CAPT JT Elder, USN
Commanding Officer
NSWC Crane

USMC Vehicle Power Prototype Joint Service Power Expo Brief

Dr. Brett Seidle
Technical Director
NSWC Crane

Presented By: Rudy Pirani
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Background

- OpFor feedback and studies have shown Marines are required to
  - Use excessive vehicle idle to power missions systems
  - Inefficient fuel use / Increased run time on engines is norm
  - Example: Forward vehicle idled 17 days to power systems

- Goal: Create an innovate rapid prototype power solutions
  - Show a potential solution to reducing vehicle idle time
  - Define true requirements through user feedback and operational performance
  - Obtain actual Return On Investment (ROI) data
- Target Vehicles and Systems
  - **Focus: HMMWV (Humvee) / Network on the Move (NOTM)**
  - HMMWV / Mobile Tactical Shelter (MTS)
  - Medium Tactical Vehicle Replacement (MTVR) / M777 Howitzer
  - Medium Tactical Vehicles (FMTV) / High Mobility Artillery Rocket System (HIMARS)
- Collaborative Team formed to leverage resources and ideas
  - MarCorSysCom and Expeditionary Energy Office (E2O)
  - NSWC Crane
  - NSWC Carderock
  - NAVFAC Expeditionary Warfare Center (EXWC), Port Hueneme (@Twentynine Palms)

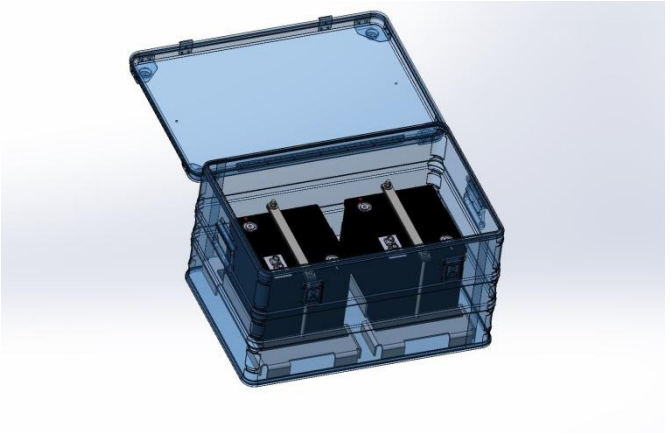
Background

- Program Requirements
  - A mature technology that did not require a lot of development
  - Need to consider safety and reliability
  - Simple vehicle integration and/or transportability
  - Easy to use

- MCSC SIAT/E2O have explored alternative power sources
  - Small Fueled Generators - Low reliability and difficulty to maintain in the field
  - Fuel Cells - Low Technology Reediness Level (TRL); Additional fuel logistics
  - GREENS - Fielded System
    - Supports some application but not all; Mission dependent
    - Volume and weight penalties: Must be packed and transported with unit; Not integrated into vehicle
    - Power Limitations: 300W/1000W peak; Increase power through more volume and weight penalties
  - Energy Storage - Selected Lithium 6T (L6T) Battery
    - Several batteries reviewed (Lead Acid 6Ts, Lithium 6Ts, Saber, etc.)
    - Mature technology; Multiple users are evaluating L6Ts; Multiple potential vendors
    - Completed Safety and Abuse testing for *multiple* vendors; Some performance data available
    - Designed to integrated into military vehicles; Potential future Lead Acid 6T replacement

