2011 Joint Service Power Expo

High Energy Density Systems Planning: A collaborative process

Kyle Werner, NSWC Crane
Division Manager, Energy, Power & Interconnect Technologies
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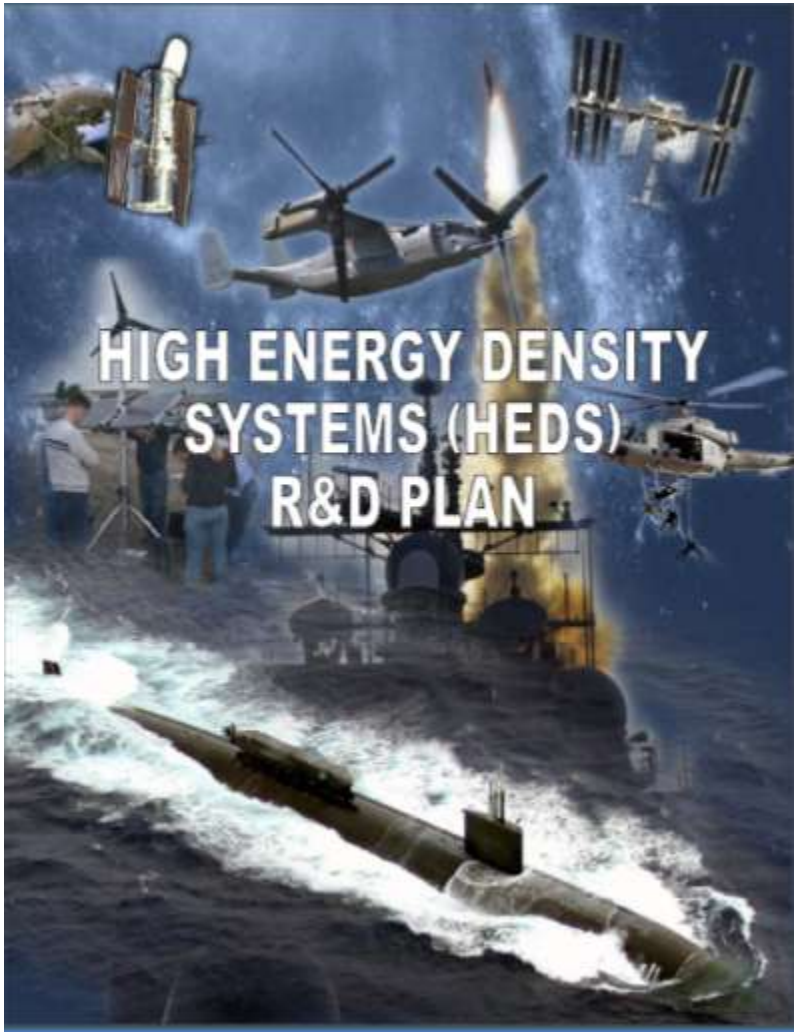
High Energy Density Systems (HEDS) Outline

- HEDS Document Overview
- HEDS Conclusions
- HEDS Paths Forward

HEDS Technology Planning Document: Overview

- Began with a NAVSEA request for action…
  - Assist implementation of HEDS for Navy applications
  - Help coordinate efforts
  - Document technology development needs
- Followed EO-IR "model"…
  - Expert community invited
  - Held event July 2010
  - Resulted in plan document



HEDS Technology Planning Document: Process Overview

Basic Research (6.1-6.2; TRL 1-3)	Applied R&D (6.3; TRL 4-5)	Eng. & Man. Dev. (6.4-6.5; TRL 6-7)	Production & Dep. (6.7-Proc; TRL 8)	Ops. & Support (O&M; TRL 9)

Build Knowledge Base	Introductions	Workgroup Orientation	Stakeholder Analysis	Systemic Challenges		Tuesday
Build Document	Build Technology List	Prioritize Technology List	Timelines	Technology Descriptions	Walkthrough	Wednesday
Analyze Document	Analysis	Critical Success Factors/Dependencies	Insights	Recommended Actions	"Blank Sheet" (Time Permitting)	Thursday
Workgroup Brief-out	Brief-out Prep	Brief-out Presentation				Friday

HEDS Technology Planning Document: Organization & Leadership

Sponsors:

George Drakeley, SES, SEA-05Z
Duane Embree, SES, Technical Director, NSWC Crane

Core Team:

Workshop Chair: Joe Gaines, NSWC Crane
Tech Leader: Sue Waggoner, NSWC Crane
Process Leader: David Smith, HBMG
David Cherry, NAVSEA 05Z34
Kevin Cook, NAVSEA 05Z34
John Dement, NSCW Crane
Eric Dow, NUWC Code 823
John Dow, NOSSA Indian Head
June Drake, NSWC CTO
Joe Fontaine, NUWC Newport
Peter Keller, NSWC Carderock
Bill Kleinebecker, HBMG
Corey Love, NRL
Scott Littlefield, NSWC Carderock
Brett Stafford, NUWC Keyport
Al Stern, NSWC Indian Head
Sam Stuart, NSWC Crane
Kyle Werner, NSWC Crane

Contractors:
HBMG – R&D Plan Process Consultants
TSC – Workshop Support
McKean Defense Systems – Logistics Support

Workgroup Co-chairs

Fuel Cells
John Heinzel, NSWC Carderock at Philadelphia
Ian Peek, NSWC Carderock at Philadelphia
Ken Burt, NSWC Crane

Lithium Rechargeable Batteries
Sam Stuart, NSWC Crane
Lloyd Zilch, NSWC Crane

Other Electro-chemical Batteries
Bill Johnson, NAVAIR
Justin Govar, MARCORSYSCOM

Advanced Energy Conversion Systems
Jerry Czarnecki, NSWC Crane
Tom Adams, Purdue

Capacitive Storage
Tricia Smith, NSWC Carderock

Safety/Risk
Dave Cherry, NAVSEA 05Z34
Mark Tisher, NSWC Crane
Larry Ruckriegel, NSWC Crane

Energy Systems Management
Frank Ferrese, NSWCCD Philadelphia
Mike Golda, NSWCCD Philadelphia

Advanced Application Technology
Scott Duncan, NAVSEA

HEDS Technology Planning Document: Mission/Vision

- Provide a Research & Development Plan with key technological elements that can be used for planning *safe* and *highly effective* HEDS for US Navy (USN) systems.
- Address HEDS used in USN systems above personnel carried systems and below primary propulsion and main electrical power for ships.
- Provide a comprehensive document that communicates the timing of technological development in this domain over the 2010-2030 strategic period.
- Provide key HEDS technological information for making strategic decisions in selecting technologies using mutual terminology, established technology maturity definitions, and a shared understanding of key issues.

HEDS Technology Planning Document: Synergistic Relationships

HEDS planning and development leveraged a variety of other Federal Agency Power & Energy future looking documents, some of which include:

Document	Sponsor	Scope	Distribution
DoD Power Sources Technology Roadmap	DoD JDMTP	Provides a concise, coherent strategy that assures the state of the art power sources are available now and in the future to the Nation's Warfighters	US Gov Agencies and their contractors
S&T UUV Energy Roadmap	ONR	Provides UUV energy sources for future Warfighter requirements	US Government only
Torpedo Energy & Propulsion Roadmap	ONR	Provides Torpedo energy and propulsion sources for future Warfighter requirements	US Government only
HEDS R&D Plan	NAVSEA	Provides a future focused strategic technology R&D plan with key technological elements that can be used as a tool for planning highly effective, safe, affordable High Energy Density Systems for Navy systems	US Gov Agencies and their contractors

HEDS Technology Planning Document: Focus Areas

- The plan document covered seven focus areas:
  - Fuel Cells
  - Lithium Rechargeable Batteries
  - Other Electrochemical Batteries
  - Advanced Energy Conversion Systems
  - Capacitive Storage
  - Safety/Risk
  - Energy Systems Management
- Developing technology plans followed an adopted approach:
  - Identify needs
  - List technology solutions
  - Propose development bridges for the gaps

