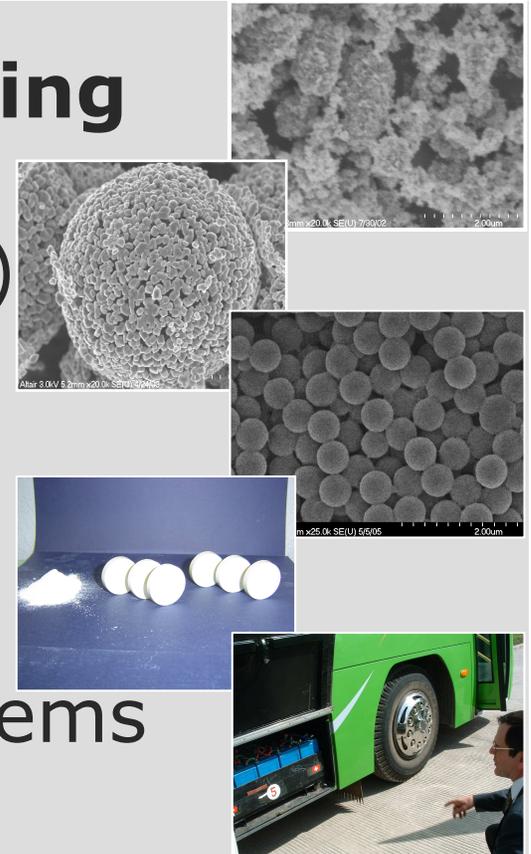


# Status of Lithium Batteries Using Lithium Titanate Based Anode (Safety, Rapid Charge, Cycle Life)

**V. Evan House, Ph.D.**

Director

Advanced Materials & Power Systems



With the exception of historical information, matters discussed in this presentation regarding product development, target markets, revenue and income projections, are forward looking statements that involve a number of risks and uncertainties as defined under the Private Securities Reform Act of 1995.

- Public company (NASDAQ: ALTI)
- An innovator in ceramic nano-materials
- With titanium dioxide and metal oxides
  - Having performance never achieved before
- Revolutionize electric and hybrid vehicles
- And, that's just part of the story

# Offices, Labs & Semi-Works

- 100,000+ sq ft facilities
- Reno, NV and Anderson, IN
- 77 employees
- Rapid prototyping
- NIOSH partnership



Win-Win, Rapid Product Development

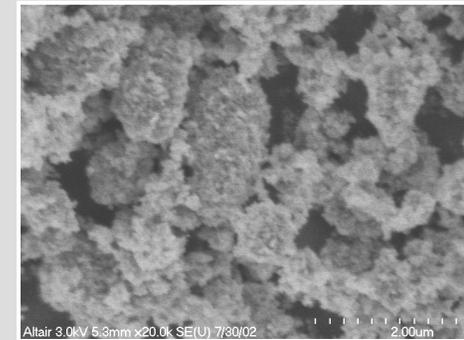
## Performance Limited / Safety Compromised

- Surface area impacts Li ion diffusion rate
  - Limits charge and discharge rates
- Crystal fracture and electrode poisoning
  - Limits cycle and calendar life
- Hazardous combination of chemicals
  - Products are not safe.

Only Suitable for Low Rates / Ambient Environments

## Replacing Graphite Leads to .....

- Nano-structured electrodes
  - Increase electrode surface area
    - Small particle size
    - High surface area
  - Use stable 3 dimensional host materials
  - Replaces graphite eliminating most hazards
- The performance impact?
  - Battery performance dramatically improved
  - Products are intrinsically safe

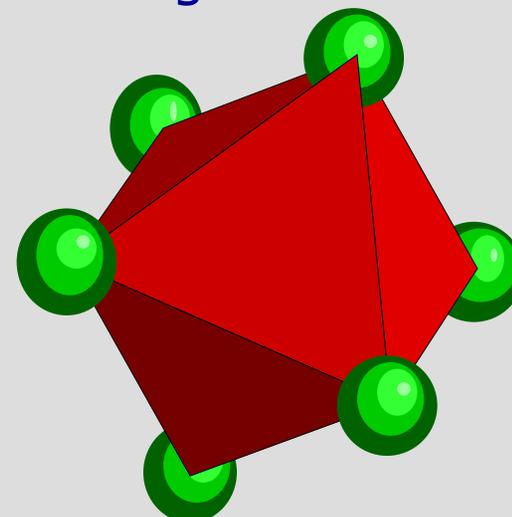


.....Superior Performance Characteristics

# n-LTO ( $\text{Li}_4\text{Ti}_5\text{O}_{12}$ ) Based Anode

## Nano Lithium Titanate Possesses Unique Properties

- n-LTO is a stable 3-D crystal structure (spinel)
  - Lithium can insert from any angle – *fast kinetics*
- Retains fast 3-D kinetics at low temperatures
- Stable crystalline morphology
  - Near zero deformation from charge / discharge
- Stable to 700°C
- High capacity - 160 mAh/g
- Voltage vs. Lithium
  - Eliminates lithium metal formation
  - Eliminates SEI formation
  - Allows aluminum current collector
  - Reduces electrolyte side reactions



