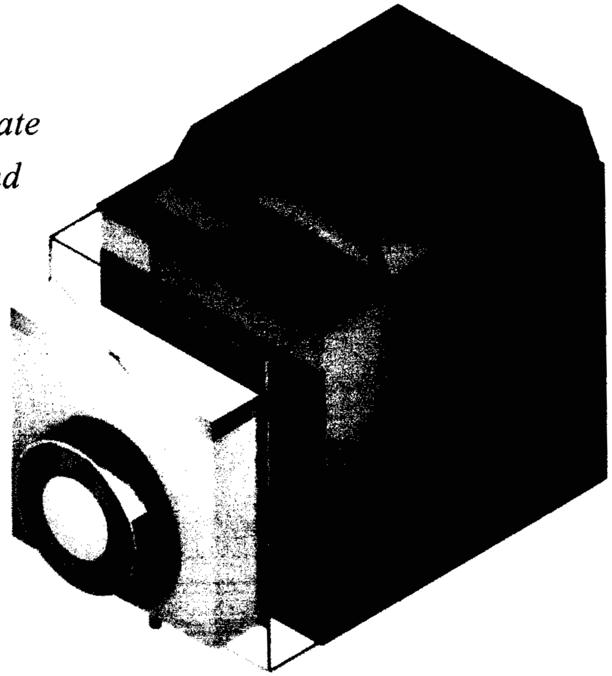
Jet Propulsion Laboratory

DIRECT METHANOL FUEL CELL SYSTEM ANCILLARY POWER SOURCE FOR ARMORED VEHICLES

Transformation Technology Directorate
US Army Operational Test Command
Fort Hood, Texas
Mr. Henry Merhoff (POC)



Jet Propulsion Laboratory
Pasadena, California
M. Gangal (PM)
S. Surampudi (PM)
T. I. Valdez (PI)

T&E/S&T EA Workshop
March 18th and 19th, 2003
Embassy Suites Destin
at Miramar Beach
Destin, Florida

Electrochemical Technologies Group

Background and Requirements

Background

- The Army currently uses four deep cycle marine batteries to provide auxiliary power to armored vehicle external test instrumentation. The total battery weight is 180 kg (400 lb) and can only provide power to the armored vehicle ancillaries for 8 hours of operation.

Objective

- To design, fabricate, and test a 300 W direct methanol fuel cell power source based on state-of-art technology meeting the following requirements.

Summary of Requirements

- Power 300 W, (Continuous)
- Energy: 30,000 Whr
- Target Weight: 36 kg (80 lb) (Including Fuel)
- Other Attributes:
  - Rapid Startup
  - Field Refueling for Extended Operation
  - No Recharge Time
  - Quiet
  - Low Thermal Signature

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Focus Area: T&E/S&T Direct Methanol Fuel Cell (DMFC)

Principal Investigator (NASA/JPL, Thomas Valdez)

POC (Henry Merhoff, USAOTC)

Description:

- **T&E Technologies:** Alternative Power Sources
- **Benefit to T&E:**
  - •Provides power for external test instrumentation during long duration tests w/o effect on OPTEMPO
  - •Reduces field support manpower
- **Applications**
  - Power for FCS external vehicle instrumentation
  - Field Instrumentation (non-vehicular) power source
- **Deliverables:**
  - 1 each prototype DMFC
  - Procurement documentation package
- **Supports DTOs:** M.15

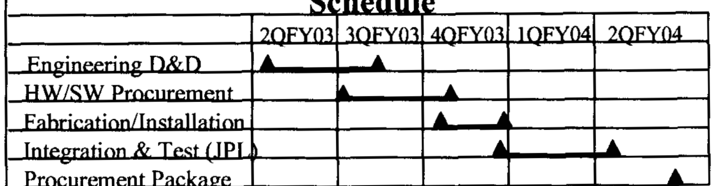
Requirement:

•Develop an alternative power source for FCS external test instrumentation (ETI). FCS OPTEMPO and realism will be affected without an ETI power source as platforms will:
1)either not have ETI power available (power for embedded instrumentation only) which will limit data collection, or
2)will require frequent access to change batteries, or
3)require frequent vehicle runup to charge batteries which will create unwarranted signatures and affect OPTEMPO.
•Fuel cell technology is state-of-the-art but the DMFC solution is the lowest risk approach consistent with meeting the FCS requirements.
• Test DMFC with CVII instrumentation at ATC and Ft Hood

Contract Information:

- MIPR to NASA/JPL under contract NAS7-1401 and JPL Task plan 66-7584 to design and develop DMFC, conduct demonstrations, support commercial procurement
  - •Subcontractor: Giner (DMFC Stack)
- Some team members are Caltech adjunct professors (other Caltech faculty available on-call as part of JPL staff)

Schedule



Financial Summary ($K)

	2QFY03	3QFY03	4QFY03	1QFY04	2QFY04
DMFC Fabrication		300			
Integration & Test (JPL)				90.2	
Procurement Package					20
Program &Test Support			60		
(ATC, CECOM, TESCO)					

