Georgia Tech Research Institute
Problem. Solved.

Examining the Replacement of Lead Acid Batteries with Lithium Titanate Batteries in Military Vehicles

Enhancing Performance, Energy Storage, and Energy Flexibility for Deployed Units

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Introduction

- Research Engineer with GTRI
- Maj USMC, CH-46E
- Naval Postgraduate School, MSEE
- Focus on Expeditionary Energy

Camp Arifjan Kuwait 2009

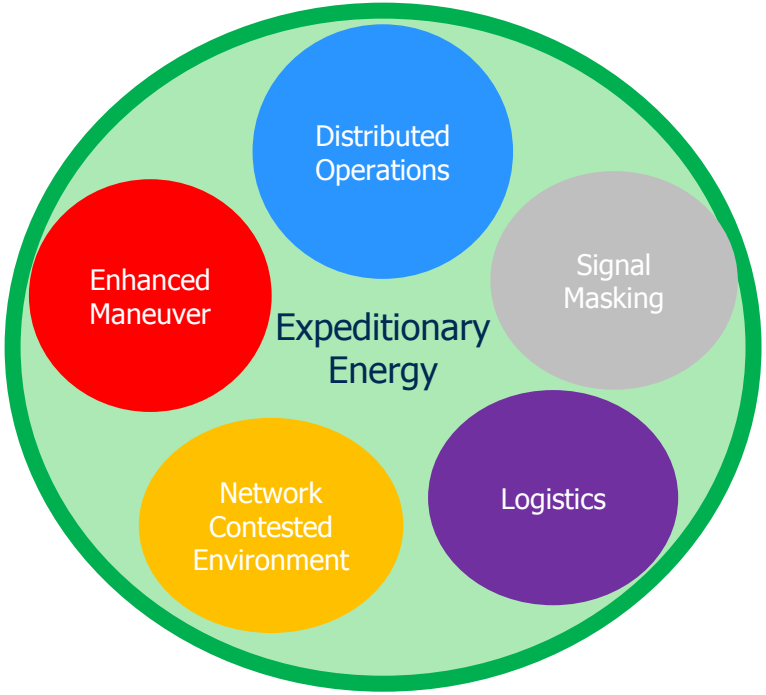
- Economic Problem
- Logistics Problem
- Operational Problem

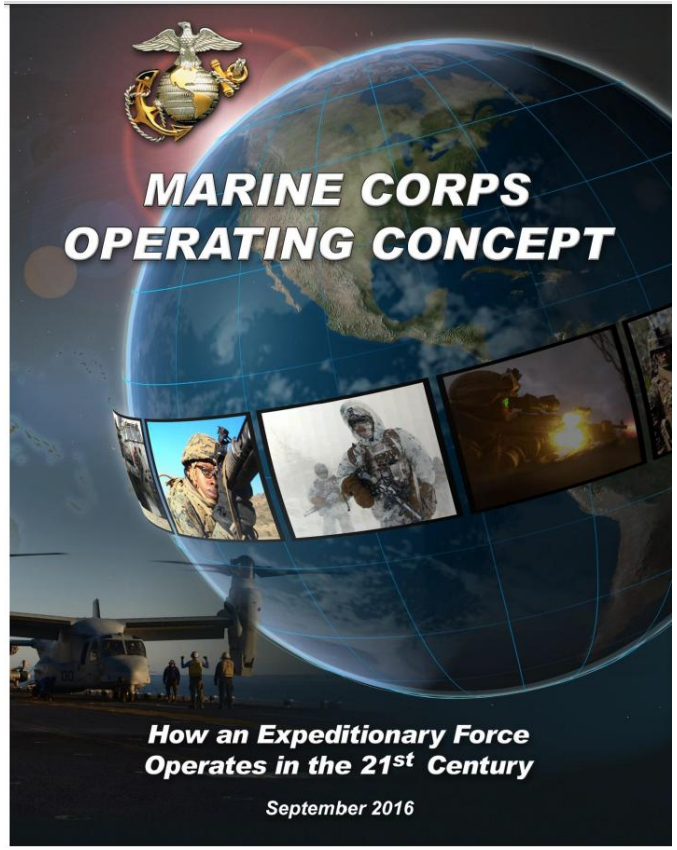
Logistics Problem

- Moving fuel, and water around the battle field is costly
  - $400.00 loaded cost per gallon of fuel
  - Tactically weakest point in an operation
- Track, store and maintain thousands of Lead Acid batteries
  - Shelf life of 3 months
  - 300 charge discharge cycle life
  - Heavy
  - Self discharge