Enables a New Class of Batteries

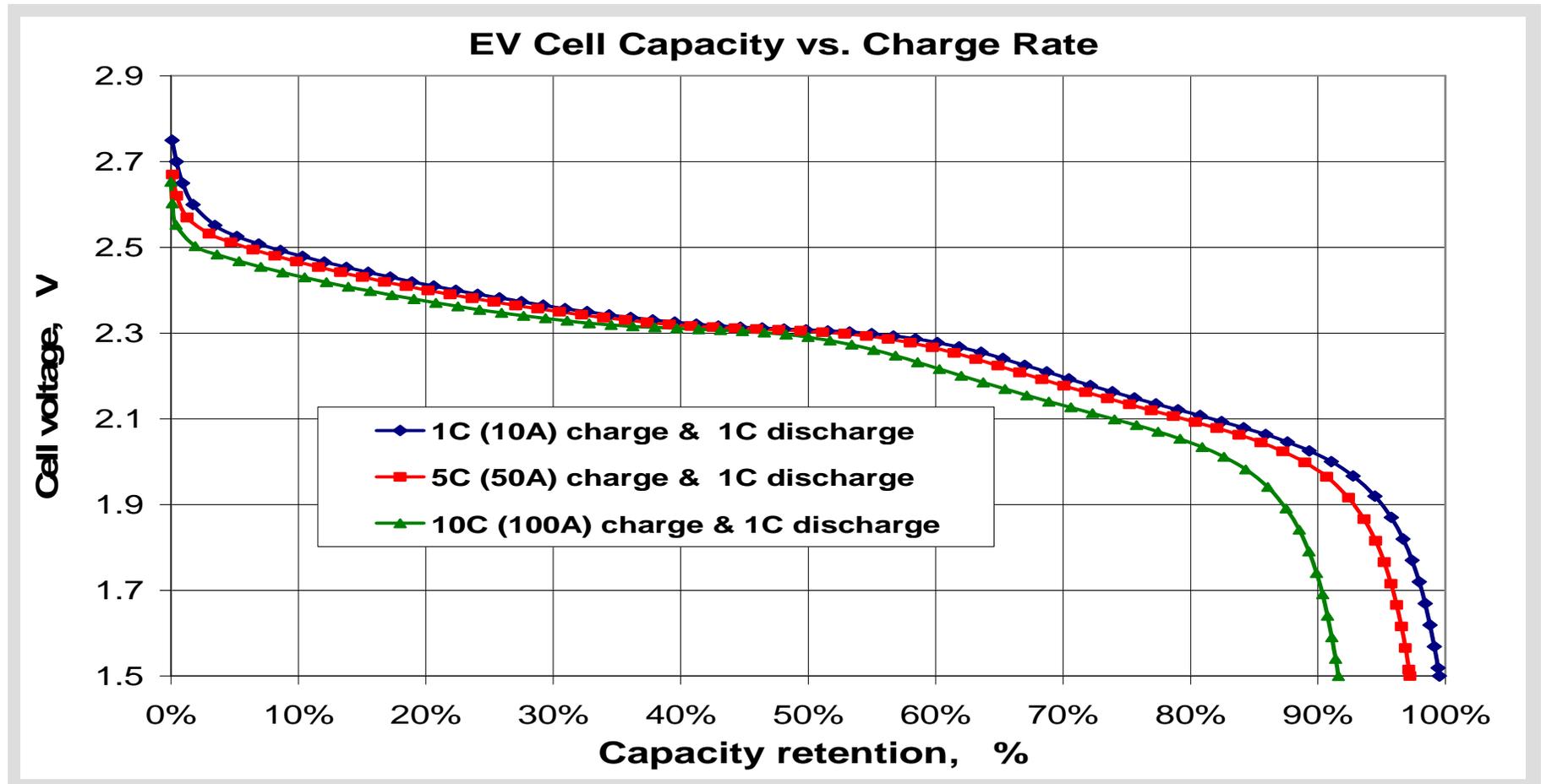
## The Evidence Speaks for Itself

- Characteristic Voltage Curve
- Recharge Rate Performance
- Cycle Life
- Power Performance
- Cold Temperature Recharge
- High Temperature Recharge
- Safety

Nano Lithium Titanate IS a Disruptive Technology

# NanoSafe Rapid Charge

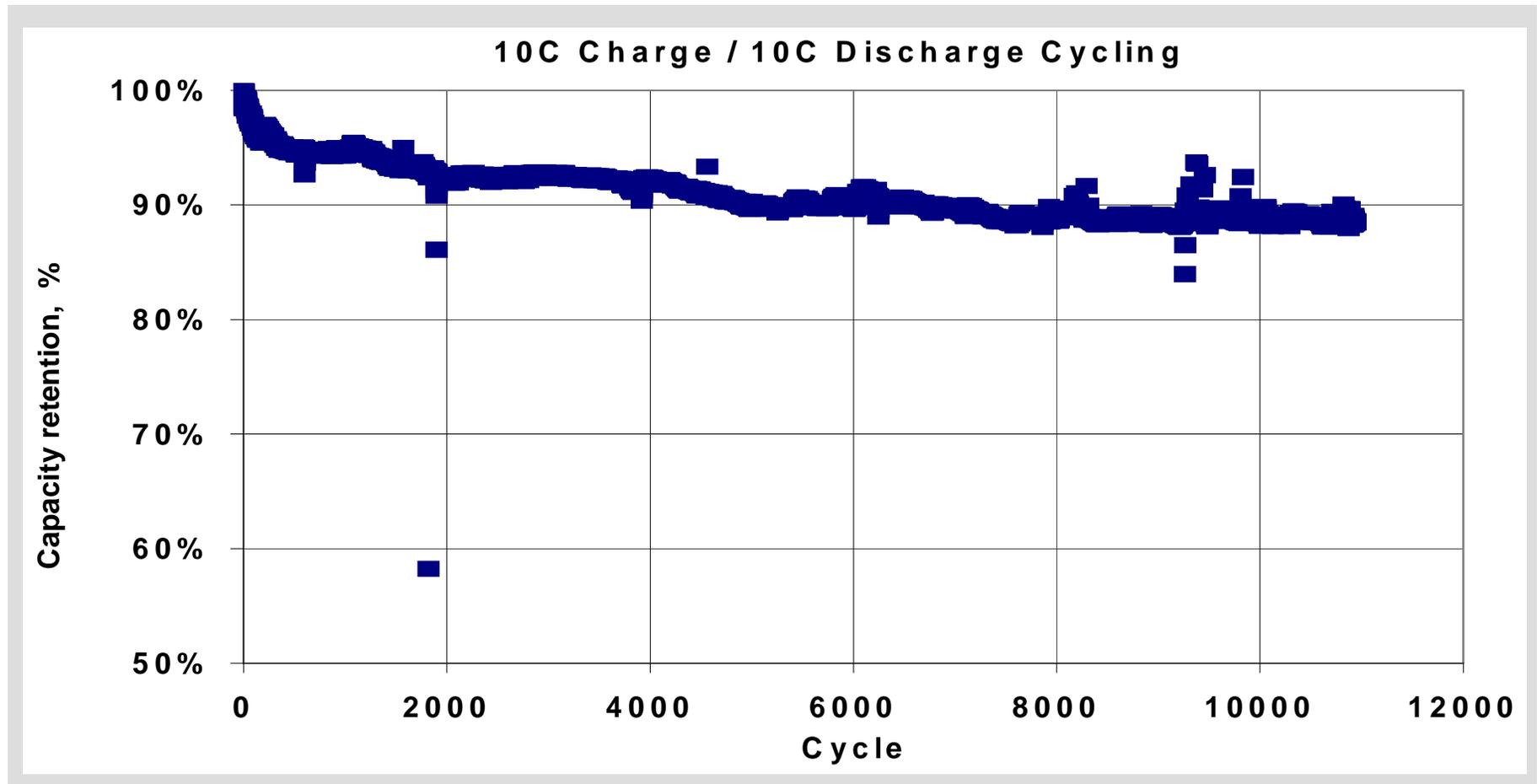
## Over 90% Charge Capacity in 6 Minutes



