



# High Performance 6T Lithium Iron Battery



## U.S. Army's Ground Vehicle Energy Storage

### Energy Storage Goals and Mission

#### Energy Storage Goals

- Develop **safe, reliable and cost-effective** energy storage systems
- Reduce **battery weight & volume burden** (Increase Energy & Power Density)
- Reduce logistics and fuel burdens
- Extend **calendar and cycle life**

#### Energy Storage Mission

- **Develop and mature** advanced ES technologies for transfer to vehicle platforms
- Test & evaluate ES technologies for prequalification and to **assess TRL (Technology Readiness Level)**.
- Identify **technology barriers** and develop technical solutions
- Be recognized as the team of experts in ES components and systems
- Provide technical support to customers, other teams and government agencies for all ES requirements
- Provide **cradle-to-grave** support for all Army ES systems



## ***Apogee Role in Army Batteries***

The Apogee Energy Storage Team is the single point of accountability to provide full-service lifecycle engineering and integration support (cradle-to-grave) for Energy Storage systems for Army Ground vehicle platforms.

Apogee Energy Storage Team Role is the Engineering Support Activity (ESA) to ensure conformance with the specification & recommendation for QPL acceptance. Apogee Standardization Team Role is the Qualifying Activity that maintains the modifications to the MIL-PRF 32143B and QPL.

- ✓ First Article in-house Testing & Qualification Test Issues
- ✓ Develop, publish, and maintenance of battery standards and performance specifications
- ✓ Participate with DLA on audits of production facilities
- ✓ Establish vendor qualification criteria
- ✓ Provide technical expertise on energy storage systems for all stakeholders
- ✓ Project Management
- ✓ Preparing and updating Tech Manuals
- ✓ Provide SMEs for Analysis of Alternatives (AOAs)
- ✓ Provide sustainment and fielding support of batteries
- ✓ Research, develop, and mature advanced energy storage technologies for enhanced capability
- ✓ Establish and leverage collaborative projects, battery working groups, MOUs/MOAs with other government agencies



# Energy Storage Applications and Challenges



## Major Applications/Drivers

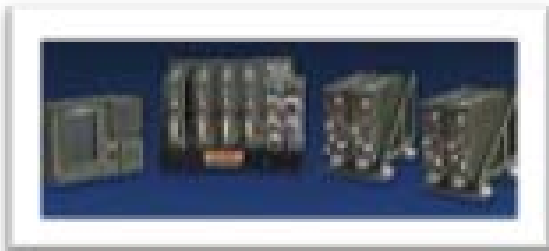
- Increased Electrical Power Draw
- Robotics
- Survivability
- Weapons Systems
- Electromagnetic Armor (EM Armor)
- Starting, Lighting and Ignition (SLI)
- Hybrid Vehicle Acceleration and Silent Mobility
- Silent Watch



Hit Avoidance

## Energy Storage Challenges

- Delivering reliable battery solutions in standardized military form factors (logistics/sustainability/compatibility)
- Safety – Understanding thermal runaway process and its control, improved BMS and alternative cell technologies.
- Developing energy storage systems with higher energy and higher power densities (focus on designs and chemistries).
- Manufacturing process development and quality (Reliability & Safety)
- Cost control (balancing \$ with ↑ performance & ↑ durability)
- Thermal Management



Communications



Targeting Systems

Batteries represent one of the top ten ongoing maintenance costs in theater



- Current Lead acid battery: ~\$300/kWh
- Current Lithium ion battery: \$2000-\$5000/kWh
- Target price for Li-ion battery is \$500/kWh



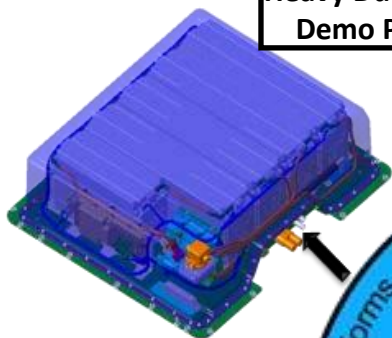
# Commercial vs. Military Energy Storage Requirements



Extreme operating environments

## Divergence of Military and Commercial Requirements:

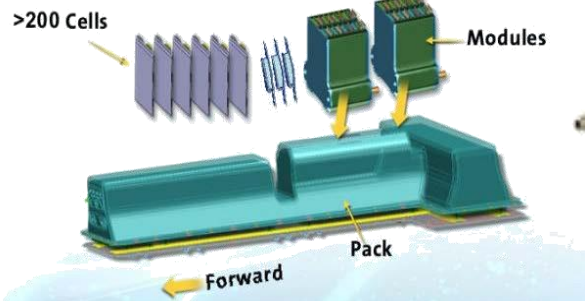
Heavy Duty Truck Demo Pack



Automotive Pack



Automotive Pack



Automotive Pack

Customer specific forms

### Commercial Focus

- ✓ Fuel Economy/Hybridized vehicles
- ✓ Increased energy – EV applications
- ✓ Increased power – HEV applications
- ✓ Cost (\$250/kWhr)
- ✓ Life (cycle/10-15 year calendar life)
- ✓ Safety
- ✓ SAE Standards
- ✓ Operation TMP to -20°C to +55°C

