Powermers

Lithium-air Battery

NDIA
August 24, 2015

Powermers' Electroconductive NanoPolymer Catalyst and Development of Li-air Batteries

Frank Scardena, President

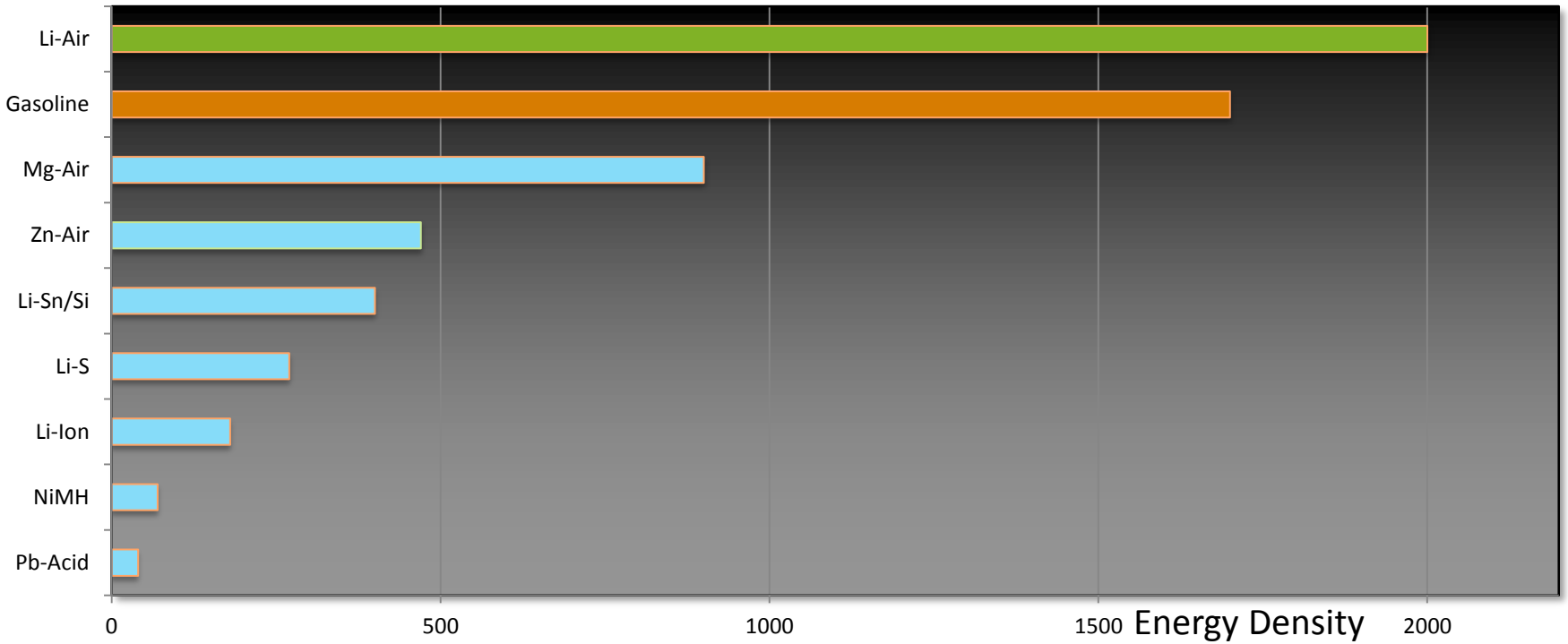
Key Battery Characteristics

- Water Bottle Comparison

- **Specific Energy** (Energy Density) – Water Content
- **Specific Power** (Power Density) – Size of the Nozzle
- **Voltage** – Water pressure
- **Cycle Life** – Number of times the bottle can be filled and emptied before breaking

Lithium-Air Batteries: Highest Practical Energy Density Potential

Lithium-air batteries theoretically should supply large amounts of Energy in a small and lightweight package