Intention was to produce a tool for collaborative HEDS development…

HEDS Technology Planning Document: Workshop Attendees

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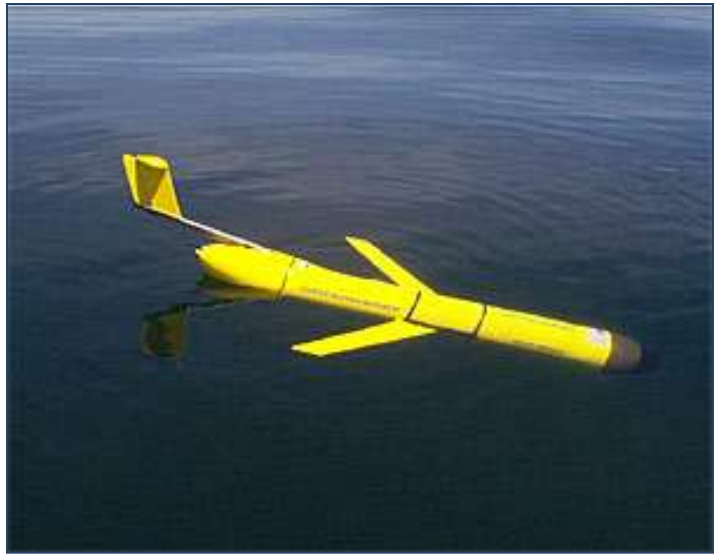
HEDS Technology Planning Document: Technology Boundaries

Factor/Year Fielded	2010	2016	2030
Max Gravimetric Density	200 Wh/kg	1000 Wh/kg	2000 Wh/kg

The boundaries represent the consensus achievable levels.

The plan will address HEDS used in US Navy Storage and Conversion systems above personnel carried systems and below primary propulsion and main electrical power for ships.



HEDS Technology Planning Document: Highlight Conclusions

Conclusion #1. Significant safety and risk issues are present; particular focus on materials.

Conclusion #3. Future HED systems will require hybrid solutions.

Conclusion #4. Providing high energy density and power needs a system of systems approach.

Conclusion #6. Must have domestic sources for some materials & possibly manufacturing equipment.

Conclusion #8. Need new/improved collaboration, resource sharing, and knowledge transfer.

Conclusion #10. Must increase funding of High Energy Density Systems to address the hard problems.

HEDS Technology Planning Document: Sample Focus Area, Lithium Rechargeable Batteries

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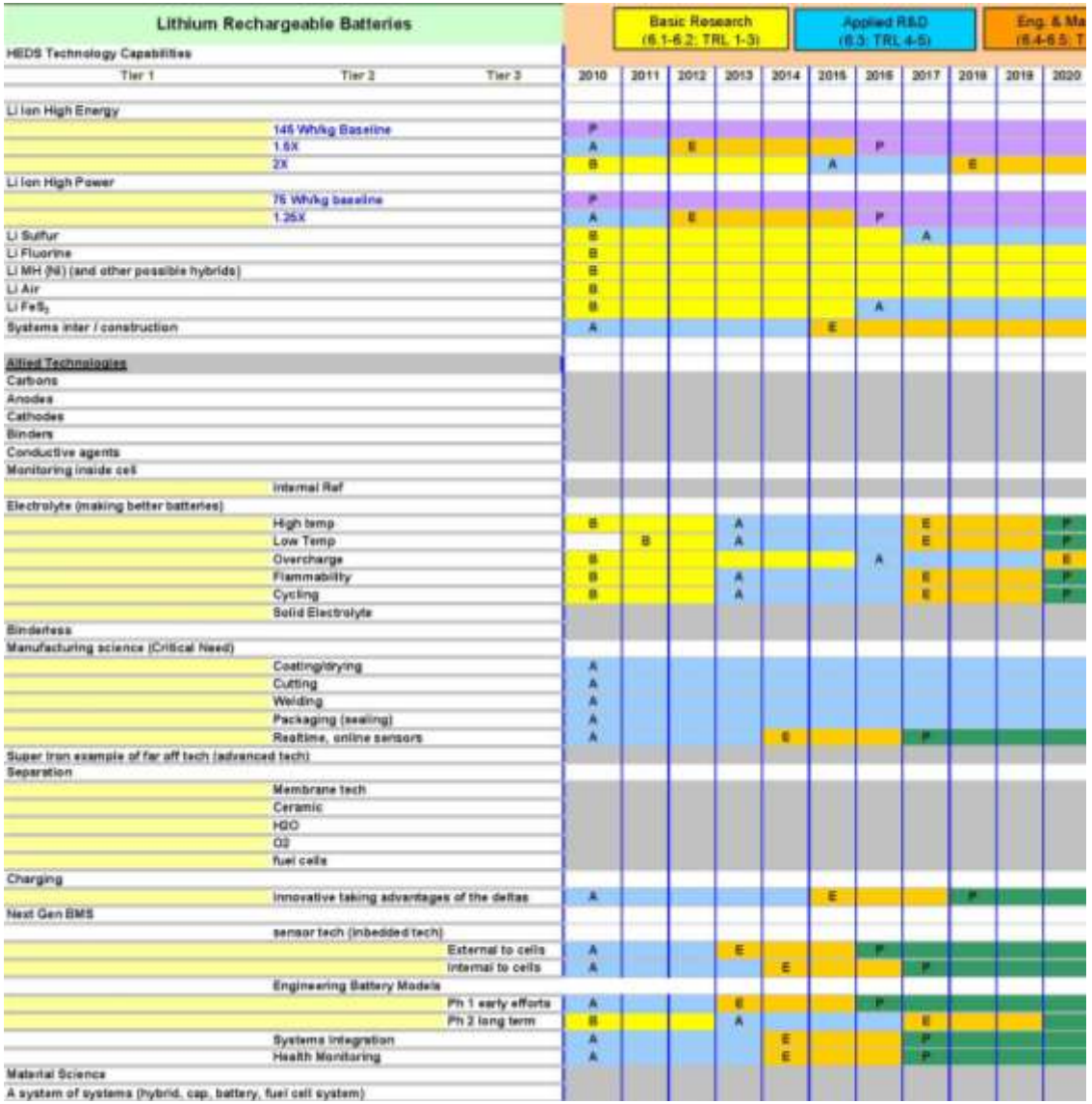
Insights

