Future Trends and Thrusts for Army Manportable Power Sources

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AGENDA

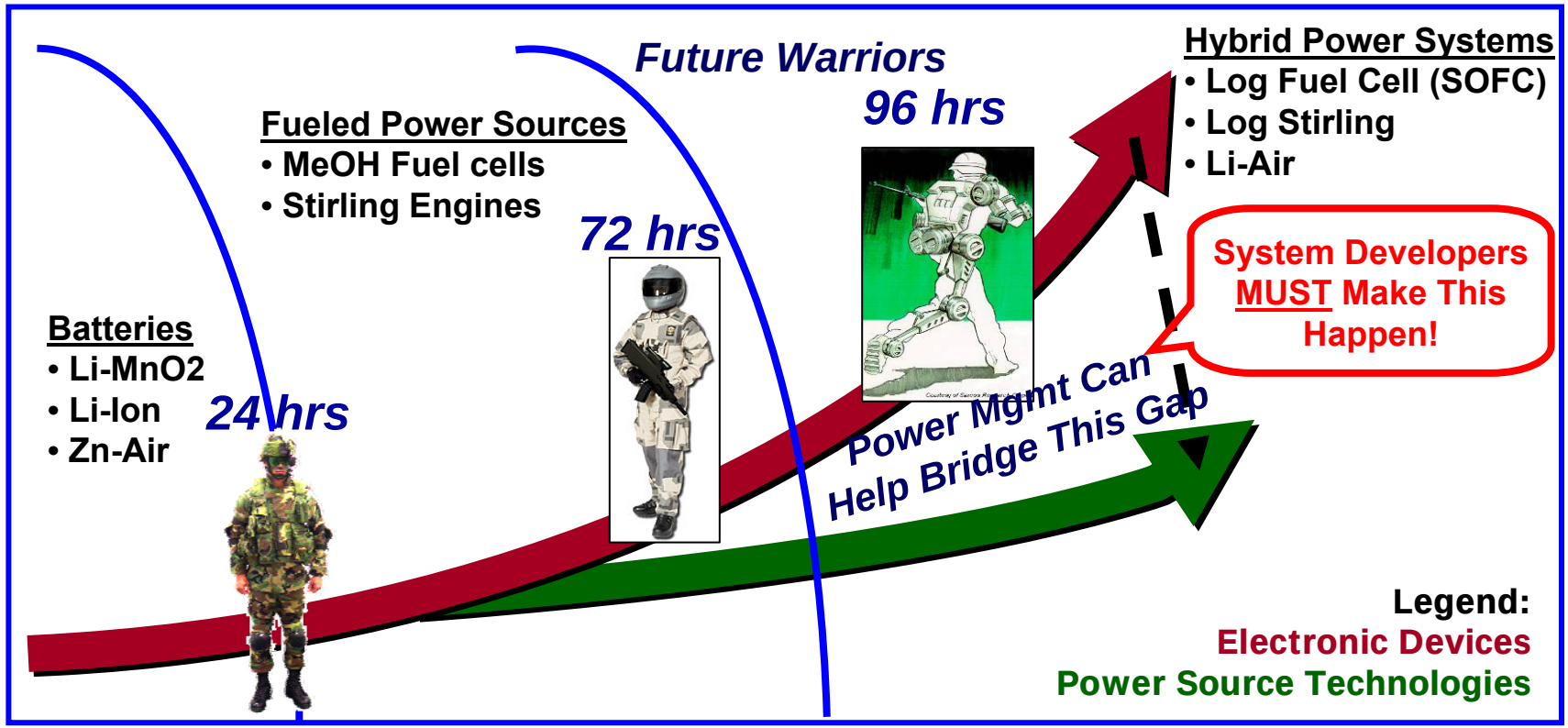
- Soldier Power Requirements
- Science & Technology Programs
- Solutions Available Today
- What's Next
  - High Energy Batteries
  - Hybrid Power Sources
  - Fuel Cells
  - Stirling Engine
- Summary

Our Challenge

…Lighten Their Load

Power Requirements

MORE POWER …… *…… LESS WEIGHT*



Science & Technology Programs

Mounted/Dismounted Soldier Power IV.LG.2006.01

FY06 – FY08

Soldier Power- Watts ⟷ *Kilowatts Tactical Power-*
Batteries/ Hybrid *Logistics Fuel*

