uses air from the environment. Thus, the reaction chamber, where the electrochemical reaction occurs, is separate from the reactant storage compartment. The by-products will be separated and the electrolyte can be re-circulated. In these respects it is similar to a fuel cell. One possible design that incorporates the aforementioned features is shown below in Fig. 1. The schematic is not necessarily the optimum design, but it introduces the critical design elements.

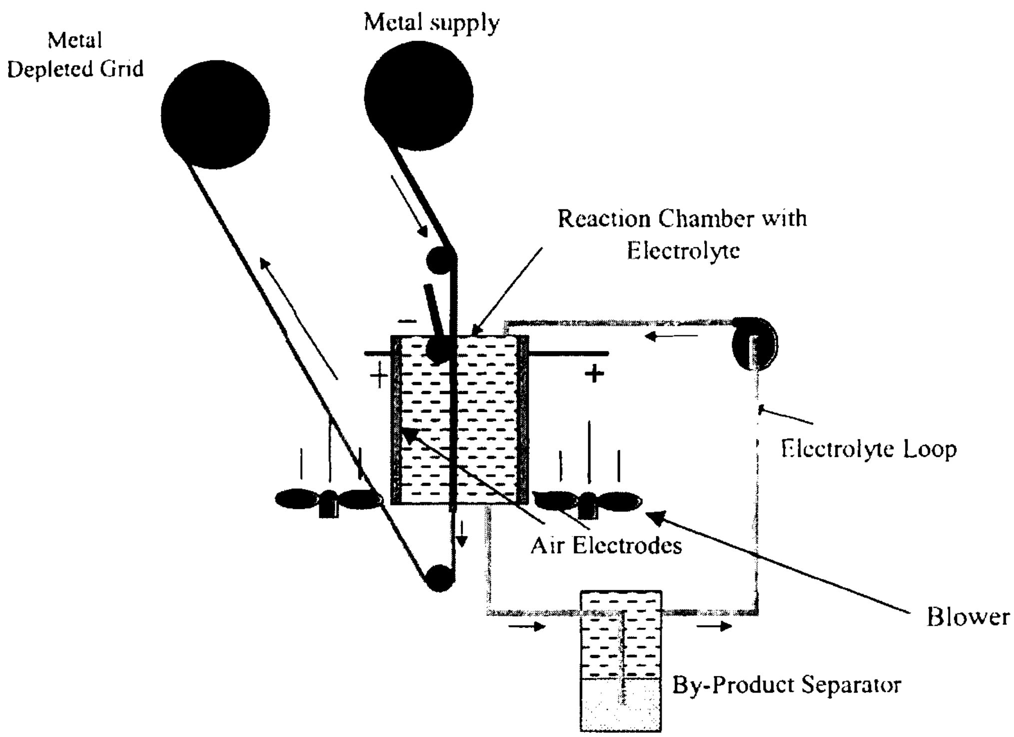


Fig. 1 Schematic of the metal-air power source with mechanically-fed reactants.

In the system represented by Fig. 1, a thin reactive metal strip supported on a grid made of another inert metal. The supported strip is continuously passed through a reaction chamber between two air cathodes. As the electrochemical reaction proceeds, the thin metal strip is dissolved. In order to sustain the reaction, the small volume of electrolyte is continuously refreshed by re-circulation. A variable speed blower provides both cooling air and facilitates the reaction at the cathode. Although Fig. 1 appears to indicate that there are two blowers, in actuality, a single blower will provide air through a manifold. The electrochemical reactions generally produce insoluble byproducts. The electrolyte is cleaned of these by products by use of a separator.

There are at least three advantages of using this mechanically fed configuration.

i) **The metal fuel storage can be "topped off"**. More metal can be added to the fuel storage container to increase the range of the vehicle even before all the metal is exhausted. By contrast, a conventional metal-air battery must be used until the metal is exhausted before replacement, to avoid costs resulting from premature replacement.

ii) **Safety is greatly increased**, since all the active metal is not in the reaction chamber at one time. An electrical short-circuit could only release energy equivalent to the metal in the reaction chamber. The supply of additional metal could be stopped under the control of sensors.

iii) **Corrosion of the metal will be prevented** as a consequence of a limited amount of metal being in the reaction chamber. Corrosion usually occurs when the metal is exposed to electrolyte.

There are several metal air systems that are known. These are Lithium-Air, Aluminum-Air, Magnesium-Air, Zinc-Air, and Iron-Air. Superficially, it may seem that the best possible system would be the one with the highest energy density. In this case, that would be Lithium–Air. However, in reality the choice is not obvious at all. Each metal air system presents slightly different challenges to implementation. For example metals such as lithium are highly reactive and the reactions can be hard to control. Magnesium and aluminum present corrosion issues. In the case of lithium the reaction product lithium hydroxide is highly soluble, while in the case of aluminum and magnesium the hydroxide produced Is insoluble. While lithium prefers to work in an alkaline electrolyte, magnesium and aluminum prefer a solution with neutral pH. There are other distinguishing factors as well. Most metal air systems cannot reach their full potential without overcoming some technical hurdles first. This is why they have had limited application. The exception is the zinc-air system which has reached a high state of development. This system has a high energy density, but not as high as the lithium, aluminum, or magnesium systems. It is better than Iron-Air when compared on the basis of practical energy density. Zinc-Air has a theoretical energy density of 1350 watt-hrskg and a practical energy density of 200 watt-hrs/kg. Iron-Air batteries have been built with 75 watt-hrs/kg. Although laboratory versions of a mechanically fed system have been created, commercial units are strictly batteries with fixed metal electrodes. A mechanically fed version of this type has the highest likelihood of success and the biggest payoff where safety, corrosion and ease of metal delivery are achieved. JPL will consider Aluminum-Air, Magnesium-Air, and Zinc-Air as the most likely candidates.

The proposed task plan is aimed at examining the feasibility of this and related design metal-air fuel cells, and selecting the most promising system, and demonstrating a proof-of-concept laboratory unit.