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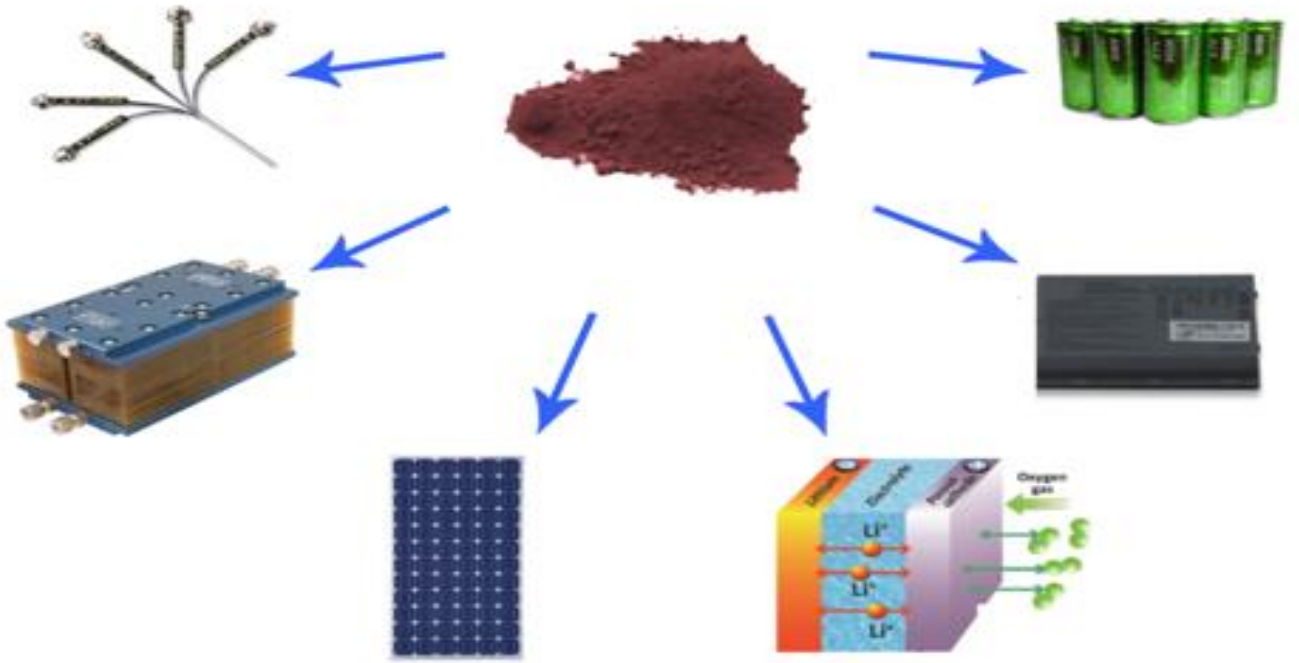
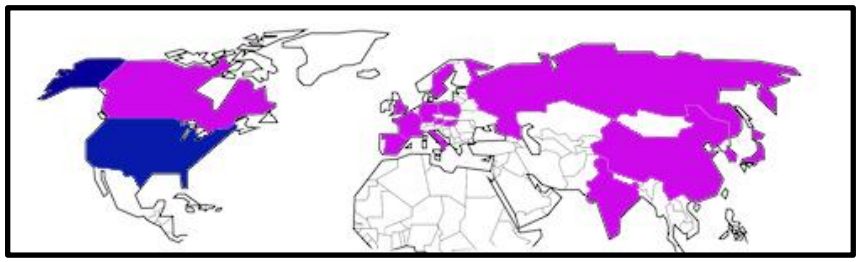
The basis of Powermers technologies are transition metal-based complexes and related monomers