Last Update: 7 March 2003

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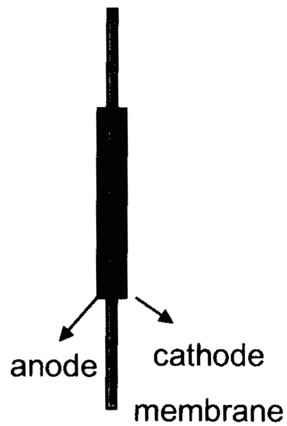
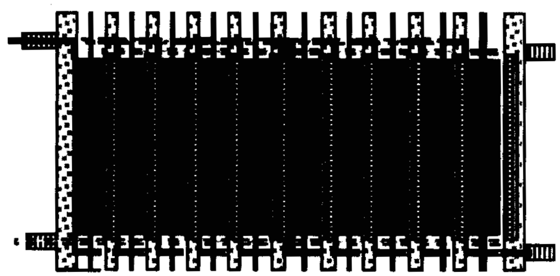
Fuel Cell Terminology

MEMBRANE ELECTRODE ASSEMBLY MEA

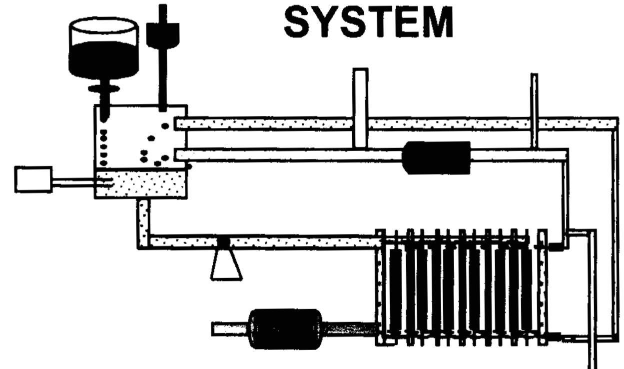


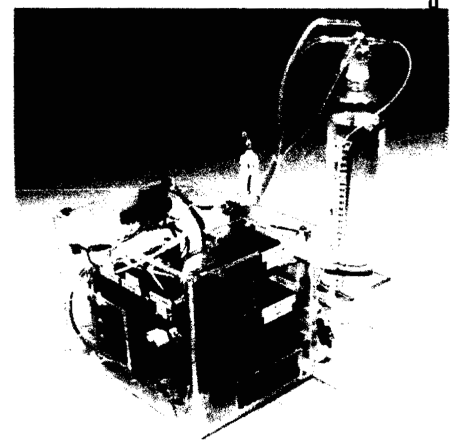
Amb (96)