Operational Problem

Expeditionary Energy Impacts all these Critical Areas in the MOC





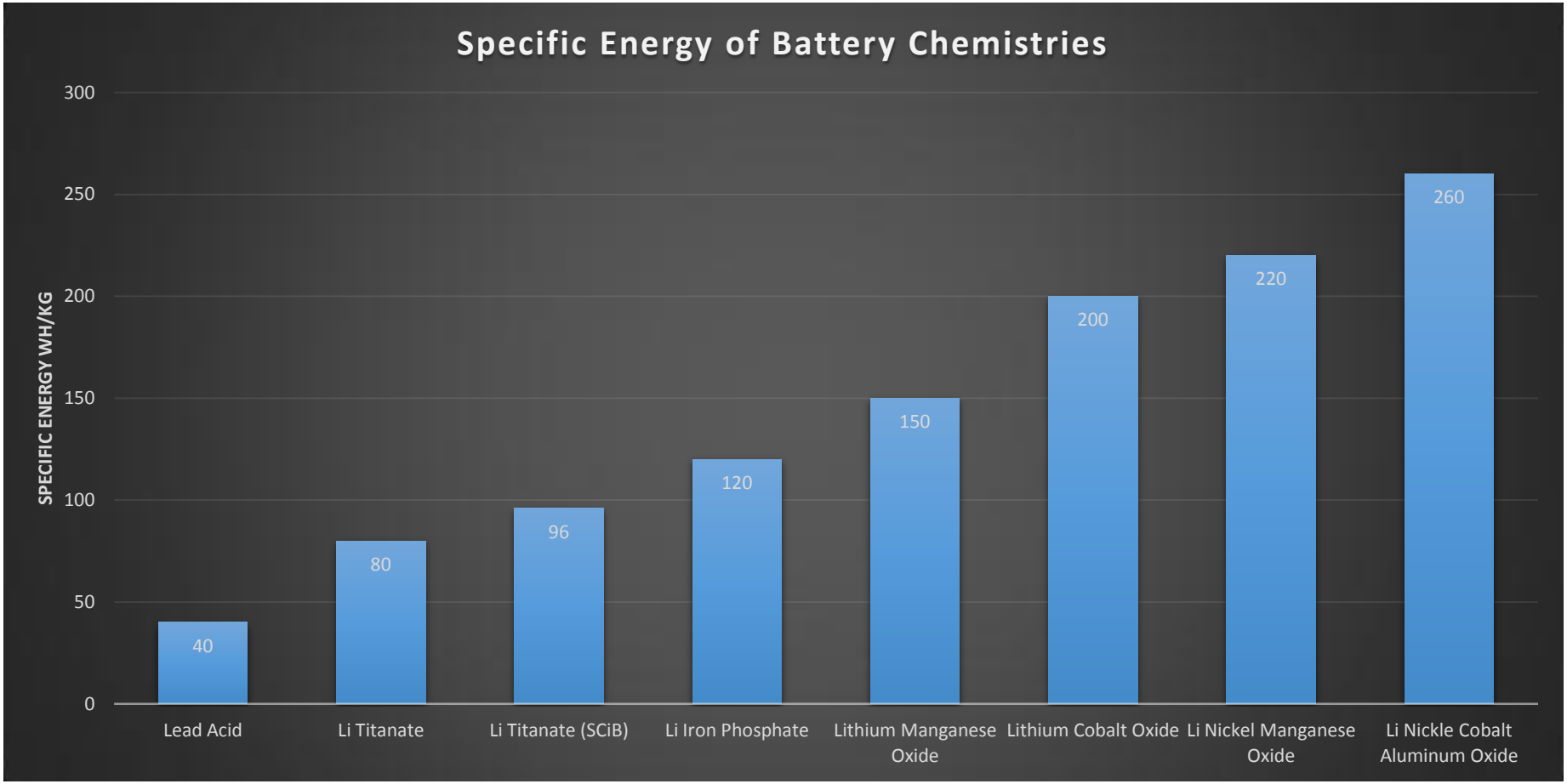
USMC Artillery- Light Reaction Raid Force

- 30 Marine Platoon
- 8 trucks
- 3 120mm
- 30 MP4s
- 6 240G
- 3 .50 Cal
- 49 Radios
- Batteries????