5 Issued U.S. Patents and 46 Issued International Patents

Key Technology - Catalytic Polymer

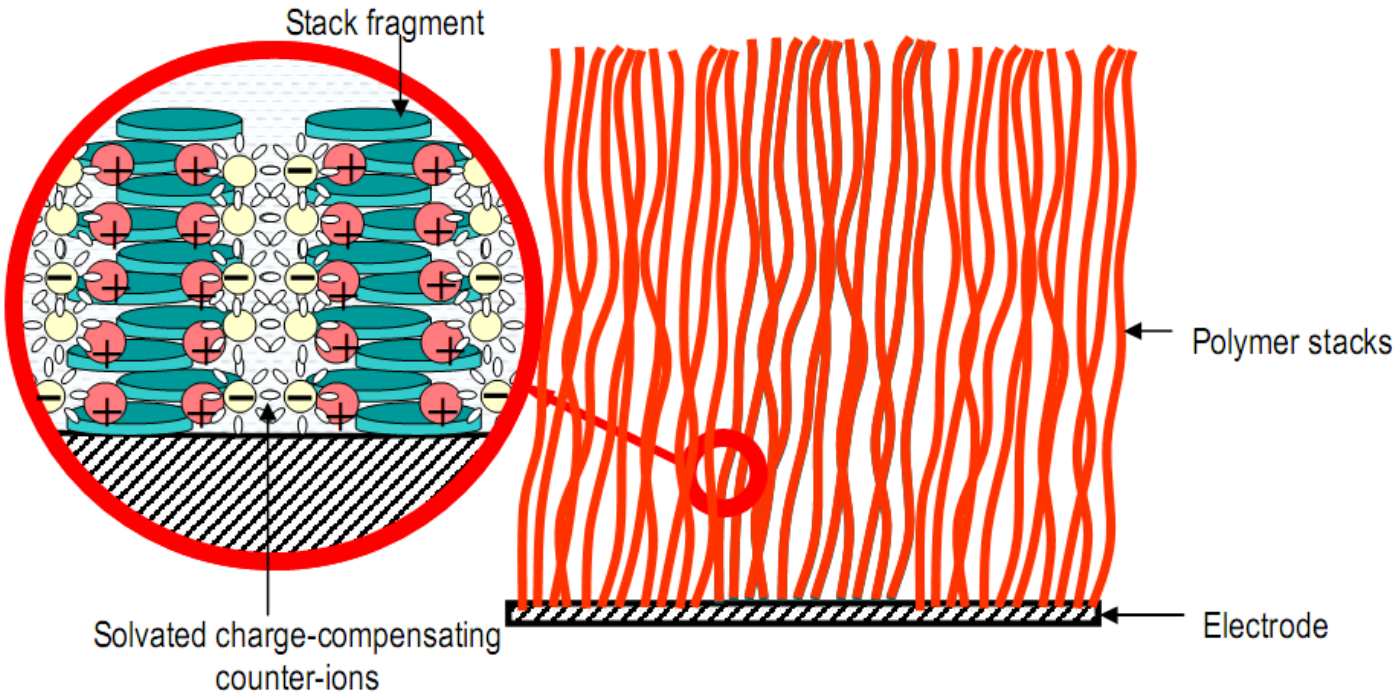


Figure 2. Schematic representation of poly[M(Schiff)] polymers with respect to the molecular structuring methodology

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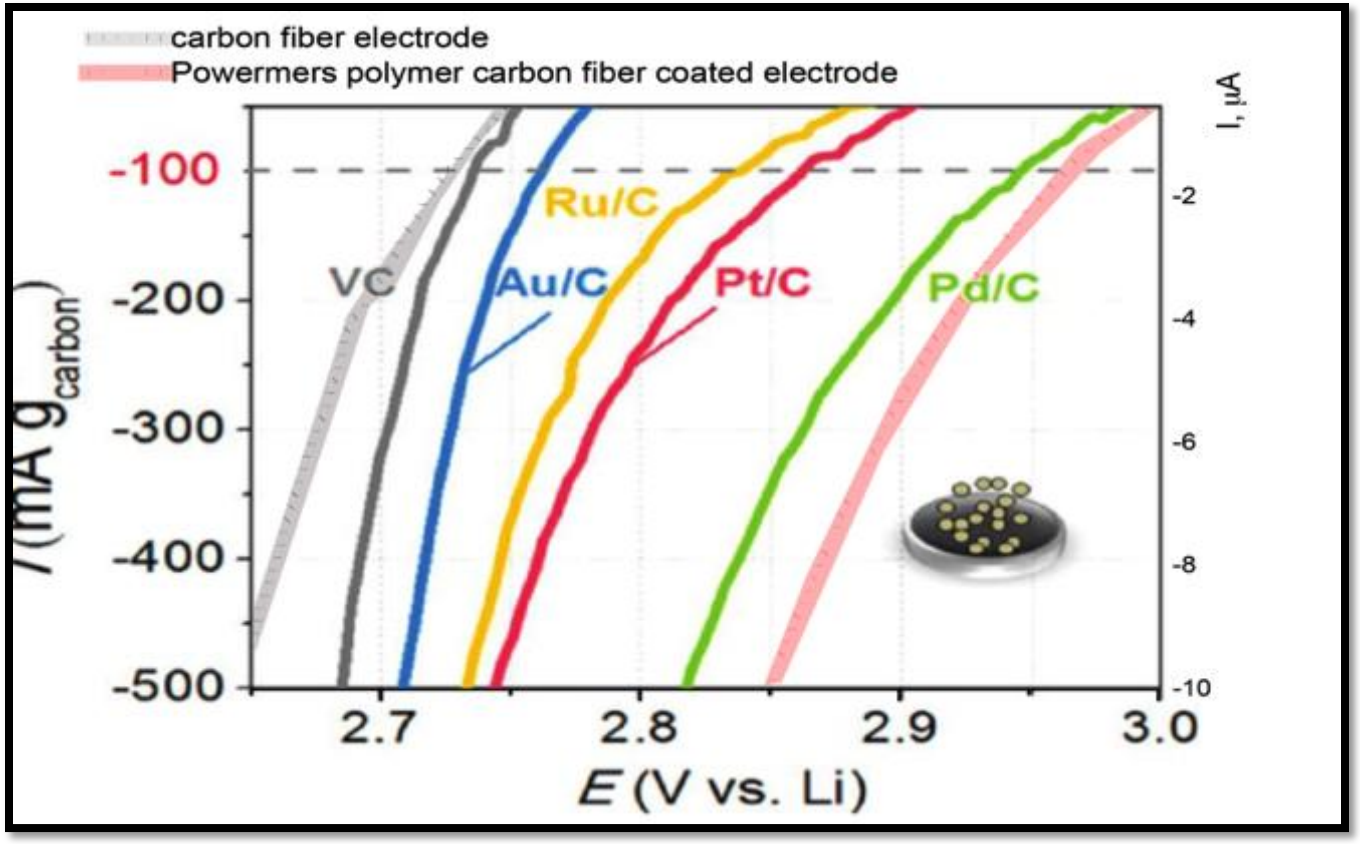
Catalytic Comparison