STACK

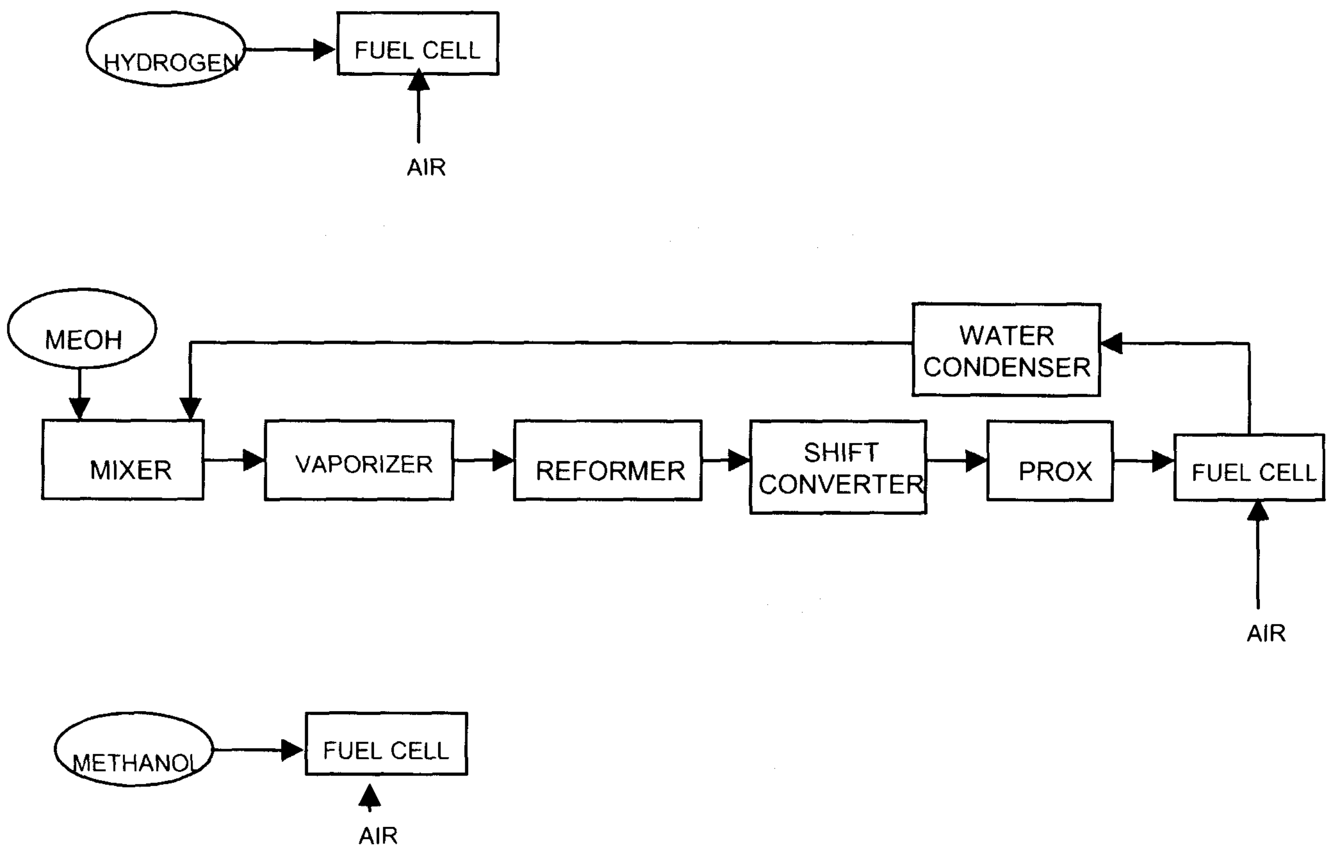


SYSTEM





Polymer Electrolyte Membrane Fuel Cell Systems



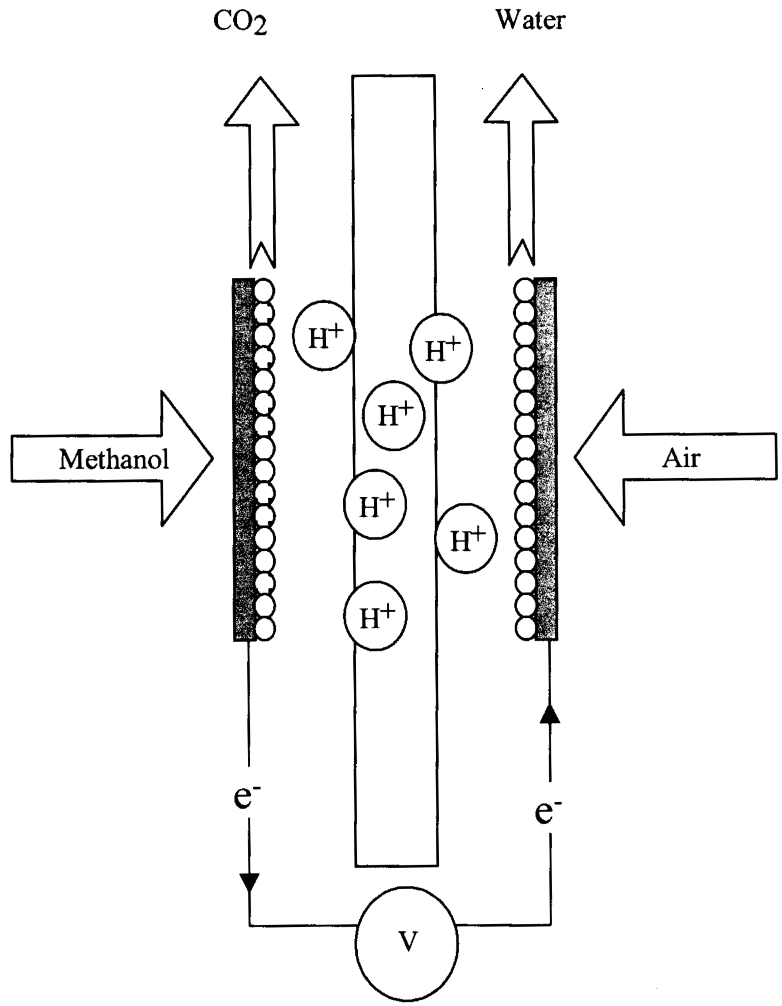
The Direct Methanol Fuel Cell

Direct Methanol Fuel Cell Reaction:

Anode: $CH_3OH + H_2O \rightarrow 6H^+ + 6e^- + CO_2$

Cathode: $3/2O_2 + 6H^+ + 6e^- \rightarrow 3H_2O$

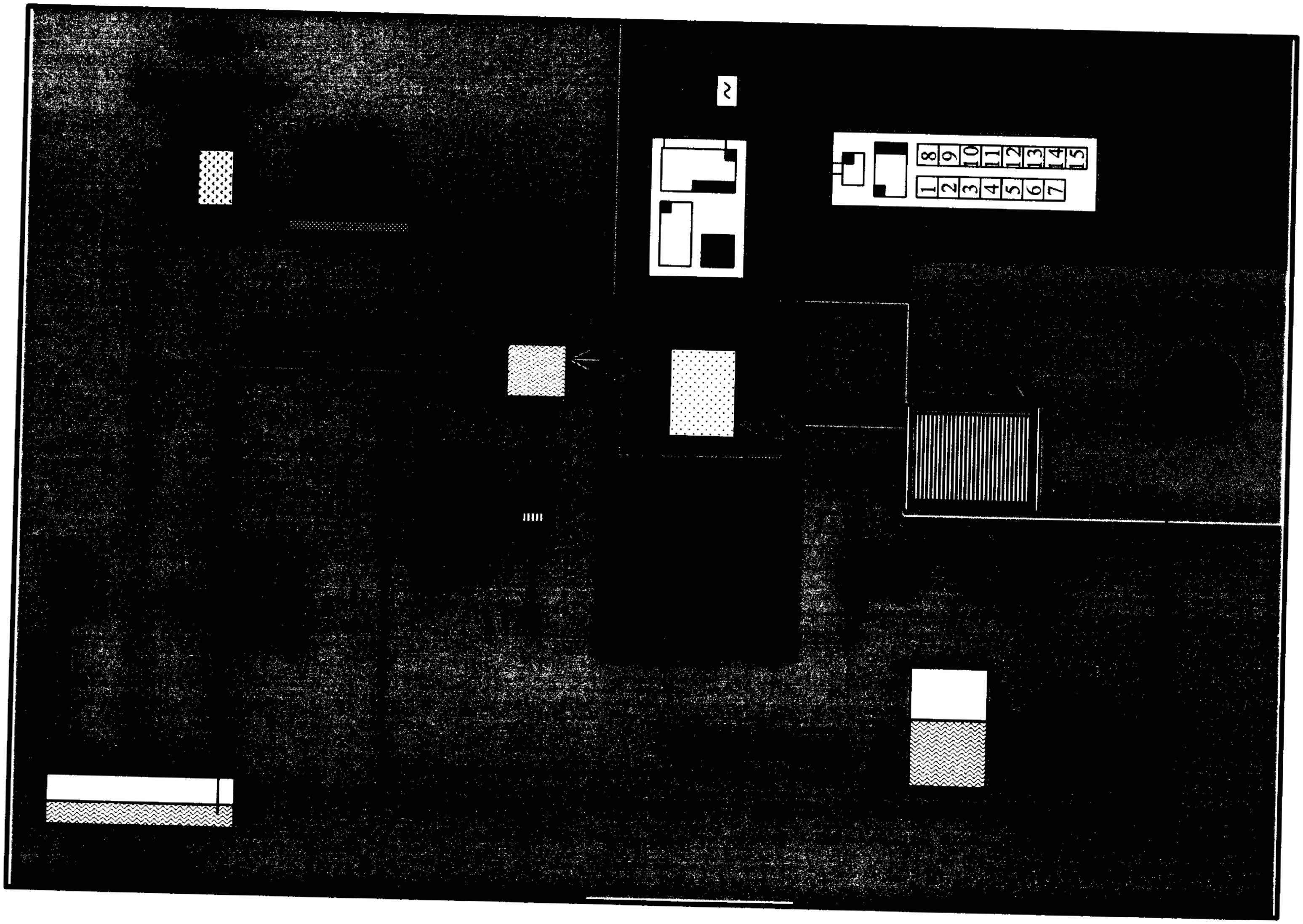
Cell: $CH_3OH + 3/2O_2 \rightarrow CO_2 + 2H_2O$