Pack Rated to 90% in < 10 Minutes

# NanoSafe Cycle Life

Common Li-Ion Capable of  $\sim 750$  Cycles at C/2 Rate

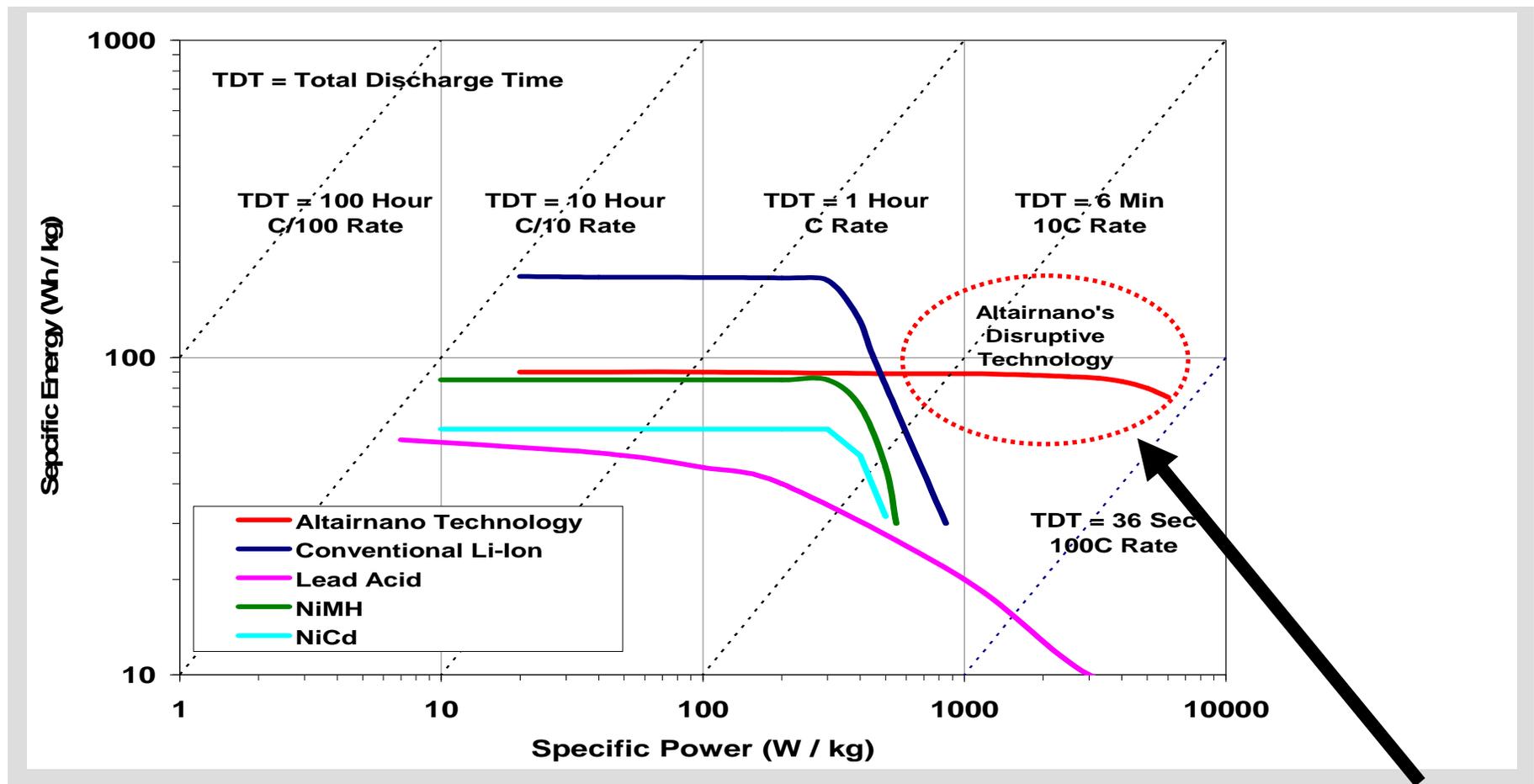


Altair = Over 15 Times the Cycle Life at 20 Times the Rate

# Altairnano Battery Performance



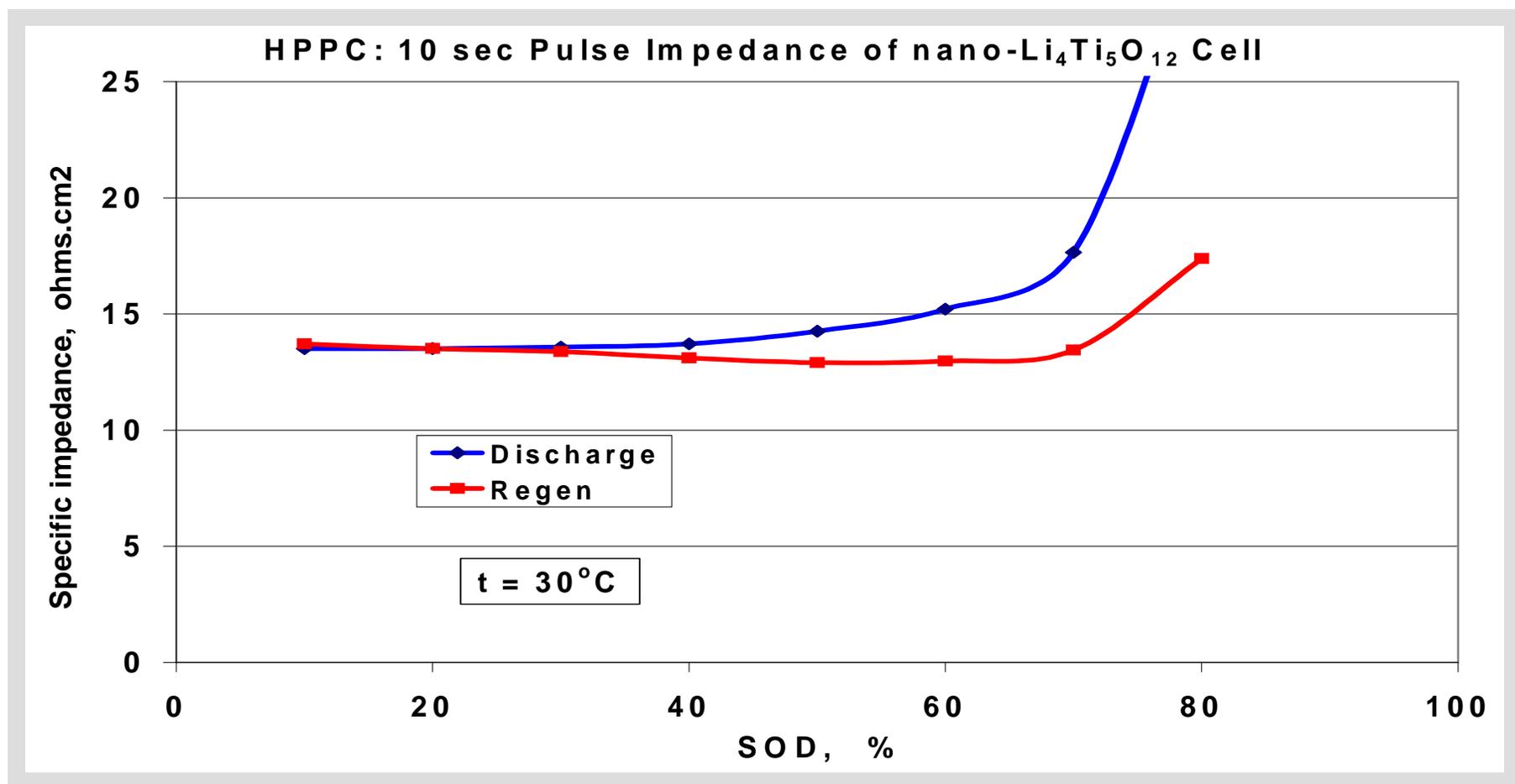
## Nano-Structured Electrodes Provide Advantages