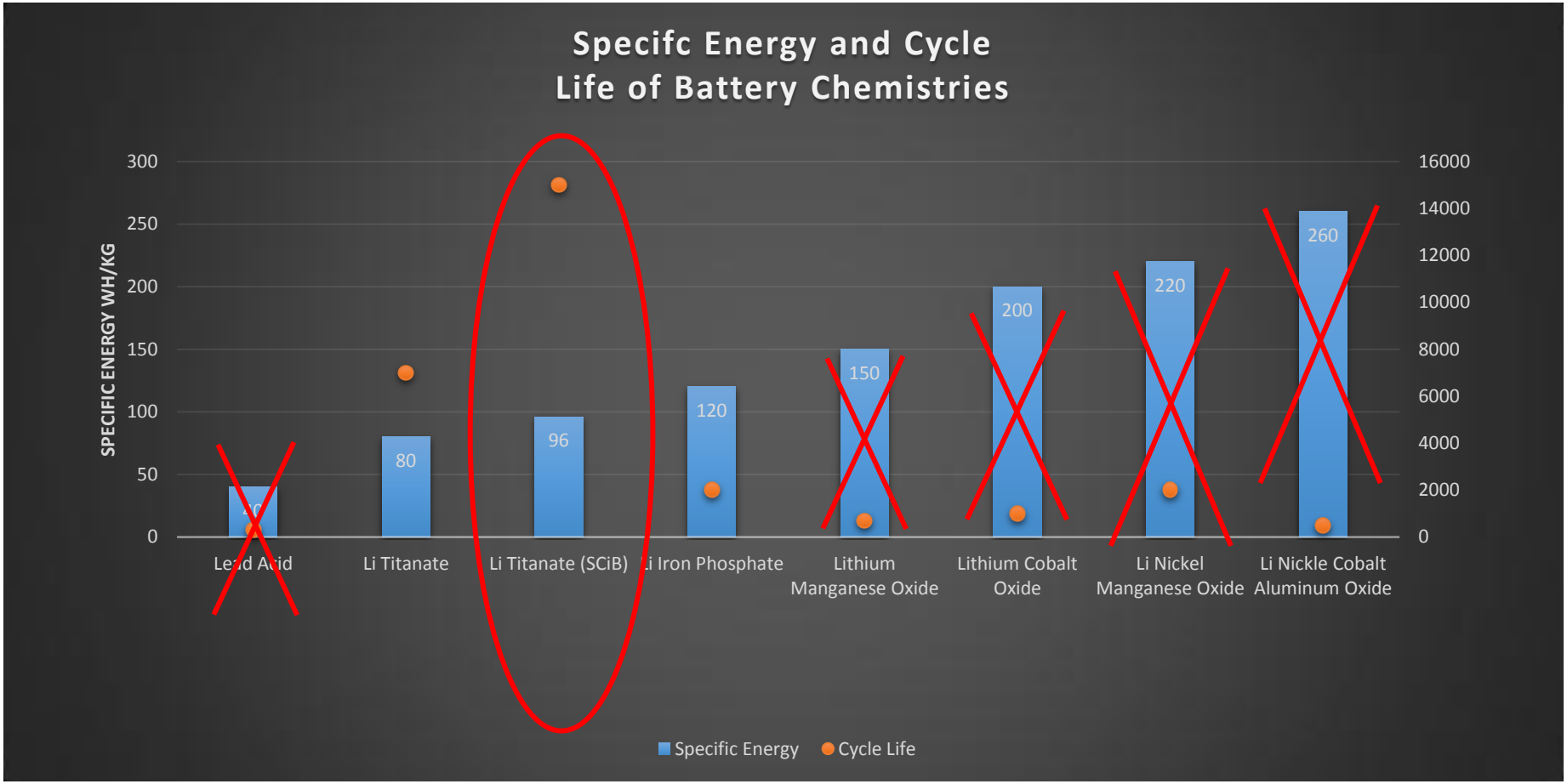
Energy Storage is Lynch Pin

- Technology exists to generate power supply in the field
  - Solar
  - Wind
  - Tactical Quiet Generators
- Fossil fuel remains the most efficient energy storage system
  - Specific Energy Roughly 13,000 Wh/kg
  - How can Batteries compete?

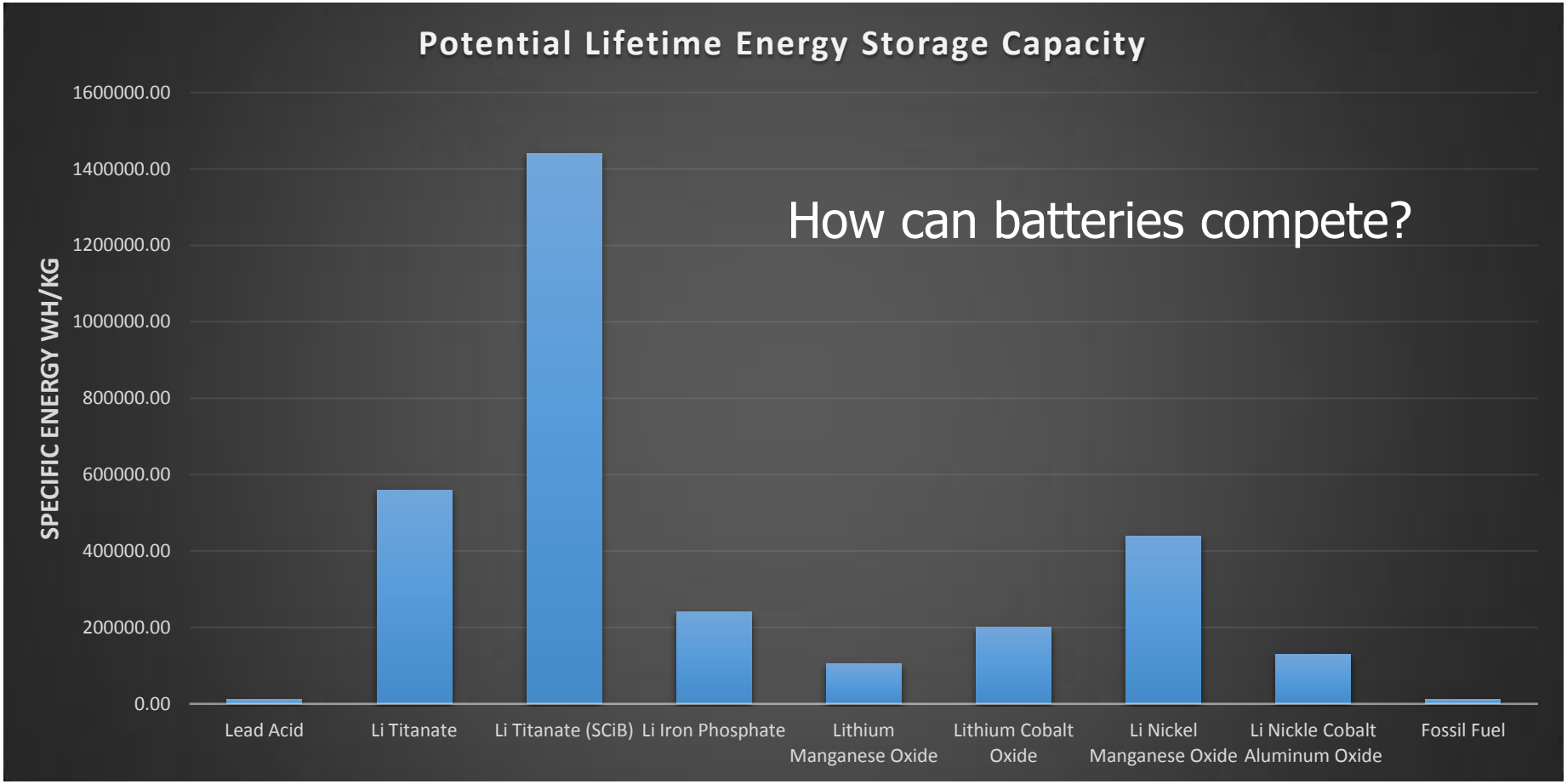
Chemistry Variation in Lithium Batteries (Cells)