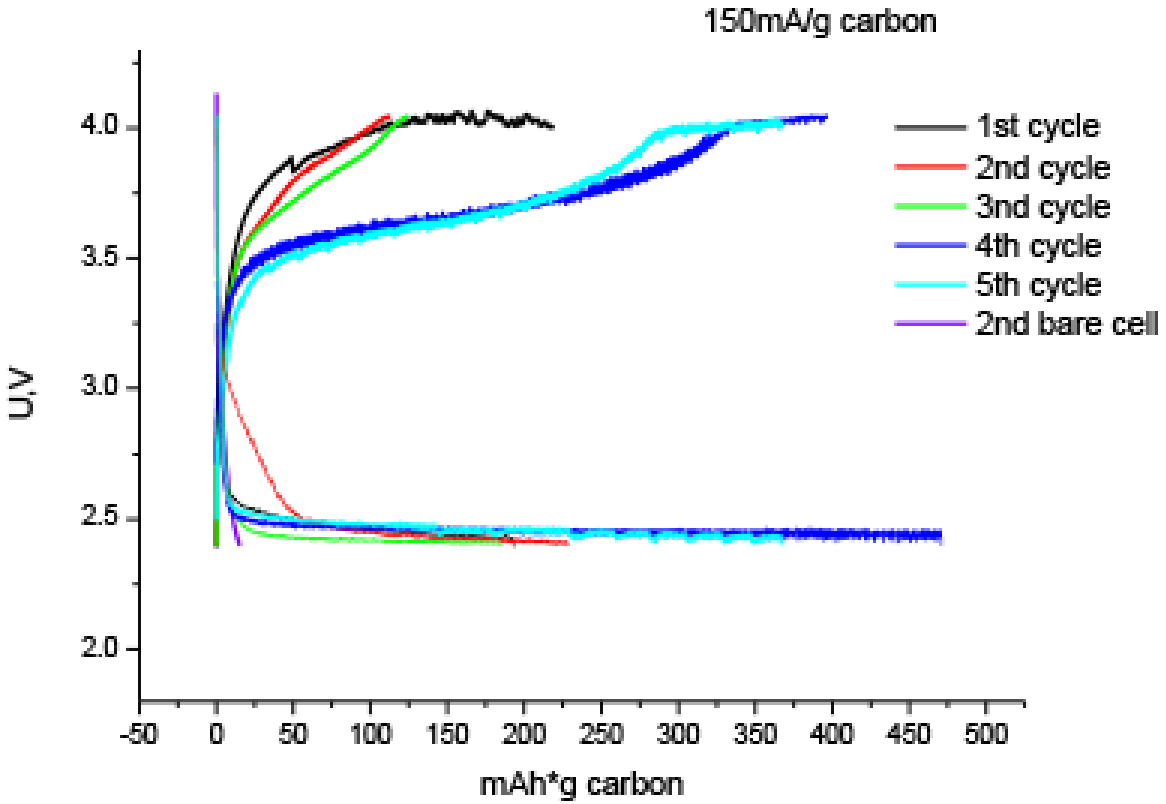


Polymer (Pink) is showing higher catalytic efficiency than Pd

Powermers catalyst is currently the most effective catalyst for the reaction of Oxygen electroreduction potential and has shown near 100% reversibility in Li-O reactions

Powermers' results vs Lu, Yi-Chun, Hubert A. Gasteiger, and Yang Shao-Horn. "Catalytic Activity Trends of Oxygen Reduction Reaction for Nonaqueous Li-Air Batteries." *Journal of the American Chemical Society* 133, no. 47 (2011): 19048-19051.