Lithium Batteries with POWER

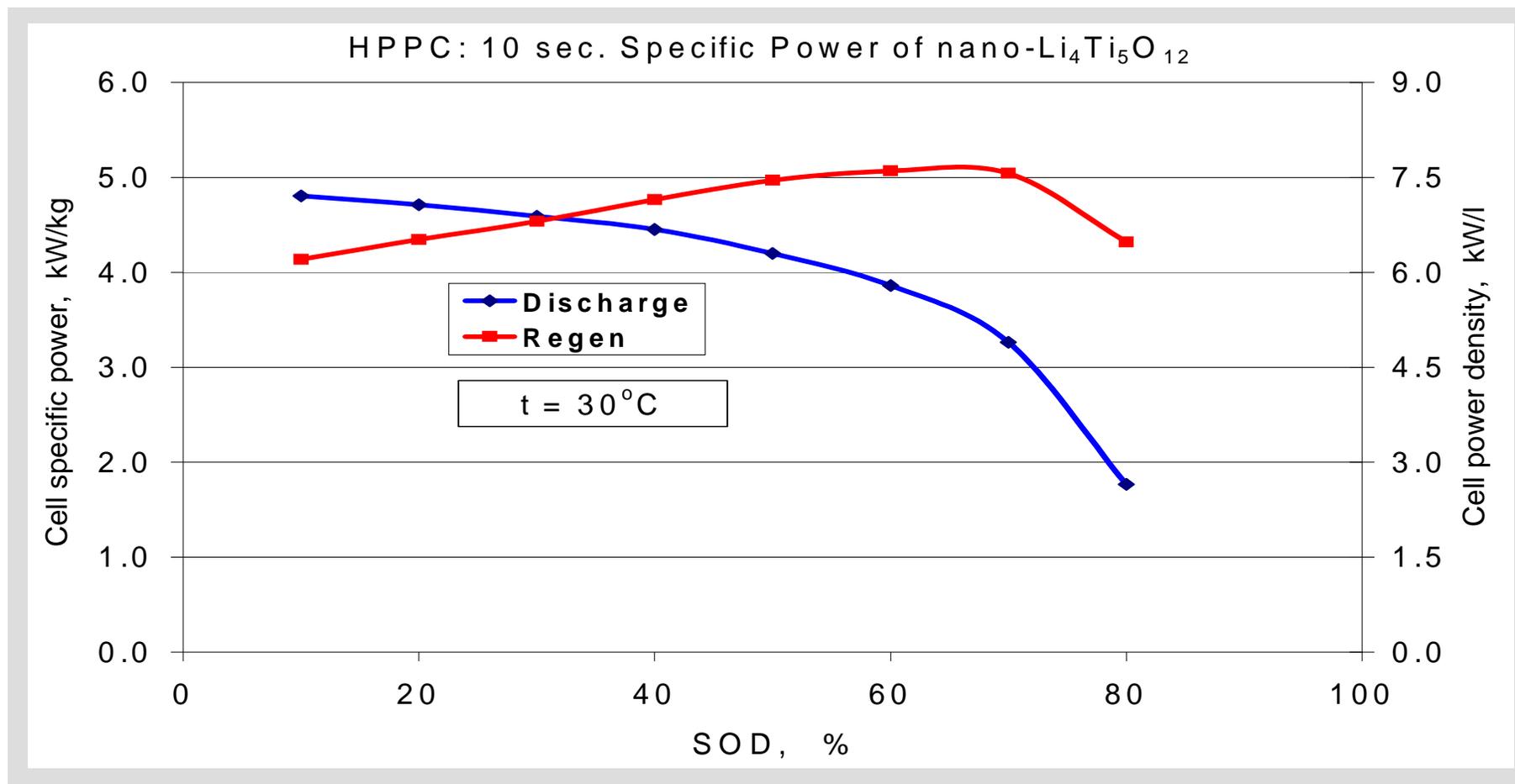
# Specific Impedance

## Nano-Structured Electrodes Provide Advantages

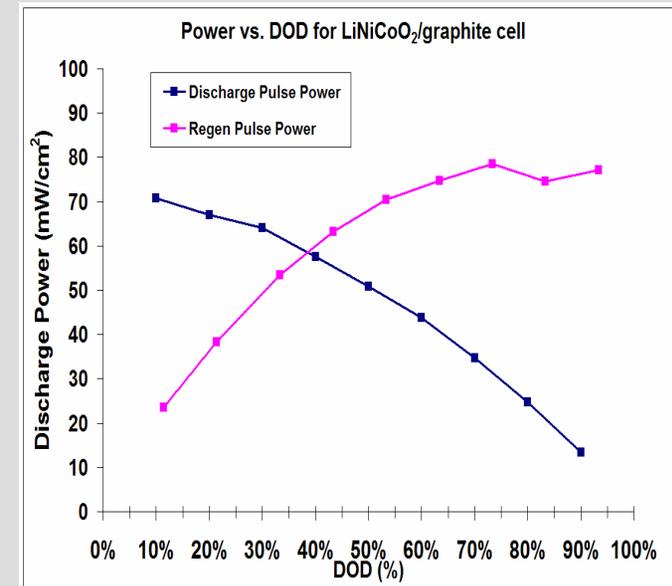
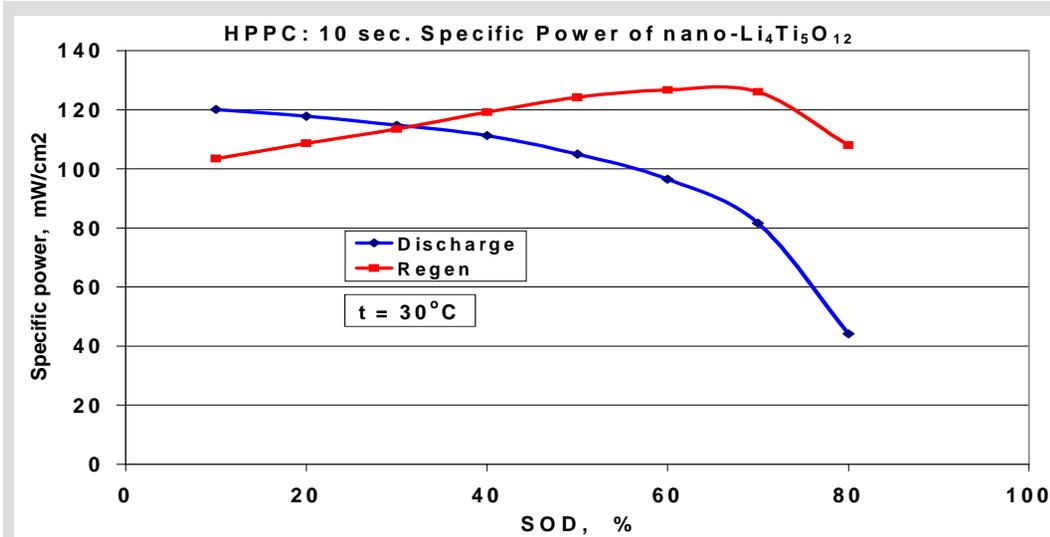