2. JPL SPECIAL COMPETENCIES

JPL is a lead center for battery and fuel cell research in the country. JPL has developed primary lithium-thionyl chloride batteries, bipolar lead acid batteries, and more recently lithium-ion batteries for NASA and the Department of Defense. JPL has also been involved in the development of direct methanol fuel cells from concept innovation to demonstration of complete stacks and systems. The Electrochemical Technology Group has end-to-end capability to respond to development in both areas of batteries and fuel cells. This capability is particularly unique to the proposed Task Plan on metal-air fuel cell which incorporates both battery and fuel cell concepts. In addition JPL has extensive experience in the area of electrochemical performance characterization and a strong background in the understanding of aqueous batteries based on reactive metals. JPL's capability encompasses materials development, cell design and development, system integration, analysis of performance, modeling and study of failure mechanisms for batteries and fuel cells. This comprehensive range of capabilities is important for accomplishing the proposed task.

B. OBJECTIVE

Phase I

- Determine the power requirements for the delivery vehicle provided by Universal Power Vehicles Corp.
- Conduct a design study to estimate mass and size, identify operational issues, for reactant-fed 100 kW metal-air fuel cell systems and recommend the most promising approach.

Phase II

- Design, assemble and test a 100-watt proof-of-concept system based on the down-selected metal-air system.

Phase III

- Design, assemble and test a 1-kilowatt system based on experience generated in Phase II.

C. APPROACH

This effort will be implemented through the following sub-tasks:

Phase I
Task 1.1 Establishing Power Requirements
Task 1.2 Design Study

Phase II
Task 2.1 Design, assembly and testing of 100-Watt laboratory unit
Task 2.2 Follow on Task Plan for 1 kW unit.

Phase III
Task 3.1 Design, assembly and testing of 1-kilowatt proof-of-concept unit
Task 3.2. Follow-on Task Plan and estimates for 100 kW unit

The following provides detailed technical approach to the various sub-tasks.

Phase I

Task 1.1 Establishing Power Requirements

The power requirements will be determined by measuring the current drawn from the power source for vehicle operation during various phases of operation. Universal Power will provide appropriate shunt arrangements for measuring the currents and taps for voltages. JPL will multiplex the voltage/current inputs and acquire the data using an on-board laptop computer. The data will be gathered for typical drive profiles and analyzed. This data will also be used to support Task 1.1 in order to identify the requirements for the design study, Task 1.2.

Task 1.2 Design Study

This task is aimed at achieving the following:

a) Estimates of the weight, and volume of different metal air systems including fuel
b) Identification of issues with electrolyte and fuel regeneration
c) Analysis of a hybrid configuration with a high-power battery
d) A schematic of the proposed design of the power source, with the relevant operating parameters.

In performing this task, the following characteristics of the system will be determined based on existing literature data:

1. Metal electrode current density – voltage dependence
2. Air electrode polarization characteristics
3. Required electrode area for peak power
4. Volume and weight of electrode per kWhr generated

5. Metal electrode corrosion during discharge as a function of load and surface area
6. Efficiency of power generating reaction
7. Air flow rate to support reaction
8. Metal feed rate
9. Factors involved in metal utilization
10. Electrolyte volume weight and flow rate
11. Optimum reaction chamber temperature
12. Effect of temperature on performance
13. Volume and weight of the temperature control system
14. Reaction chamber weight and volume
15. Ancillary components (pumps, fans, etc.) weight and volume
16. Volume and weight of hybrid battery or starting battery
17. Conditions and efficiency of electrolyte regeneration

These characteristics will be used in the calculations for the mass and size estimates, and determining the operational characteristics of various systems. Based on these results, the most promising system that will satisfy the power and energy requirements of the vehicle (output of Task 1.1) will be recommended. Also, a detailed implementation plan for Phase II effort will be presented specific to the actual system selected.

Phase II

The description of the tasks for Phase II presented below is based on the processing requirements and chemical characteristics for a zinc-air system. As mentioned earlier, metal-air systems have several common and some unique features that affect the system design. Thus, if a system other than zinc-air is chosen as result of the Phase I study, the plan provided here will need to be modified appropriately.

Task 2.1 Design, Assembly and Test of 100-Watt Laboratory Unit

This task is aimed at verifying the design issues and operational characteristics for the recommended metal-air system. This unit will be designed to have all the key elements of the metal-air fuel cell system (as shown in Figure 1) and deliver 100 watts. It is anticipated that the unit will require 1 to 3 cells depending on electrode size. The design will be based upon the data developed in Phase 1. The unit will include the mode of metal feed, a reaction chamber, provision for electrolyte circulation, thermal management, and by-product removal. These elements will be considered in greater detail below. Most components required for this unit will be off-the-shelf. The ancillaries used in this unit will be operated with power external to the battery so that a separate power electronics and management unit will not be required at this stage. The unit will be assembled and operated on a laboratory bench. The unit will be tested for continuous operability, electrical performance, electrolyte maintenance, and by-product removal. The studies on this unit will serve to identify of the risk elements and areas for focus before scaling up to a proof-of-concept 1 kilowatt unit under Task 3.1. The overall configuration, the approaches to metal feed system and the air-electrodes are now discussed.

Overall Configuration

There are a number of ways that a mechanically rechargeable cell could be configured. Two of the most promising configurations are deemed the most applicable. The two configurations are shown in Fig. 2 and Fig. 3 are now considered. Modifications to these approaches could result from the Phase I study, and therefore the applicability of these approaches will be re-considered at the beginning of Phase II.

The key to the design is the form of the reaction chamber. The design of the reaction chamber determines how the entire system works.