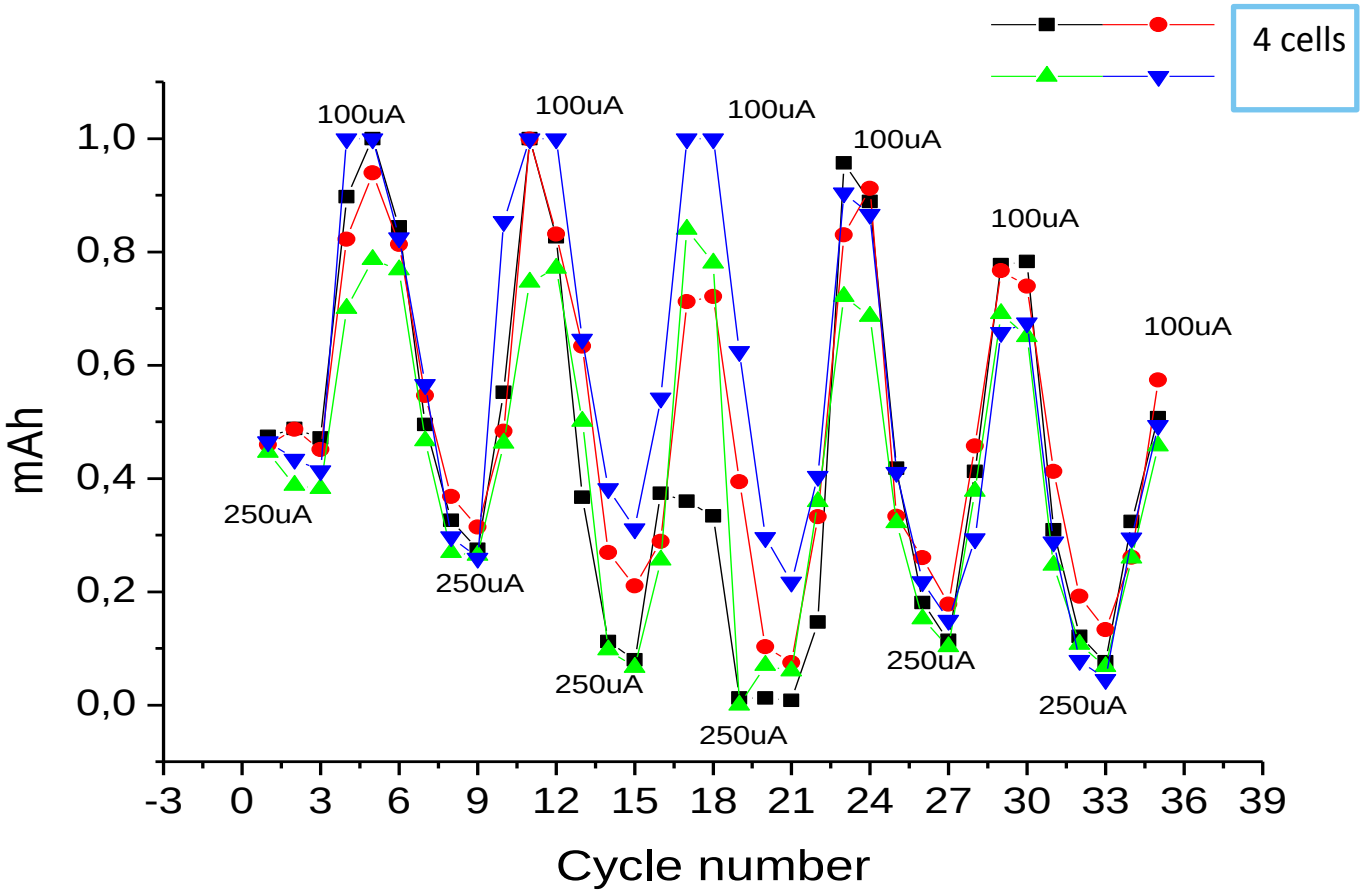
Reversibility - Coin Cells Li-Air November 2013



Capacity Shows Initial Increase as Polymerization is Completed in the Cell

Results validated through Ohio State University's Center for Automotive Research

Reversibility - Coin Cells Li-Air February 2014



Results validated through Ohio State University's Center for Automotive Research

Gated Development Process

Scientific Validation: Monomer Has Catalytic Properties

Technology Validation: Working Battery for 18 Days (6 Wh/kg *(casing excluded)*

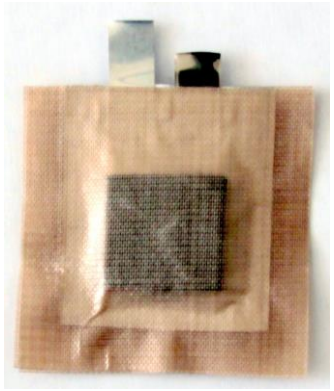
Scale the Electrodes 100 Wh/kg *(casing included; ambient air)*

IS THE TECHNOLOGY WORTHWHILE?

563 Wh/kg

Electrode Mock-up

Small-scale prototype



Large-scale prototype

Advanced prototype

White Board to Real Results – Proof that the fundamental science is correct!