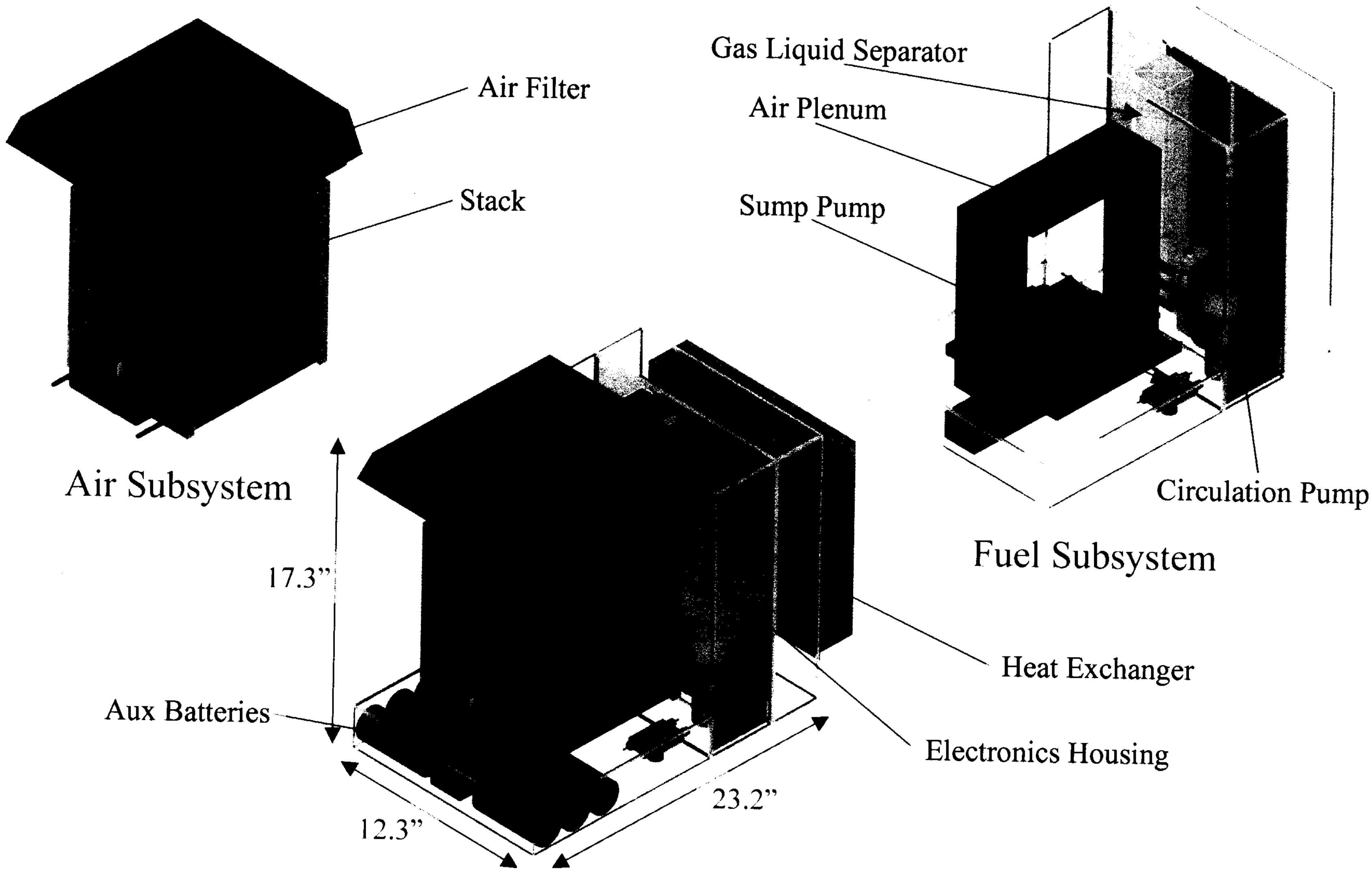
DMFC Advantages

- Safety of handling a liquid fuel versus compressed gas fuel tank (i.e. Hydrogen)
- Low methanol concentration (<3%) in the “working” fuel loop