### Military Requirement

- ✓ Operating Temperatures: -46°C to 71°C
- ✓ Storage Temperatures: -54°C to 88°C
- ✓ Electromagnetic Interference: MIL-STD-461F
- ✓ Ballistic Shock: MIL-STD-810G
- ✓ Life Fire: MIL-STD-810G
- ✓ Explosive Environment: MIL-STD-810G
- ✓ Altitude to 60,000ft: MIL-STD-29595
- ✓ Explosive Decompression: MIL-STD-810G
- ✓ Salt fog: MIL-STD-810G
- ✓ Sand and Dust requirements: MIL-STD-810G

### Additional Military Focus

- ✓ NATO Standardized Form Factors (i.e. 6T)
- ✓ Maximized Power AND Energy density
- ✓ Sustainability and Logistics issues
- ✓ Silent Watch/Silent Mobility

Standardized Military Batteries (i.e. 6T)  
Used in 95% of Military Vehicles



Commercial

Military



# Lithium Iron 6T Program

## Accomplishments to date:

- Demo 2x increase in energy density
- Cut weight of each 6T in half (20kg vs. 40kg)
- Demo starting of HMMWV with single Gen1 24V battery (replacing 2 6TAGM)
- **Replaces 2 Lead Acid 6T batteries (@ 25% of weight!) 20kg (Li-ion) vs 80kg (Lead acid)**

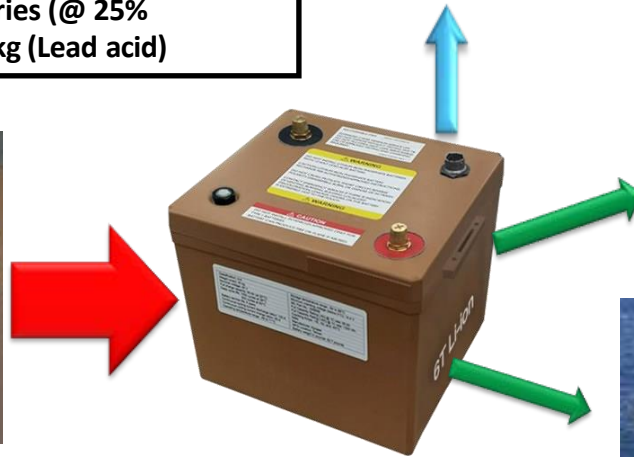
## Commercial Platforms



## Combat and Tactical Vehicles



12V Lead-Acid  
6T Batteries  
80kg total



24V Li-ion 6T Battery  
Replaces 2 lead acid 6Ts  
20kg



Army Watercraft Systems (AWS)

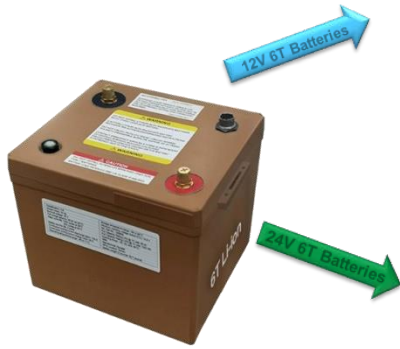
## Purpose and Products:

- The 6T battery form factor is currently utilized in ~95% of the military ground vehicle platforms, therefore improvements with this technology would have widespread implications.
- Apogee has developed prototype Generation 1 24-V 6T form-factor Lithium ion (Li-ion) batteries (Gen 1 6T) from two different manufacturers. A third supplier is under development.
- Gen 1 6T batteries are designed to be backward compatible such that they can be used as a direct replacement for currently used lead acid systems. Additionally, Gen 1 6T batteries provide the following benefits: reduced weight, reduced volume (2 for 1 replacement 24V vs. 12V), reduced logistics & sustainment burden, increased cycle life, and advanced battery management with state of charge and state of health indicators.
- Apogee is also demonstrating the standardized batteries in support of anti-idling and start/stop applications for commercial truck and vehicle applications – to leverage commercial volumes and reliability (reduce costs).



# Dual Use Standardized Li-iron Batteries

## (Alion/Calstart/Navitas, Saft & EaglePicher)



12V 6T Batteries

24V 6T Batteries



**Li-iron 6T Standardized Batteries**

### PURPOSE AND PRODUCTS

Leverage ongoing TARDEC investments/efforts to develop advanced Li-ion battery energy storage systems with improved energy and power density in standardized 6T form factors to develop dual use batteries in support of anti-idling and start/stop applications for commercial truck and vehicle applications.

Products:

- Advanced 6T size 12V and 24V Li-ion battery systems with improved power and energy densities capable of operation at extreme temperatures.
- Commercial based passenger and truck demonstration vehicles to establish dual use capability of the standardized military batteries in support of anti-idling and start/stop applications.