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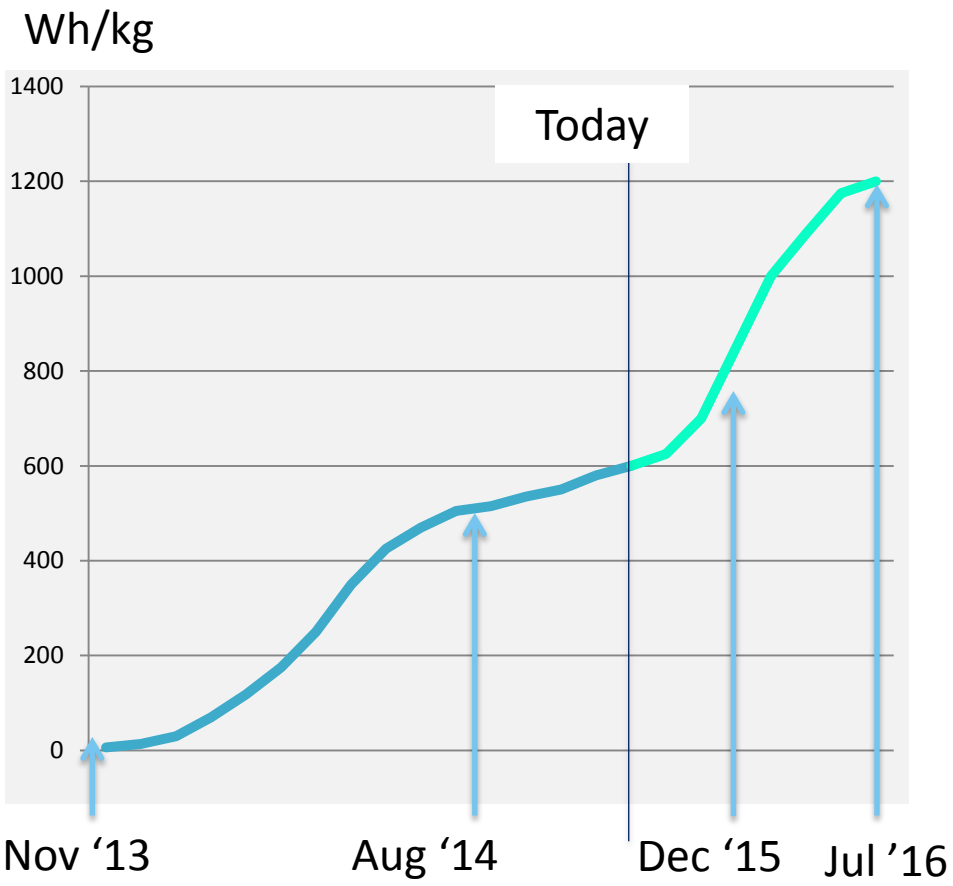
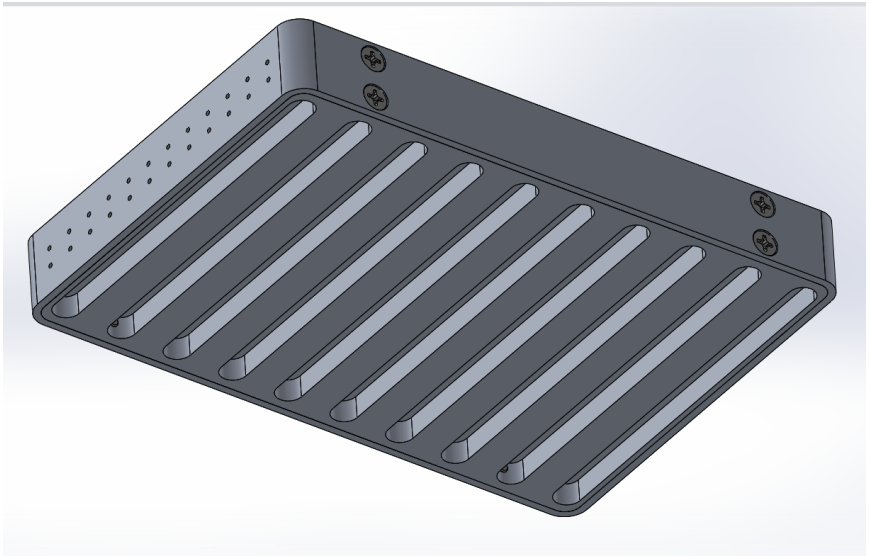
Energy Density Progression



Expected gains in Energy Density will come from reduction of cathode thickness and less electrolyte. Higher compression in better cases (shown below) will aid in energy and power as well.



