USMC Battery Efforts

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Joint Service Power Expo

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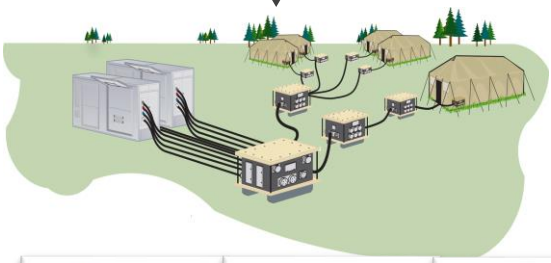
Introduction

- Overview of EPS
- USMC battery drivers
- USMC battery needs and programs
- EPS R&D efforts
- Upcoming opportunities
- Conclusion

U.S. Marine Corps Expeditionary Power Systems

Mobile Power, Water and Fuel



Advanced Power Team

Radio Power Adaptors

Power Supplies

Renewable Energy

Hybrid Systems

Battery Management / Sustainment Systems

USMC Battery Drivers

- More disperse operations
- Resupply requirements
- Growth in electrically powered gear
- Digital data
- IED protection
- Mobility concerns
- Cost

Marine Assault Load

1990

65.40 lbs – 67.40 lbs

Increase of ~ 27 to 30 lbs/Marine

-Representative of Marine assault load
-Does not include billet specific items
-Does not include spare batteries

2009

92.69 lbs – 98.28 lbs

Individual Marine Power Requirements 1990

Angle Head Flashlight
D Cell Battery
Qty: 2

Individual Marine Power Requirements 2010

AN / PVS-17
AA Battery

AN / PVS-14
AA Battery

AN / PAS-13D
AA Battery

AN / PEQ-16A
CR-123A Battery

Hand-held flashlight
AA Battery

MIOX Water Purifier
CR-123A Battery

AN / PSC-13 D-DACT
Unique or AA Battery

DAGR
AA Battery

AN / PRC - 148 or 152
Unique Batteries

AN / PRC-153
Unique Battery

Quiet Pro Headset
Unique Battery
CR-123A

Squad Digital Camera
Unique Battery

AN / PRC-117F
BA-5590 / BA-5390 / BB-2590 Batteries

Rugged Laptop
Unique Battery

Hybrid and Grid Systems

Large format batteries
Hybrids - High energy density
Girds - High power density
High cycle life
Low cost

Vehicles

High Power – SIL applications
High Energy – Silent watch

Weapon Systems

Wide Range of Needs
High Energy

Man Portable Applications

High energy
Physically rugged
Quickly exchangeable
Right size

Small Cell Development

Higher energy cells
Rechargeable mandate
Rechargeable 123A

Alternate Form Factor Batteries

Family of battery sizes
Low profile batteries

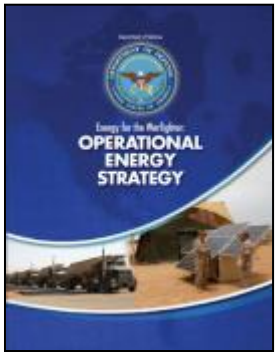
Portable Power Generation

Renewable energy
Portable generators

Wireless Charging

Power > 300W
Distance > 2 ft
Eff > 80%
Number of systems > 5
High degrees of freedom