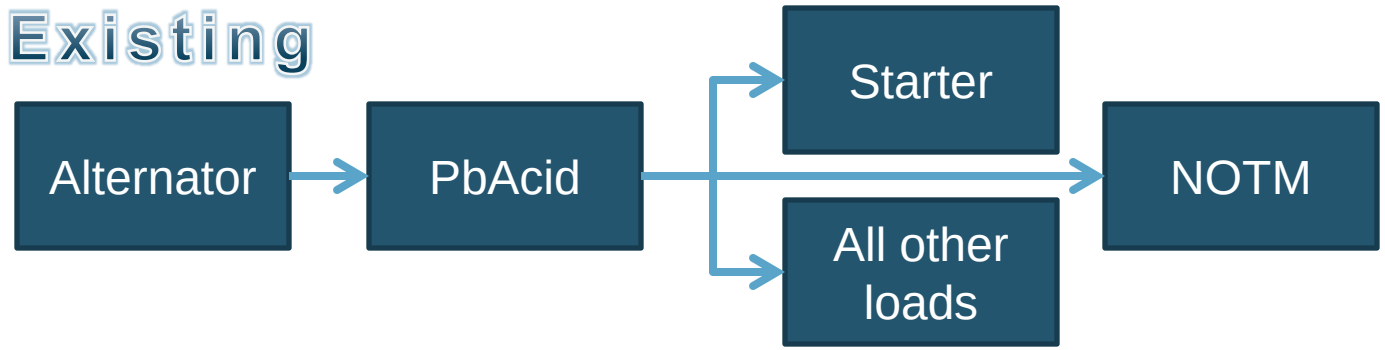
System Overview

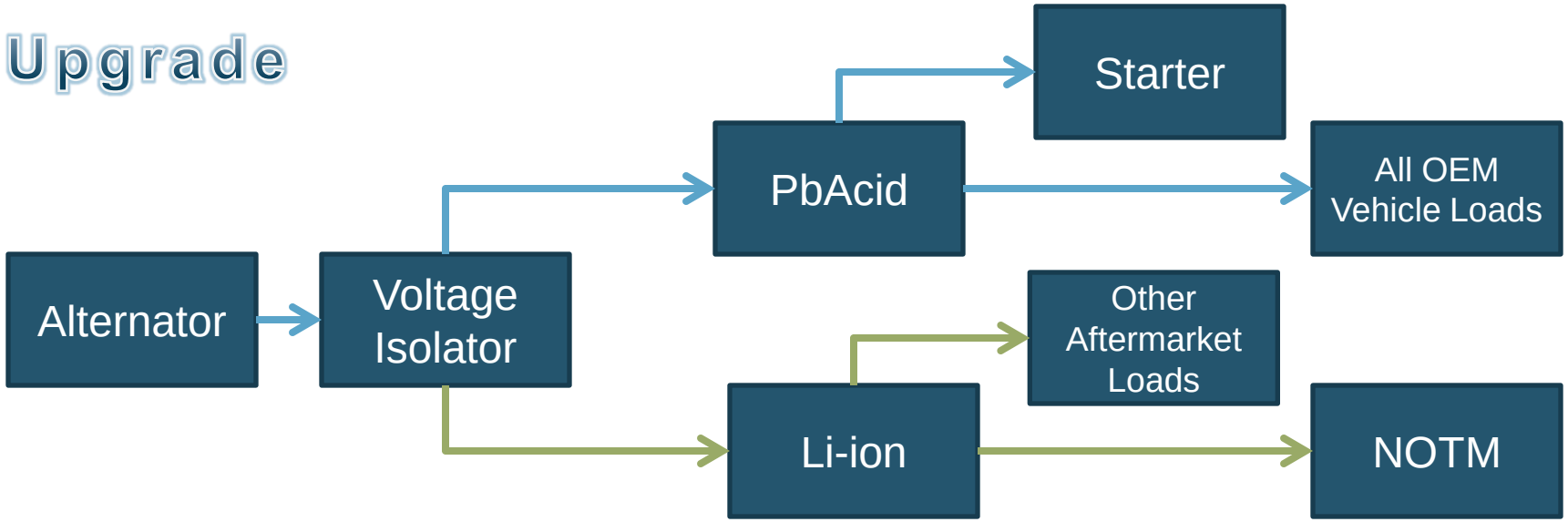
- System Concept
  - Two L6T batteries are mounted in an enclosure (L6T module)
    - Mounted external to the vehicle for safety
    - Lead Acid 6T batteries remain but isolated and used for engine start
  - L6T module has a State of Charge Indicator
    - Communicates with Battery Management System though CAN Bus
    - Provides user real time remaining battery capacity
    - Active notification to the user that the battery is at low capacity
  - L6T batteries integrated into the vehicle DC Bus
    - Powers NOTM and other non-native vehicle loads
  - Vehicle engine can power all loads and recharge L6Ts and Lead Acid 6Ts



