

STRATEGIC MISSIONS



**DETER
DEFEND
DEFEAT**



Joint Services Power Expo ARPA-E BEEST & NSWC Crane

Advancing Power Systems Technology

David G. Miller

**Manager, Test and Evaluation Branch,
Energy, Power & Interconnect Div., NSWC Crane**

May 2-5, 2011

ARPA-E History

- **America Competes Act establishes Advanced Research Projects Agency-Energy (ARPA-E) in 2007**
- **Funded \$400M in 2009 by American Recovery and Reinvestment Act**
- **ARPA-E mission is to fund projects that will enhance the economic and energy security of the U.S., and ensure that the U.S. sustains a technological lead in developing and deploying advanced energy technologies**

ARPA-E Principles

- **Funding High Risk/High Reward R/D projects that may not otherwise be pursued due to high risk of failure**
- **Cross disciplinary approach using government labs, private industry and academia**
- **Selected performers will be funded with deliverables/milestones being actual power systems that can be measured for success against program metrics**

ARPA-E Programs

- **Innovative Materials & Processes for Advanced Carbon Capture Technologies (IMPACCT) Electrofuels**
- **Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS) Microgrid Technology**
- **Agile Delivery of Electrical Power Technology (ADEPT) Power Transmission / Control**
- **Building Energy Efficiency Through Innovative Thermodevices (BEET-IT)**
- **Batteries for Electrical Energy Storage in Transportation (BEEST) Advanced Power Systems**

BEEST & NSWC Crane

- In line with the DoE / DoD overarching MoU of July 2010
- BEEST purpose is to develop and test new, next generation power systems and provide benefits to US Industry.
- The Energy Power & Interconnect Technologies Division, Test & Evaluation Branch at Crane Division Naval Surface Warfare Center will work with ARPA-E and their performers to develop program specifics and independently verify/validate BEEST test assets compared to actual test metrics.

ARPA-E BEEST

Metrics for Success

- **Specific Energy Density – 400Wh/Kg**
 - Cell Value @C/3
- **Volumetric Energy Density – 600Wh/L**
 - Cell Value @C/3
- **Volumetric Power Density – 1200W/L**
 - Cell 80% DOD, 30 Sec
- **Specific Power Density – 800W/Kg**
 - Cell 80% DOD, 30 Sec
- **Cycle Life**
 - 1000 @ 80% DOD
- **Temperature Tolerance**
 - -30C to 65C
- **Self Discharge**
 - < 15% / Month
- **Safety**
 - Over Charge, Heat, Crush