Standards Development



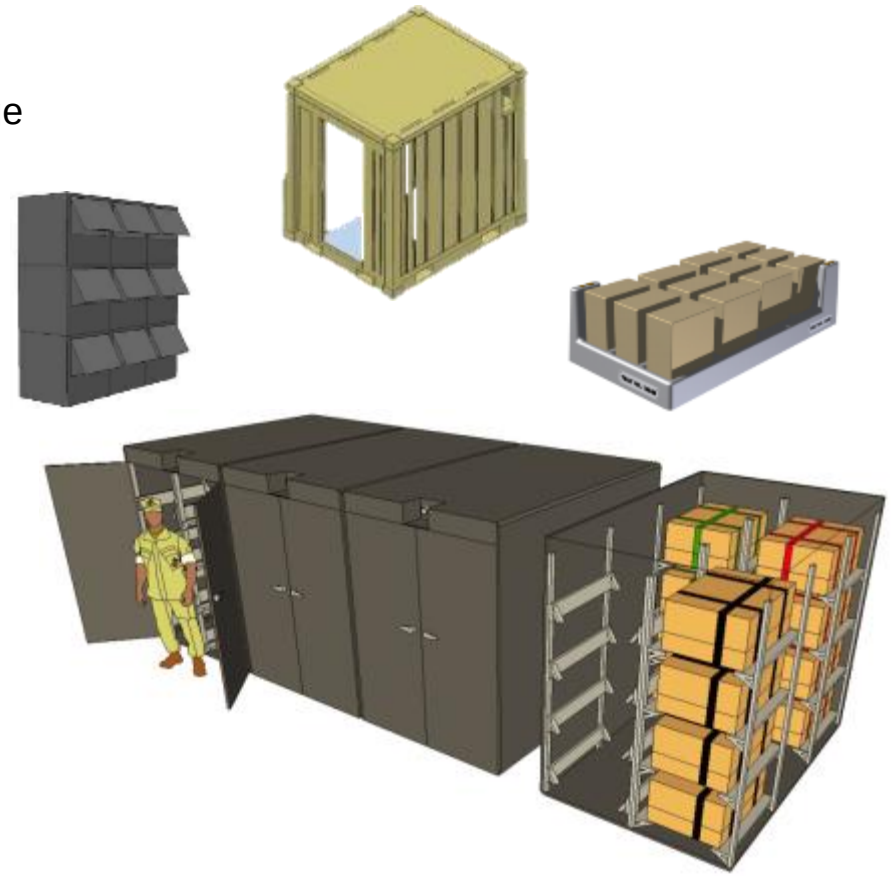
Family of batteries
Interface standards
Connector standards
Mission power planning

Advanced Battery Charger (ABC)

- Replacement of the SPC
  - More efficient
  - High power/selectable power
  - Charge new battery times
  - Faster battery charge time
  - Volume and weight reduction
  - High environmental survivability
- Planned FY16 RFP release for production items

Lithium Battery Maintenance

- Recent Marine Corps study found that vessels caring Marine Corps assets are inadequate to meet future large format lithium battery storage needs.
- Problem
  - Growth in lithium batteries
  - Lack of proper ground and ship based storage
  - Million in damaged batteries
  - Lack of maintenance capabilities
- Critical Parameters
  - Safety
  - Electrical Interface (Interoperability)
  - Mobility
  - Modularity
  - Autonomous maintenance
  - Environmental Control
  - User Feedback



Mobile Electric Hybrid Power Systems (MEHPS)

Generator

- Militarized generator
- Flexible Fuel
- Universal Generator Control Technology (Remote start/stop)

Power Inverter

- High Efficiency Inverter
- Fully Ruggedized
- 3-Phase Power
- 2-Way DC/DC Converter

Trailer

- Military HMMWV Trailer
- Trailer Mounting & Integration Hardware

Cables

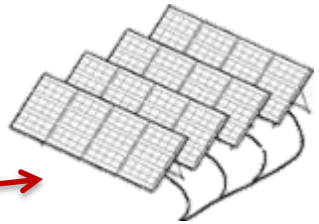
- Power and Data Cables
- Environmentally Rugged
- Quick Connect Tech.

Battery

- High Energy Density
- Modular & Expandable
- Broad Operating Temperature Range

Intelligent Controller

- Software Controls
- Human Interface
- Compact Electronics



Expeditionary Solar Array

- Lightweight, Compact Composite Panels
- Rugged and rapidly deployable

Development effort focuses on smaller, lighter, more efficient, easily maintainable systems.