Direct Methanol Fuel Cell System Schematic

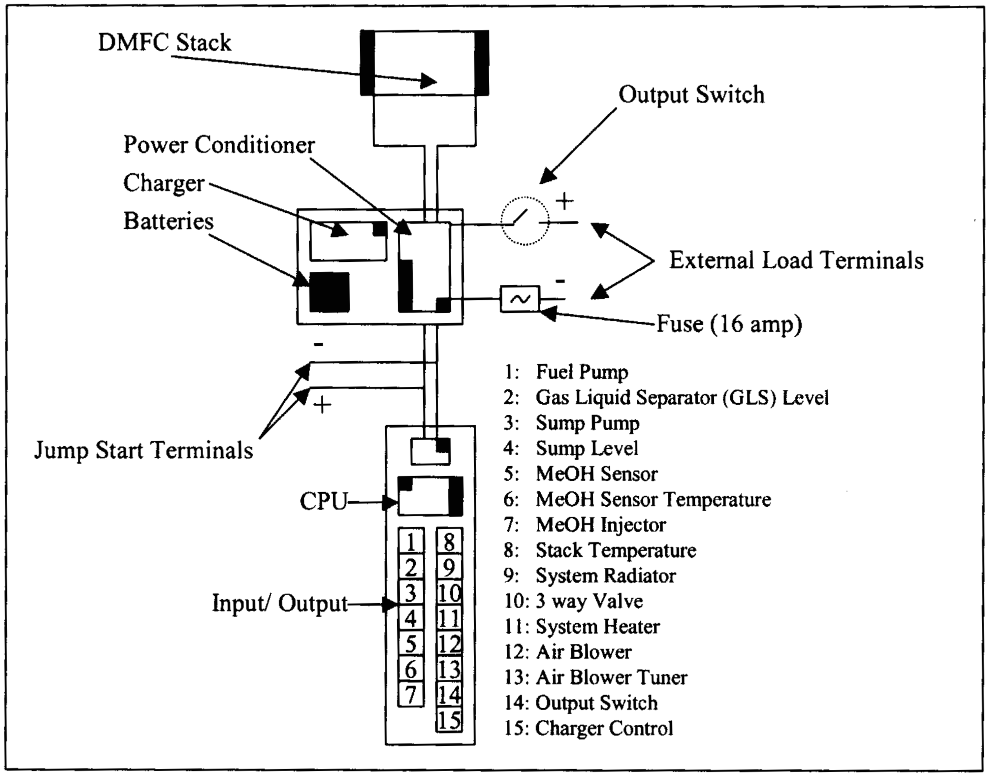


Direct Methanol Fuel Cell System



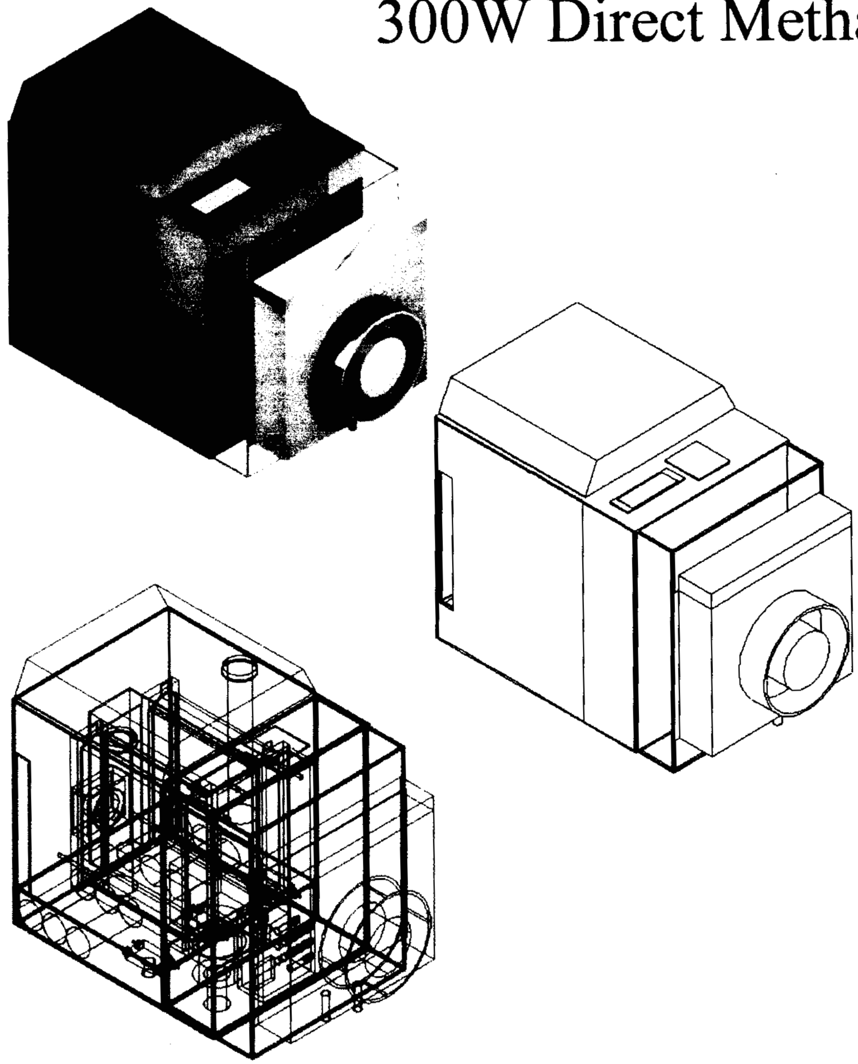
Fuel Cell System

Electronics and Control Subsystem



- The electronics subsystem is composed of the following components: Control Logic, Microprocessor Controller, LCD, Key Pad, Ancillary Battery, Battery Charging Electronics, Power Converters and Temperature Sensors
- Software logic and hardware developed under a previous DARPA program

300W Direct Methanol Fuel Cell System



System Specifications

Electrical:

- Output Voltage: 20 to 30 V
- Power: 300 W
- Max Current: 15 A

Physical:

- Dimensions: 12.3 in x 23.2 in x 17.3 in
- Volume: 81 L (2.9 ft^3)
- Mass: 19 kg (42 lb)

Fuel Tank:

- Fuel: Methanol
- Fuel Source: Methanol (Supplied from external fuel tank)
- Capacity: 30000 Whr
- Tank Volume: 35 L (1.2 ft^3)
- Mass: 29 kg (64 lb)

Operational Environment

- System Startup: Instantaneous when ambient temperature is greater than 5 °C (41 °F)
- Storage: TBD to 70 °C (158 °F)
- Air Temperature: TBD to 45 °C (113 °F)
- Attitude Sensitivity: +/- 45° to vertical
- Shock and Vibration: Survive a three-foot drop on concrete.
- Unit must be protected during wash rack cycle.

Electronics Subsystem, Control Logic Demonstration

Technical Summary

	Batteries	Fuel Cell	Change
Weight (pounds)	250-270	100	-60%
Size (Cubic ft)	4.5	3.1	-30%
Duration (W-hrs)	4800	30000	525%

- Substantial reduction in mass and volume as well as increased operating time over battery system result with DMFC based power source.