In Fig. 2, the reaction chamber is simply designed around an anode and two cathodes separated by liquid electrolyte. There is one cathode on either side of the anode. Two cathodes are used because the rate limiting reaction is oxygen reduction. The anode is a metal ribbon continuously fed into the reaction chamber. It is supported on an inert metal that also provides an electrical connection. This grid is recovered from the chamber after reaction. More detail on anode structure is given below in the section on metal feed. The liquid electrolyte is re-circulated through the chamber to remove by products and bring fresh electrolyte. Air is provided from the rear of the cathode. It facilitates the chemical reaction and provides cooling. The reaction chambers can be stacked by placing a duct between them. The duct allows air access for cooling and reaction. Reaction air is routed through holes in the duct.

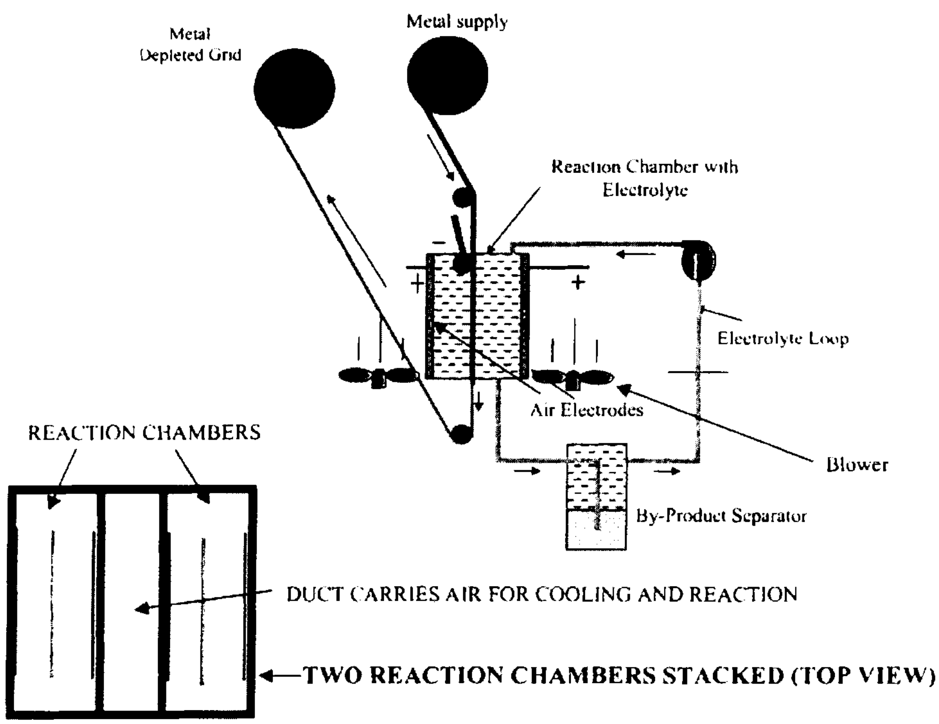


Fig. 2 Schematic of the metal-air power source with mechanically fed solid metal anode

In Fig. 3, a reaction chamber is shown for a different kind of anode structure. In this arrangement an air cathode is placed on either side of gelled anode. Such a gelled anode is prepared from metal powder, electrolyte and a gelling agent. Two cathodes are used because the rate limiting reaction is oxygen reduction. Covering the cathode is a separator. It is needed because the gelled anode fills the entire gap between electrodes. Without it, there would be a short circuit. During operation, the gelled anode is extruded into the gap between cathodes as needed. In the center of the gap holding the electrode, there is an inert metal grid. It provides electrical contact. Obviously, in this scheme, electrolyte circulation is not an issue and the product of the reaction is gelled material that is removed and stored separately. Cooling and provision of reaction air is the same as for scheme 1 and 2.

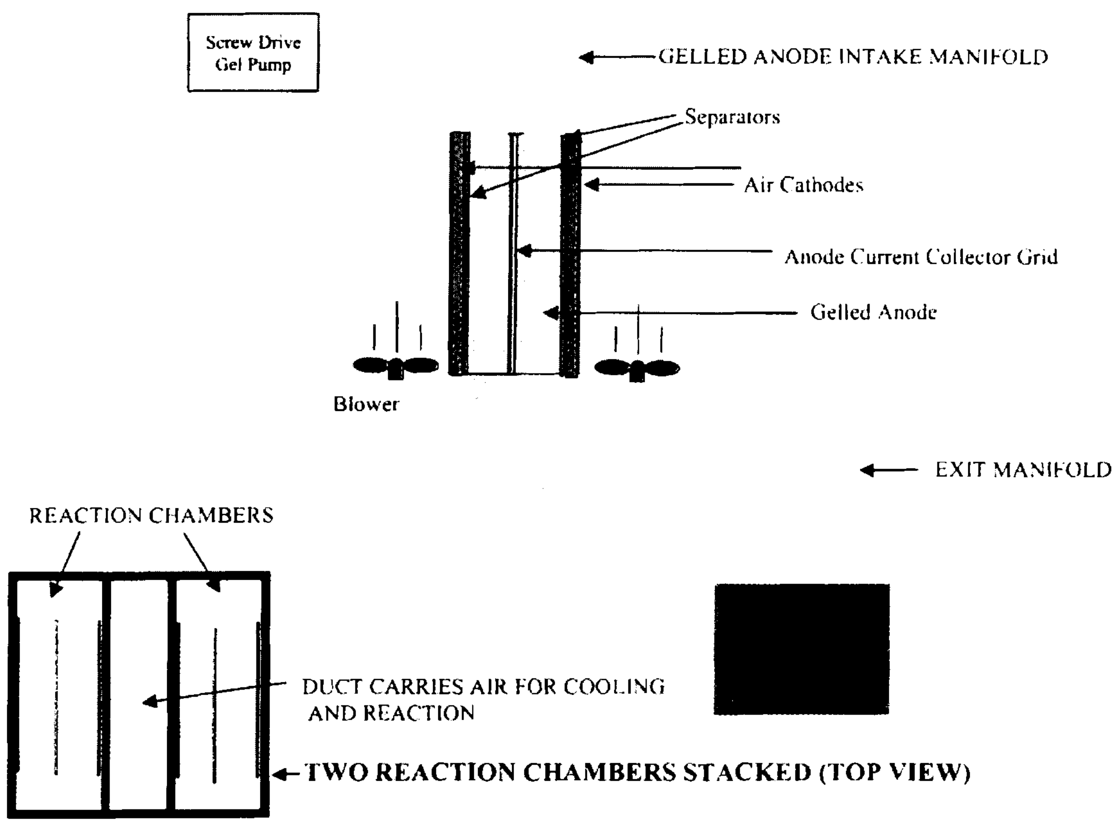


Fig. 3 Schematic of metal-air power source with mechanically fed gel anode.

