QUALLION




Quallion Large Battery Pack Technology

May 2009

Hisashi Tsukamoto, PhD. CEO/CTO Quallion LLC

Powering Life.

Quallion Milestones

1998 — Company established in Southern California, USA

2001 — Developed 7 new cell designs (4 implantable grade); shipped 30,000 production units; plant reached 6,000 unit per month volume

2002 — Entered Aerospace/Defense market with OGA and CECOM Contracts Initiated Development of Primary Chemistries

2003 — Registered under ISO 9001 &13485; Zero-VoltTM technology patented (recertified in December 2004)

2004 — Zero-Volt™ technology patented

2005 — SaFE-LYTE™ technology patented

2006 — Title III Award; Registered AS9100

2007 — Frost & Sullivan Award for Lithium Ion Power Sources

2008 — Boeing Technology Supplier Award

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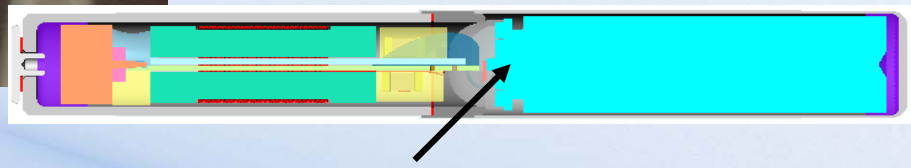
Origin of Quallion:
Implantable Micro Battery

Inductive charging Technology



Miniature Injectable (implantable) neurostimulator

Quallion Battery
(2.8mmD, 12mmL, Li-ion)

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High Reliable Li-ion Cells for USG Satellite

QL075KA

	QL075KA
Height	173.7.0 (mm)
Width	80.9 (mm)
Thickness	56.2 (mm)
Weight	1820 g
Operating voltage	2.7 – 4.1V
Discharge capacity	72 Ah
Weight energy density	148 wh/kg
Zero-Volt™ technology	Applicable

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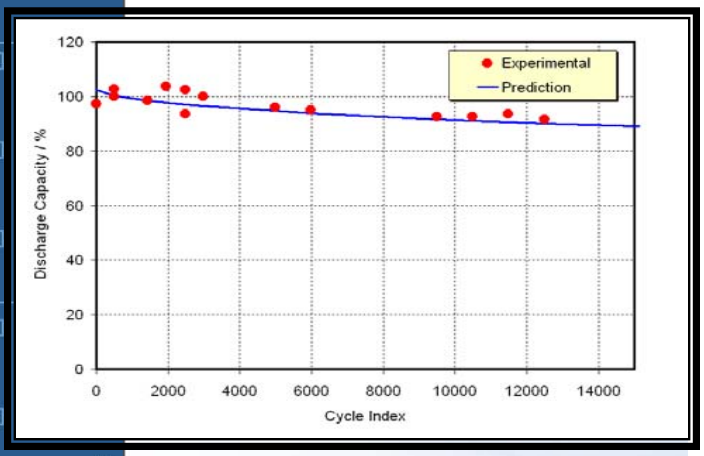
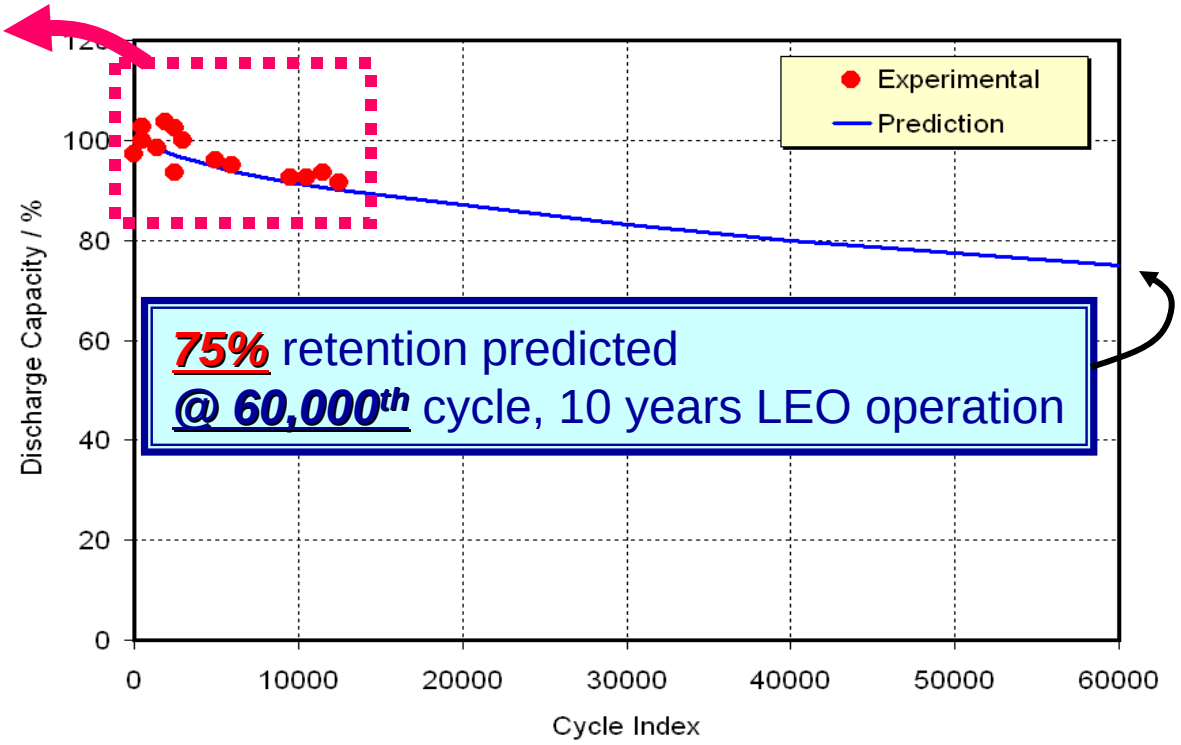
QL075KA Cell: Cycle Life
40% DOD Cycle @ R.T.

Capacity retention equation *)

(Discharge capacity retention) = 100 - ***k*** x $\sqrt{N_{cycle}}$

*) ***k***: constant to determine capacity fading rate
N_{cycle}: charge and discharge cycle index





Powering Life.

Zero Volt™ Capability
Cycle Performance after 0V Storage (17 months) (200mAh model cell)

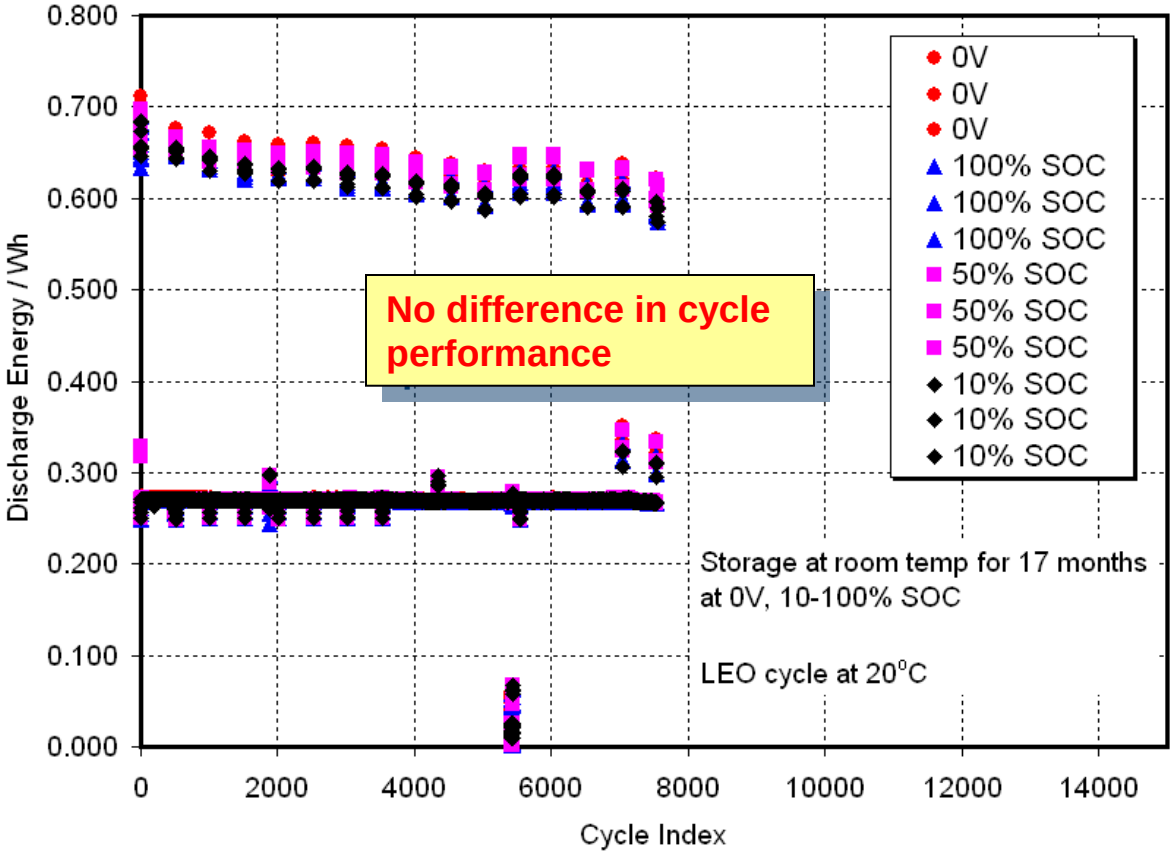
Storage Condition
For 17 months,
- 100% SOC (3 cells)
- 50% SOC (3 cells)
- 10% SOC (3 cells)
- 0V (3 cells)

(at room temperature)

Cycle condition
- LEO cycle (40% DOD)

Capacity check
- 100% DOD
  at every 500 cycles

(at 20°C)



Powering Life.