Fuel Cell Battery Hybrid

Less weight, lower cost longer missions

Self Powered Battery Charger

Quiet Power Sources

Less fuel, smaller, quieter power sources

Purpose:

Develop component technologies for power systems for increased mission duration while decreasing logistics burden

Products:

- *Soldier*
  - *<500 Watt Man-portable field battery charger and improved rechargeable batteries*
  - *Hybrid power source (fuel cell & battery)*
  - *Li-Air battery and improved photovoltaics*

Payoff:

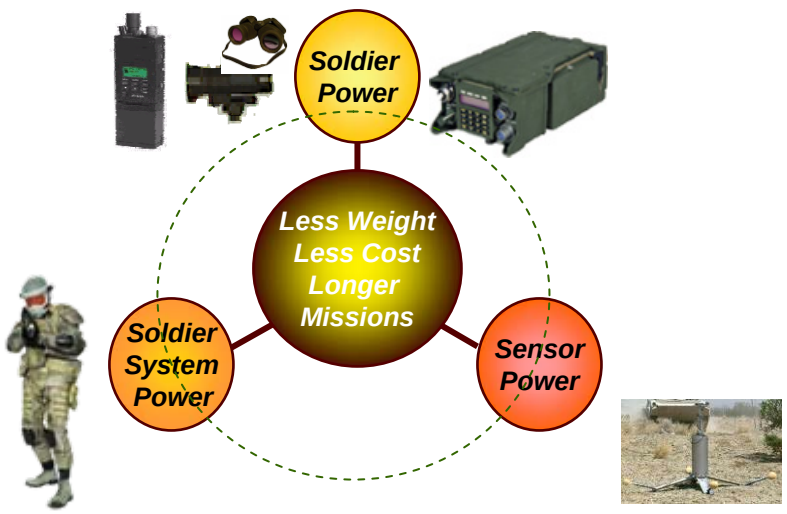
- *Provides savings by reducing number of batteries required for soldiers. Increased power/energy adds mission capability.*

- *Transitions:*
  - *Hybrid demonstrators to PM-Soldier in FY06; improved technology for Ground Soldier System in FY08*

Science & Technology Programs (cont)

D.CER.2008.08 Power for the Dismounted Soldier

FY08 – FY11



Purpose: *To provide the Warfighter with small light weight power sources that maximize specific energy for core Soldiers, integrated Soldier systems and sensors.*

Products:

- *Prototype Half-size/2X energy primary C4ISR batteries*
- *Conformal rechargeable Soldier system batteries*
- *Soldier mission extending hybrid fuel cell system*
- *Logistic fuel (JP8) powered Soldier portable power source to enable tactical battery recharging*

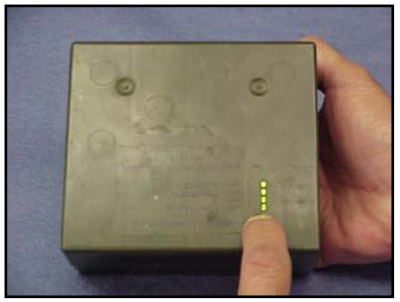
Payoffs:

- *Reduction in Soldier weight load*
- *Extended mission times in Soldier and sensor applications*
- *Battlefield energy independence; reduced logistics*
- *Increased Soldier mobility, sustainability, survivability and deployability by providing higher energy sources*
- *Power sources and charging technologies that meet Soldier-as-a-System requirements*

Solutions Available Today

Batteries With State-Of-Charge-Indicators

- Instantly Indicates Remaining Capacity in BA-5590A and BA-5390A
- Adds No Additional Weight to Battery
- BA-5590A/U (Li/SO_2)
  - All Production Converted to SOCl
- BA-5390A/U (Li/MnO_2)
  - In Stock & Available Now