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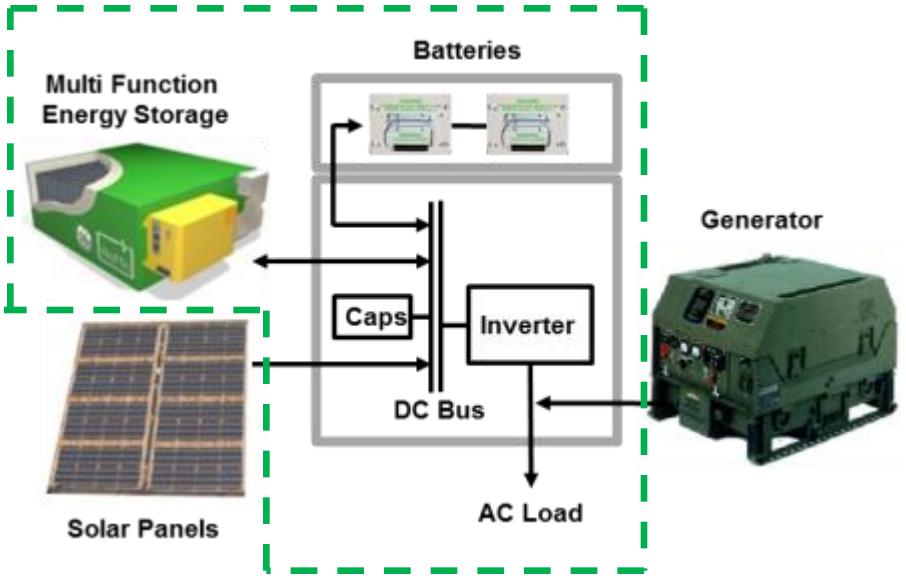
Compact High Density Tactical Energy Storage

Objective

Advance module-level energy storage technology to expand the envelope of safe storage, transport and operating conditions.

Approach

Scalable/modular energy storage
High cycle life battery chemistries
Reconfigurable, cell level control technology
Communication and controls integration



What it means to the warfighter

Reduce need for fuel resupply
Support future high pulse loads
Common use, transportable, high density
Enable Safe operation, storage, and transport
Advance open system architecture concepts
Enable intermittent silent watch

Future Naval Capability (FNC) P&E-FY12-03, FY-15 to FY-18 Effort

Modular, Scalable, Safe and Compact High Energy Density Sodium Metal Halide Battery

Program Objectives

Develop and demonstrate a modular, scalable, safe, and compact high density sodium metal halide battery energy storage (ES) with optimized complementary DC to DC converter integrated with BMS for MEHPS applications.

Naval Relevance

+ 10-15 year operational life, >4500 cycles
+ Safer chemistry
+ Extremely long shelf life (~20 yrs)
+ Robust operation, independent of ambient temperature.

Technical Approach

Base Phase (BP) / Phase I:

- Ruggedize Durathon™ battery for MEHPS application
- Demonstrate hybrid power system with ES and emulated solar PV, diesel gensets, and loads.
- Develop integrated DC/DC converter with BMS concept.

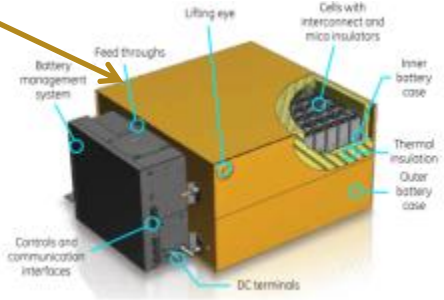
Option Phase (OP) / Phase II:

- Design and prototype integrated DC/DC converter with BMS
- Integrate the prototype component into base phase demonstrator
- Demonstrate fully integrated system with combined DC/DC & BMS.

ONR-GE MEHPS Concept

MEHPS demonstrator with one ruggedized Durathon™ battery, two rectifiers, an inverter, and a controller

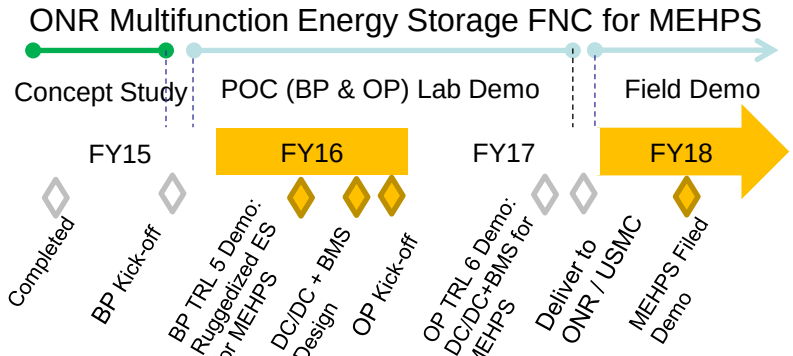
Scalable 10 kWh module



Ruggedized Durathon™ battery

Goals / Accomplishments by FY

✓ Pre-contract cost agreement: May 12, 2015
✓ Project kick-off: June 5, 2015 (Tcon & WebEx)
✓ Post-award Scope of Work review: August 7, 2015.