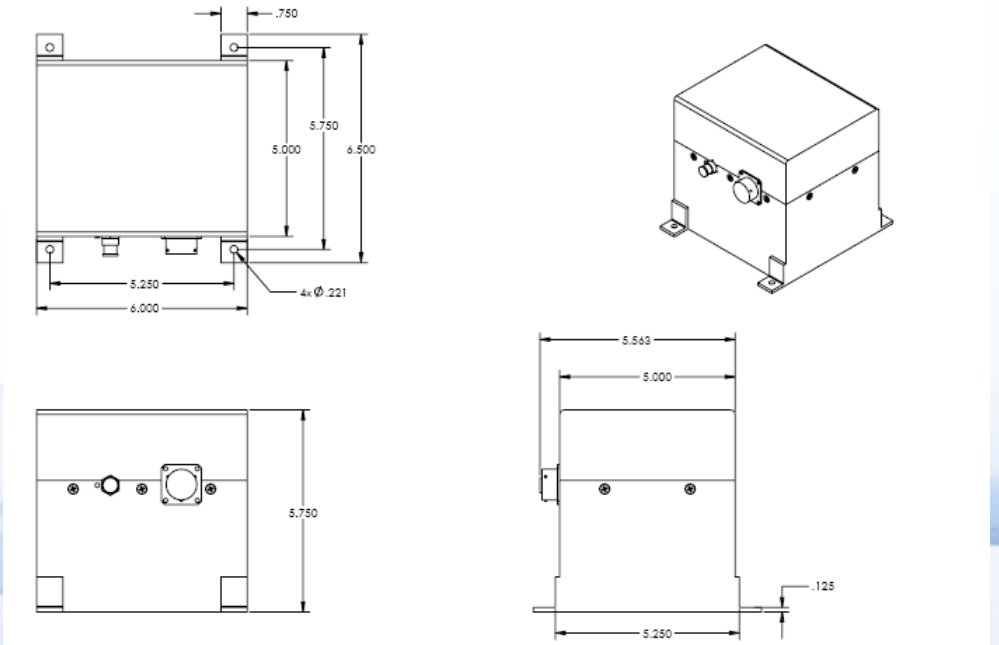
Matrix™ Battery, QL038KM for Little Bird, MH-47 ,MH-60 and U2

24V Lithium-ion (Lead Acid Replacement)

- **38 Ah capacity**
- **0.912Kwh (100wh/kg)**
- **9.75^{L}x8.125^{W}x5.3^{H} inch**
- **24 lbs**

Powering Life.

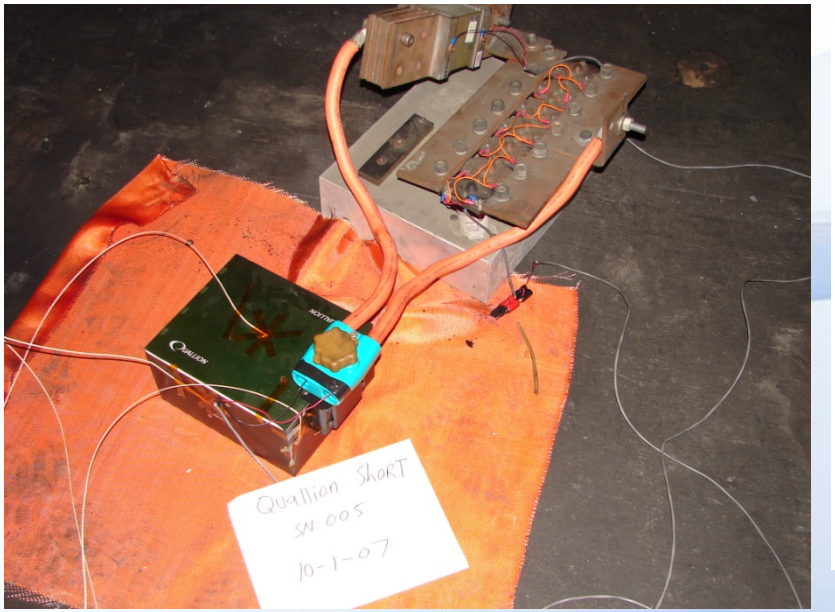
24V, 9.5Ah Matrix Battery™ for C-17 Aircraft EBPS

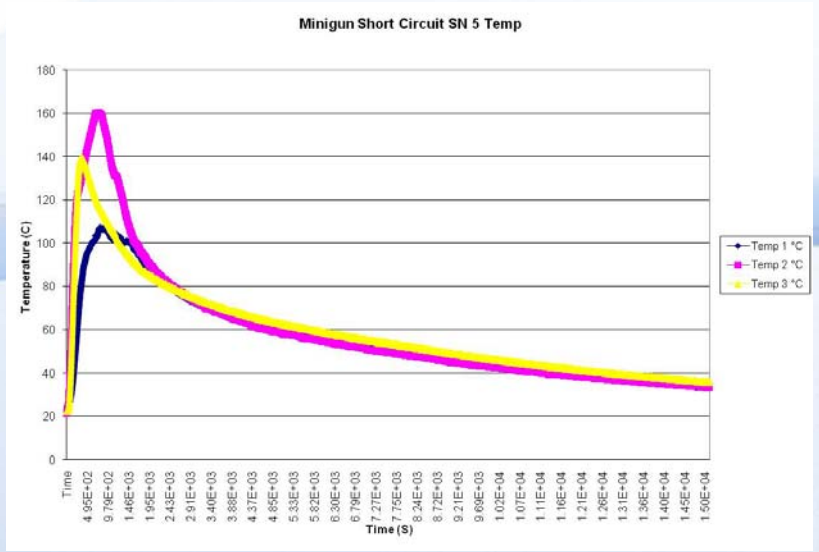


- Qualification Program to Replace Current Ni-Cd System
  - Low maintenance and long life
  - Fully integrated charge control electronics, battery management electronics & BIT/SOC capability
  - -65ºF to 160ºF (with heaters)
  - Less than 8.5lbs
  - Full charge in 75 minutes over 21V to 32V input range
  - Plug N Play

Powering Life.

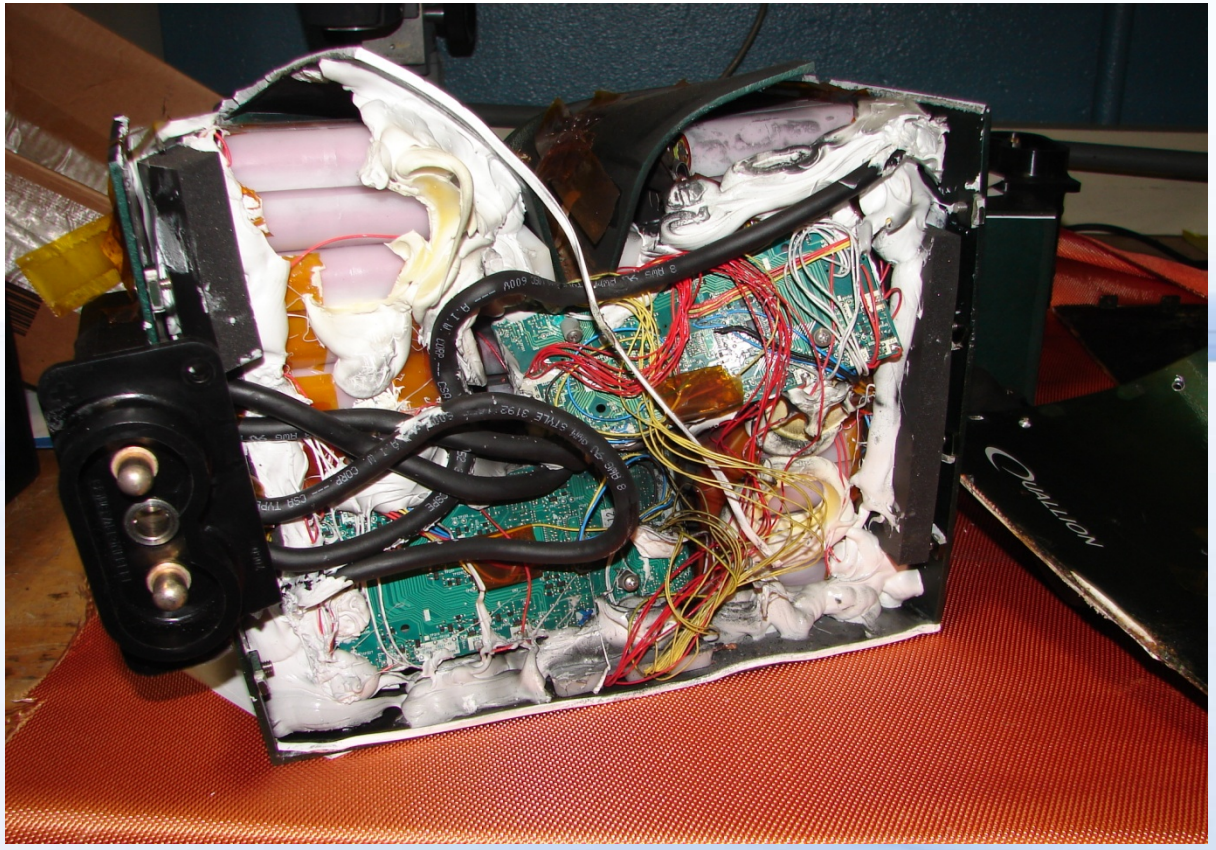
QL038KM External Short Test
5 mohm external short with BMU disabled
Passed with no flame or explosion





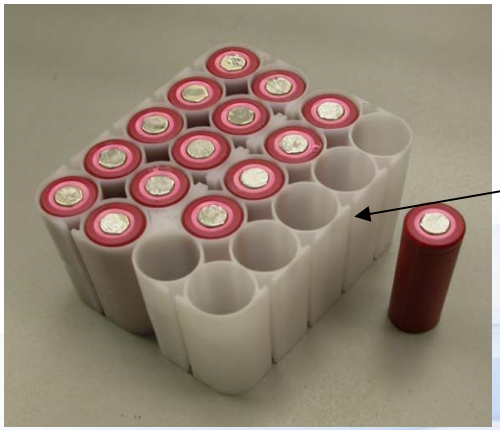
Powering Life.