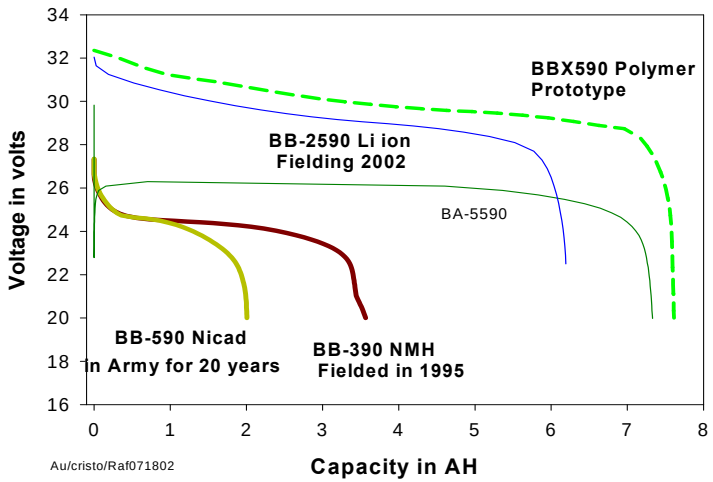


BA-5590A/U

BA-5390A/U

High Energy Rechargeable Li-Ion Batteries

BB-590 Nicad, BB-390 NMH, BB-2590, BB-X590 Batteries and Primary BA-5590 Discharge at 2A



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Solutions Available Today (cont)

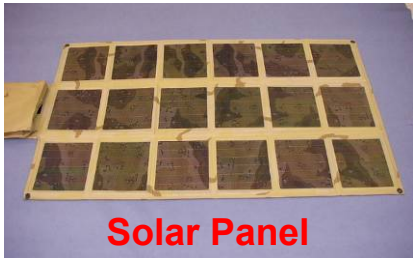
AA 8 - PACK SCAVENGER

Portable Fast Battery Charger for AA-size Cells

8 - PACK SCAVENGER

- Recharges commercial AA cells
- Charges 8 cells in 100 minutes
- Scavenges un-used energy from Military power sources
- Saves 25lbs per Platoon over 5 days

Any 12 VDC source



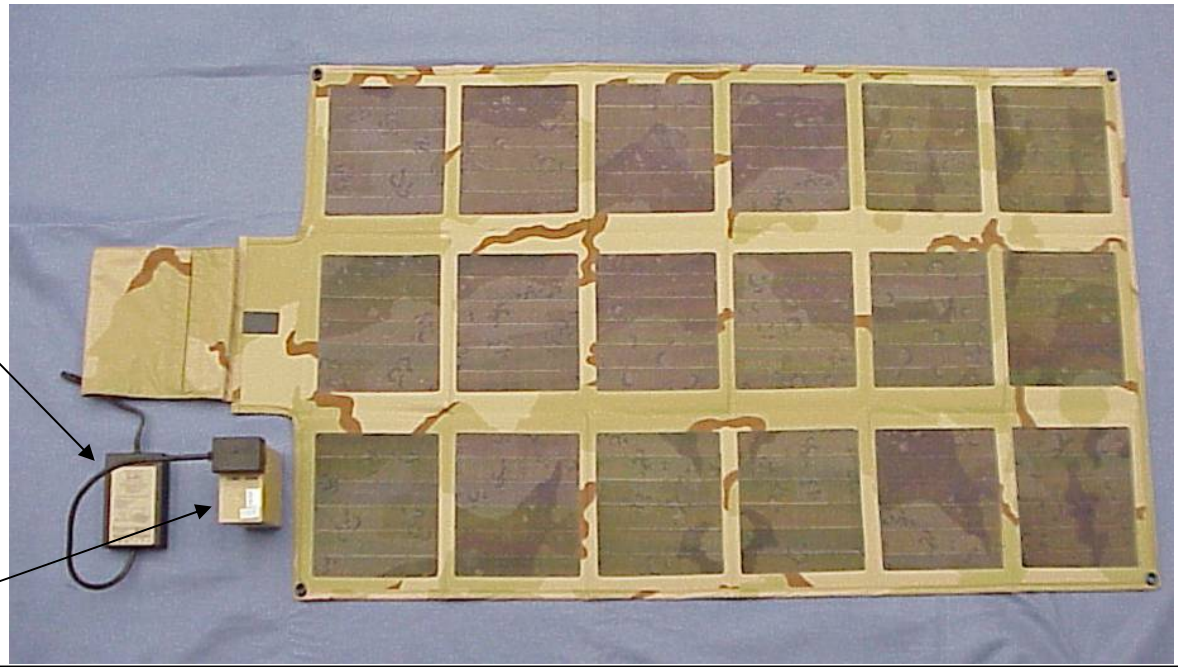
Charging Sources	# of AA-cells Charged
BA-8180	128
BA-8150	80
BA-8140	64
BA-5590	24
BA-5390	32
BB-390	20
BB-2590	24
SP4-solar panel	∞
Vehicle Adapters	∞