# Specific Power / Specific Energy

## High Power Across Wide State of Charge



## Wide Power Range Means Smaller Batteries



Long Cycle Life Means Smaller Batteries

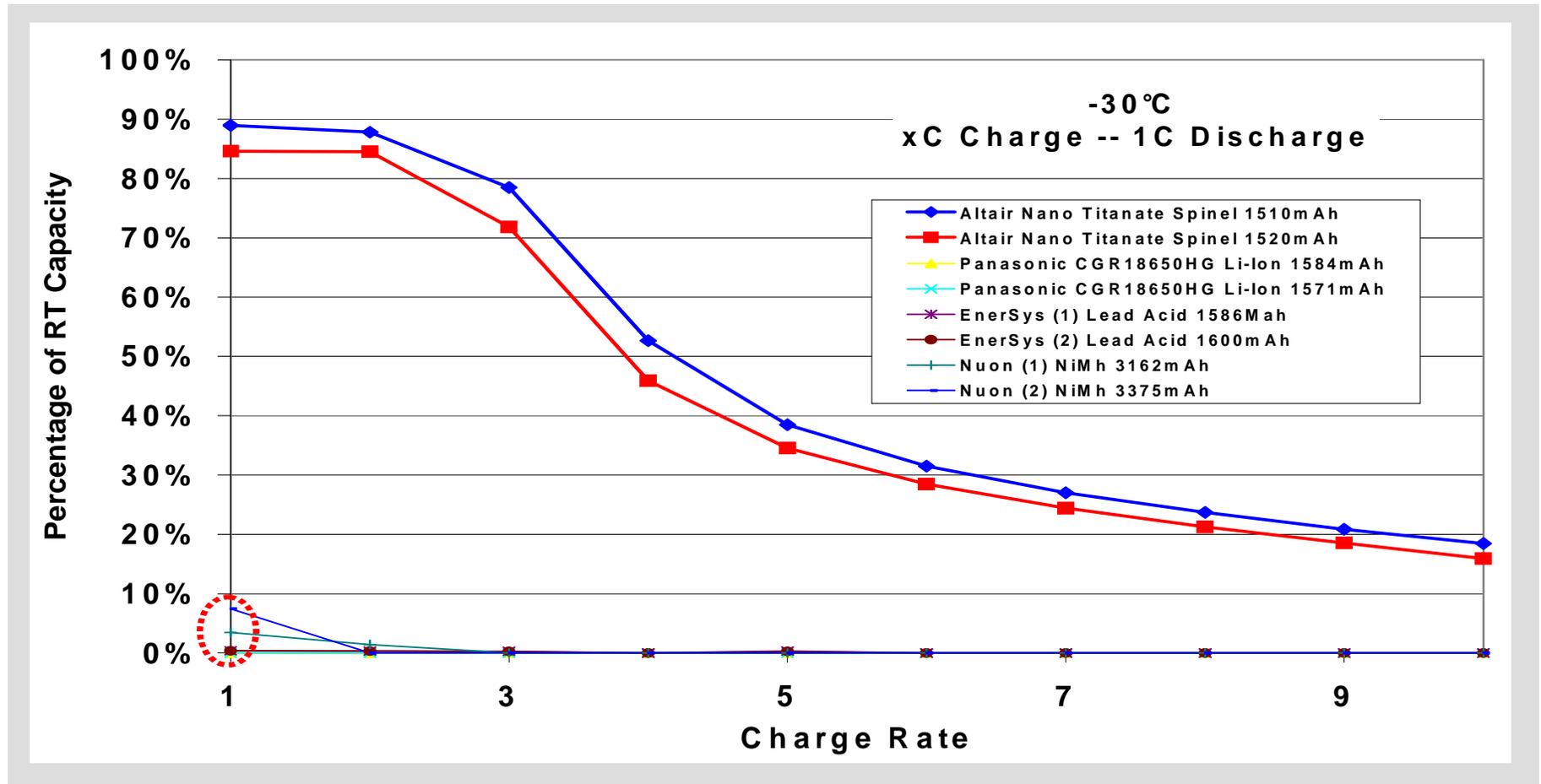
## Nearly Full Battery Utilization at Very Low Temperatures

- Nano-structured  $\text{Li}_4\text{Ti}_5\text{O}_{12}$  spinel materials
  - Allows high cold temp charge / discharge rates
    - Nano particles compensate for lower kinetics
    - 10 to 20 times higher charge rates at  $-30^\circ\text{C}$
  - No SEI Layer
    - No Li deposition at high rate or cold temps