Compact High-Density Tactical Energy Storage

Objectives:

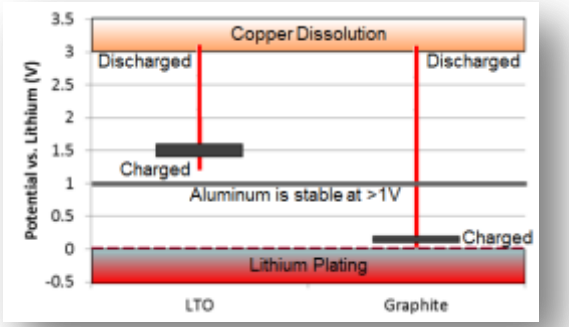
1. Reduce impedance growth and improve high temperature performance of Lithium Titanate (LTO) cells
2. Incorporate cells into a modular system design (including BMS), capable of being extended up to 12kWh of total energy storage
3. 65 Wh/kg energy density at cell level
4. <$450/kWh goal in high volume production
5. Indefinite 0V storage (and shipment)

Naval Relevance:

- Long cycle life (20k – 80k 80% depth-of-discharge, 2C/2C cycles)
- Safe chemistry

Technical Approach:

- Investigate alternative electrolytes, including alternative salts and advanced additives along with alternative formation procedures with the goal of forming a stable, low impedance surface coating on the LTO.
- Work closely with material suppliers to investigate and test alternative fabrication techniques and surface treatments.
- Screen LTO from suppliers to identify and implement the best materials for high temperature life.
- Modify the cell design, especially the positive to negative ratio (LTO allows negative or positive limited designs vs. graphite where negative electrode excess is always required to avoid lithium plating), to optimize cycle and calendar life.
- Test and improve (as necessary) the safety profile of the cells under all relevant abuse conditions (nail penetration, short-circuit, over-charge, crush, over-discharge, etc.) to ensure excellent abuse tolerance.



LTO operates in a potential range far from lithium plating providing cycle life and safety advantage.

Goals / Accomplishments by FY:

- Pre-contract Cost Agreement: 19 March 2015
- Contract Award: 29 June 2015
- 1st 6 months: Focus on reducing gas generation rate at 55°C
- 2nd 6 months: Focus on reducing impedance growth and improve the cycling stability
- 3rd 6 months: Optimize cell and battery module for performance and cost
- 18-month option period to achieve TRL 6

High Efficiency Lithium-ion Lightweight Assembly (HELLA) Battery

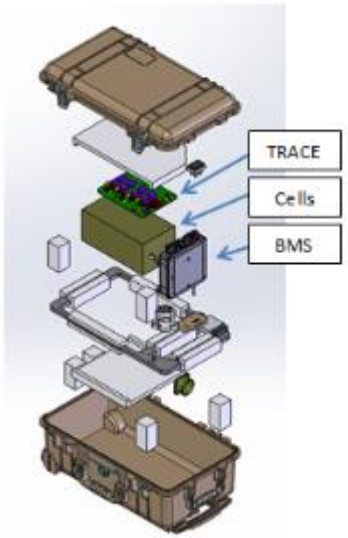
IRIS TECHNOLOGY

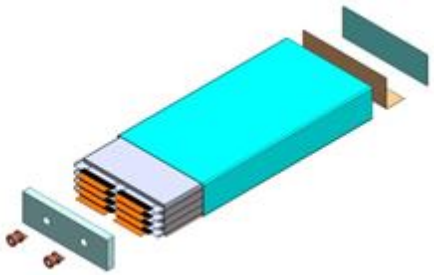
Objectives:

- Highly energy dense battery cell
- Potential to meet objective cycle life goals of 20,000 cycles.
- 1-Marine portability, 1300 Wh module, 32 lbs.