Solutions Available Today (cont)

55 W Solar Charger - Soldier

- Charges two 6.2Ah BB-2590 Li-Ion batteries in ~5-6 hrs
- Flexible Panel Design
- Anti-Glint, Inlaid Cammo

Maximum Power	Nominal Voltage	Maximum Current	Weight	Deployed Area	Packed Volume
(Watts)	(Volts)	(Amperes)	(lbs.)	length x width (in.)	length x width x height (in.)
55.0	16	2.8	4.4	55 x 32	11 x 9 x 1.3

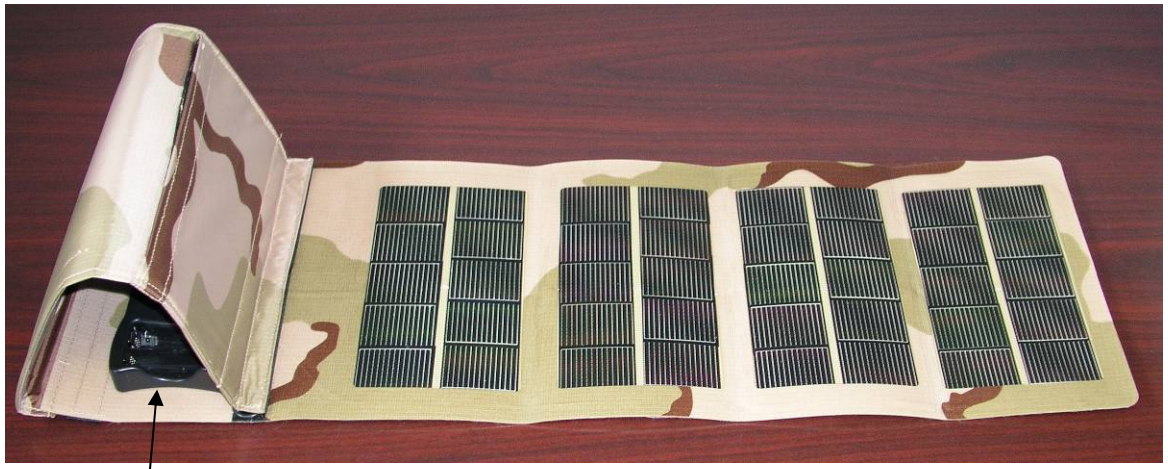


Renewable Energy – Lighten Soldier Loads, Reduce Logistics, Lower Costs

Solutions Available Today (cont)

AA-Cell Solar Charger - Soldier

- Charges four 2.3Ah AA NiMH batteries in ~4 hrs
- Flexible Panel Design
- Anti-Glint



AA-Cell Holder
& Charge Controller

- 9” x 5” x 2” folded
- 9” x 25”, deployed w/shade
- 0.87 lbs without batteries

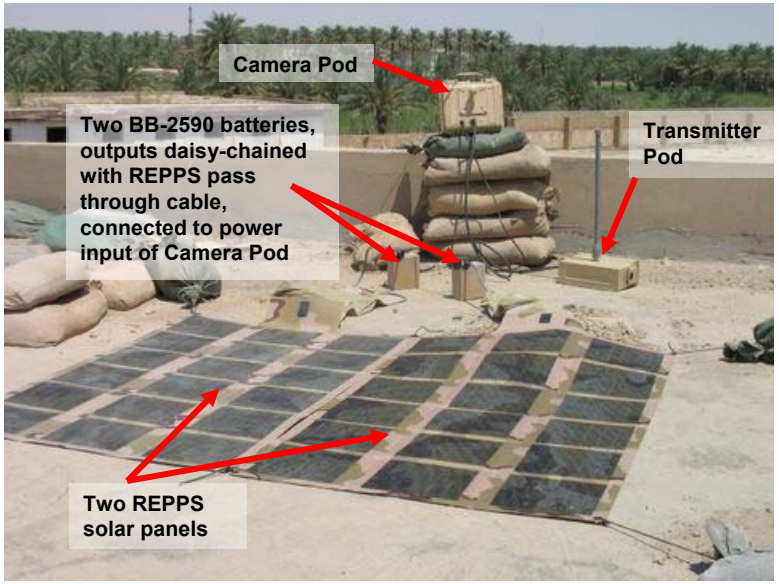
Renewable Energy – Lighten Soldier Loads, Reduce Logistics, Lower Costs