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Schedule

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Engineering D&D	▲	▲			
HW/SW Procurement		▲	▲		
Fabrication/Installation			▲ ▲		
Integration & Test			▲		▲
Procurement Package					▲

Financial Summary ($K)

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DMFC Fabication	▲	300		▲	
Integration & Test			▲	90.2	▲
Procurement Package				▲	20 ▲

Last Update: 27 Jan 02

Backup Slides

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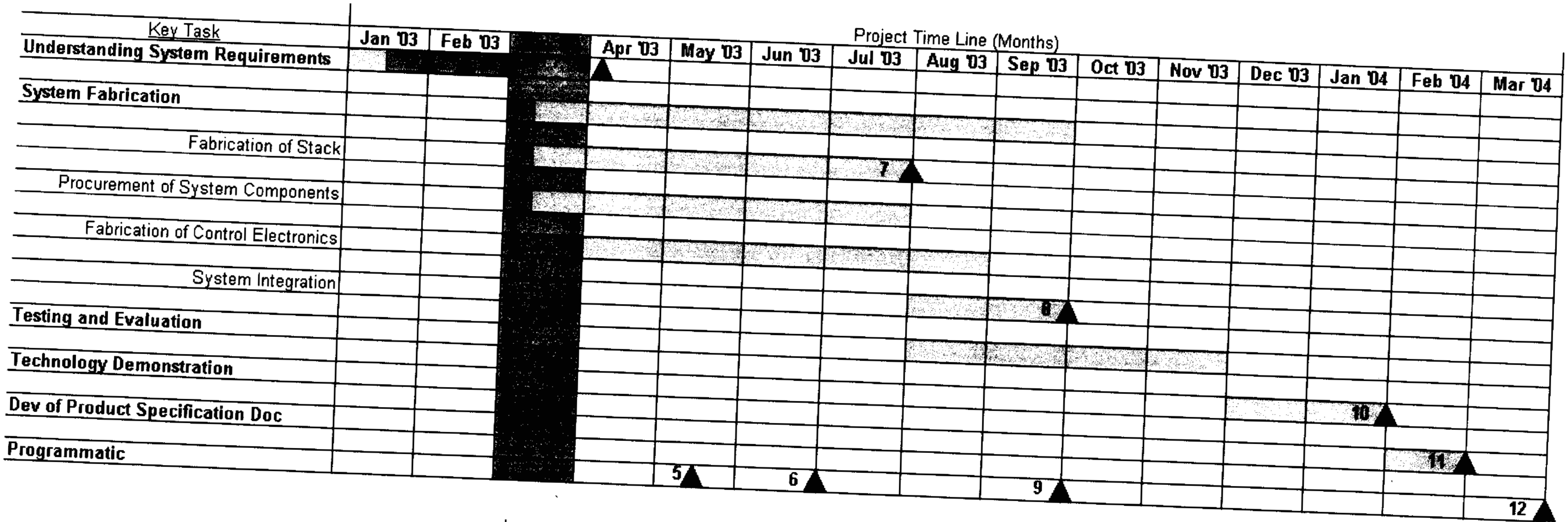
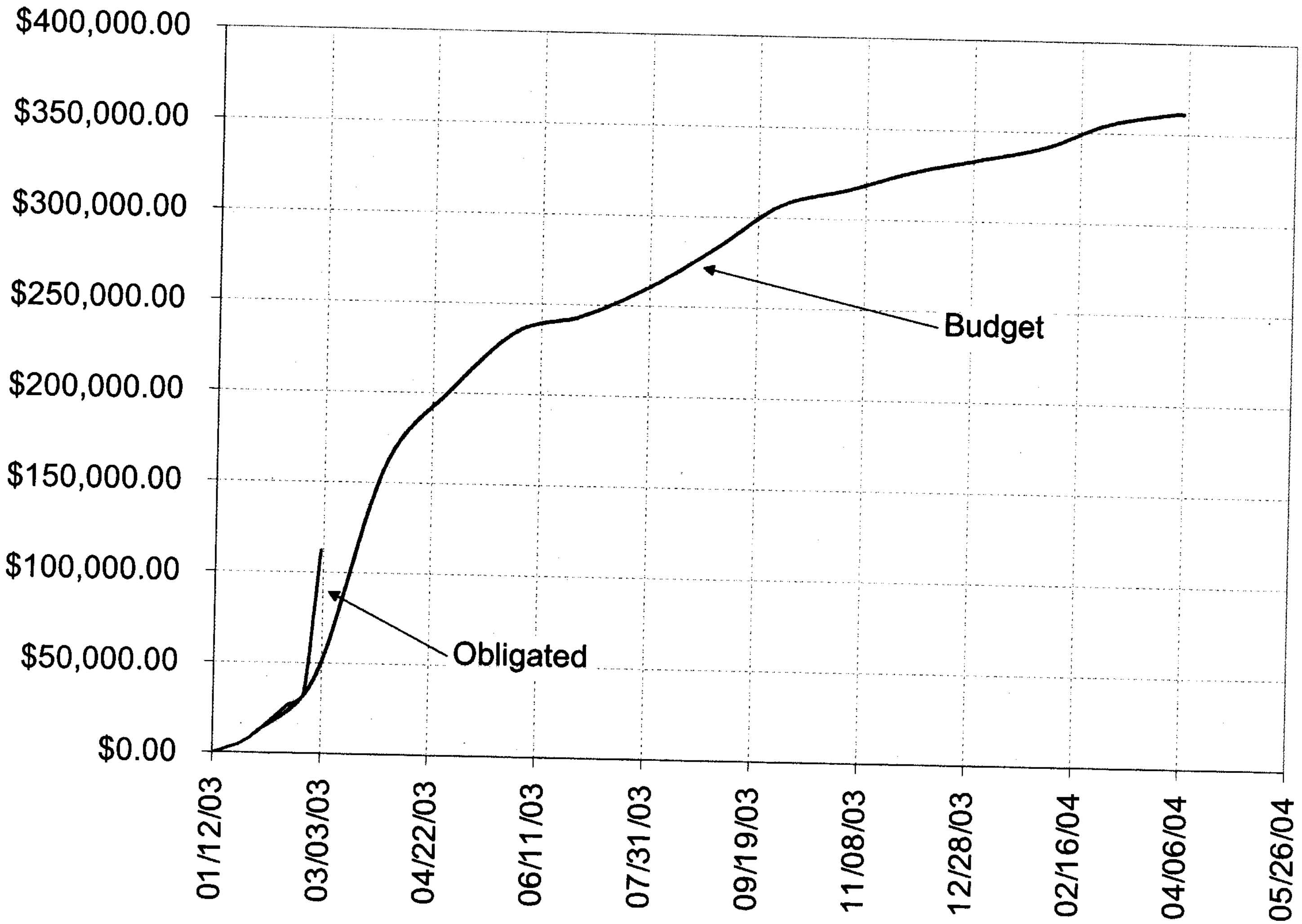
Schedule and Milestones