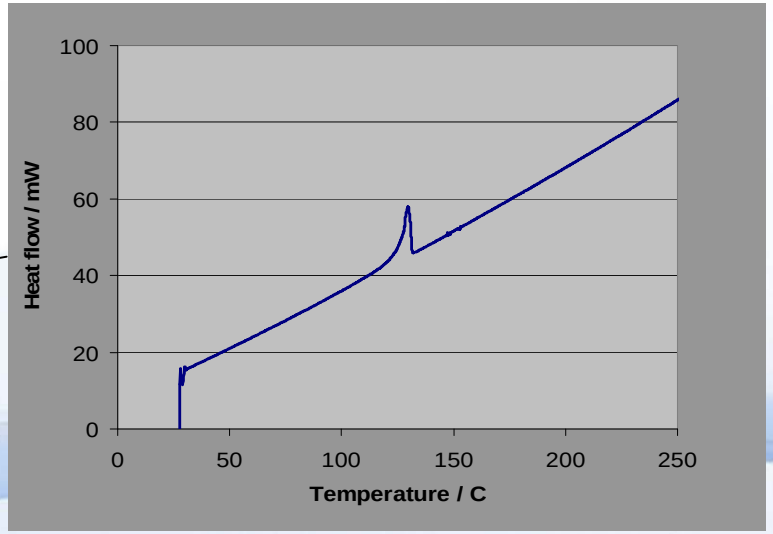
QL038KM Crush Test
Unit fully charged to 29.4V
Passed with no explosion of fire

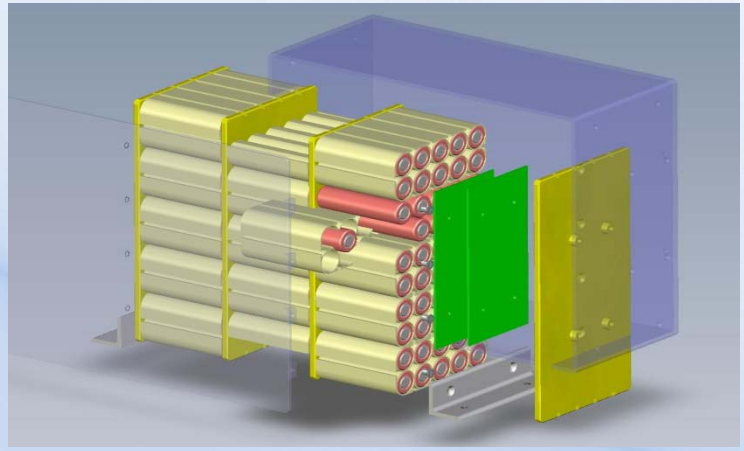


Powering Life.

Quallion Unique Safety Technology; HAM™ (Heat Absorption Material)







Powering Life.

Demonstration of HAM™ Technology

Test Battery-

Sanyo 18650W cell, 10 cells in Parallel connection.

Capacity- 15.0 Ah

Overcharge test condition-

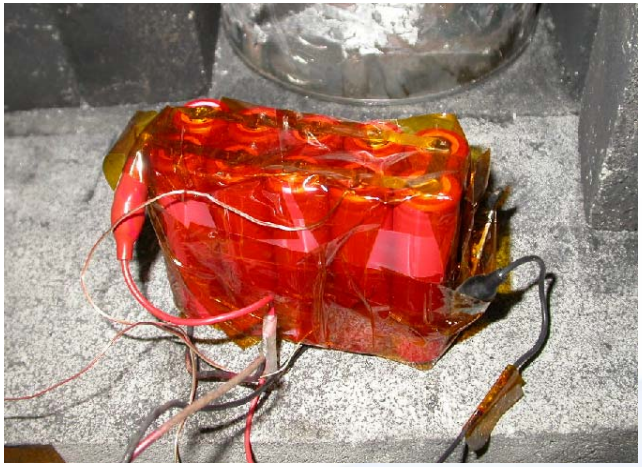
Charge battery pack @6A to 12V, hold voltage @12V till temperature dropping

Without HAM sleeve

With HAM sleeve

Powering Life.

Battery Failed without HAM™



Connection

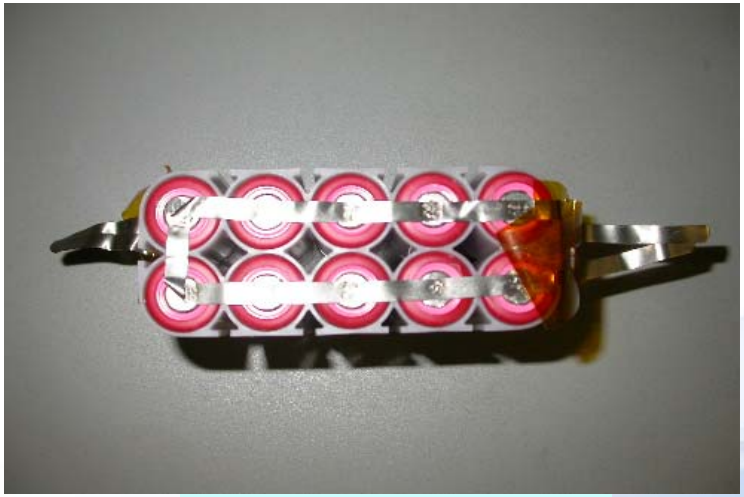
Insulation

After Test

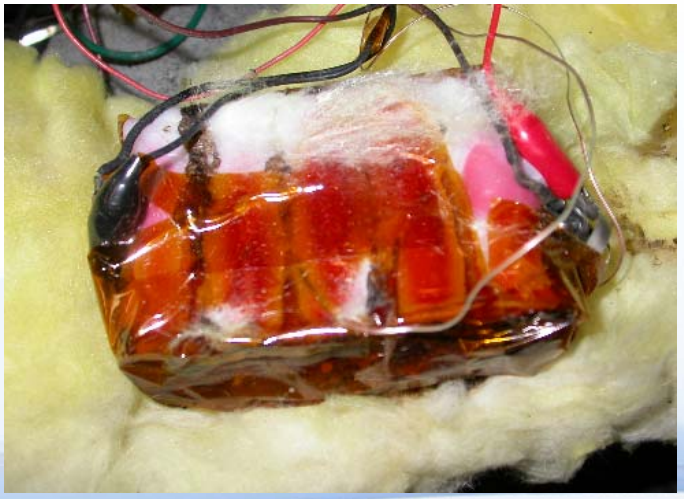
Powering Life.

Battery was Safe with HAM™

HAM® melted and latent heat stopped thermal run away



Connection



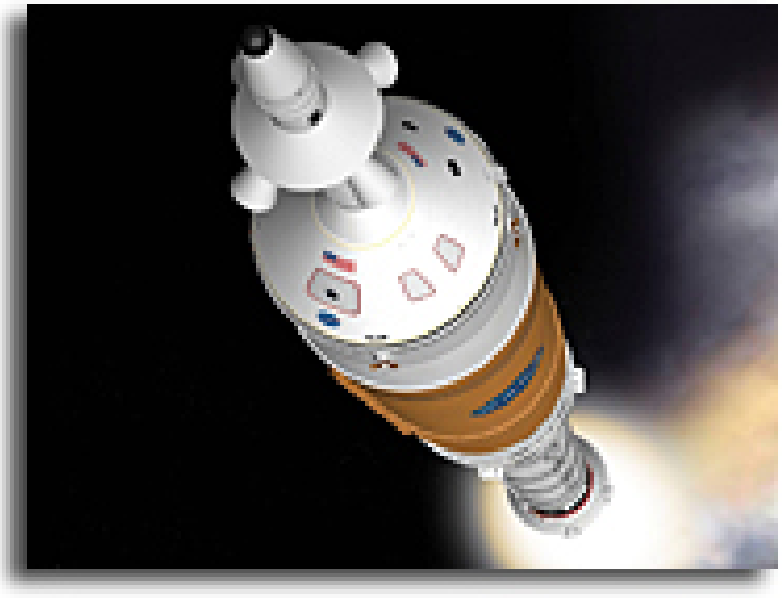
After Test

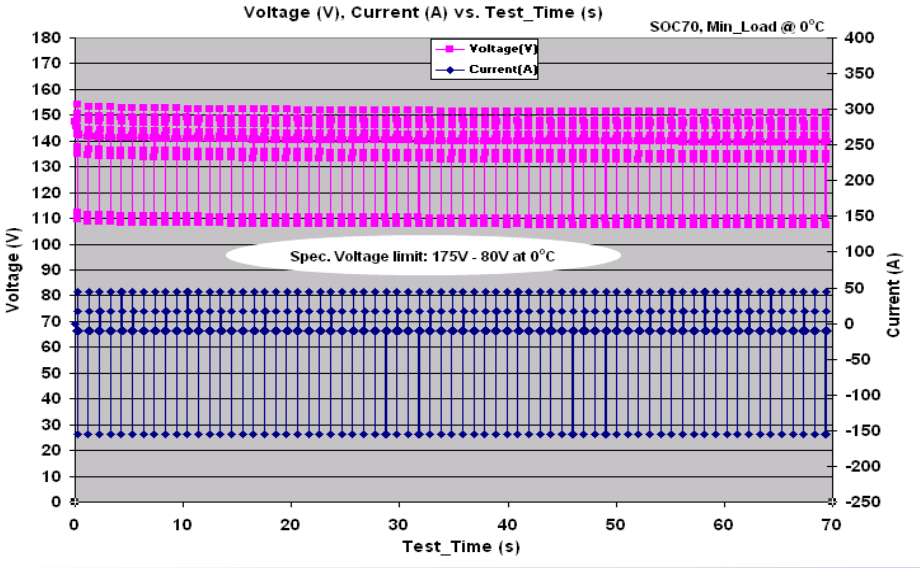
Insulation

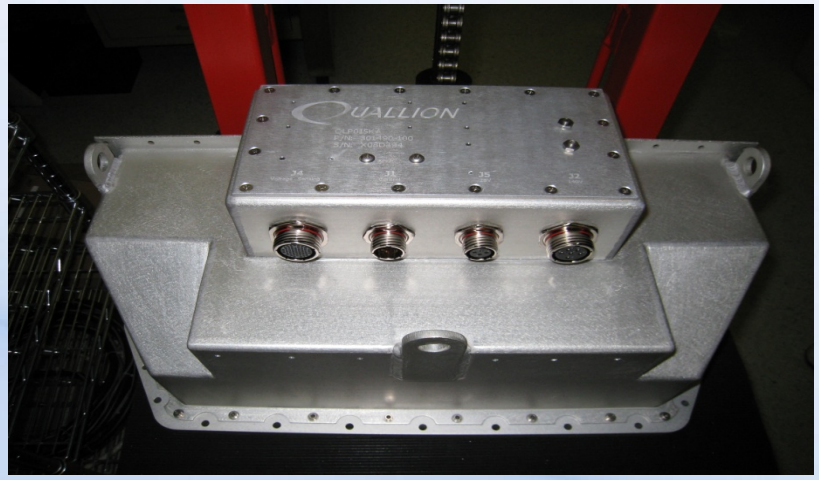
Powering Life.

140V, 28V Battery for the NASA Launch Abort System (LAS) for ARES I

- 140V, 15Ah & 28V, 1.5Ah Lithium-ion Pack
- (378) Commercial 18650 High Power Cells
- 140V Battery is capable of over 220A peak discharge current and 50A peak charge current







- 70% SOC @ 0°C,140V Battery Mission Profile

Powering Life.