Solutions Available Today (cont)

Rucksack Portable Power System - Soldier

- **Solar Panel, Charger, Inverter, and NATO/Commercial Power Adapters.**
- **DC/AC power output and Charger for military batteries.**
- **In field use for unattended ground sensors (UGS) and surveillance systems.**

Soldier Feedback:
"I wanted to thank you again for everything. The camera system [using a REPPS system for 24 hour operation] has been a huge success thus far and I believe has saved lives by keeping our soldiers out of harms way."
SPC Fiorino, David G.



Renewable Energy – Lighten Soldier Loads, Reduce Logistics, Lower Costs

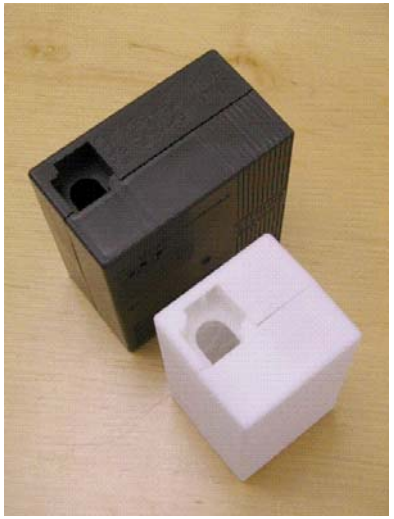
What's Next – High Energy Batteries

Extended Run-Time Lithium Carbon Monofluoride (Li/CFx) Batteries

Objective

The development of high energy density Li/CF_x batteries allow for:

- **A BA-5590 replacement with twice the run time at equivalent weight and volume**
- **A half-sized BA-5590 with equivalent run time at half the weight and volume**



Technology

Disposable Battery	Chemistry	Weight (lbs)	Energy (Wh)
BA-5590	Li/SO_2	2.16	200
BA-5390	Li/MnO_2	2.94	300
BA-XX90	Li/CF_x	**2.2**	**400**

Twice the Mission Runtime at same weight versus the BA-5590

Participants

- **Sponsor (s): U.S. Army RDECOM CERDEC**
- **Gov't Contributors: PM JTRS Ground Domain HMS, USAIC**
- **Industry: Five Known Interested Parties**

What's Next – Hybrid Power Sources

Hybrid Power Mission Extender

Case Study: For a 72hr Mission How many batteries/hybrids do we need to support the Land Warrior System?

Li-145 Lithium Ion (Baseline)

Gen 4 Zinc-Air/Li-145 Hybrid System

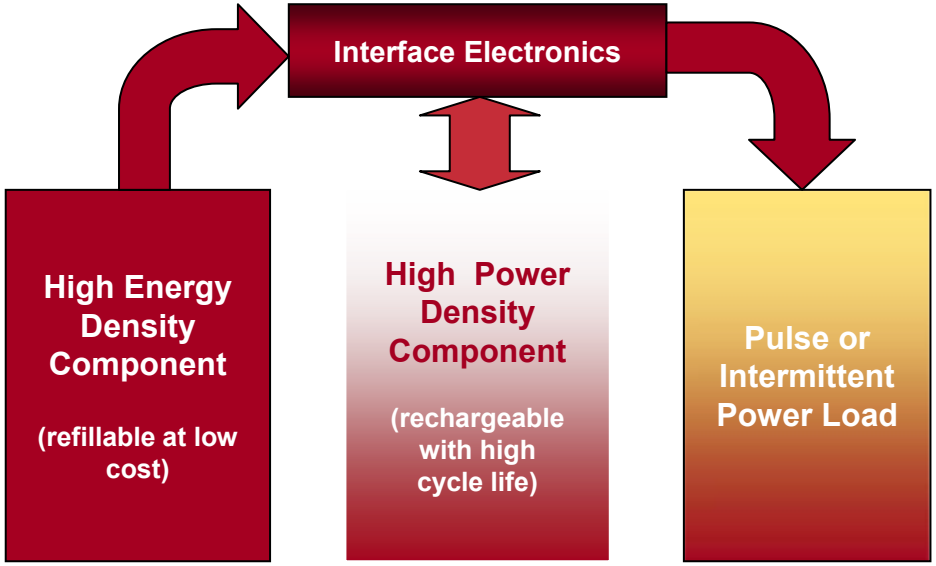
UltraCell Fuel Cell Li-145 Hybrid System