Metal Feed

The metal can be fed into the reaction chamber in a number of ways. Three basic approaches are currently will be considered and modified as needed.

The first approach is to feed a very thin metal ribbon supported by an inert metal grid, into the reaction chamber. Electrical contact is made through the grid because it is more robust. The reactive metal is consumed, leaving the bare web to exit the chamber in the same manner as it entered. This scheme requires that the ribbons have a large superficial surface area to facilitate the electrochemical reaction. The area requirements will cause the chamber to be larger and heavier. On the other hand, this scheme is relatively simple. Another advantage with this system is that the metal and electrolyte are kept separate until use. This will minimize corrosion, a problem inherent to most metal air systems.

The second approach is similar to the first, but it involves laying a porous reactive metal structure on an inert metal grid. The effective area of this structure is larger than the geometric area so the reaction chamber size can be reduced. This scheme is also relatively simple but electrode preparation is more complicated.

A third approach, allows considerable simplification of the entire system. It consolidates the electrolyte and anode feed and owing to its greater simplicity will result in a more robust system. This approach involves using the reactive metal in powder form. It is combined with electrolyte and gelling agents to produce a gelled electrode. The gelled electrode is injected into the reaction chamber where it comes into contact with both sides of a non-reactive metal screen there. The screen makes electrical contact. When the electrode is consumed, it is displaced by fresh electrode. Although this scheme may be more difficult to implement, it results a in a mechanically simpler and more reliable system. The electrode has a much greater surface area per unit weight and Electrolyte and metal do not have to be independently fed to the reaction chamber. A gelled electrode is unlikely to jam during feed. Also, contamination of the electrolyte by CO_2 and subsequent carbonate precipitation is not much of an issue because there is no electrolyte re-circulation. Used electrolyte is immediately disposed of. Any precipitates formed are eliminated at the same time. Another advantage is that when batteries are formed with multiple reaction chambers, anode material can be fed from a manifold. This mode of anode feed has another useful feature. Because the electrode is plumbed to the reaction chamber sealing between the plumbing and the chamber is easy. By contrast, the ribbon feed system has to allow the metal to enter the reaction chamber by a seal that is less likely to be robust. On the downside, the gel system will not work as well for metals that easily corrode on exposure to electrolyte. In such a case the gel would have to be created in-situ from metal powder and electrolyte.

Air-Electrode (Cathode)

The cathode is a multilayer structure containing a current collector sandwiched between two layers of catalyzed carbon. The catalyst can be a cobalt porphyrin, or a number of other materials. The carbon facing the air side is wet-proofed with a Teflon microporous material so that electrolyte will not "weep" out of the electrode and allow access of air to the catalyst. Cathodes will be obtained from manufacturers of metal air systems.

Phase III

Task 3.1 Demonstration of a proof-of-concept 1 kilowatt metal-air fuel cell system.

The 1-kiloWatt system will demonstrate the feeding of air, electrolyte and a metal into a reaction chamber to produce electricity. This proof-of-concept demonstration will be primarily intended to show functionality and to identify the practical issues with operation. Being a proof-of-concept, there will not be a particular focus on reducing mass and volume. Also, the unit will not have automatic temperature controls, and the pumps, fans, and motors will be operated using mains power in the laboratory rather than being powered by the unit.

Based on the results from the 100-Watt unit, a detailed system design will be prepared for the scaled up 1-kilowatt proof-of-concept unit. The system will be based mostly on off-shelf components. The unit will be assembled in the laboratory, and performance will be demonstrated by discharge into an electronic load. The system design in this case will focus mostly on scaling up the reaction chamber, and delivery of the fuel. This will not be just a matter of increasing component size, for, increasing the reaction chamber size causes the thermal design to change. This may require some redesign of the cooling system. The supply of oxygen to the electrodes will also be affected and require re-design. Delivery of fuel will become much more critical because there will be many more reaction chambers. Each one will have to be fed independently. The approach will depend upon which anode feed method is chosen. These will be designed based on the single anode construction but modified so as to minimize the number of components and complexity in general.

Thermal management will be performed through air cooling the "stack" directly or using an air-cooled heat exchanger. The power generated will be de-rated to take into account the pumps, fans, and motors that would normally be connected to the fuel cell/battery. Results of the study will be summarized in a Final Report.