Specific Energy and Cycle Life (Cells)



Potential Lifetime Capacity (Cells)



Purpose of GTRI Evaluation

- Marine Corps Systems Command Task
- GTRIs role evaluate the Toshiba SCiB™ as a perspective drop in replacement for Tactical Vehicle Lead Acid Batteries
  - Will the battery do the work?
  - Are the performance characteristics worth the swap?
  - Is there a safety concern?

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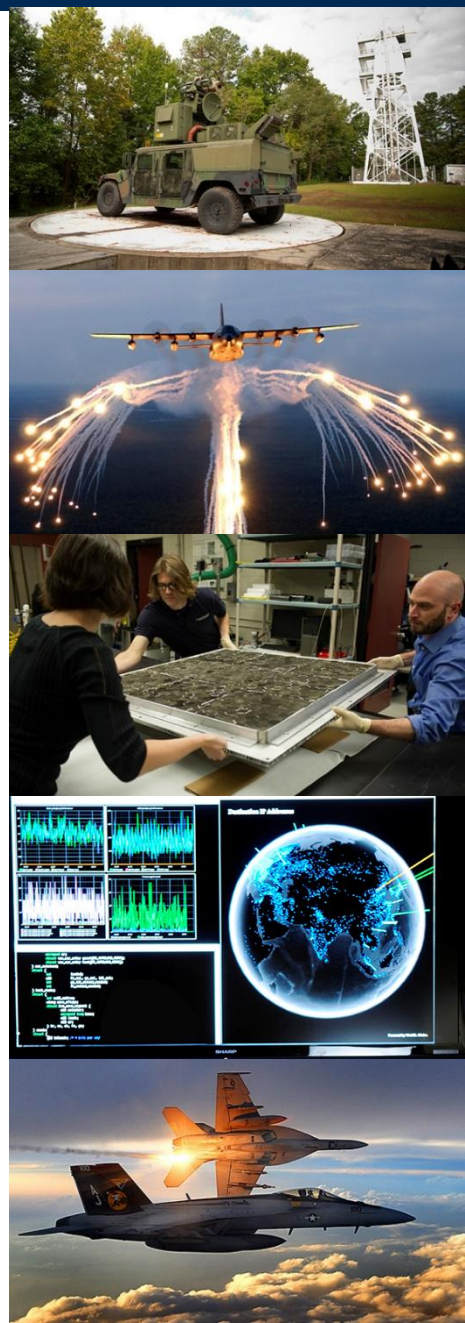
Test Events

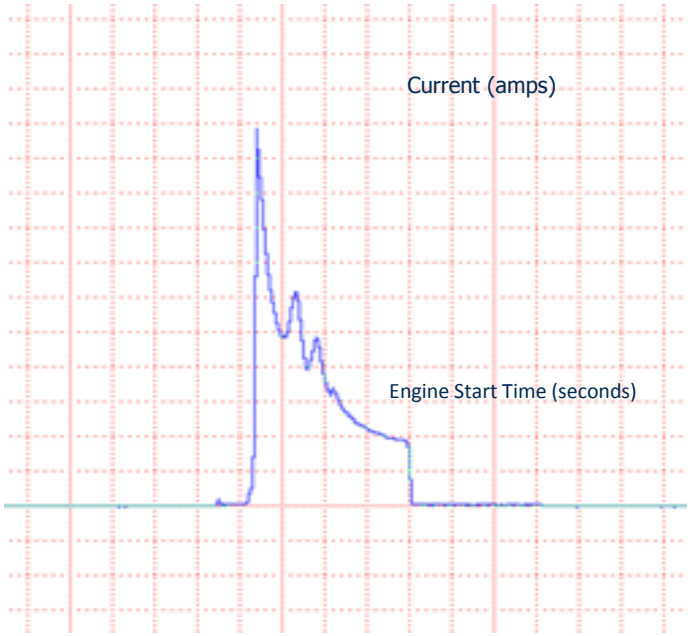
- Test Event I: determine if the lithium ion battery would start the vehicle.
- Test Event II: stress the batteries over a period of several days and note any degradation.
- Test Event III: determine the least amount of time the engine needed to run to recharge the batteries to a nominal level that could restart the vehicle.
- Test Event IV: determine the number of starts each battery type could produce until the batteries failed.