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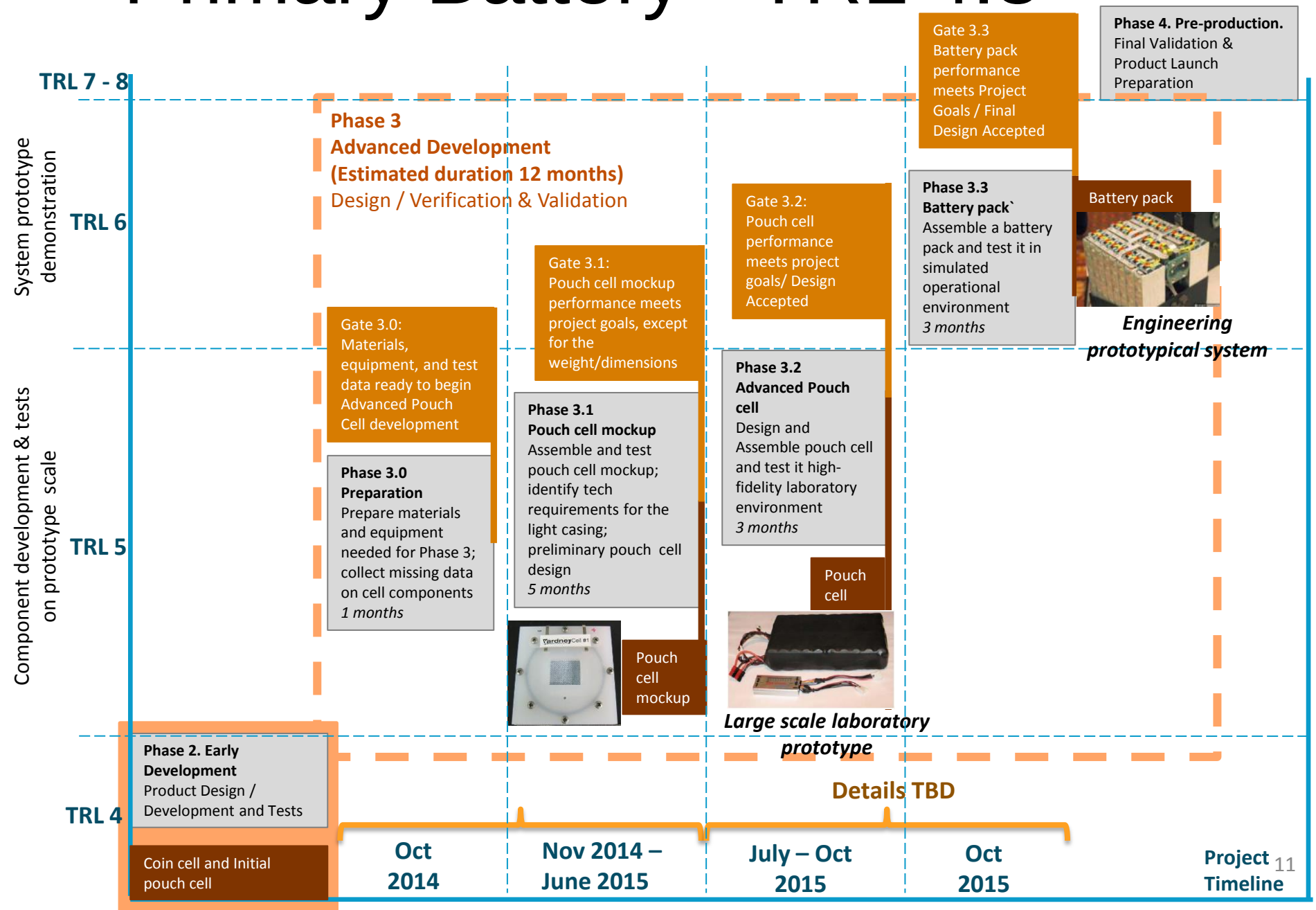
Primary Battery - TRL 4.8

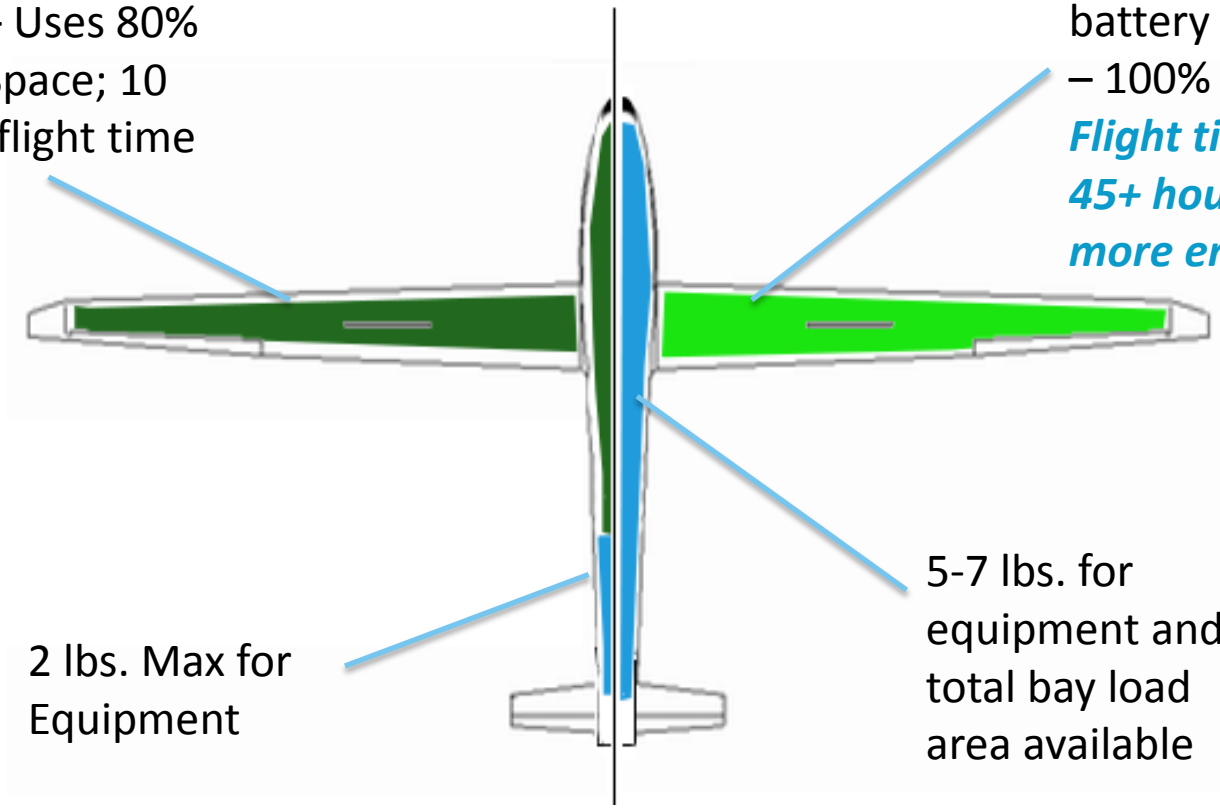


Market – Primary Drones

Max 40 lbs. Total Weight

Currently 30 lbs.
Batteries – Uses 80% Available Space; 10 est. hours flight time