Task 3.2 Follow-on plan and Estimates for 100 kW system

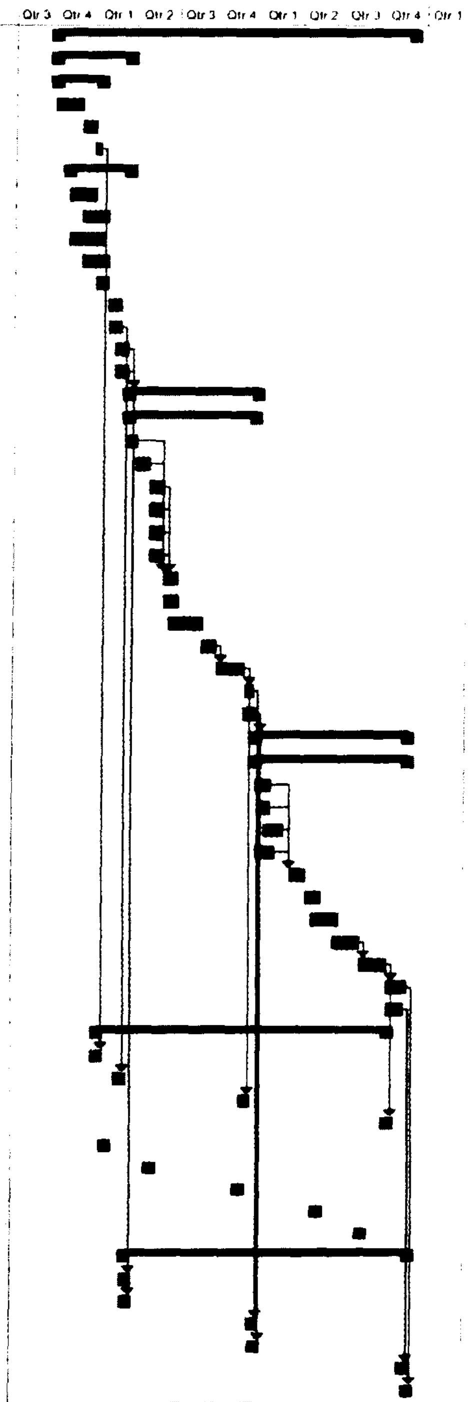
Based on the results of the 1 kW study, JPL will prepare a follow-on Task Plan for the design and demonstration of a 100 kW system. JPL will consider involving with industrial partners in this effort.

D. DETAILED SCHEDULE

The program has been organized into three phases and a 27- month effort is proposed. The detailed schedule is shown in Figure 4.

Figure 4. Schedule for the proposed effort

ID	Task Name
1	**Mechanically Fed Metal-Air Fuel Cell for Electric Vehicles**
2	**PHASE 1**
3	**1.1 Defining Power Requirements**
4	Perform Measurements
5	Analyze Power Data
6	Summarize Power Requirements Document
7	**1.2 Design Study of Metal-Air Systems**
8	Estimate of the specific energy, energy density
9	Estimates of power density
10	Identify electrolyte, electrode, and fuel regeneration issues
11	Conduct trades on system design
12	Analysis of a hybrid configuration with a high-power battery
13	Prepare Design Schematics
14	Select Metal-Air system and Prepare Recommendations
15	Prepare detailed Phase II implementation plan
16	Prepare Phase I Report
17	**PHASE II**
18	**2.1 Design, assembly and test of 100-Watt laboratory unit**
19	Define system requirements
20	Select System Configuration
21	Perform Thermal Balance calculations
22	Perform Water Balance Calculations
23	Design Metal Electrode Feed
24	Design Electrolyte Handling and Product removal sub-system
25	Prepare detailed design for 100 Watt laboratory Unit
26	Identify sub-system Components
27	Procure components
28	Assemble system
29	Test System
30	Prepare Phase II report
31	**2.2 Prepare detailed Phase III implementation plan**
32	**PHASE III**
33	**3.1 Design assembly and test of Proof-of-concept 1 kw system**
34	Define System Requirements
35	Define Issues relating to Scale up from 100 Watt
36	Define approaches to metal delivery
37	Define Thermal and Water Management Approach
38	Define system design
39	Identify Components
40	Procure Components
41	Assemble System
42	Test System
43	Prepare Final Report
44	**3.2 Prepare Prel. Implementation Plan for 100kW system**
45	**Major Milestones**
46	Preparation of Power Requirements Document
47	Downselection of Metal-Air Fuel Cell System
48	Test and demonstration of 100 Watt laboratory Unit
49	Demonstration of 1kW Proof-of-concept system
50	Progress Review 1
51	Progress Review 2
52	Progress Review 3
53	Progress Review 4
54	Progress Review 5
55	**Deliverables**
56	Phase I Report
57	Phase II Implementation Plan
58	Phase II Report
59	Phase III Implemantation Plan
60	Preliminary Implementation Plan for 100 kW system
61	Final Report



Personnel

Dr. Andrew Kindler will be the Task Manager for this effort. Andrew holds a Ph.D in electrochemical engineering and has considerable experience in the area of batteries and fuel cells. Jay Whitacre and S.R. Narayanan will support Dr. Kindler in the technical efforts relating to power requirements measurements, system design and implementation.

II. BUSINESS/COST SECTION

A. SCOPE OF WORK

JPL will, for **Universal Power Vehicles Corp.**, perform a feasibility study with respect to the designs of various metal air fuel cell systems. Using these designs, the most promising candidate will be selected for proof-of-concept. This proof will take the form of a 100 watt and a 1000 watt laboratory scale metal air fuel cell.

In the performance of this work, JPL will, on a best-effort, non-interference basis:

Phase I

1. Define/determine the power requirements of Universal Power's fleet electric vehicle.
2. Prepare a document summarizing power requirements.
3. Perform a design study of Metal-Air Systems for electric vehicle.
4. Conduct quarterly progress reviews for the task.
5. Prepare a Phase I Report.

Phase II

6. Design, assemble and test a 100-Watt laboratory scale unit based on the mechanically fed metal air fuel cell concept selected from design study.
7. Prepare a Phase II Report.
8. Prepare a program implementation plan for Phase III.
9. Conduct quarterly progress reviews for the task.

Phase III

10. Design, assemble and test a 1 kilowatt proof-of-concept unit based on the mechanically-fed metal-air fuel cell.
11. Prepare a preliminary implementation plan for 100kW system.
12. Prepare a follow-on Task Plan, if requested.
13. Conduct quarterly progress reviews for the task.
14. Prepare a Final Report.

B. DELIVERY SCHEDULE

JPL will, deliver to **Universal Power Vehicles Corp.**, in JPL format for the Phases as follows:

<u>Phase I</u>

1. One copy of a summary documentation of the power requirements for the Universal Power fleet electric vehicle, 6 months after the contract start date.

2. One copy of the design study and trade-offs on the various mechanically-fed metal-air fuel cell systems, 6 months after the contract start date.
3. One copy of the Program Implementation Plan for Phase II, 5 months after the contract start date.