Quallion 24V, 1250A Capable Matrix™ Battery Pack for HMMWV

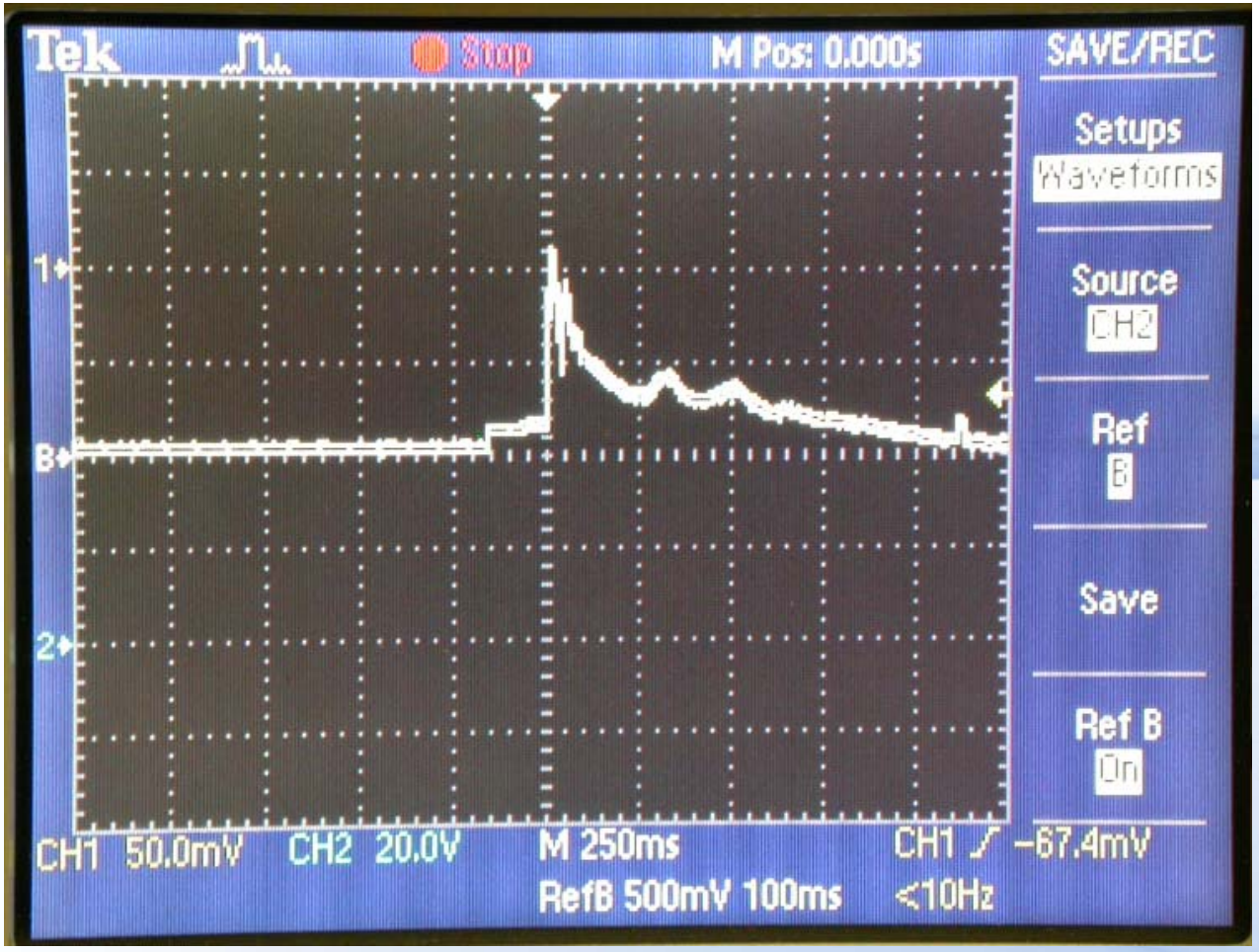
Less than ½ SLAB Weight and Deep Discharge Capable

Current Lead-Acid Battery
24V, 65Ah, 120lb (2 batteries in series)

Quallion Drop-in Li-ion APU
24V, (78Ah, 98.8Ah, 156Ah), 52lb

Powering Life.

Engine Start Test (Max Current 1100A) at SOC 70%



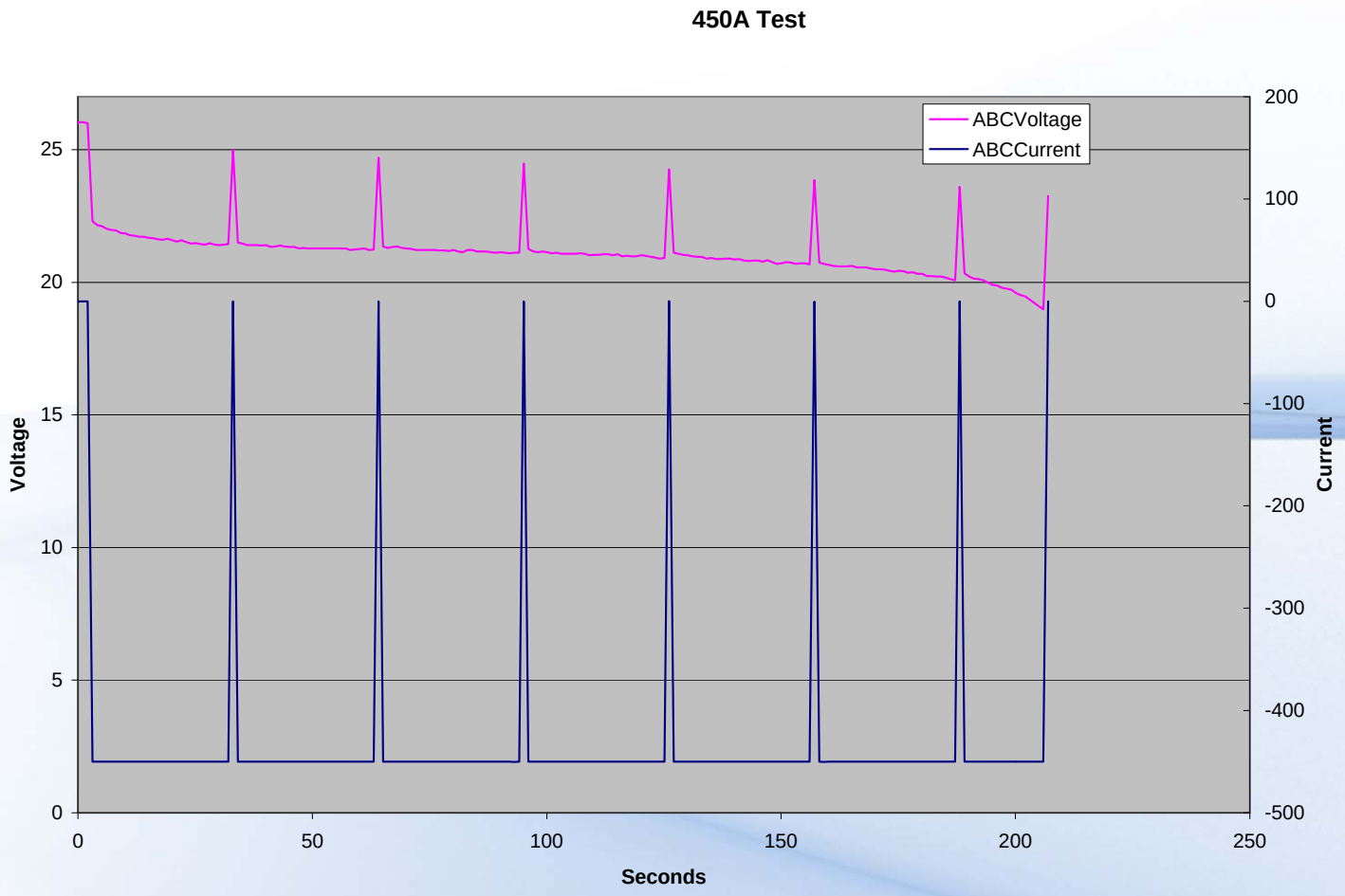
Scale: 500mV 100ms

Current: Discharge

- Peak current ~ 1100A in first 20ms
- Two peaks 500A during the first 200ms – similar profile as the lead acid battery

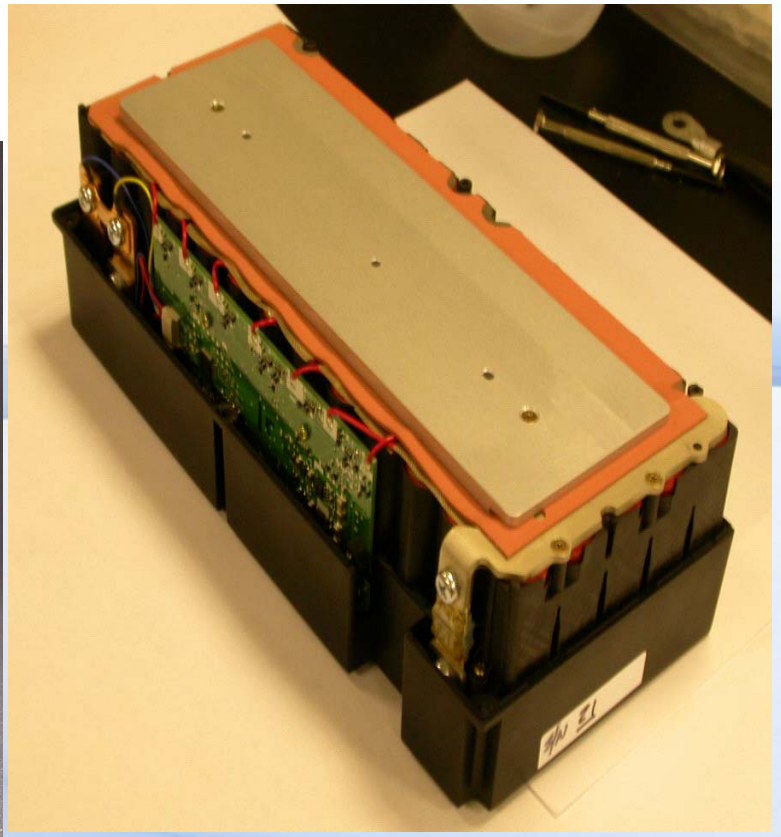
Powering Life.

450A-30 Seconds Pulse Discharge Test at SOC 40%



Powering Life.