Li-air would reduce battery weight to 25 lbs. – 100% wing placement
Flight time extended to 45+ hours (less weight more energy)



2 lbs. Max for Equipment

5-7 lbs. for equipment and total bay load area available

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Current Battery Pack Calculations

	Battery	
Nominal Voltage	2.45	
Ah/cm^2	0.045	
A/cm^2	0.001	
Parallel #	50	
Series #	25	
Weight per 1.22cm^2	0.25	
Weight/area	0.2049	
	Application	
# of Cells per Pack	19	
# of Packs	66	
Cell Ah	2.25	Ah
Pack Ah	112.5	Ah
Pack Voltage	60	V
Pack Constant Power	150	W
Total Pack Weight	13.50	kg
Pack operation time	45	h

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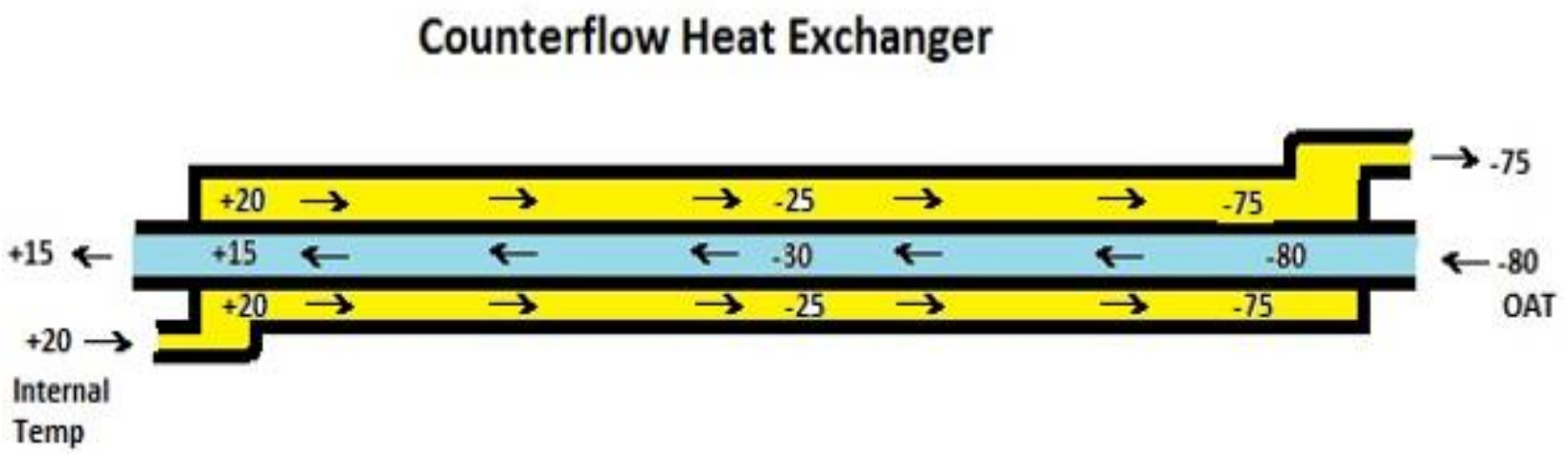
Extreme Application – Persistent Arctic Surveillance

Rapidly-deployable, unmanned sensor systems above the Arctic Circle



Heat exchanger in the wings of a drone and increase air temperature from as low as -80° C to 15° C.

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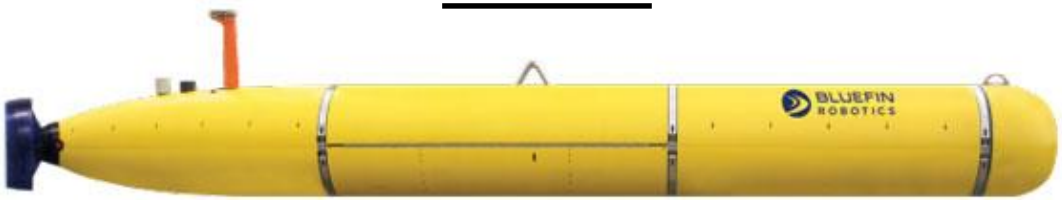
Additional Extreme Military Environments

Reduction from 10-20 lbs
of batteries to 4 lbs

UUV's



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Consumer Products

- Hearing Aid Batteries – seek FDA approval beginning in 2016
- Sensor-Based
  - Air Temperature/Air Composition sensors in Nuclear Reactor Stack
  - Environmental Monitoring Devices
  - Security Systems

Contact Information

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