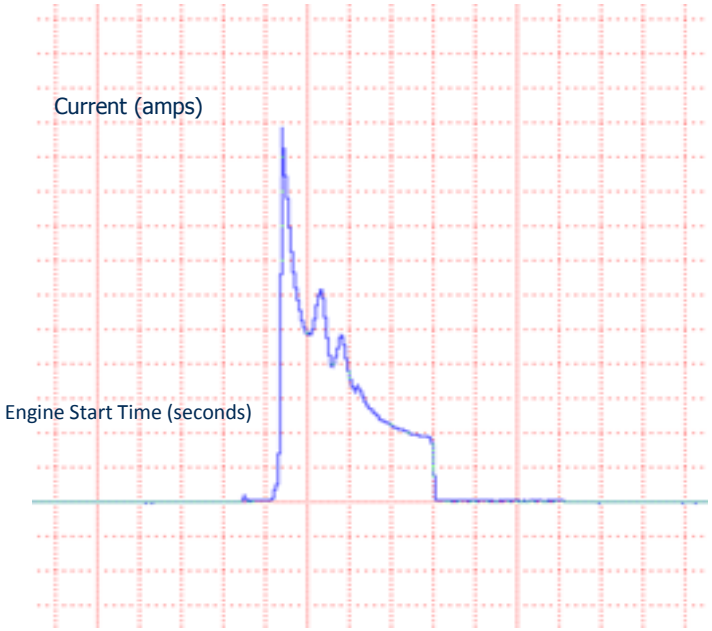
Test Event I

Determine if the lithium ion battery would start the vehicle.

Lead acid battery: average in 0.65 seconds.

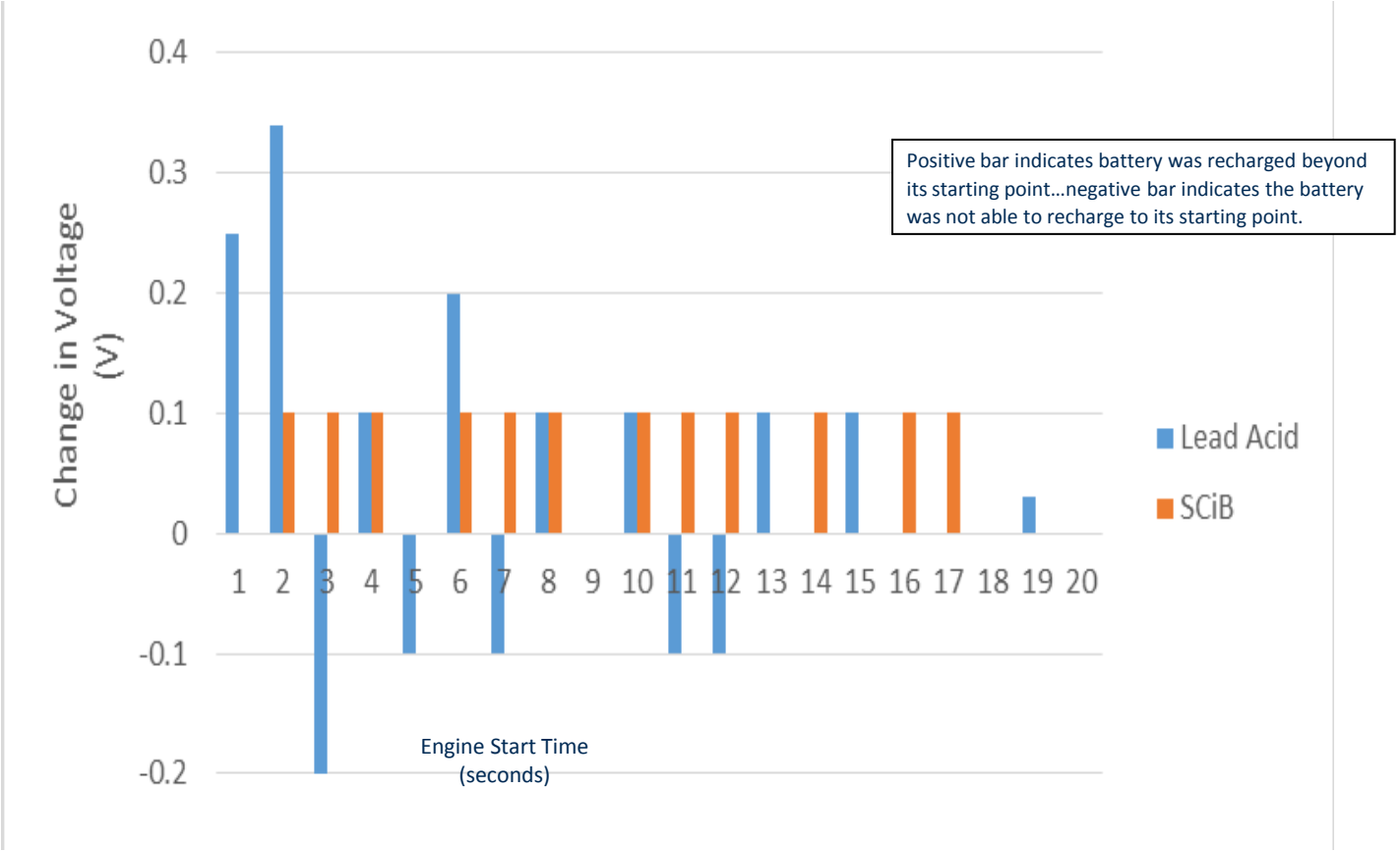


SCiB™ lithium ion battery: average in 0.68 seconds.