Naval Relevance:

- Advanced energy storage approach relevant to the USMC
- High energy density potential
- TRACE system will allow interoperability with multiple systems and chemistries





HELLA UNIT CELL CONCEPT, WITH THE CONSTITUENT CELLS PACKAGED IN THE INTER-CELL SEPARATOR SYSTEM

Technical Approach:

- Advanced Nickel Cobalt Manganese oxide (NCM) chemistry
- EPT-Yardney to develop battery cell and perform critical safety and performance testing and develop the accompanying Battery management System (BMS)
- Iris to develop Translator/Regulator Adaptive Control Electronics (TRACE) module for plug & play communication with the host hybrid system, facilitate safe and efficient charging and discharging, protect the HELLA from external faults, and protect users and equipment from battery events.

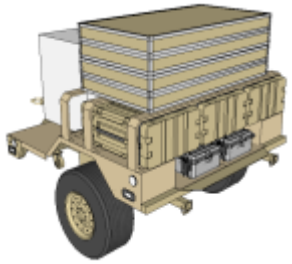
Goals / Accomplishments by FY:

- Precontract Cost Agreement: 10 April 2015
- Contract award: 29 May 2015
- Requirements Definition: Apr-Jun 2015
- SRR held at Yardney 10 July 2015
- Battery Cell & BMS Development: Jun – Apr 2016
- TRACE Development: Jun – Jan 2016
- Battery Enclosure: Jun – Jan 2016
- Integration & Test (TRL 5): Jan – Jun 2016
- Delivery of TRL 5 HELLA Battery 30 Oct 2016
- 18-month option period to achieve TRL 6

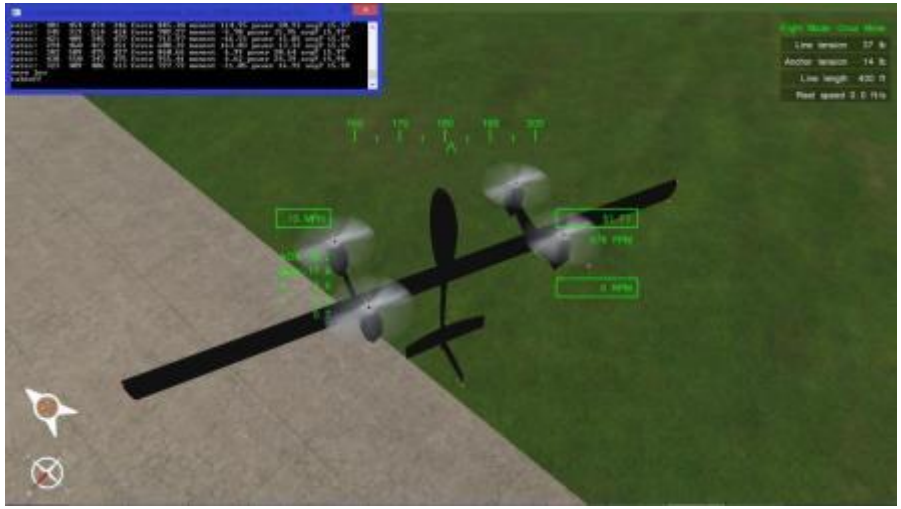
R&D Efforts

- ONR FNC Programs
  - Renewable Sustainable Expeditionary Power (FY12-FY15)
  - Multifunction Energy Storage FNC (FY15-FY17)
- Rapid Innovation Fund Programs
  - Integrated Hybrid Power System
    - Iris Technologies
  - Renewable and Efficient Electronic Solution
    - Protonex
  - Generator Controls w/ Intelligent Power Distribution
    - IPERC
  - Remote Water Purification System
    - Marine Dynamic Design
  - Gray Water Conditioning System
    - Marine Dynamic Design
  - Scalable Hybrid Intelligent Power System
    - Iris Technology