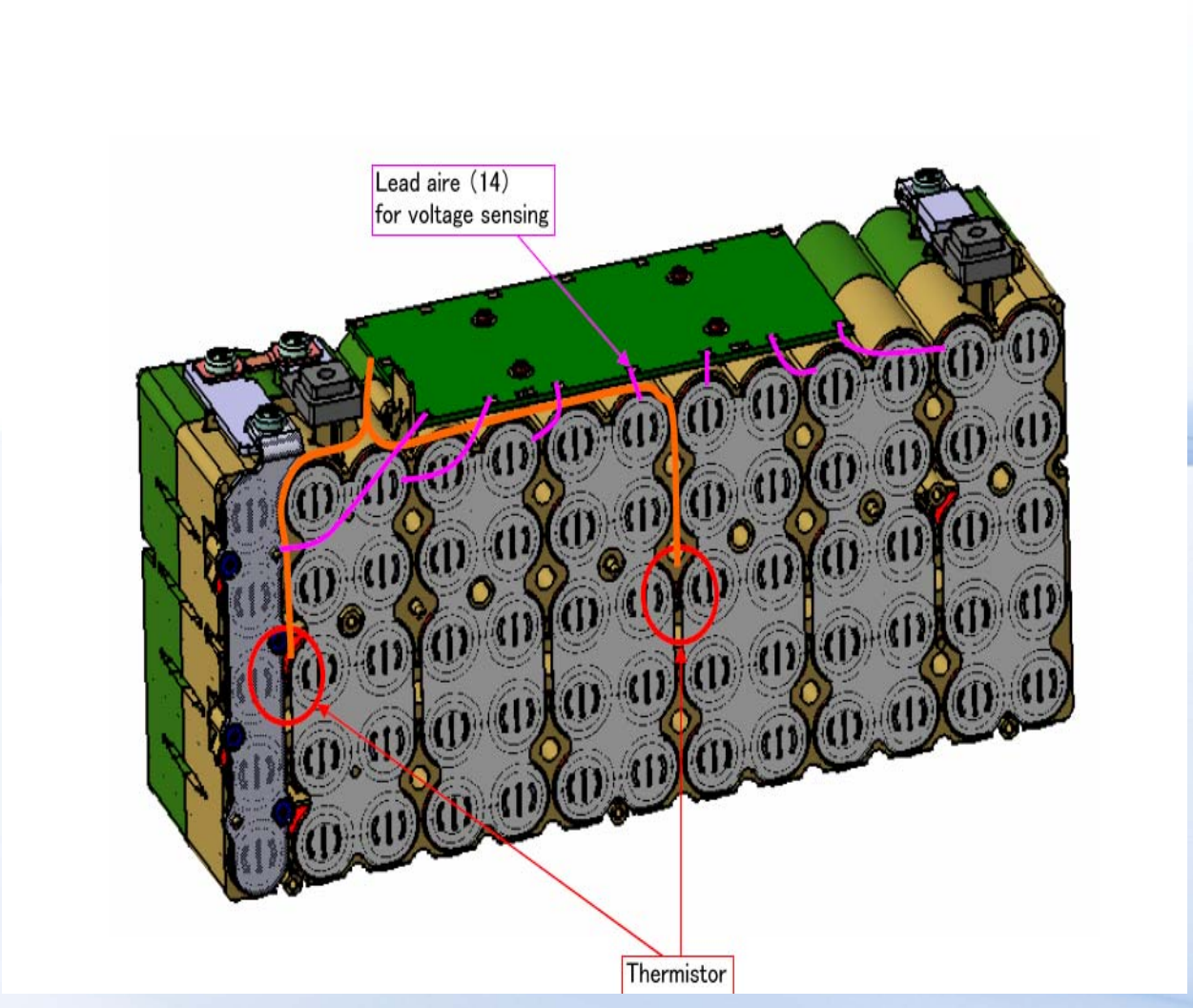
Quallion Matrix™ Module
48V, 9.5Ah, 0.456Kwh*, 78x115x260mm



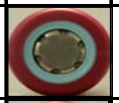
*** Standard Module (Whr and W capability varies in energy module and power module)**

Powering Life.

Voltage Sensing, Current Measuring and Temperature Monitoring



One Mechanical Configuration can bring Multiple Performance Varietals

Cell							MBD pack				
Model Name		Capacity (mAh)	Weight (g)	1KHz AC Impedance (mili ohm)	Wh/kg	W/kg	Wh	KW	Max. discharge current (A)	Kg	Remark
18650 F3		2500	47	45	197	390	600	1.2	25	4.3	Highest Energy
18650 F1		2100	47	58	165	330	500	1	21	4.2	High Energy
18650 Y		1900	43	40	162	970	460	1.4	29	4.1	Energy/Power Balance Model
18650 W		1500	44	28	125	1600	360	3.6	75	4.2	High power
18650 SA		1200	41	25	108	2200	289	4.8	100	4	Highest Power

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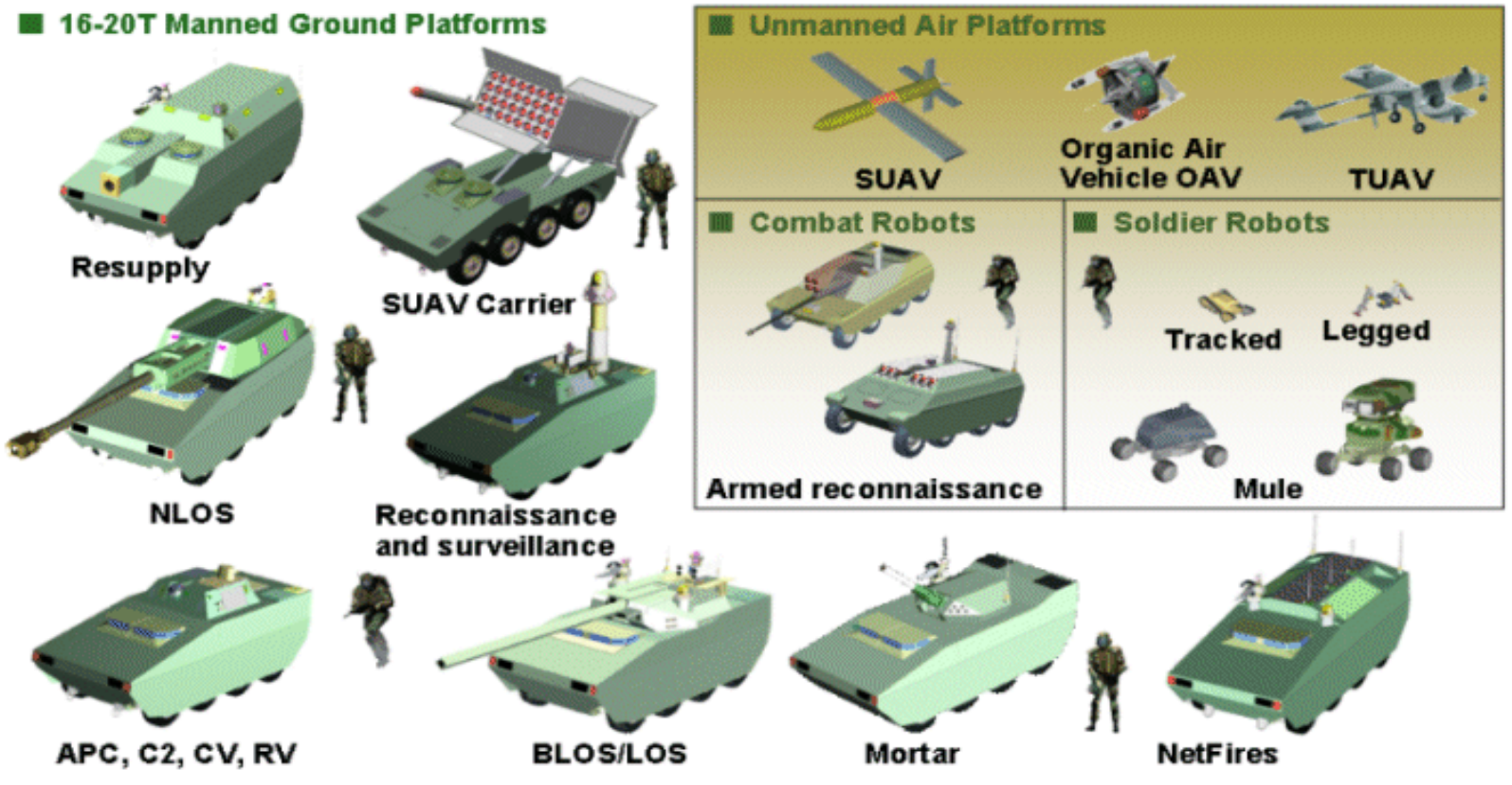
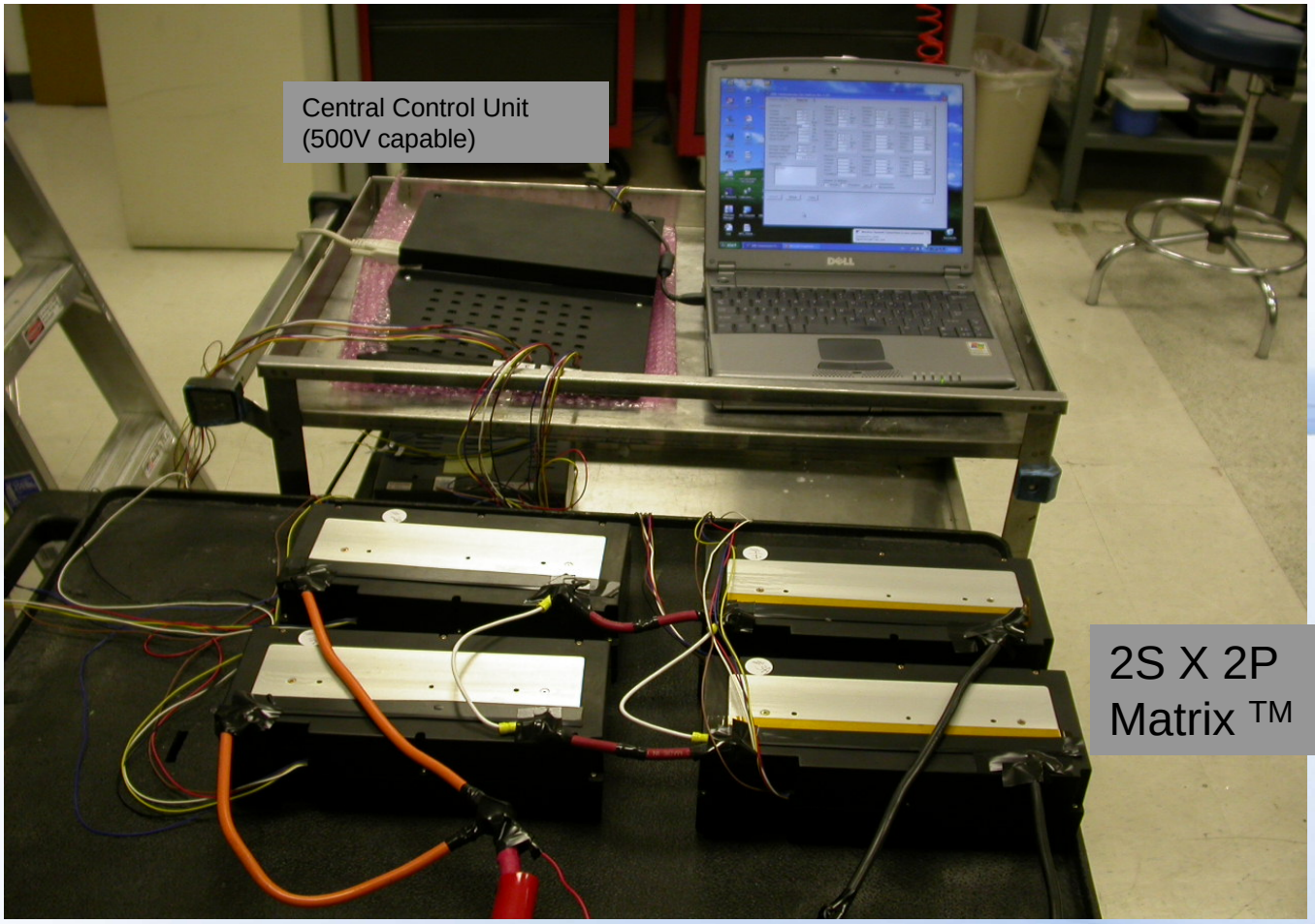
Modular Design for Flexible Performance, Flexible Shape and Inexpensive Cost