	Li-145 Lithium Ion (Baseline)	Gen 4 Zinc-Air/Li-145 Hybrid System	UltraCell Fuel Cell Li-145 Hybrid System
Weight:	13.2 lbs	9.4 lbs	6.1 lbs
Volume:	216 in^3	218 in^3	94 in^3
Energy: (available)	870 Wh	1145 Wh	895Wh

What's Next - Hybrid Power Sources

- Extends Mission Runtimes
- Reduces the Battery Weight and Volume Required for Multiple Day Operation
- Reduces Logistics Costs

Hybrid Power Sources



Lithium Ion / Zinc-Air Battery/Battery Hybrid for UGS

Lithium –ion Battery / Solar Panel Hybrid for UGS

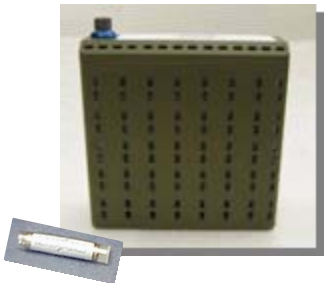
Sealed Pb-Acid / Zinc-Air Battery/Battery Hybrid for SATCOM Radios

Zinc-Air Battery / Capacitor Hybrid for Javlin

What's Next - Hybrid Power Sources

Battery Hybrid Power Source - Soldier

High Energy Component



Zinc-Air Battery

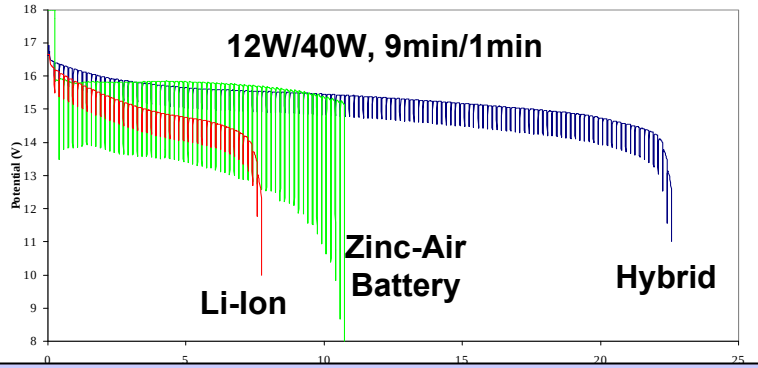
- Nominal potential: 14 V
- Nominal rating: 15 Ah
- Weight: 900 g
- 42- Cell "AA" Design:
- 14S3P cell configuration

200 Wh/kg

High Power Component

Li-Ion Battery

- Nominal potential : 15.2 V
- Nominal rating: 7.2 Ah
- Weight: 882 g (1.94 lbs)
- 16 18650G 2 Ah cells
- 4S4P cell configuration



Provides 1/3 Weight Reduction Over Rechargeable Alone for 24 Hours

What's Next - Fuel Cells

20W DMFC - Soldier

- Dimensions: 9.75" x 2.31" x 3.06"
- System Dry weight: 1.18 kg
- Fuel cartridge: 500 ml / 0.47 kg
- 24 hr mission weight: 1.6 kg
- 72 hr mission weight: 2.6 kg
- Efficiency: 22.4%
- Fuel Cartridge Duration: 24 hours
- Fuel is 100% methanol at low temp; water/methanol mix at high temp >40ºC
- 72 hour mission energy density 554 W-hr/kg