Enables Applications Unattainable With Other Batteries

# Charge Rate Comparison

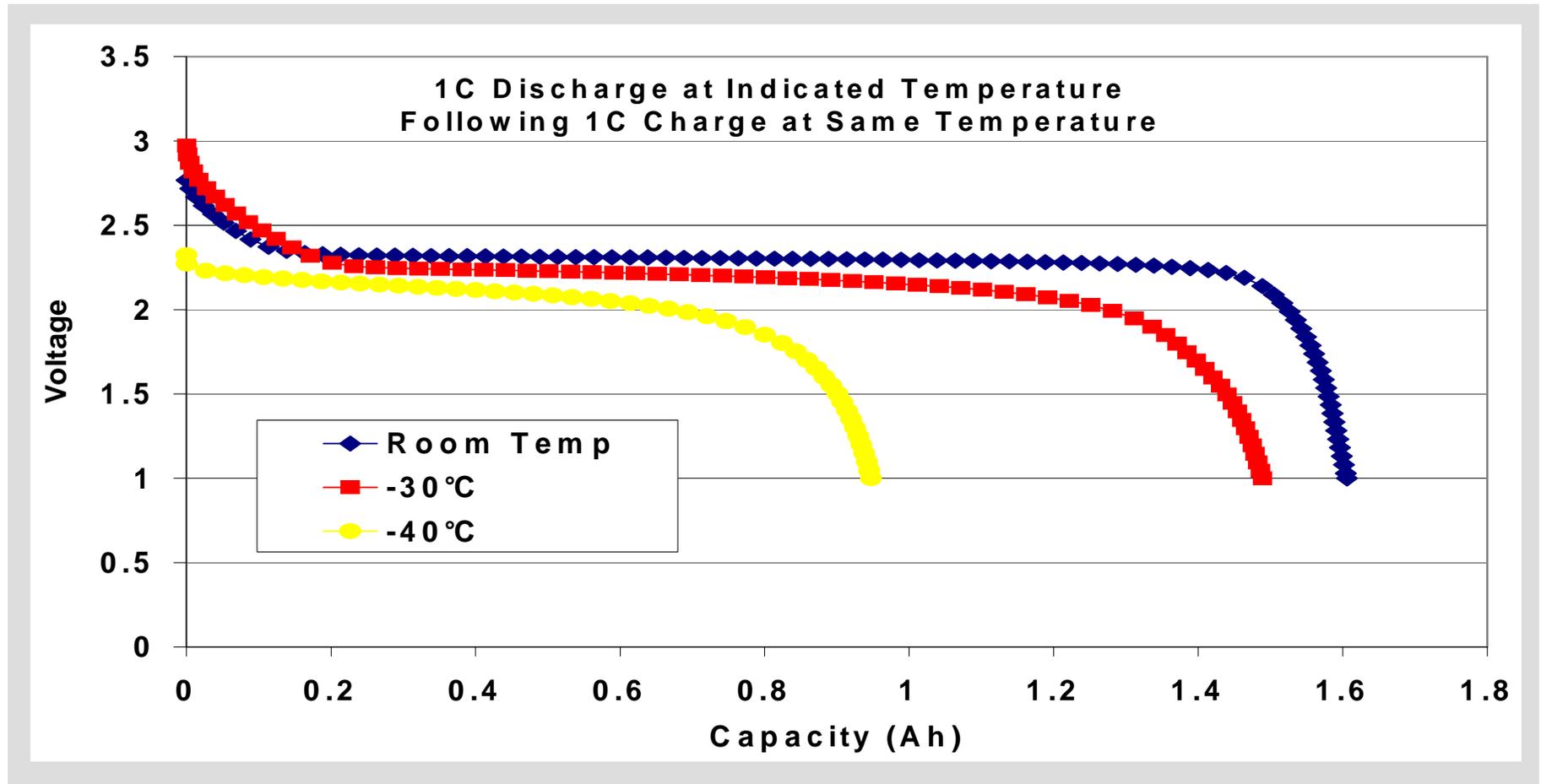
90% of Room Temperature Capacity in 1/2 Hour @ -30°C



Other Batteries Can't Perform

# Voltage Comparison

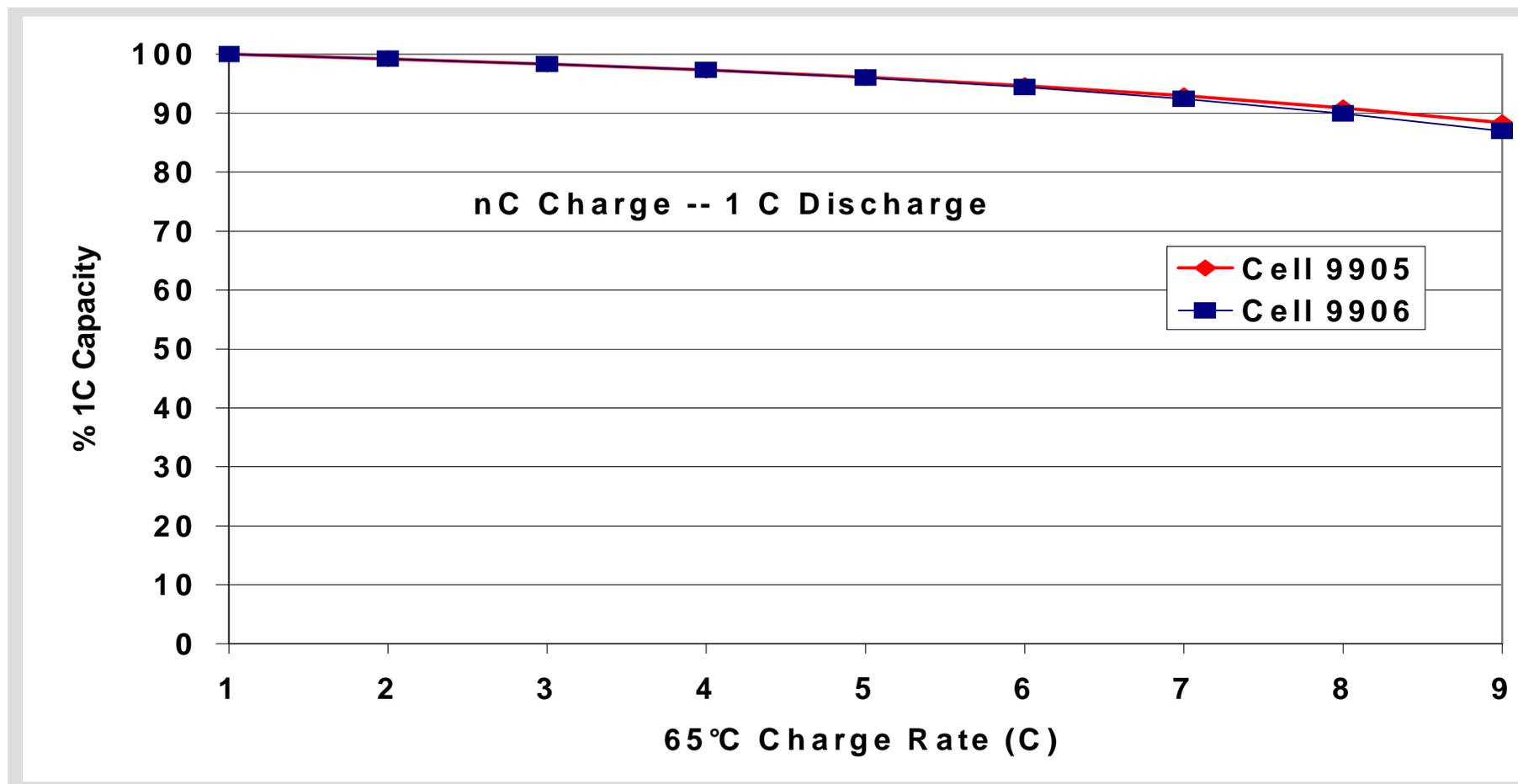
Voltage Stays High at Temperatures of 25, -30 & -40°C