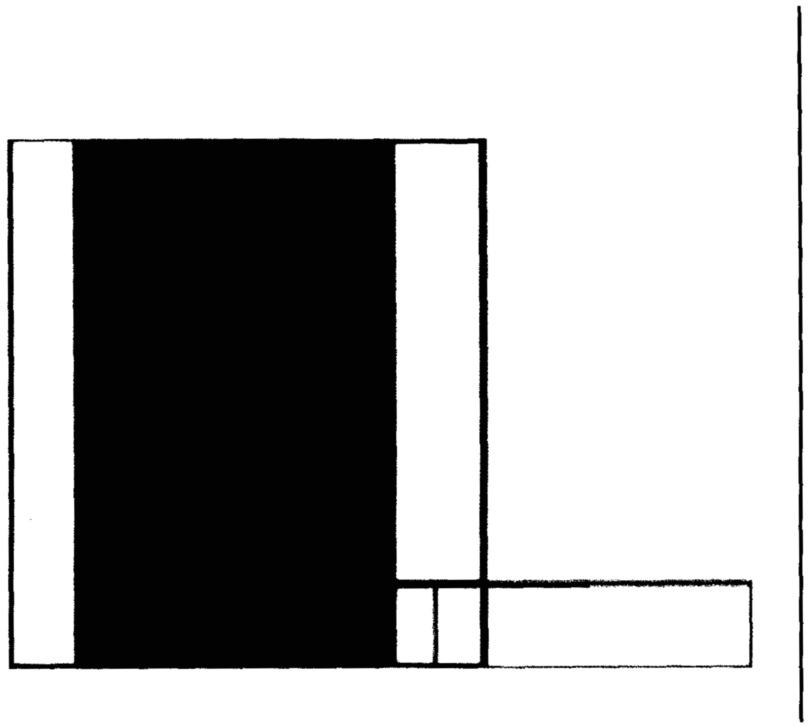


	Milestones	Date
~~1~~	~~Present Fuel Cell System Design~~	~~1/30/2003~~
~~2~~	~~Deliver Preliminary Product Spec. Doc.~~	~~2/28/2003~~
~~3~~	~~Progress Review~~	~~3/4/2002~~
4	PDR	4/8/2003
5	Progress Review	5/15/2003
6	CDR	6/27/2003
7	Complete Stack Fabrication	7/31/2003
8	Complete DMFC System	9/26/2003
9	Progress Review	9/26/2003
10	DMFC Field Test	1/16/2004
11	Deliver Product Specification Doc	2/28/2004
12	Deliver Final Report	3/31/2004

Program Budget



300W Direct Methanol Fuel Cell Power Source



Fuel Cell Types

Type	Op. Temp (°C)	Application	Efficiency
Alkaline Fuel Cell	60-90	Space	50-60%
Phosphoric Acid Fuel Cell	180-200	STATIONARY, EV	55%
Molten Carbonate Fuel Cell	400-600	STATIONARY	60-65%
Solid Oxide Fuel Cell	800-1000	STATIONARY	50-65%
Polymer Electrolyte Fuel Cell	60-90	EV, Distribiuted Power Source, Potratable Electronics, Space. DOD	50-60%
Direct Methanol Fuel Cells	60-90	EV, Distribiuted Power Source, Potratable Electronics,DOD	30-40%