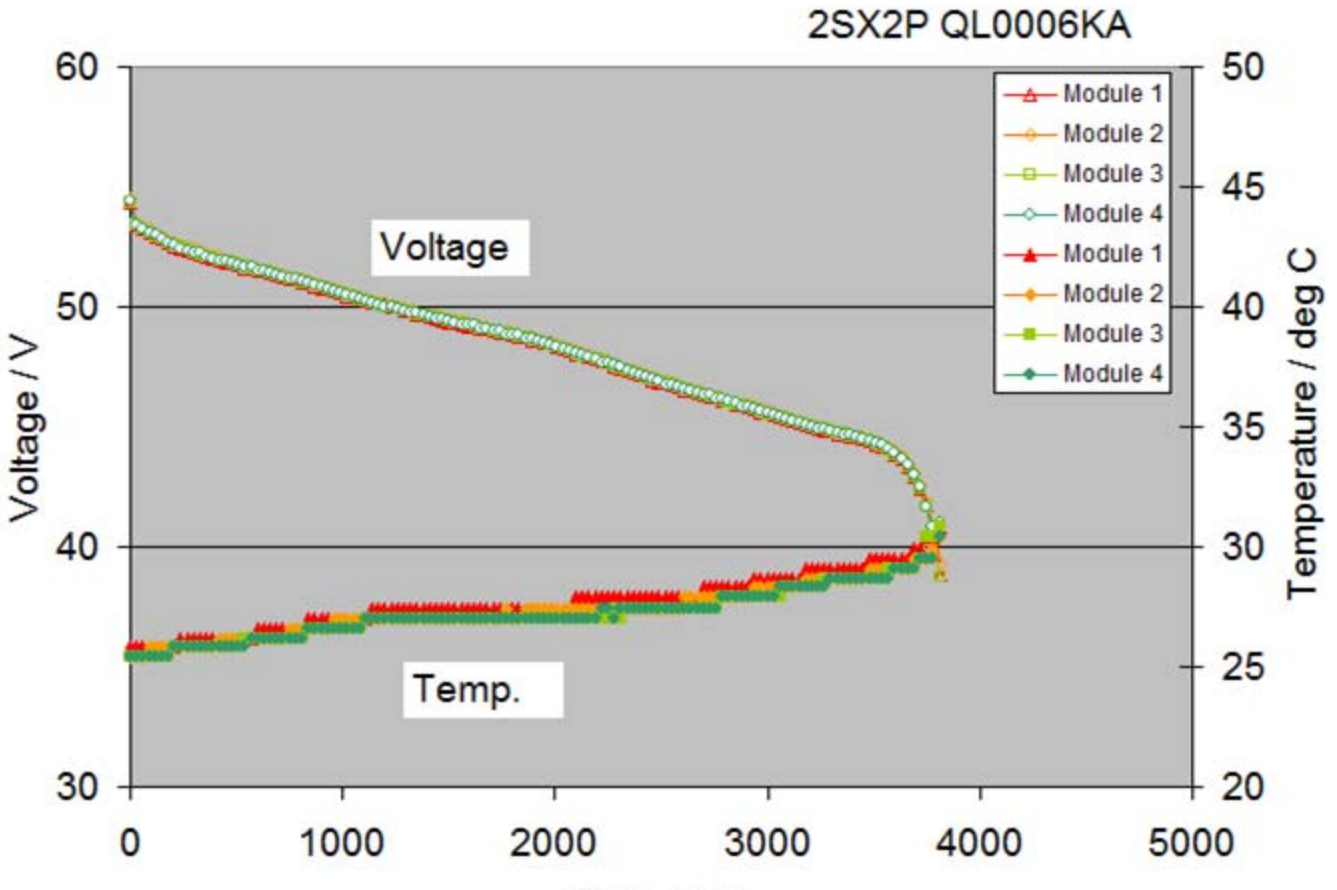
Powering Life.

96V -1.83Kwh Matrix™ System



Powering Life.

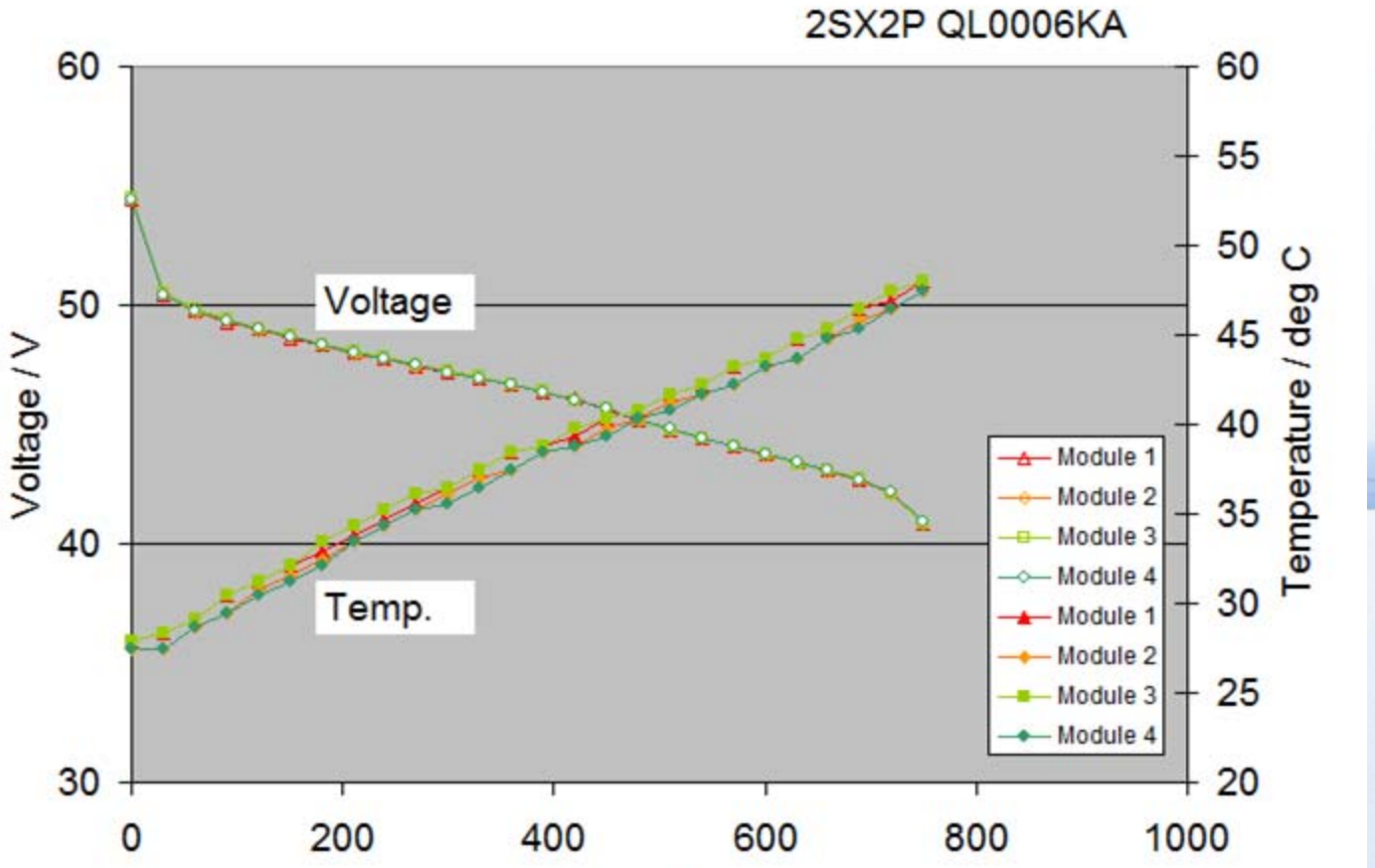
1C Discharge Curves



Charge : 1C 109.2V CCCV C/20CA cutoff at R.T.
Discharge : 1C to 78V at R.T.

Powering Life.