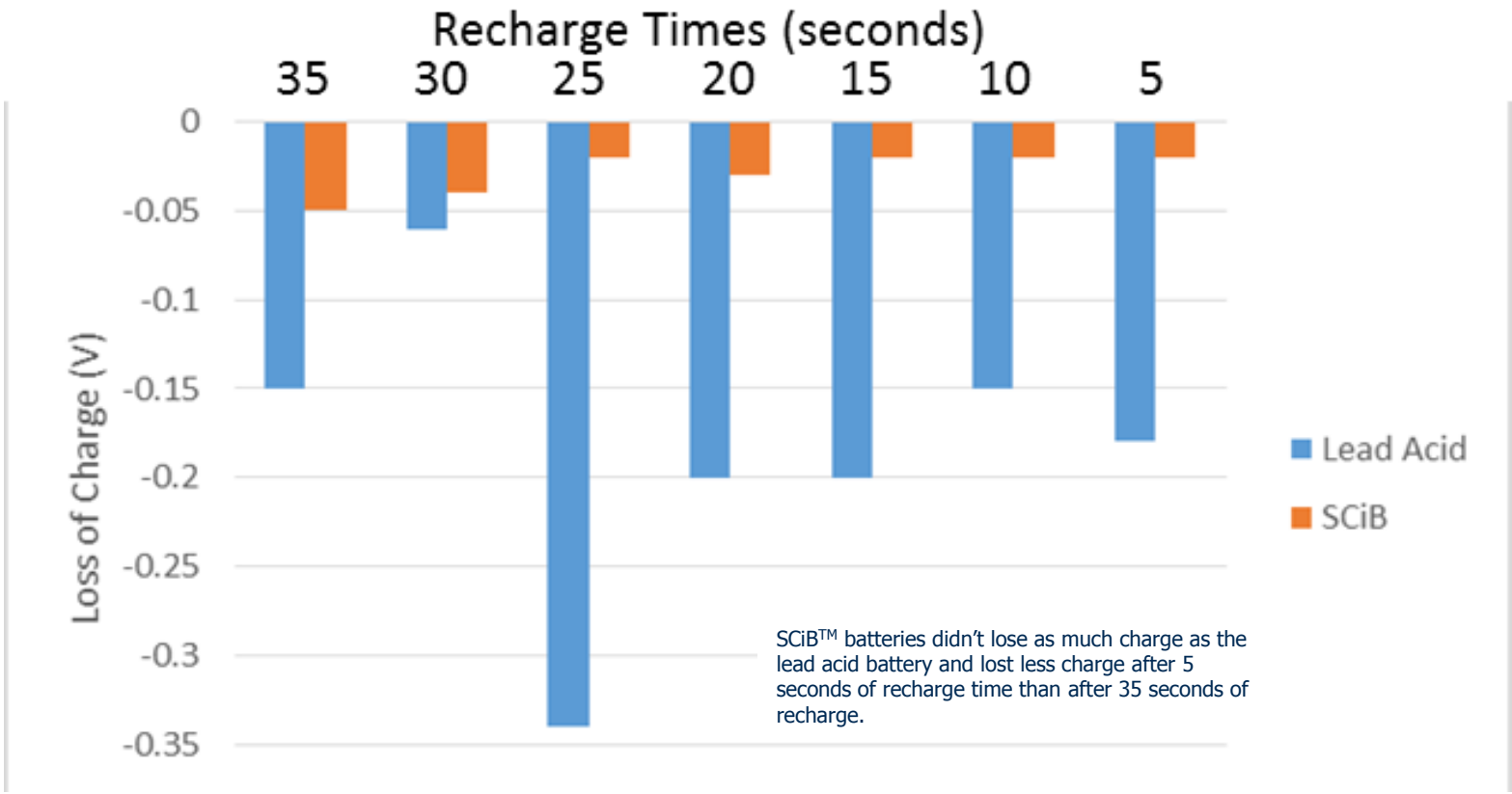
Test Event II

Stress the batteries over a period of several days by starting engine repeatedly with minimum recharge time between starts.