- 4 Active Topics -
  - Battery Maintenance
    - One Phase 2 Contract (FY15 end)
  - Fuel Efficient FOB
    - Three Phase 2 Contracts (FY15 end)
  - Renewable Energy System Trailer
    - Three Phase 2 Contracts (FY15 end)
  - Lighten the Load
    - One Phase 2 Contract (FY15 end)



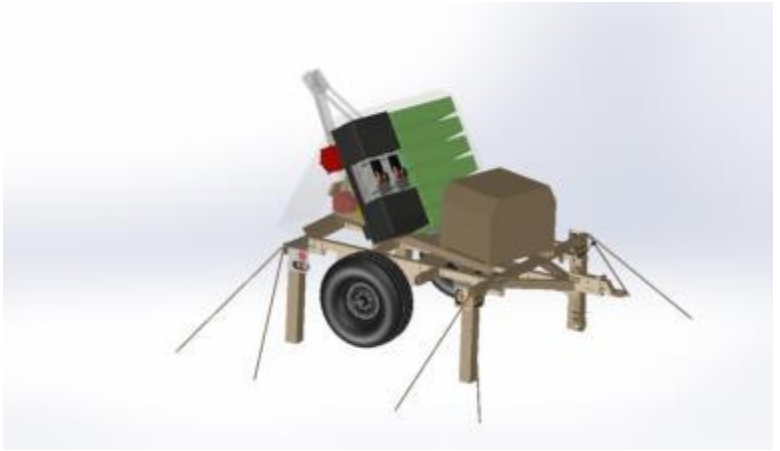
- 3 New Topics
  - Harvestable Energy in Covered Locations
  - Platoon and Squad Water Purification Technology
  - Light Weight and Compact Renewable Energy Systems in the 1kW power range



Tethered Autonomous UAV

- 24’ wing-span UAV (120 lbs.)
- 8 control surfaces
- Emergency parachute
- 500’ tether (25 lbs)
- Vertical take-off and landing
- 7 ‘ LTT Trailer-mounted Ground Station
- 9kW of Electrical Power
- Wide area persistence surveillance
- Communication relay