20 Watt DMFC System

Mission Extender Power Source, Battery Charging

What's Next - Fuel Cells

25W RMFC - Soldier

CERDEC collaboration with DARPA

Dimensions: 9.3'' X 5.38'' X 1.8''

System Dry Weight: 1.2 kg

Fuel Cartridge Weight: 0.325 - 0.350 kg

24 hr mission weight : 2.25 kg
72 hr mission weight : 4.23 kg

Efficiency: 23.8% @ 20 watts
Fuel Cartridge Duration: 9 hours

72 hr mission energy density: 340 Wh/kg


25W Reformed Methanol Fuel Cells


Soldier System Hybrid

Mission Extender Power Source, Battery Charging

What's Next - Fuel Cells

20 W Solid Oxide Fuel Cell - Portable

CERDEC collaboration with DARPA and SOCOM

Power:	**20 W**
Start Up Time:	**20 minutes**
Dimensions:	**11.6'' X 3.7 '' X 5.11''**
System Weight:	**1.55kg**
Fuel Cartridge Weight:	**0.406kg (propane/butane)**
24 hr mission weight:	**1.95 kg @ 20 Watts**
72 hr mission weight:	**2.77 kg @ 20 Watts**
Fuel Cartridge Duration:	**25 hours @ 20 Watts**
Energy Density:	**520 W-hours/kg (72 hrs@ 20 watts)**

20 Watt SOFC

Platoon Level Portable Power Source, Battery Charging – JP-8 Target Fuel

What's Next - Fuel Cells

250 W Solid Oxide Fuel Cell - Portable

- **Developing a 250 W portable fuel cell system operating on de-sulfured JP-8 fuel.**
- **Current system uses Propane/Butane fuel.**
- **Partial Oxidation (POX) reformer design for JP-8.**
  Air oxidation, smaller reactor
- **<10kg target for 250 W.**

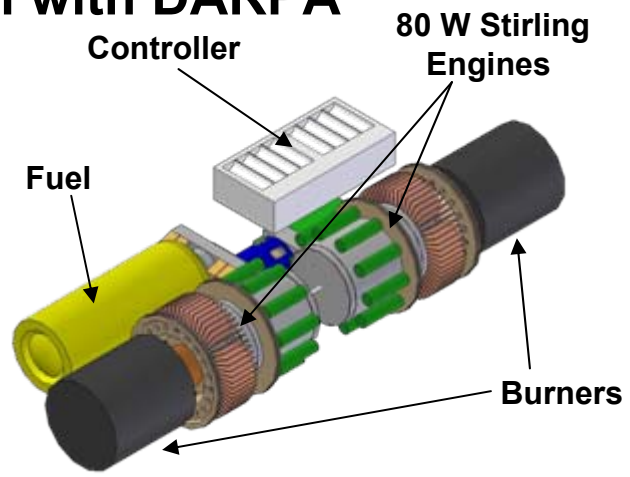
Platoon Level Portable Power Source, Battery Charging – JP-8 Target Fuel

What's Next - Stirling Engine - Portable

CERDEC collaboration with DARPA

- **Air cooled design**
- **Propane (FY06)**
- **JP-8 fuel (FY08)**

Projected JP-8 160W_e Performance	Target
Hot-end Temperature	650 ºC
Cold-end Temperature	70 ºC
Nominal Operating Frequency	102 Hz
Nominal Voltage	28 V_{DC}
Nominal Engine/ Alternator Output Power	160 W_e
Fuel	JP-8
Engine/ Alternator Efficiency	36 %
Generator System Efficiency (without parasitics)	24 %
Net System Efficiency	20 %
System Weight	<10kgs



160W_e System (Dual Opposed 80W_e Engines)

Platoon Level Portable Power Source, Battery Charging – JP-8 Target Fuel

Summary

- Power Source Technologies continue to improve.

- Power Sources will always be seen as a weight/volume/logistic burden unless taken in as part of the equipment system level designs, which must include power management.

- Power Management of the Systems to a Fixed Power Budget will reduce the weight, volume, and logistic costs for power and energy.