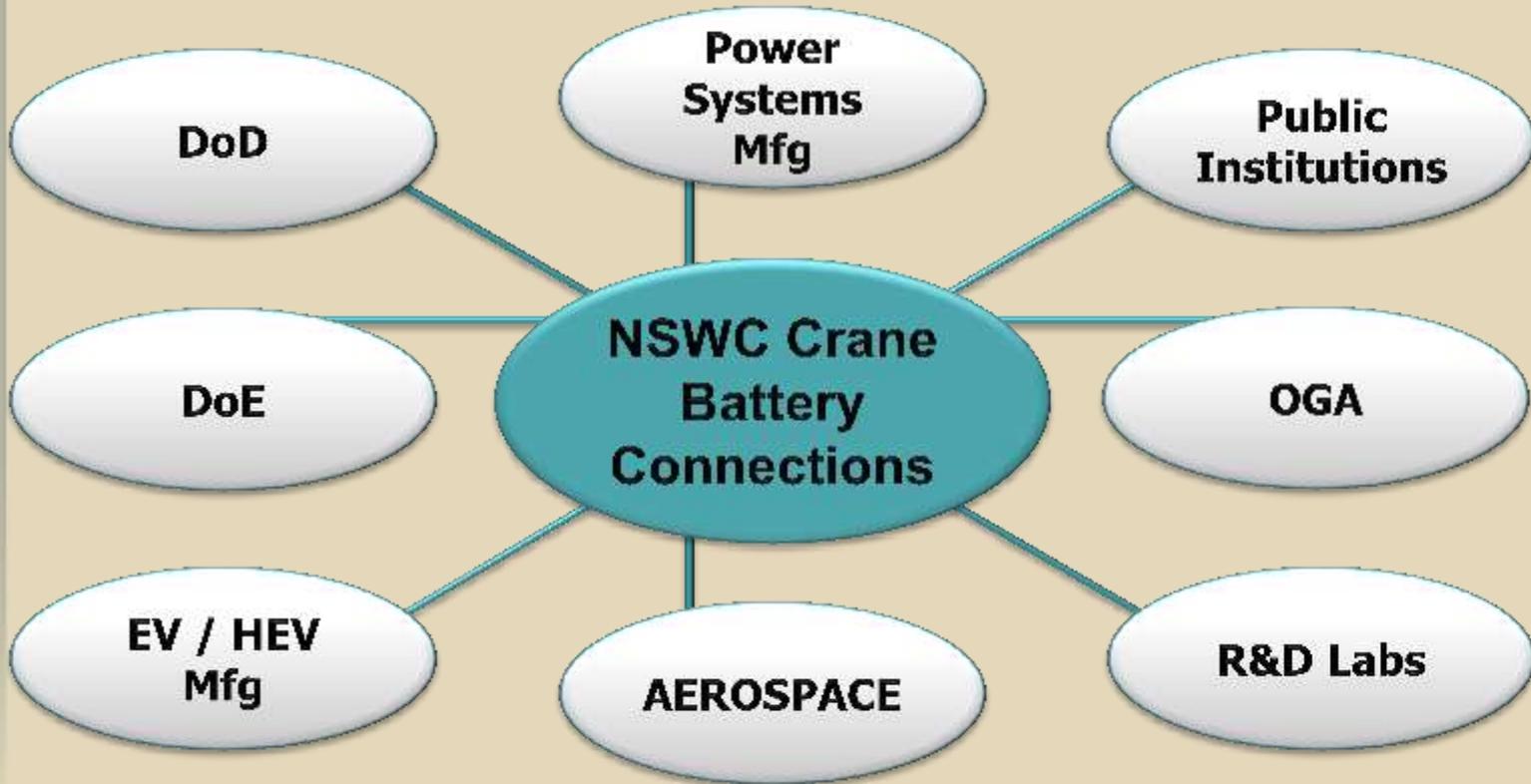
BEEST Performers

- 
- MIT
 - Fastcap
 - Pellion
 - Recapping Inc
 - Inorganic Materials
 - Planar Energy
 - Missouri Institute of Tech
 - Sion
 - Arizona State University
 - Envia
 - Applied Materials
 - Stanford University /
Honda Support
 - Polyplus
 - ReVolt
 - Eagle Picher
 - BNL
 - Max Power
 - Nanolab
 - A123
 - Rutgers University
 - NREL
 - U of Florida/Florida Central
 - U of Colorado Boulder
 - UC SanDiego
 - U of South Florida
 - Penn State

BEEST Performer Ideas & Concepts

- **All Electron Power System**
- **Solid State Power System**
- **Using Additional Valence Electrons**
- **Semi Solid and Fluidic Batteries**
- **Protonic Electrochemical Capacitors**
- **Lithium Air**
- **Sodium Power Systems**
- **Advanced Lithium Ion/Polymer**
- **And Others**

Networking for Greatest Benefit



Energy, Power & Interconnect Technologies Division Formal Charters

- **NAVSEA Center of Excellence on Batteries**
- **Technical Direction Agent (TDA) for Standard Missile Batteries**
- **Cognizant Field Activity (CFA) for Aircraft Batteries**
- **TDA for Navy Special Warfare Batteries**
- **ISEA for Submarine Batteries**
- **MoU for Army Missile Command Batteries**
- **Interagency Agreement With FAA**
- **ISEA for SDV Batteries**
- **TDA for ASDS Batteries**
- **Interagency Agreement With DoE**

Energy, Power & Interconnect Technologies Division Capabilities

- **Over 2000 Work Years experience**
- **~ 153 Personnel**
- **~ 60% are Engineers and Scientists; 6 PhD's**
- **Unbiased Independent Test Lab**
- **Established Government / Industry Team**
- **NOSSA Technical Agent for lithium battery safety.**