Phase II

4. One copy of a report summarizing the test results of 100 Watt laboratory unit, 15 months after the contract start date.
5. One copy of the Program Implementation Plan for Phase III, 14 months after the contract start date.

Phase III

6. One copy of a report summarizing the tests results of the 1-kilowatt unit, 27 months after contract start date.
7. One copy of follow-on Task Plan, if requested for the demonstration of 100 kW unit, 26 months after contract start date.
8. One copy of the Letter of Completion.

Universal Power Vehicles Corp., will provide to JPL:

1. Electric Vehicle fitted with shunts for voltage and current measurements required for executing Task 1.1., 2 months after contract start date.

NOTE: JPL's timely performance of this effort is contingent on the sponsor's delivery or review of the items stated above within the timeframe listed.

C. PERIOD OF PERFORMANCE

The period of performance for this task is from the date of execution of a task order between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech) through **27 months.**

D. CONTRACTUAL ARRANGEMENTS

1. General

The Jet Propulsion Laboratory (JPL) is a Federally Funded Research and Development Center (FFRDC), sponsored by NASA, that conducts programs in space science and other scientific areas specified or approved by NASA. The Jet Propulsion Laboratory is also an operating division of the California Institute of Technology (Caltech). Caltech is a private non-profit educational institution chartered under the laws of the State of California and is not an agent of the Government.

Under NASA Contract NAS7-03001, Caltech performs research and development tasks and operates JPL for NASA. The contract also allows a limited amount of research and development work to be performed for non-NASA sponsors (including other Government agencies and commercial entities). All work that NASA agrees to accept from non-NASA sponsors is on a reimbursable basis and is performed under Contract NAS7-03001. The work must be within the scope of work and terms and conditions of NAS7-03001, as determined by the NASA Contracting Officer.

Contract NAS7-03001 is a Cost Reimbursable Award Fee type contract. The costs to be charged for the proposed work must be consistent with contractual provisions and established procedures for costing under the current contract between NASA and Caltech (i.e., for work performed under the Contract, NASA provides JPL with the authority to incur costs and enables Caltech to receive reimbursements via drawdowns from a Letter of Credit.) JPL does not bill the Government for costs. JPL has no negotiated pricing or billing rates, and the non-NASA sponsor will be responsible for reimbursing NASA for the direct costs of the work performed together with applicable Allocated Direct Costs. Government audit is performed on a continuing basis by a Defense Contract Audit Agency resident team.

2. Funding

All reimbursable work shall be on an advance payment basis. **The sponsor shall issue a check made payable to NASA with a signed Cover Letter or Purchase Order (P.O.) as listed below.** The check, Cover Letter or P.O. must acknowledge that the work to be performed shall be solely under the terms and conditions of NAS7-03001.

Address the check, Cover Letter or P.O. to:

National Aeronautics and Space Administration
NASA Management Office-JPL
4800 Oak Grove Drive, Mail Stop 180-802
Pasadena, CA 91109

Attention: Theresa Moulse, Contracting Officer

Mail check, Cover Letter or P.O. to:

Jet Propulsion Laboratory
Reimbursable Task Order Administration Office
4800 Oak Grove Drive, Mail Stop 249-102
Pasadena, CA 91109

Attn: Helen L. Tanabe, Sr. Contract Administrator

Required Information on Cover Letter or P.O.:

a. The name, title, address, and telephone number of your proposed technical manager.

b. The name, title, address, and telephone number of the administrative point of contact for this effort.

c. A statement as to whether your organization has previously or plans to in the future solicit or accept proposals for substantially the same effort from private industrial, commercial or other profit-making organizations.

d. Reference the **JPL Task Plan number 82-10777 and date.**

NOTE: A signed **original** Attachment A, "Intellectual Property Agreement," must be returned to the Jet Propulsion Laboratory, Reimbursable Task Order Administration Office, Attn: Helen L. Tanabe, with your check.

3. NASA Acceptance

NASA will review all orders for acceptability under the contract; the processing time for reimbursable orders will be handled as expeditiously as possible. Upon receipt of NASA's placement of a Task Order, JPL is authorized to perform the effort agreed to between NASA and the sponsor.

4. Technical Direction and Monitoring

Sponsors will appoint an individual to provide technical direction and monitoring of the work performed as outlined in the Statement of Work provided in the Task Order. Overall contract administration responsibility continues to reside with the NASA Contracting Officer.

E. SPECIAL PROVISIONS

1. Publishing Work Results

JPL shall have the right to publish the results of its unclassified research for work conducted under this Task Plan. JPL shall provide copies of proposed publications to the sponsor no later than simultaneously with release for publication. JPL recognizes that such publication may impact on patentable inventions, and agrees to exert every reasonable effort to take appropriate patent actions prior to publication.

2. Accountability of Residual Property

It is intended that accountability for residual property purchased or developed in the performance of this effort shall reside with NASA.

Residual property is defined as any property not specifically identified as a deliverable in this Task Plan.

3. Accountability of Deliverable Property

As all work performed by JPL under any order or agreement entered into as a result of this task plan is subject to the provisions of Contract NAS7-03001 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech), accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on the request of **Universal Power Vehicles Corp.**, NASA will effect transfer of accountability of all such property to **Universal Power Vehicles Corp.**

4. Patent Statement

Proprietary Caltech/JPL Intellectual Property (New Technology Reports, Patents or Copyrights) may be used in the performance of Task Plan 82-10777. Any commercial use of Caltech/JPL Intellectual Property must be negotiated with the Office of Technology Transfer at Caltech.

5. Security Requirements

The effort to be performed under this task requires access to, acquisition of, or delivery of classified material; therefore, the sponsor must provide a complete Contract Security Classification Specification (DD Form 254 or equivalent) to the NASA Management Office for NAS7-03001 at the following address:

National Aeronautics and Space Administration
NASA Management Office
4800 Oak Grove Drive
Pasadena, California 91109

Attention: Mr. Charles J. Kehoe
Security Officer

with a copy to the Contract Administrator designated in the transmittal letter.