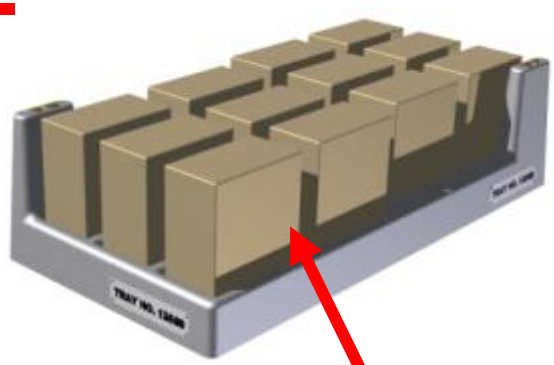
Vehicle Design



Battery Maintainers

Controller

Battery Trays

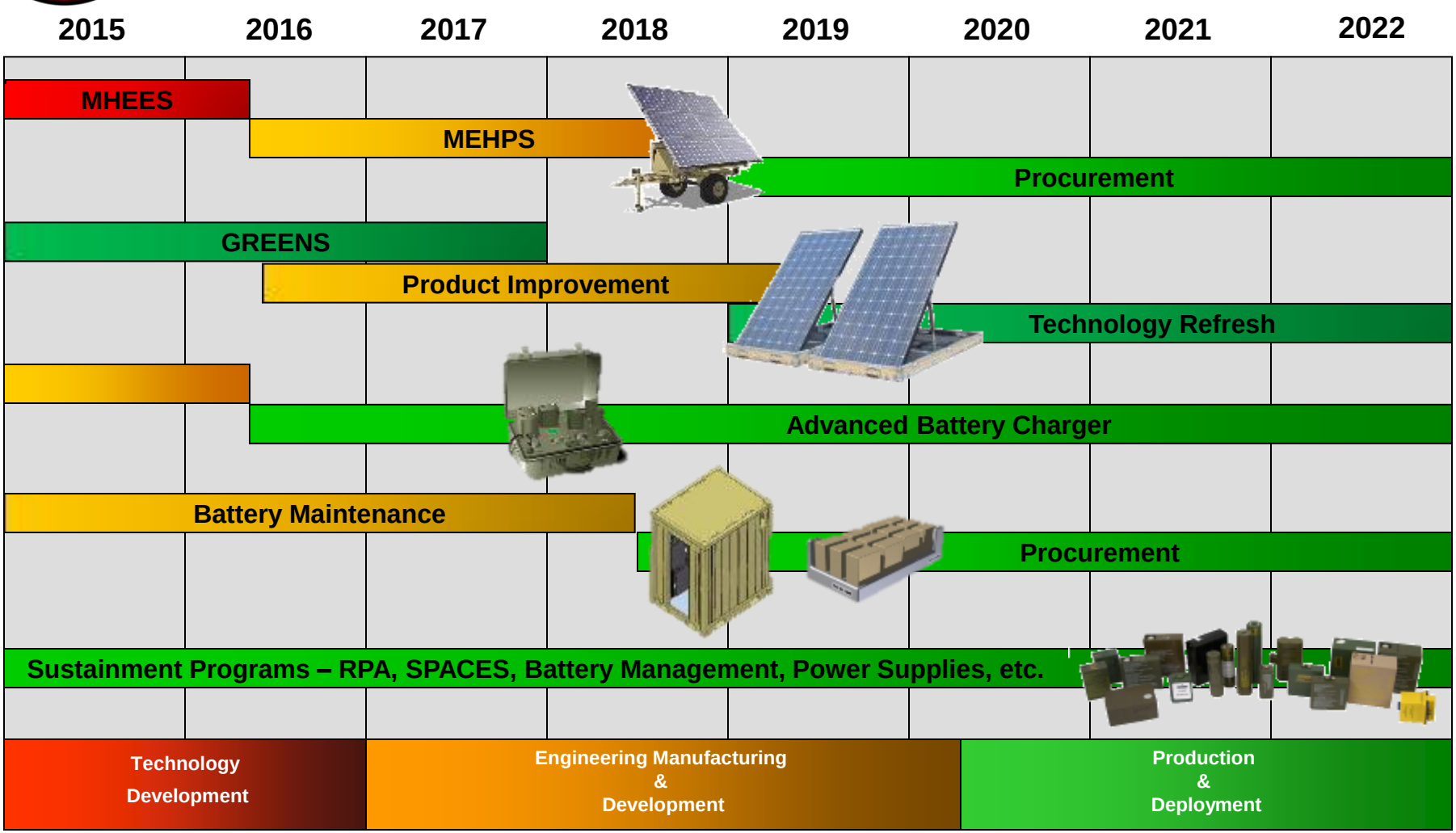


Shown with BB-2590/U Batteries

techshot

- Autonomous battery monitoring and charging
- User feedback on battery SOH
- Adaptable for multiple battery types
- Stackable for storage

Advanced Power Sources Key Initiatives



SPACES – Solar Power Adaptor for Communications Equipment System (30 Watt continuous)
GREENS – Ground Renewable Expeditionary Energy Network System (300 Watt continuous)

MHEES – Medium Hybrid Expeditionary Energy System
MEHPS – Mobile Electric hybrid Power System

Business Opportunities

Title	Funding	RFP Release
Mobile Electric Hybrid Power System (MEHPS)	RDT&E	Fall 2015
Energy Storage for Micro Grids	RDT&E	Future
Advanced Battery Charger	PMC	Fall 2015
Platoon Water Purification System	-	Future
Individual Water Purification System	PMC	Summer 2017
Renewable Energy in Covered Locations SBIR	RDT&E	Now
Light Weight Hybrid Systems SBIR	RDT&E	Now
Small Light Weight Water Purification SBIR	RDT&E	Now
Battery Maintenance Capability	PMC	Summer 2018
MEHPS Production	PMC	Fall 2017
Tech Refresh of Systems	-	various

Further Information

Email questions to:
PM_EPS@usmc.mil

Find more programmatic information:
http://www.marcorsyscom.marines.mil/ProgramOffices/EPSHome.aspx
www.onr.navy.mil
http://www.hqmc.marines.mil/e2o/E2OHome.aspx

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QUESTIONS