Power is Not Lost at Environmental Extremes

# NanoSafe - 65°C Charge

## Outstanding Performance at Elevated Temperatures

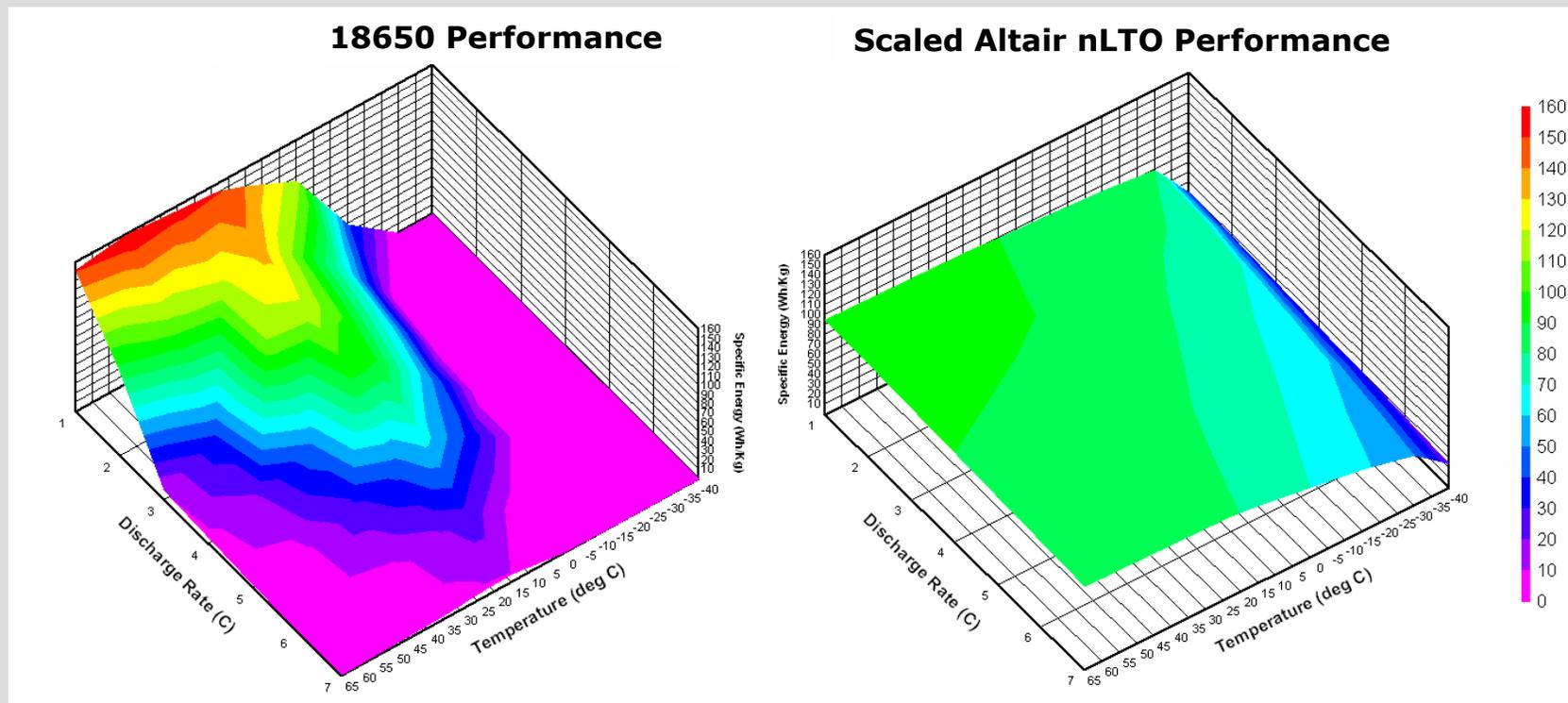


~90 % of Fresh Capacity in Under 7 Minutes – SAFELY!!

# Battery Performance

## 18650 vs Altairnano NanoSafe Batteries

### Specific Energy vs Discharge Rate vs Temp



Unmatched Performance at  $T < 0^{\circ}\text{C}$  or Rates  $> 2\text{C}$  !!!

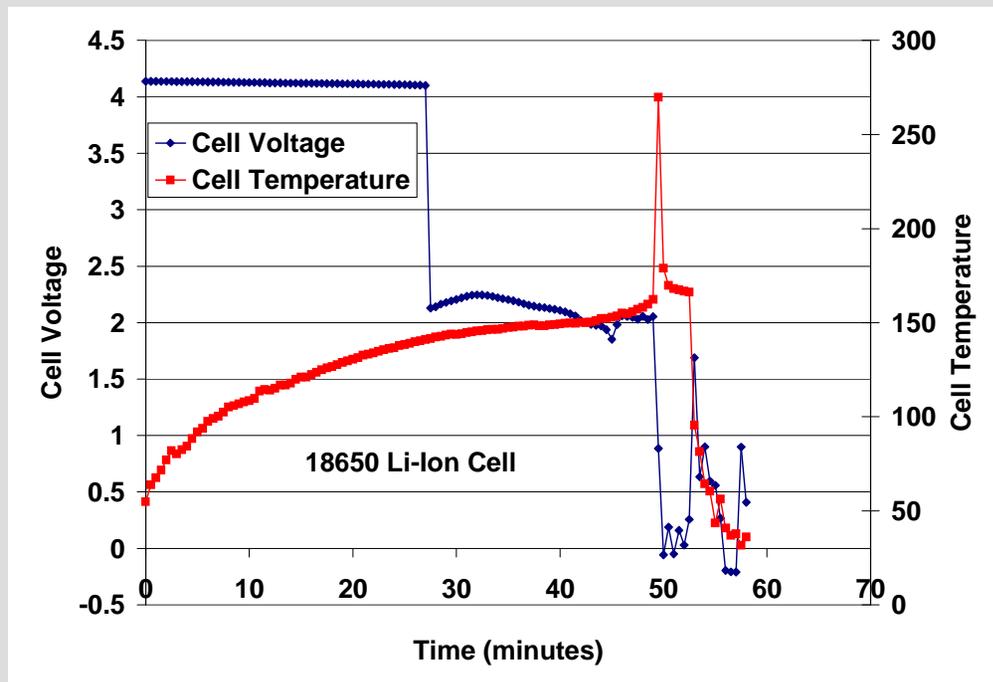
## Inherently Safe Batteries

- |                            |        |
|----------------------------|--------|
| • Short Circuit –          | Passed |
| • Forced Discharge –       | Passed |
| • Over Charge –            | Passed |
| • Over Discharge –         | Passed |
| • Nail Puncture –          | Passed |
| • Crush –                  | Passed |
| • Over Temperature (240°C) | Passed |
| • Drop –                   | Passed |