Electrochemistry Experience

Battery Types

Alkaline (Sealed/Vented)	Lithium (Reserve/Active)	Thermal
Aluminum-Oxygen (Air) Cadmium-Oxygen (Air) Carbon-Zinc Mercury-Cadmium Mercury-Zinc Nickel-Zinc Nickel-Iron Nickel-Cadmium Nickel-Hydrogen Nickel-Metal Hydride Silver-Zinc Silver-Cadmium Silver-Hydrogen Silver-Metal Hydride Silver-Iron Zinc-Manganese Dioxide Zinc-Oxygen (Air)	Carbon Monofluoride Copper (II) Oxide Copper Sulfide Iodine Ion Iron Disulfide Oxyhalide Polymer Sulfur Dioxide Sulfuryl Chloride Thionyl Chloride Vanadium Pentoxide	Calcium/Calcium Chromate Calcium/Potassium Di chromate Lithium Iron/Iron Disulfide Lithium Aluminum/Iron Disulfide Lithium Silicon/Iron Disulfide Lithium Silicon/Cobalt Disulfide Magnesium/Vanadium Pentoxide
	Other	Lead-Acid
	Seawater Ammonium Sodium-Sulfur	Absorbed Electrolyte Antimony Grid Calcium Grid Gel Electrolyte Flooded Electrolyte Pure Lead Grid

Capacity Ranges: 0.03 to Tens of Thousands of Ah

Approved for Public Release: Distribution Unlimited

Energy Power & Interconnect Technologies Division



Approved for Public Release: Distribution Unlimited



Approved for Public Release: Distribution Unlimited

Equipment & Facilities Capabilities

- **21 Custom Test Control Systems**
- **27 COTS Test Systems (Arbin, Bitrode Maccor PEC, TSC, EDA)**
- **Electronic Loads and Power Supplies up to 80 KW (240Vdc/300A; 120Vdc/600A)**
- **Full Environmental Test Capabilities**
- **Unlimited Abuse and Safety Test Capabilities**
- **Dissection and Materials Analysis Capabilities**
- **Unique High Energy Battery Test Facility**
- **Remote Ordnance Test Range**
- **Remote Underwater Test Range**

Equipment & Facilities Capabilities



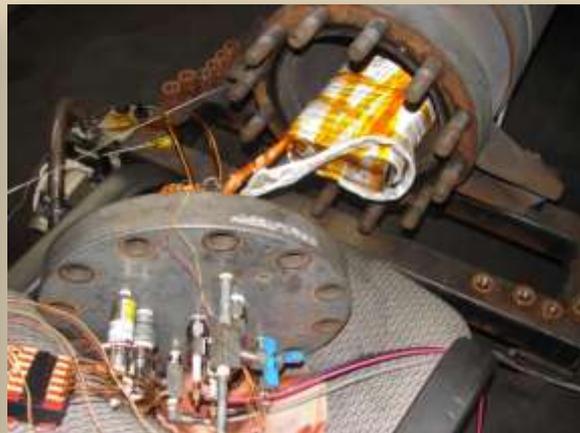
Nail Penetration



Shock & Vibration



**Temp, Altitude &
Humidity**



Gas & Pressure



Acceleration

Approved for Public Release: Distribution Unlimited

Conclusion

- **The NSWC Crane Division, Energy Power & Interconnect Technologies Division is proud and eager to be part of this new and exciting DoE ARPA-E technology advancement initiative**
- **ARPA-E Director:**
 - **With the energy concerns of today, the Country cannot afford for this initiative to fail.....**
 - **The success of ARPA-E BEEST will change the way we all live.**

Contact Information

For Questions or Comments:

Mail:

*David Miller, Mgr.
NSWC Crane
300 Hwy 361
GXSM, Bldg 3235
Crane, Indiana 47522-5001*

Telephone / E-Mail:

*Office: (812) 854-1226
Fax: (812) 854-2043
E-Mail: David.G.Miller@Navy.Mil*