Classified information should be transmitted separately and appropriate reference entered on the DD Form 254 or other appropriate security form. The security classification guidance should be provided in the form of a program classification guide, policy directive, or individual letter.

The performance of this effort could be delayed pending receipt of the completed DD Form 254 or other appropriate security form if access to any classified information is required.

Information regarding access of JPL classified products is currently held in classified documentation by the JPL Security Office and is available for viewing by persons possessing the proper access.

6. <u>Intellectual Property</u>

The sponsor's rights to intellectual property are defined in Attachment A, the Intellectual Property Agreement with Caltech for work done under this Task Plan.

7. <u>Proprietary Information</u>

The sponsor and JPL understand that, in the general course of the activities for this effort, neither party will offer the other information that is considered confidential or proprietary.

In the event that the sponsor desires to disclose confidential or proprietary information to JPL, (either written or oral), the sponsor will first inform JPL of the submission and explain the general nature of the proprietary information, to permit JPL to determine whether it wishes to receive said proprietary information. JPL agrees to hold such information that it agrees to receive in confidence for a period of three years from the receipt of the proprietary information provided that:

a. Written information has been appropriately identified by a proprietary legend; and

b. Oral disclosures of proprietary information are confirmed in writing within fifteen days by the sponsor to JPL, informing JPL of the subject matter to be held in confidence, when it was disclosed, and to whom.

c. JPL shall have no obligations regarding disclosure or use of any such information which (1) is already known to JPL, or (2) becomes publicly known through publication, inspection of product or otherwise and through no wrongful act of JPL, or (3) is received from a third party without a similar restriction and without breach of this Agreement, or (4) is shown by documentary evidence to have been independently developed by JPL, or (5) is disclosed to a third party by or on behalf of the sponsor (other than disclosure by the sponsor in connection with limited consumer testing) without a similar restriction on the third party's rights, or (6) is disclosed pursuant to the lawful requirement of a governmental agency or by order of a court of competent jurisdiction or disclosure as permitted by operation of law, provided that such disclosure is subject to all governmental or judicial protection available for like material and provided that before such disclosure, the sponsor shall have been given prior written notice to JPL's intention to disclose and a reasonable opportunity to object to such disclosure.

d. In exceptional circumstances, JPL will hold proprietary information for a period of time longer than three years, provided that such period of time is agreed upon in writing by JPL prior to the sponsor disclosing such proprietary information to JPL. Current JPL procedures relative to treatment of proprietary information are included in Item 12. below.

8. Termination

Universal Power Vehicles Corp., may terminate this effort at any time by providing to the NASA Contracting Officer written notice of its decision to terminate. Costs associated with termination will be subject to reimbursement in accordance with the terms of NASA Contract NAS7-03001. Any funds remaining will be returned to **Universal Power Vehicles Corp.,** within a reasonable time after termination.

9. No Warranty

All deliverables provided to **Universal Power Vehicles Corp.,** pursuant to this Task Order are provided "AS-IS" without warranty, express or implied, as to any matter whatsoever, including, without limitation, the performance or condition of the research or any invention(s) or product(s), whether tangible, conceived, discovered, or developed under this Task Order; or the merchantability, or fitness for a particular purpose of the research or any such invention or product. The Government and the California Institute of Technology (Caltech) shall not be liable for any direct, consequential, or other damages suffered by Sponsor, any licensee, or any others resulting from the use of the research or any such invention or product.

10. Indemnification

Universal Power Vehicles Corp., agrees that it will be responsible to the Government and the California Institute of Technology (Caltech) for, and will indemnify and hold harmless the Government and Caltech, its trustees, officers, and employees, from any loss, cost, damage expense or liability, attorney's fees, or any suit therefore, by reason of actual or alleged damages or injury of whatsoever kind or character, arising out of or in connection with **Universal Power Vehicles Corp.,** alleged or actual negligent act or omission, regardless of whether such act or omission is active or passive.

11. Export Control

In the performance of this task plan, JPL and/or **Universal Power Vehicles Corp.,** may from time-to-time be required to deliver, disclose, or transfer (export) to foreign entities, technical data, software or equipment which may be subject to the export laws and regulations of the United States and which may require an export license (or other regulatory agency approval) or the use of a license exemption/exception. Such exports, which would include, but not be limited to, export of technical data or technology, as defined at 22 CFR 120.10 and 15 CFR Part 772, respectively, may from time-to-time be required for, and be in furtherance of, the performance of this task plan. JPL and **Universal Power Vehicles Corp.,** shall comply with U.S. export laws and regulations in the performance of this task plan.

Any and all exports in support of this task plan which do not fall within generally available license exceptions/exemptions shall be exported pursuant to a license obtained by JPL or **Universal Power Vehicles Corp.** JPL shall not utilize the 22 CFR 125.4(b)(3) or other exemptions uniquely available to the U.S. Government for such exports.

Any provisos/conditions on licenses obtained by JPL which affect JPL performance under the Task Plan will be brought to the attention of Sponsor **Universal Power Vehicles Corp.** Should the export license or other U.S. regulatory agency approval be denied or unworkably constrained by provisos or conditions, Sponsor **Universal Power Vehicles Corp.,** will be notified, and a decision will be made to appeal the denial or proviso/condition, or terminate the Task Plan. The time required to process export licenses and obtain approvals/comply with provisos/conditions may result in delays in any planned deliveries and may increase the cost of the work to be performed.