Electrical Integration: Concept

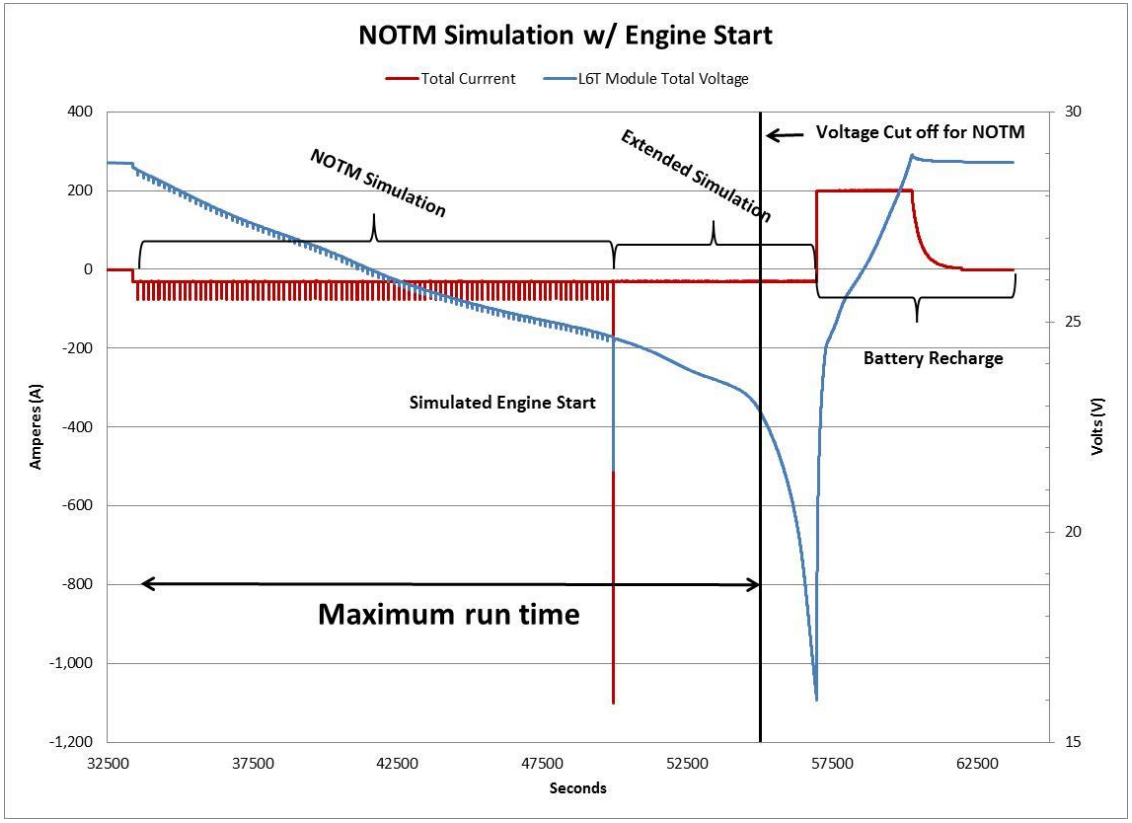
- Electrical concept
  - Isolate Lithium-ion 6T Module from Lead Acid 6T Bank
  - Insert Lithium-ion 6T Module between Vehicle Alternator and NOTM





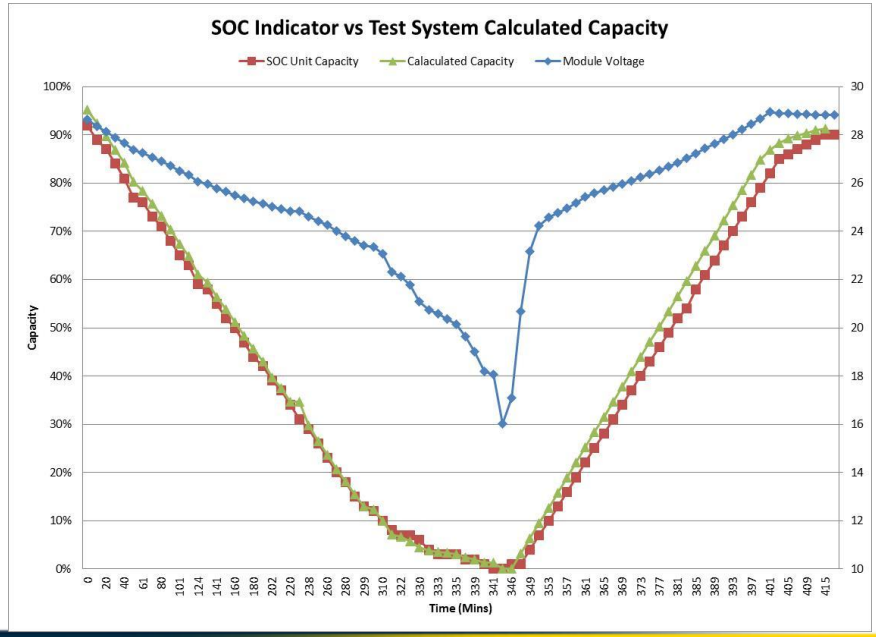
L6T Module Lab Simulations

- Characterized worst case power requirements from actual NOTM field unit
  - Average Current: ~30 Amps w/ ~70 Amps periodic peak pulses
  - Average Power: ~900 W
- Simulated load profile with initial prototype system in lab environment
  - Estimated run time at 5.5 hours
  - Battery recharge is estimated at 1.5 hour assuming 200 Amp supply