- Goal of 2000 Wh/kg in 2030 is unattainable in this area
- 2x improvement is possible for Li Ion (up to 500 Wh/kg)
- First generation of battery management has been lifted from non Li world. Li is tricky, next-generation must be Li specific
- Federal focus on alternative energy is diminishing supply of S&T skills
- Navy will benefit from collaboration in this area
- We will need to combine funding to achieve promise of Li ion
- We are behind other countries
- We need a better technology transition process



HEDS Technology Planning Document: Way Ahead…

Actions Already Taken:

- Warfare Centers have aligned S&T investments
- Industry partners have incorporated elements of the HEDS R&D Plan into their IR&D Plans
- SEA 05Z has established a High Energy Chemical Safety Storage Office (HECSSO)
  - A Platform Integration High Energy Safety Manager has been appointed
  - Navy High Energy Storage System Safety Manuel published

Way Ahead:

- Document is finalized and being routed for signature
- Briefings to Warfare Centers and NAVSEA headquarters
- Charter a HEDS Working Group in preparation for HEDS Update in 2012

HEDS Technology Document POC: Ms. Sue Waggoner, NSWC Crane, 812.854.4103, susan.waggoner@navy.mil

HEDS Technology Document: Back – Up Slides….

HEDS Document Background: Overall Conclusions for lithium rechargeable cells - cont

Technology Gaps

- For meeting 2x energy density improvement: cathodes, other materials for anode & electrolytes
- Battery Management Systems at all levels, modeling and packaging to improve safety over next 5 years
- Next gen of membrane technology
- Material availability at a reasonable price, especially for carbon nanotubes, $FePO_4$, and Nickel Manganese Cobalt materials

Brick Walls

- To exceed 2x energy density improvement (up to 1000 Wh/kg):
  - Separation technology (i.e., ionic membranes
  - Dendrites
  - Cathode technology (catalyst)
  - Electrolyte for higher voltage systems
  - Alternatives to flammable organic electrolytes
- No accelerated models/methods for life testing

Recommended Actions

- Improve materials and electro-chemical systems):
  - Nonflammable electrolytes
  - Higher energy density materials (alloys/metals)
- Develop new materials
  - Cathodes using nano-materials
  - Membrane technology (ionic exchange)
- Enhance efforts in improved Safety
  - With better battery management systems and sensors
  - Modeling and simulation
- Perform further analysis on Li-S and Li Air viability
  - Following the timeline foundation
  - Continue R&D plan improvements
- Improve communication
  - Develop a Li ion specification
  - Higher levels of collaboration
  - Partner with others to achieve greater goals

Progress against goals for 2010…

Recommended Actions

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Overall, commercial/university have most efforts

- NASA most, ARL several, NRL one effort
- DOE most, ARL/NASA many, Navy some
- DOE most, ARL several, Navy some effort
- Little effort
- DOE most, ARL, AFRL some effort
- NASA most, DOE, ARL, Navy some effort
- DOE some, ARL some effort
- JDMTP TWG, AF-AIAA, Navy efforts
- Initial discussions