5C Discharge Curves

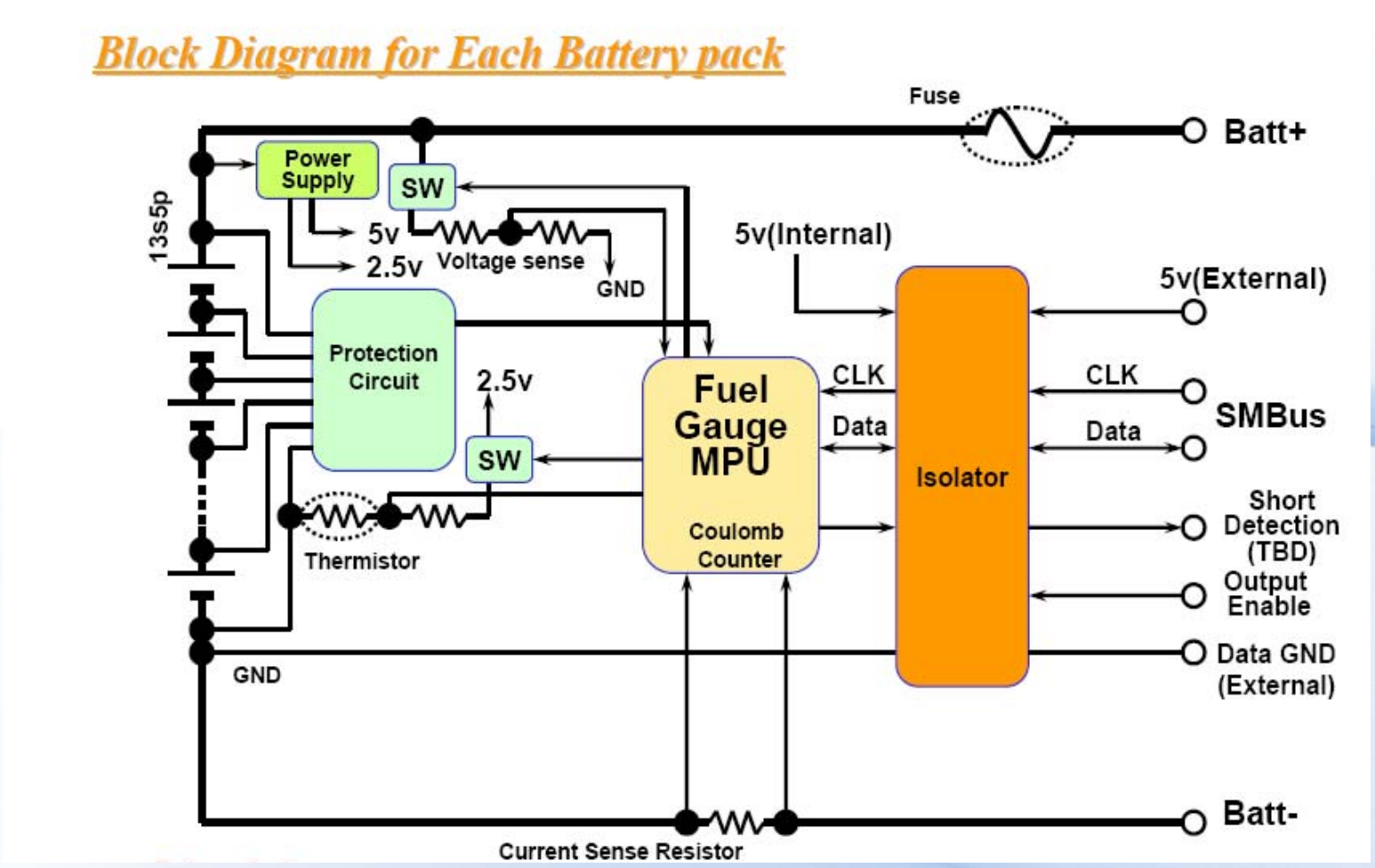


Charge : 1C 109.2V CCCV C/20CA cutoff at R.T.
Discharge : 5C to 78V at R.T.

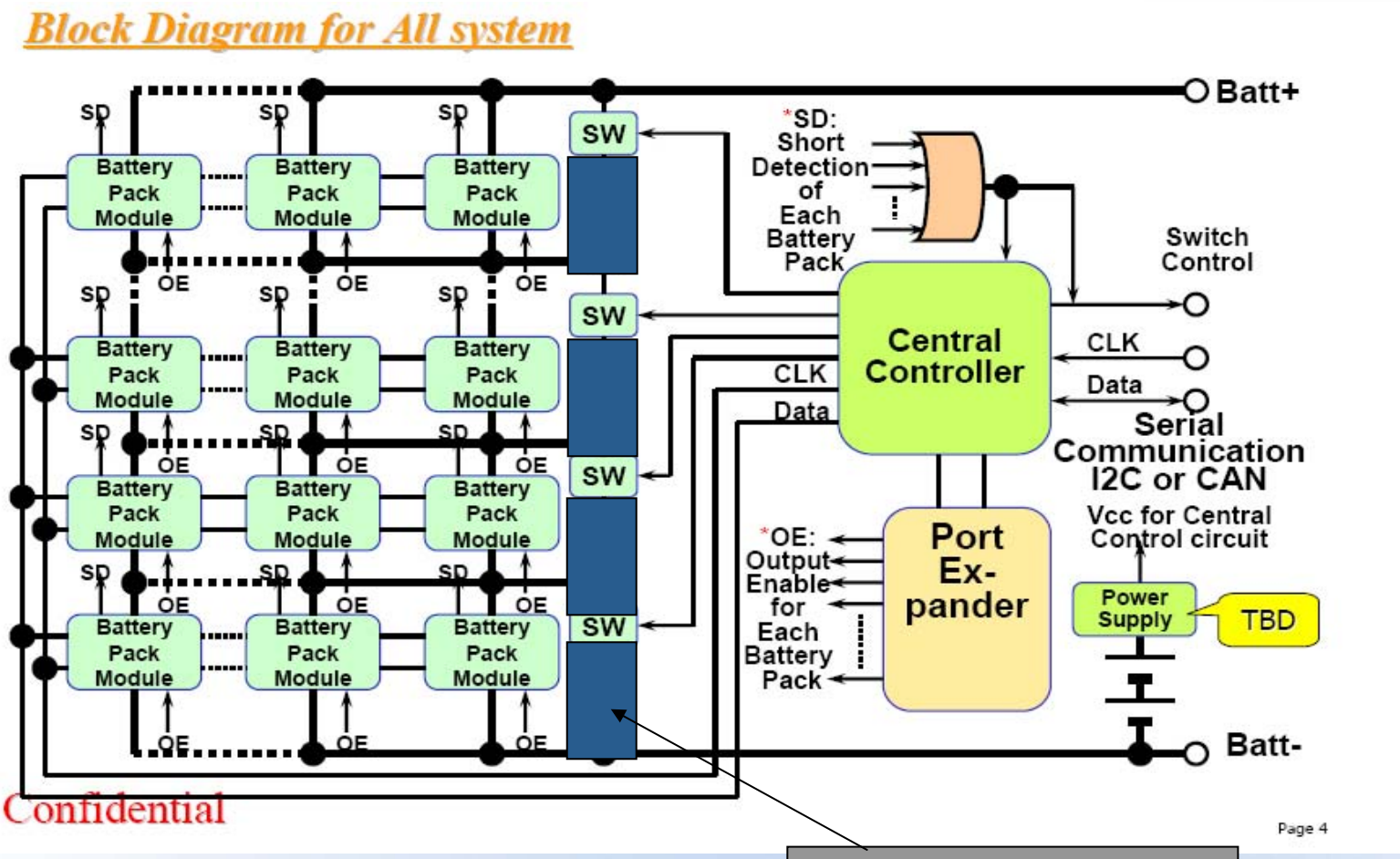
Very small temperature deviation in the packs

Powering Life.

BMU in the Matrix™ Module



Matrix™ Battery System with Matrix™ Module



Balancing Circuit

Powering Life.

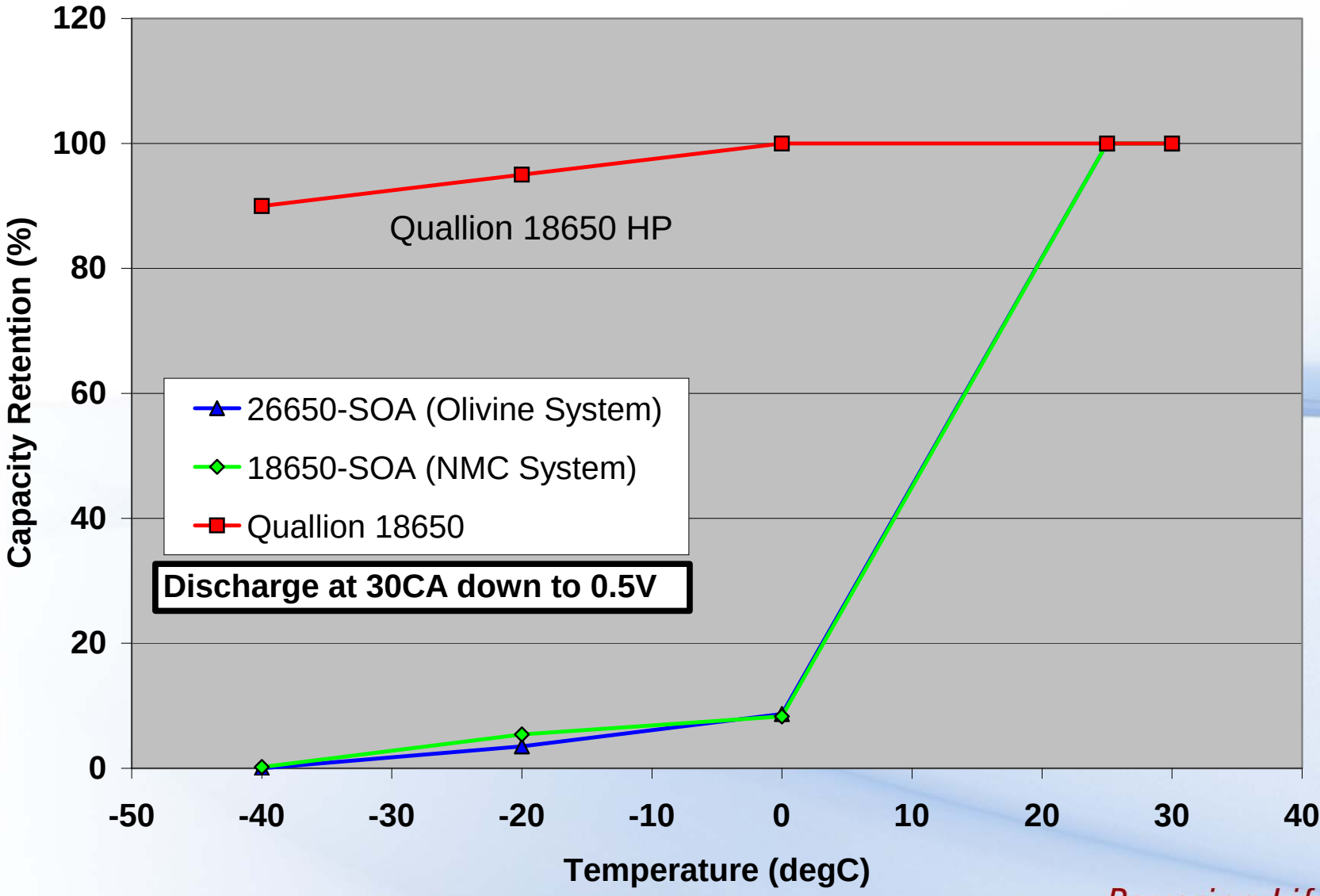
Quallion Unique High Power and Low Temperature Capability: 18650 HP