Electrical Integration: SOC Indicator

- Functionality
  - Designed in house at NSWC Crane
  - Provides state of charge the two L6T batteries via the CAN bus
    - Testing completed to validate the State of Charge communication
  - L6T's Battery Management System (BMS) for each L6T are connected through a communication cable to share information
  - SOC software will need to be modified to reflect appropriate state of charge for NOTM
    - System lower voltage limit is ~20V, L6T batteries lower limit is 16V
    - Set 0% state of charge at System lower voltage limit to not confuse users



Static Demonstration

- Great Green Fleet Demonstration (December 2016)
  - Show case multiple alternative power sources and tools
    - Used L6T battery module as alternative power source for NOTM system
    - Successfully powered the NOTM system for +2.5hrs (limited by demo time)
      - NOTM activated and fully operational with L6T module only
      - Connected through NATO Slave port

Way Ahead

- Design, Develop and Build Final Prototype System Phase (ECD – Summer 2017)
  - System design and vehicle integration
    - Develop module packaging for safety and general environmental conditions
    - Design L6T module vehicle integration plan and kit
      - Modules to be semi-permanently mounted to vehicle roof
      - System will power the NOTM and be recharged by the vehicle power system
  - State of Charge (SOC) Indicator
    - Provides the user the available capacity level for the L6T module for the load system
    - Includes an alarm when a low capacity level is reached to notify the need to recharge the battery
    - Will help to ensure that the NOTM will not lose power and the vehicle will be able to be started
  - L6T Module System Evaluations
    - Development testing will be conducted to prove design and verify proper NOTM operations
    - Testing will include electrical cycling and the following:
      - Low/High Temperature: Performance impact to high and low temperatures
      - Vibration: Validate integration and performance on vehicle
      - Rain: Validate packaging protects the L6T batteries and electrical harness
      - Electromagnetic Interference: Validate no impact to Battery Management System and SOC Indicator

Way Ahead

- Extended User Evaluation Phase (ESD – Summer 2017)
  - Provide operational unit at Twentynine Palms with L6T modules for evaluation
    - Allow unit to operate with the L6T modules for several months
    - Obtain user feedback and performance information
    - Compare use to NOTM vehicles without L6T module to ROI information
  - Support to operational unit during evaluation
    - System installation
    - Provide User training, technical manual (operational and maintenance procedures)
    - Onsite technical support from NAVFAC EXWC and remote support from NSWC Crane/Carderock
    - Spares components

Team

- Naval Surface Warfare Center, Crane Division
  - Chris Boyd
  - Joe Bailey
  - Tyler Wagler
  - Braden Hudson
  - Josh Scherschel
  - J.R. Christopher
  - Terry Meriweather
- Naval Surface Warfare Center, Carderock Division
  - Matt Huffman
  - Mike Wartelsky
- NAVFAC Expeditionary Warfare Center (EXWC), Port Hueneme
  - Ken King

Back Up

System Functionality CONOPS

- Mobility Mode 1 (Vehicle running and not connected to other power sources)
  - Alternator output is routed to battery isolator
  - Existing lead acid battery is charged independently of the new L6T battery (both systems are charged)
  - NOTM is powered via L6T/Alternator output
- Mobility Mode 2 (Vehicle off and not connected to other power sources)
  - Existing lead acid battery is isolated from the new L6T battery
    - The existing lead acid battery powers OEM electrical loads (lights, glow plug, etc.)
    - The new L6T battery powers the NOTM and any auxiliary loads that are on the vehicle (radios, laptops, etc.)
  - NOTM is powered via the L6T battery module
- Stationary Mode 1 (Vehicle running and NOTM connected to Tactical Power Supply TPS)
  - Alternator is routed to battery isolator
  - Existing lead acid battery is isolated from the new L6T battery, and is charged from the alternator
    - OEM electrical loads are powered from the alternator/existing lead acid battery
    - The new L6T battery is charged by both the alternator and Tactical Power Supply (depending on source Voltage)
  - NOTM is powered by both the alternator and TPS (depending on source Voltage)
- Stationary Mode 2 (Vehicle off and NOTM connected to TPS)
  - Existing lead acid battery is isolated from the L6T, powers OEM battery loads, and will not be recharged
  - The new L6T battery is isolated from the existing lead acid battery and charged by the TPS
  - NOTM is powered by the Tactical Power Supply

If the L6T battery is removed from vehicle, then the battery combine switch in the battery well may be actuated to combine the main and auxiliary outputs of the battery isolator. This will restore power to the NOTM system.