### SCHEDULE AND COST

MILESTONES	FY12	FY13	FY14
Applied Research	4	6	TRI
6T Li-iron 12V & 24V Battery Dev	4	6	
Development of Demonstration Vehicles			

### ARMY/DOE BENEFITS

- **Dual Benefit:** By leveraging military investment, a versatile battery system would be developed providing a significant improvement in overall capability for military and commercial applications. Furthermore, by developing commercial market overall systems costs would be reduced.
- **DA Benefit:** Development of standardized form factor battery systems with maximized power and energy density would enable a single battery system that could meet both energy requirements as well as pulse power requirements while reducing the logistic footprint.
- **DOE Benefit:** With minimal investment, DOE will leverage standardized batteries in support of anti-idling and start/stop applications for commercial truck and vehicle applications.





# 1 Million DOD Lead Acid 6T's In Use

DEPARTMENT OF DEFENSE (DOD) is designing all weapons systems and trucks for new lithium iron 6T format.

SAFT, Navitas and Eagle-Picher have all failed testing at TARDEC to build the lithium ion battery that the DOD needs as they all have thermal runaway.

Apogee Power has NO thermal runaway – (patent examples)

- <http://patents.justia.com/assignee/apogee-power-inc>
- <https://www.google.com/patents/US8138713>
- <https://www.google.com/patents/WO2003056684A1?cl=es>
- <https://encrypted.google.com/patents/US20110064994>

## Apogee smart battery at Military

Apogee delivers custom battery systems with proven defense experience.

Apogee had passed the audit of DCMA (Defense Contractor Management Agency) USA.

## Applications

- Robust, Intelligent, reliable and cost-effective battery solution for battery solutions for the most demanding defense applications.
- Naturally our batteries are also suitable for use in other mission critical roles such as aboard merchant vessels, Police, fire, heavy duty industry, coastal warning and surveillance stations, etc.

## 6T Lithium Iron Battery Features and Functions

- **More Power:** 20 C discharging current.
- **More Safety:** Smart control and fuel indicator.
- **Quickly Charging:** 15 min charging time.
- **Heavy duty duration:** Waterproof (IP167) and strong
- **Apogee Marine Battery Advanced Design:**
- Over voltage protection.
- Over current protection
- Low voltage protection.
- Short circuit protection.
- Over temperature protection.
- BMS leak-current sleeping design
- 4 blue LED capacity indicators.
- Two color LED charge status indicator.
- RS-485, CAN bus communication interface.
- (Blue tooth, Wi-Fi, LTE) optional boards.



# Apogee Power Pass DCMA Part number of the defense supply chain

NOTE: This draft, dated 17 Oct 2018, prepared by the U.S. Army Tank Automotive Research & Development Engineering Center, has not approved and is subject to modification. DO NOT USE PRIOR TO APPROVAL. (Project 6140-2019-001).

METRIC  
MIL-PRF-32565B  
DRAFT

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SUPERSEDING  
MIL-PRF-32565A  
w/AMENDMENT 1  
14 November 2017

## PERFORMANCE SPECIFICATION

BATTERY, RECHARGEABLE, SEALED, 6T LITHIUM-ION



Comments, suggestions, or questions on this document should be addressed to U.S. Army Tank-Automotive Research, Development and Engineering Center, ATTN: RDTA-SIE-ES-SI MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or sent by email to <mailto:usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil>. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

AMSC N/A

FSC 6140

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# Apogee Taiwan team becomes US Department of Defense Supply Chain



DEPARTMENT OF THE ARMY  
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND  
TANK AUTOMOTIVE RESEARCH, DEVELOPMENT AND ENGINEERING CENTER  
6501 E. 11 MILE ROAD  
WARREN, MI 48397-5000

REPLY TO  
ATTENTION OF  
RDTA-SIE-ES-PLEP-SI (PLANT SURVEY: AT-17-01)

16 May 2017

MEMORANDUM FOR DCMA PACIFIC COMMANDER (SINGAPORE)

SUBJECT: Request Plant Survey of Listed Plants

1. Apogee Power USA, Inc. has requested a plant survey of the following facilities located at the following locations:

- a. A123 Systems (china) Materials Co., LLC  
A7 Building  
No. 2 Xinzhu Road, EZP  
New District, Chongzhou, Jiangsu, 213031, China
- b. Formosan United Corporation  
4F, No. 15, Ln. 28, Sec. 1, Huan-Shan Rd.  
Nei-Hu, Taipei, 11442, Taiwan
- c. Darfon Electronics  
No. 167, Shanying Rd.  
Hukou Township, Hsinchu County, 30345, Taiwan
- d. Candmark Electroptics Co., Ltd  
No. 1300 Chenggong Rd.  
Hukou Township, Hsinchu County, 30345, Taiwan
- e. Apogee Green Power Technology  
No. 5 Alloy 4, Lane 202, Min-chang Road  
Pan-chiao District, New Taipei City, 220 Taiwan

2. This survey is to facilitate qualified product list (QPL) testing of the 6T Li-ion battery in accordance with SD-6 and MIL-PRF-32565. The purpose of this memorandum is to request your services for the plant survey. All work instructions, specifications, drawings, and process controls should be located at this plant.

3. The following are the points of contact for each facility:

- a. A123 Systems (china) Materials Co., LLC  
Zhiqiang Pan  
Phone: 86-137-0173-1798