12. <u>Procedures for Processing Sponsor-Provided Proprietary Documents</u>

a. If a Sponsor requires a Non-Disclosure Agreement to be signed before any sponsor proprietary information is discussed, a pre-signed Caltech Non-Disclosure will be provided. Any changes in or substitutions for this Non-Disclosure Agreement must be approved by Caltech Intellectual Property Counsel before it can be effective.

b. Disclosure discussions relative to proprietary information should be attended by as few personnel as practicable. Except for any U.S. Government personnel who may attend, one key individual from JPL and one from the sponsor and each other outside organizations in attendance of such a discussion will sign the Non-Disclosure Agreement binding the individuals and companies involved.

c. The general nature and purpose of the discussion must be agreed upon by all parties before proprietary discussions are initiated.

d. Only those proprietary documents deemed necessary for JPL to perform their technical and management functions under this Task Plan will be retained at JPL.

e. Proprietary information and documents will be clearly marked as "Proprietary" and will be filed, closely monitored and controlled by a JPL-designated individual.

Any oral disclosure of proprietary information will be included in the Non-Disclosure Agreement only to the extent it is identified as being proprietary at the time of disclosure, and then reduced to writing, clearly marked as Proprietary and delivered to the JPL-designated individual within one week of the oral disclosure.

f. Copying of sponsor-provided proprietary information by JPL without the permission of the sponsor, will be prohibited.

F. COST ESTIMATE (dollars expressed in thousands)

		Phase I	Phase II		Phase III		
		FY06	FY06	FY07	FY07	FY08	TOTAL
1	Workyears	0.3	0.5	0.3	0.6	0.2	2.0
2	Total Direct Compensation (includes Employee Benefits)	50.8	79.4	49.3	115.9	40.9	336.3
3	Travel	-	-	-	-		-
4	JPL Services	-	5.0	-	5.0	-	10.0
5	Procurements						
	Chargebacks	2.8	4.4	2.9	6.5	2.3	18.9
	Procurement Subcontracts	5.0	-	-	-		5.0
	Procurement Purchases	2.8	10.0	-	20.0	-	32.8
6	Multi-Program Support	9.1	14.2	8.6	18.7	6.5	57.0
7	Total Direct Costs	70.5	112.9	60.8	166.0	49.6	459.9
8	Allocated Direct Charge	25.0	40.1	25.0	62.2	18.1	170.4
9	Total JPL Costs	95.5	153.0	85.8	228.3	67.7	630.3
10	NASA Costs	4.5	7.2	4.1	10.8	3.2	29.7
11.	**Total Estimated Cost**	**100.0**	**160.2**	**89.8**	**239.1**	**70.9**	**660.0**

ATTACHMENT A

INTELLECTUAL PROPERTY AGREEMENT WITH CALTECH
FOR JPL TASK PLAN No. 82-10777

The sponsor has agreed to fund, under the attached Task Plan, certain work to be done by Caltech pursuant to a NASA task order. This Intellectual Property Agreement is an exclusive Agreement between Caltech and Universal Power Vehicles Corp., and does not imply that NASA is a party to the Intellectual Property Agreement.

Caltech, subject to terms and conditions of NASA Contract NAS7-03001 and other applicable pre-existing contract obligations, if any, agrees to grant the sponsor Intellectual Property rights for work done under this Task Plan as follows:

1. DISCLOSURE

Caltech will inform the sponsor of subject innovations, inventions and discoveries hereinafter collectively termed "Intellectual Property," made in the performance of tasks funded in part or in whole by the sponsor.

2. PATENTS

a. Filing

In the event that Caltech indicates in writing that it does not choose to file a patent application on Intellectual Property in a domestic or foreign country but the sponsor desires to have an application filed, Caltech shall file such an application upon the written request and at the expense of the sponsor and title to such Intellectual Property shall remain in Caltech. In such event, the sponsor shall pay Caltech all reasonable expenses for filing and prosecuting the patent applications filed at the sponsor's request and all expenses for maintaining the patents resulting therefrom. Where time permits, drafts of said applications will be sent to the sponsor and its comments considered. Where the sponsor pays all reasonable expenses for filing and prosecuting said patent applications and/or maintaining said patents resulting therefrom, then the sponsor and Caltech shall share equally in the income derived from licensing said patents to third parties, after the sponsor first deducts said expenses from any licensing income.

b. Non-Exclusive Licenses

For all Intellectual Property developed under tasks that are funded in part or in whole by the sponsor, the sponsor will receive upon request, at a minimum, a non-exclusive, royalty-free license. Except as provided elsewhere in this Agreement, licenses granted to other, non-funding, parties shall be on a royalty-bearing basis.

c. License Rights Greater than Non-exclusive

(i) This provision relates to individual tasks initiated under this Agreement where the sponsor believes that the acquisition of rights greater than a non-exclusive, royalty-free license to intellectual property is necessary to the successful development and marketing of a product likely to emerge from such a task. In such event, upon application by the sponsor for greater license rights, prior to initiation of the task involved, Caltech shall consider whether under current Caltech policy, such greater rights are available to the sponsor and if so, to grant them on mutually agreeable terms and conditions. The sponsor reserves the right to withdraw the funding for said task if a satisfactory agreement relative to said greater rights cannot be reached beforehand.

(ii) Where not agreed upon in advance, for all subject inventions made in the performance of tasks funded in part or in whole by the sponsor, Caltech shall consider and, if appropriate under the current Caltech policy, to grant the sponsor greater license rights under mutually agreeable terms and conditions.

d. License to U. S. Government

The United States Government will receive a non-exclusive, non-transferable, royalty-free license for all Intellectual Property made in the performance of tasks.

3. COMMUNICATIONS

Communication between the sponsor and Caltech/JPL on Intellectual Property matters shall be addressed as follows:

Caltech:

Adam Cochran
The Intellectual Property Counsel
California Institute of Technology
201-85 Central Engineering
Pasadena, CA 91125

Universal Power Vehicles Corp.
53975 Avenida Cortez
La Quinta, CA 92253

4. This Agreement will be interpreted in accordance with the laws of the State of California.

5. IN WITNESS WHEREOF, the parties have caused the Intellectual Property Agreement to be duly executed and effective as of the date of signing by both parties.

California Institute of Technology

September 13, 2005

By Date

Adam Cochran
The Intellectual Property Counsel

Universal Power Vehicles Corp.

By Date

Print Name

Title