Test Event III

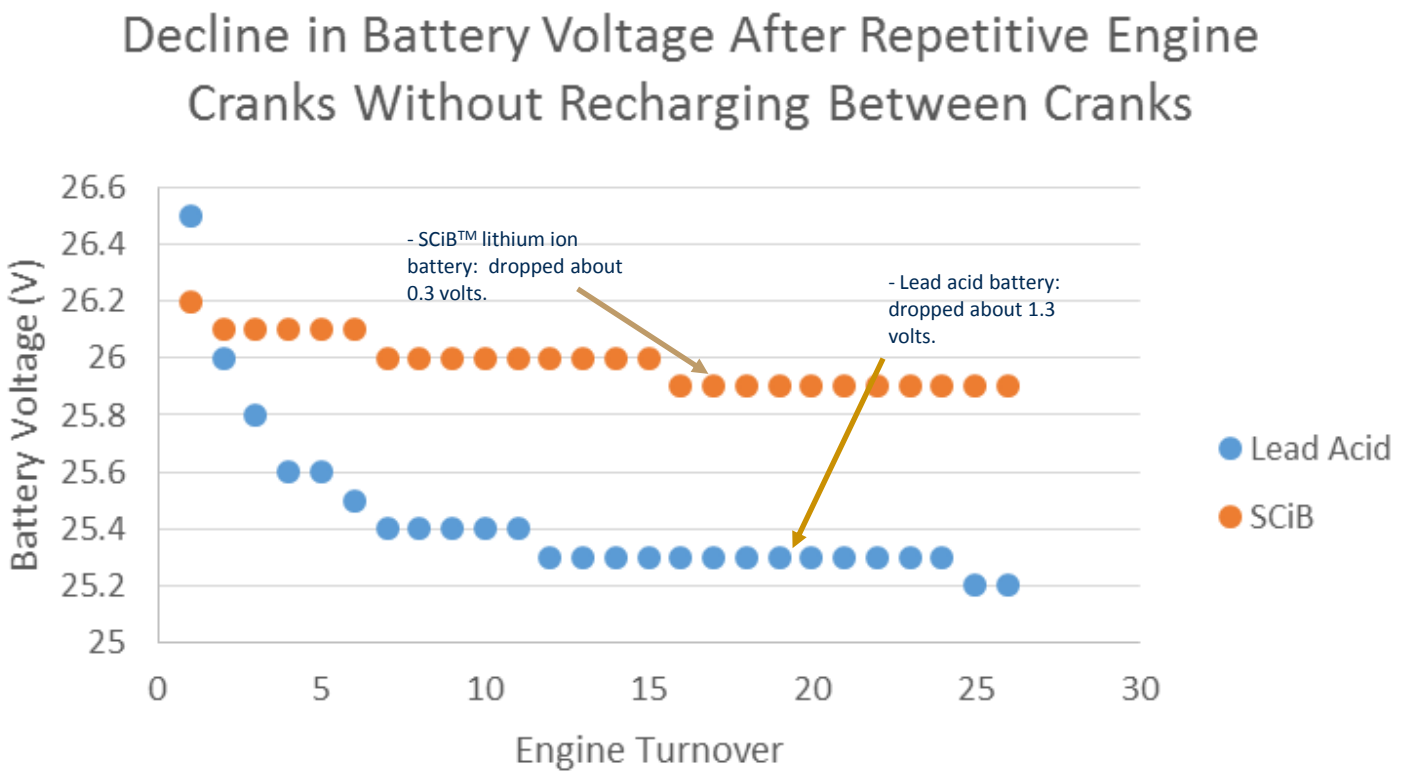
Determine the least amount of time the engine needed to run to recharge the batteries to a nominal level that could restart the vehicle.



SCiB™ batteries didn't lose as much charge as the lead acid battery and lost less charge after 5 seconds of recharge time than after 35 seconds of recharge.

Test Event IV

Determine the number of starts each battery type could produce until the batteries failed.



SCiB™ Cell Safety

There is a very low risk of fire or explosion from internal short circuit caused by external pressure or other factors. Therefore, SCiB™ is suitable for various applications requiring high levels of safety and reliability, such as automobiles, industrial equipment and stationary systems.

Source : http://www.scib.jp/en/about/index.htm

SCiB™ Cell Features

SCiB™ provides a long life of over 15,000*charge/discharge cycles, rapid charging, high Input/output power performance and excellent low-temperature operation, all while maintaining a high level of safety.

- Safety:
  Uses highly safe lithium titanium oxide (LTO)
- Long life:
  Over 15,000 cycles*
- Low-temperature operation:
  Can be used at temperatures as low as -30°C
- Rapid charging:
  Rechargeable in 6 minutes*
- High input/output:
  Chargeable at large current and provides large current output
- Wide effective SOC range**:
  Provides a large available capacity

* Measured with a particular single cell under specific conditions
** SOC: State of Charge

Source : http://www.scib.jp/en/about/index.htm

Is the swap worth it?

- Lead Acid Batteries
  - 2 x 12VDC 6T
  - 88 lbs

- Toshiba SCiB™ Lithium Ion Battery
  - 1 x 24 VDC 6T
  - 60 lbs

USMC Artillery- Light Reaction Raid Force

- 30 Marine Platoon
- 8 trucks
- 3 120mm
- 30 MP4s
- 6 240G
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- 49 Radios
- Batteries????