At -40°C, 30C rate discharge capable

- Electrical Characteristics
  - Nominal Capacity = 900 mAh
  - Operating Range = -40°C to +71°C
  - Chemistry = NCA/MCMB
- Physical Characteristics
  - Diameter = 18.1 mm
  - Height = 65.4 mm
  - Volume = 66.7 cc
  - Weight = 39 g
- Heritage Materials
  - Active materials are the same as Quallion SATELLITE cells
  - USG T3 program enables Quallion to produce Cathode NCA and Anode MCMB in-house by 2012

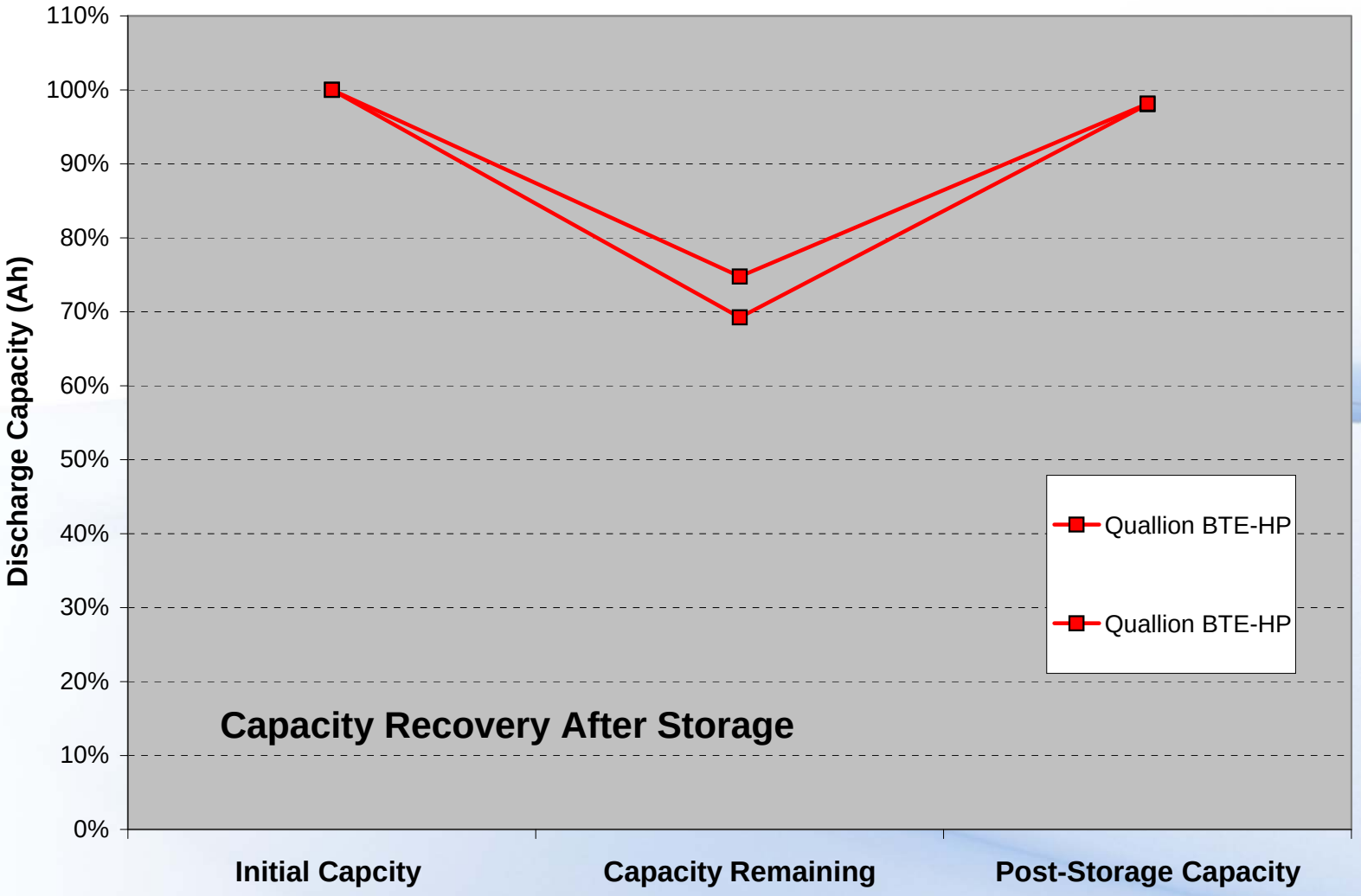
Powering Life.

30C Discharge Data Comparison



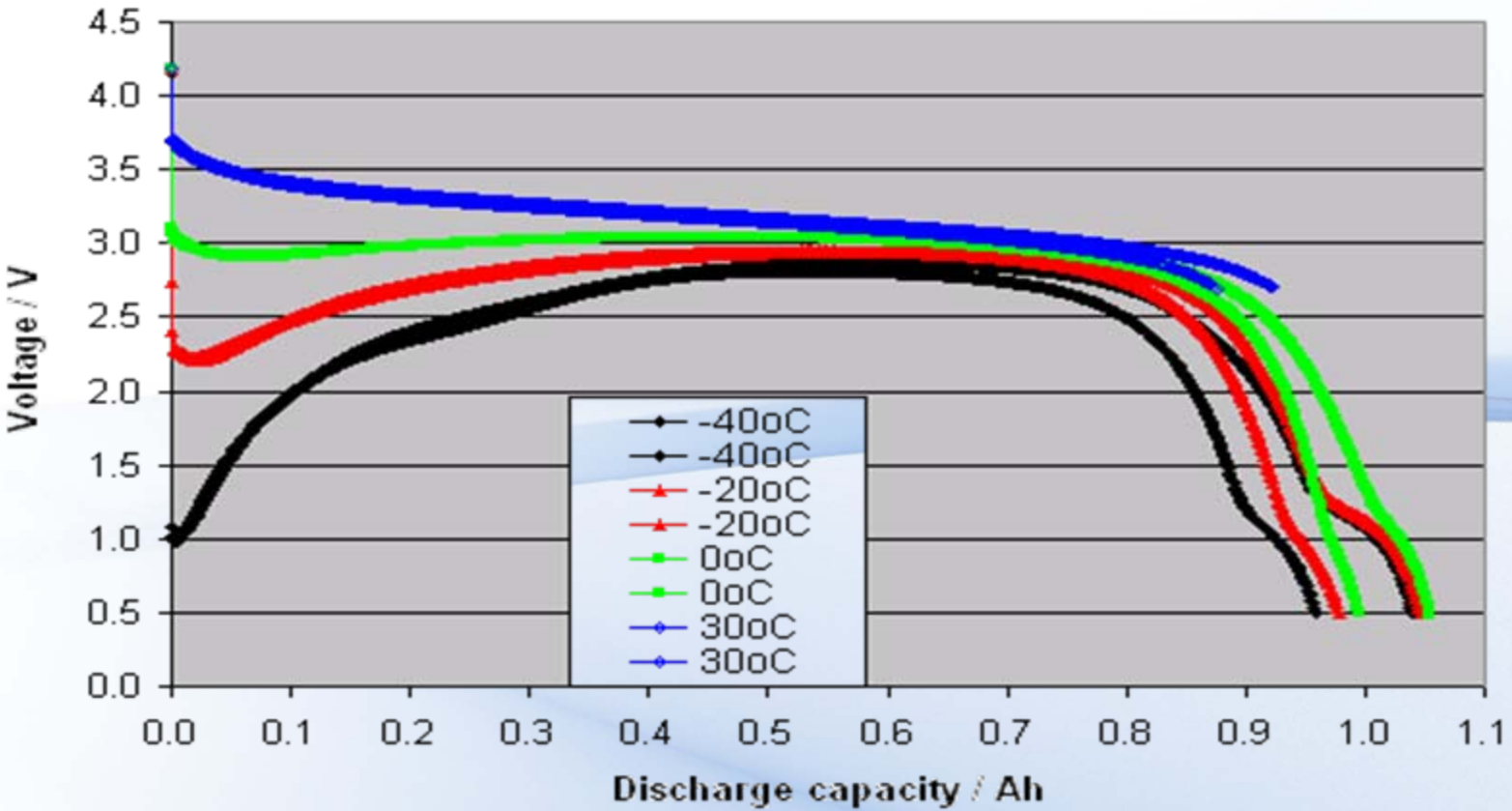
Powering Life.

Storage of Quallion HP Cell at +71°C/2 Weeks



Powering Life.

Discharge Temperature data of Quallion HP Cell at 30C Rate



Charge : 1C, 4.2V CCCV C/20 cutoff at RT
Discharge : 30 C to 0.5 V at Different temperature

Powering Life.

Matrix™ Technology: Modular Design for Flexible Performance, Flexible Shape and Inexpensive Cost

Automated Cylindrical Cell Production Line

Automated Module Production Line

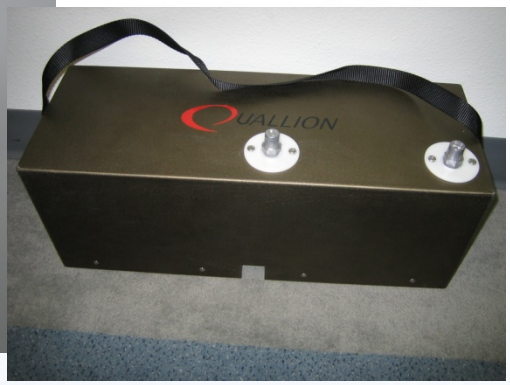
Battery Fabrication Facility with Test Equipment

Cost Competitive Battery Solution

COTS cell (non-domestic, most inexpensive)

Powering Life.

QUALLION



Quallion: US Domestic Battery Company with Unique Material, Cell and Battery Capability

Powering Life.