# Graphite Based Li-Ion Batteries

## Hotbox Test -- Laptop Type Battery Cell

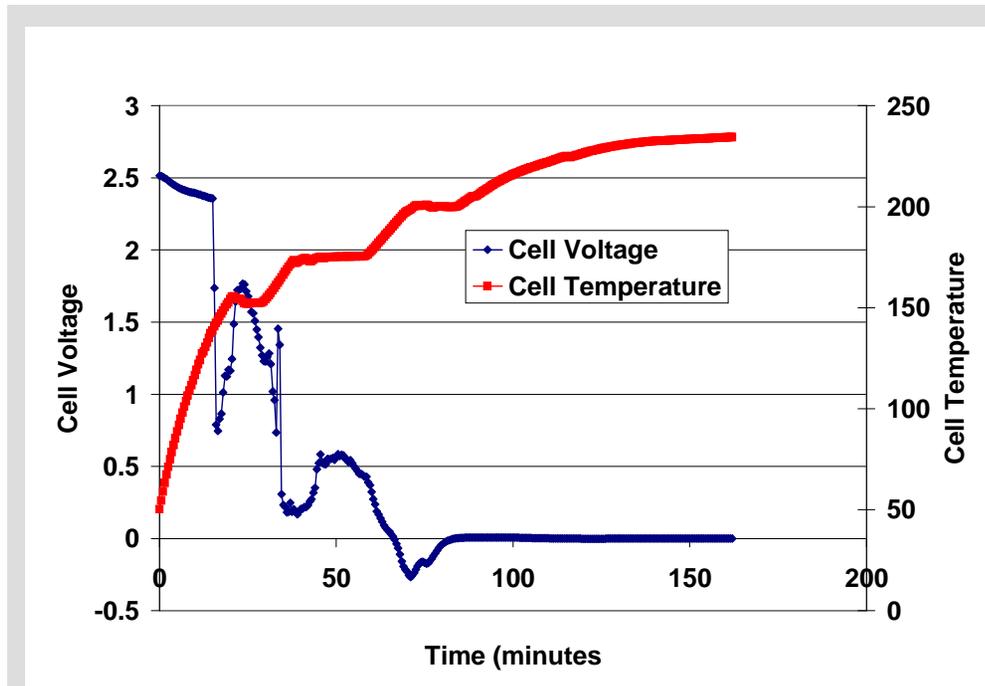
18650 Li-Ion Cell



Routinely Explodes - High Temperatures / Other Stresses

# Altairnano n-LTO - Hotbox Test

## Nano Lithium Titanate Batteries at EXTREME Temperature



**NO Smoke – NO Fire – NO Explosion**

# Cell Phone Battery

## Typical Overcharge Result From ANY Graphite Battery



**Altair nLTO Based = NO Smoke – NO Fire – NO Explosion**

# Altairnano's NanoSafe Battery



Full Size 12 Volt Battery Module ~ 1,250Wh



Module Contains Internal Controller, Connection to Master

# Altairnano's Demo EV

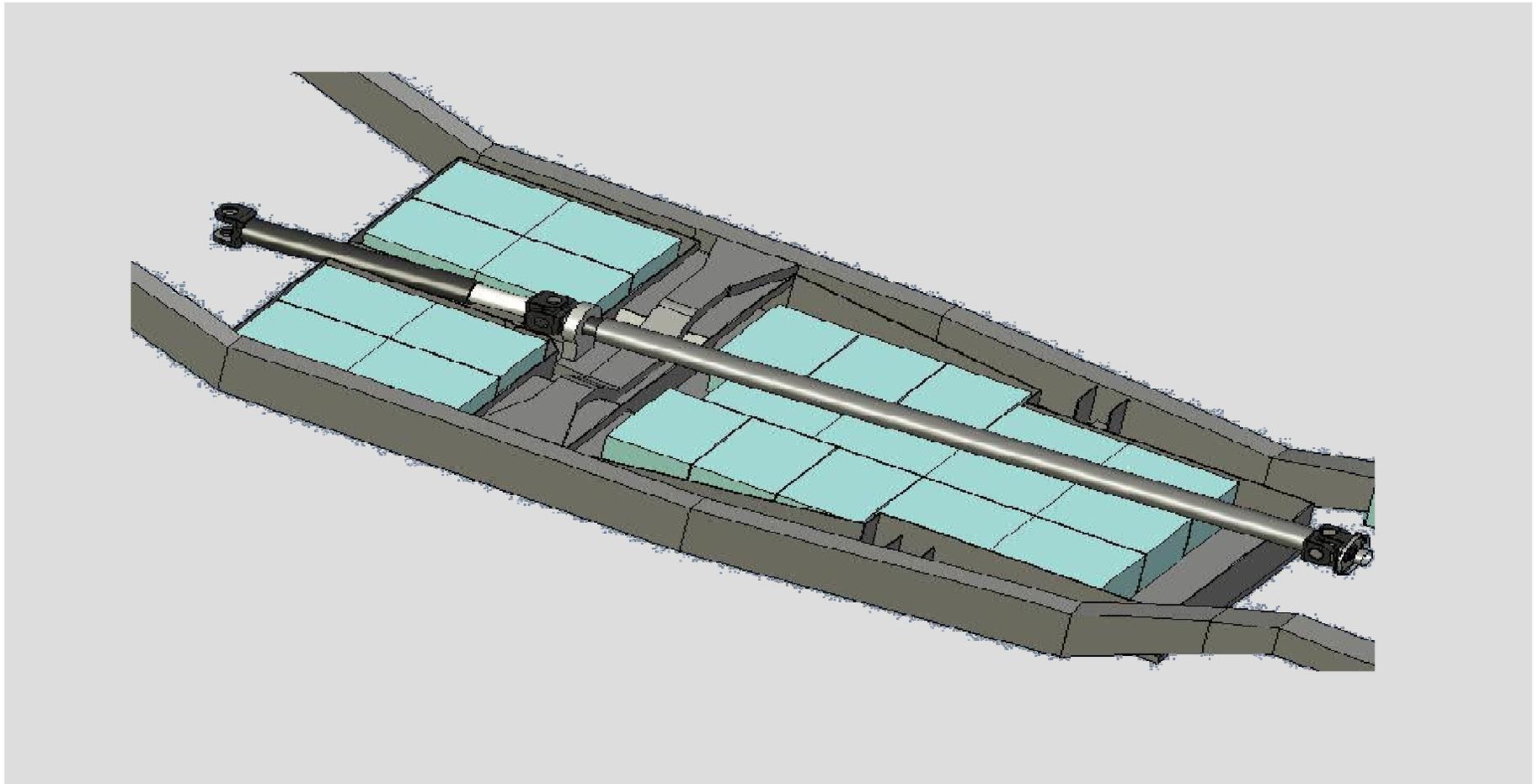
## SUV Long Range EV



>150 Mile Range, ~10 Minute Recharge Capable

# Altairnano's Demo EV

## 12 Volt Modules Base Unit of the Battery Pack



The Pack Resides Under the Car

# Altairnano's Demo EV

## Underbody Battery Pack



Typical Arrangement for Commercial Batteries

# Altairnano's Demo EV

## Under-hood Demo Pack



Experience the Altairnano Difference

# Phoenix Motorcar EV

## ZEV Class 3 Compliant



- '07 Model – Exclusive to US Market
- Employs 33 Modules (35kWh @ 386V)
- 136 Mile Range
- 10 Minute Recharge
- 10 Packs Deliverable by end Q4 '06



Focus on Fast Charge Infrastructure

## Altairnano has...

- Disruptive technologies
  - Nano-structured electrode materials...
    - Rapid battery recharge -- in a few minutes
    - **POWER** for numerous applications
    - Four (4) times longer battery life (est. 12+ years)
    - Inherently safe battery designs
    - Green battery design
- Establishing Large nLTO Materials Supply
- Rapid development capabilities
- Looking for early adoption partnerships

Imagine the Possibilities!

**Dr. Evan House, PhD**  
**Director, Advanced Materials & Power**  
**Systems Business**

**775.858.3714**

[ehouse@altairnano.com](mailto:ehouse@altairnano.com)

[www.altairnano.com](http://www.altairnano.com)

**Realize the Possibilities!**