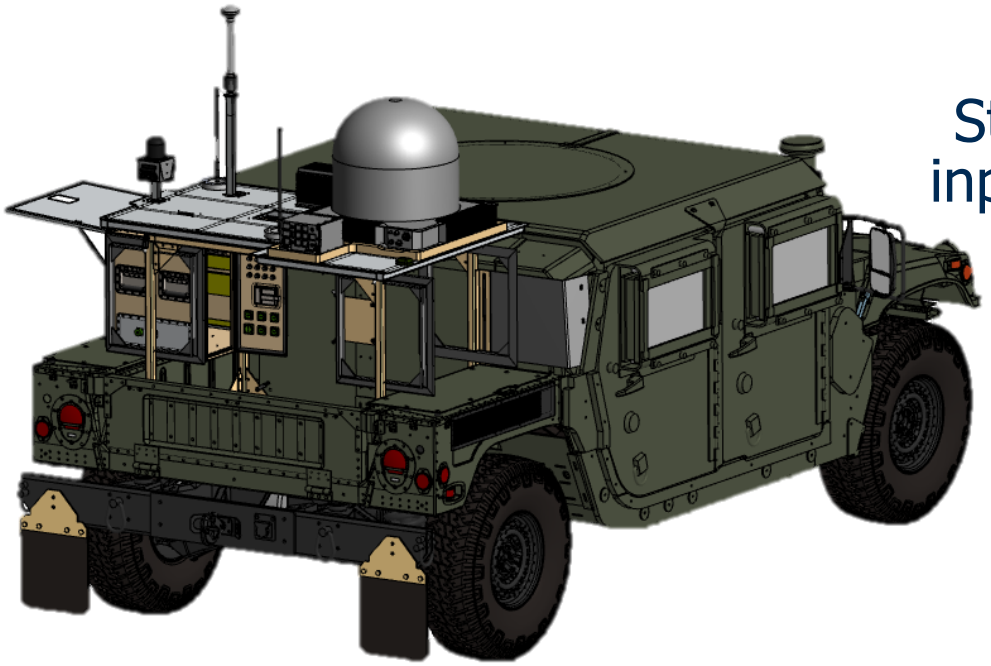
Recommendations

Large Battery Bank

Charge smaller batteries

Run comm and nav systems

Provide at the halt power

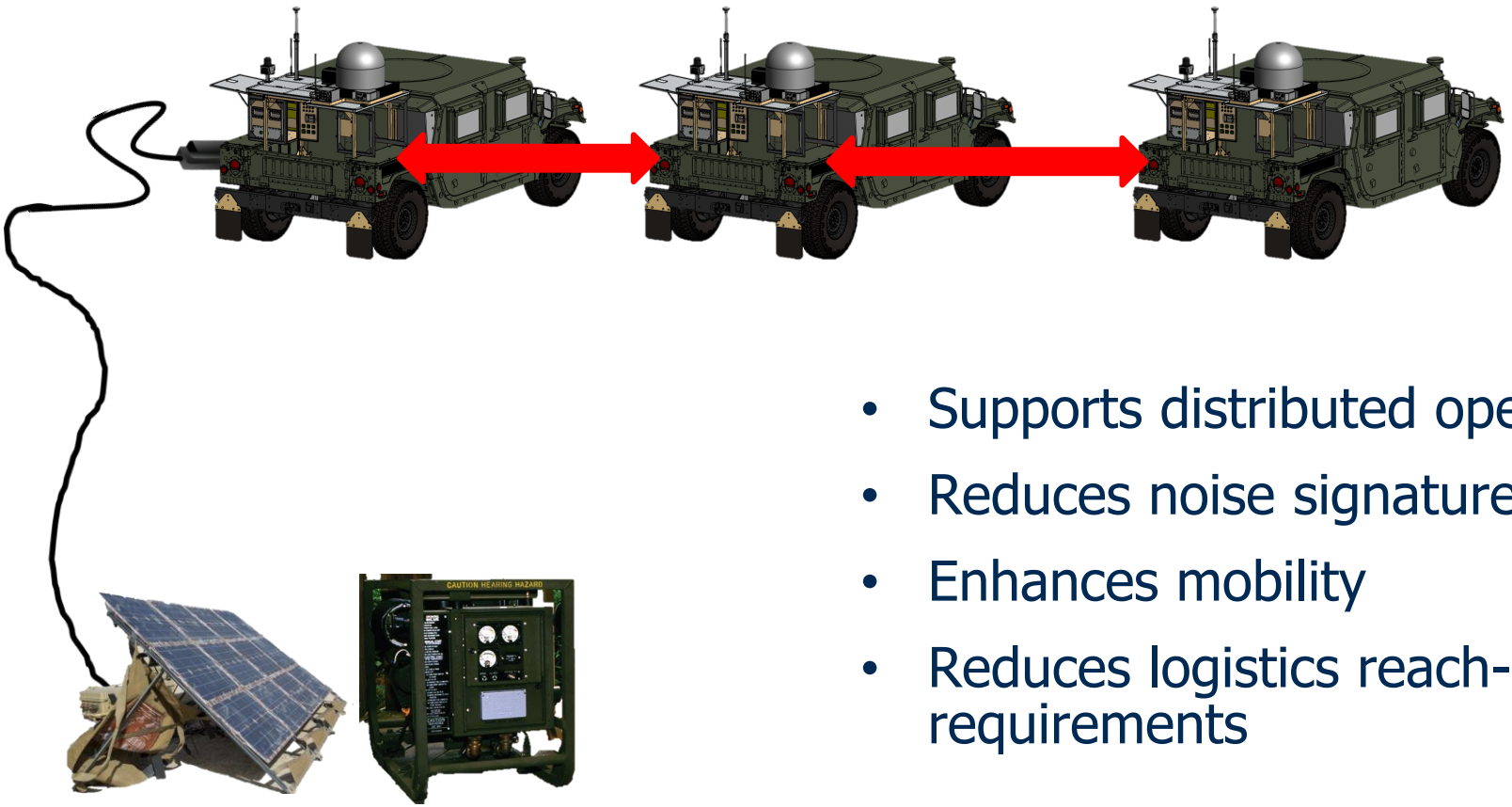


Standard power input and outputs

Charged by the engine on the move

Charged by solar, wind, TQG at the halt

The future of Mobile Distributed Ops



- Supports distributed operators
- Reduces noise signature
- Enhances mobility
- Reduces logistics reach-back requirements

Questions?