



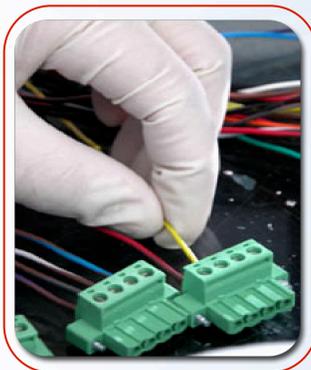
QUALLION



Li-Ion Battery with Wide (-42°C to $+71^{\circ}\text{C}$) Operational Temperature Range

Michael Tomcsi, Mikito Nagata, and Hisashi Tsukamoto

Powering Life.

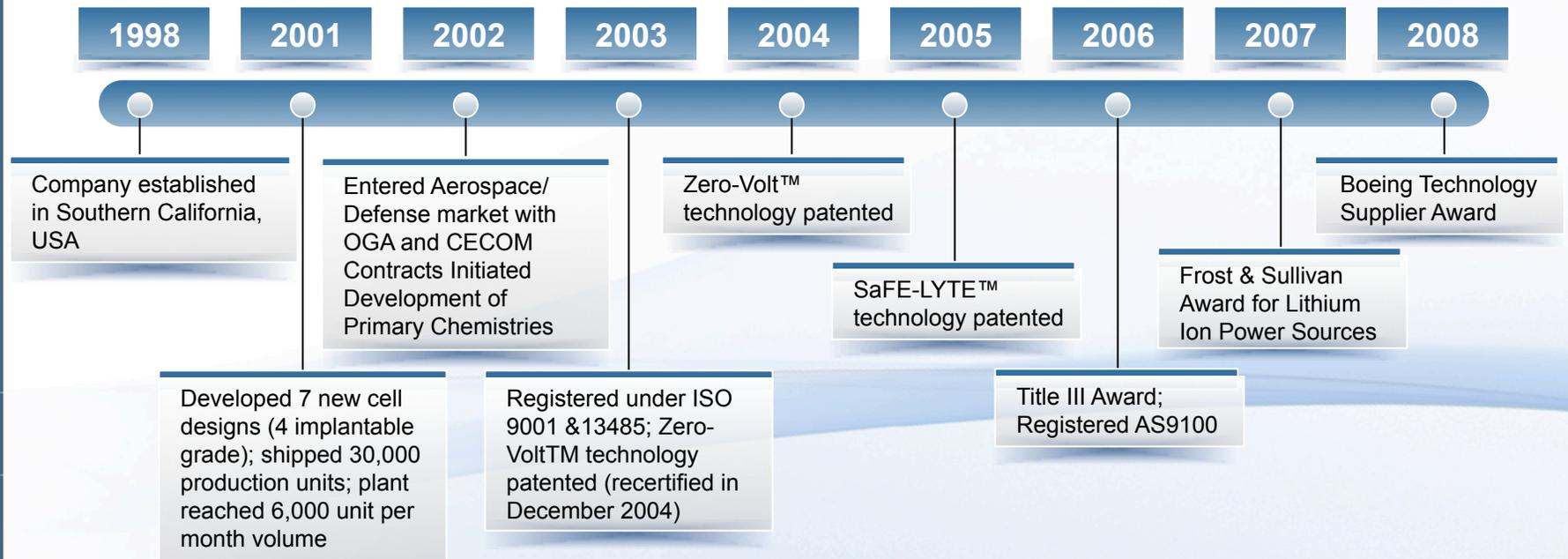


Key Business Metrics:

- Diversified across medical, military, vehicle and aerospace markets, 104 employees. More than 60,000 cells produced annually
- Quallion is fiscally sound with cash reserves and profitable. Quallion is not reliant on the external credit markets for expanding production
- Unique knowledge of Li ion chemistry as technology is rooted in Material science
- Active large Li ion battery programs include: USG Title III, Aircraft Retrofit, NASA Orion program (new space shuttle), Blackhawk Helicopter Retrofit, APUs for HMMWV, UAVs, Launcher Vehicle Batteries, Satellite Systems, USAF X-51 Scramjet
- In-house battery electronics design capability
- 5year/\$40M United States Military contract to establish 30 year supply of materials and cells for satellite and military applications
- Strong Li ion battery IP Position with over 60 chemistry, cell and battery patents issued and numerous patents pending
- Operations contained within 52,000 sq ft production facility in Los Angeles, CA, with an option to expand to 200,000 sq ft of contiguous manufacturing space
- Certifications include ISO 9001:2000, AS9100B, and ISO 13485:2003

Powering Life.

Company Milestones



Powering Life.

Batteries Are Critical Priority for the US Military

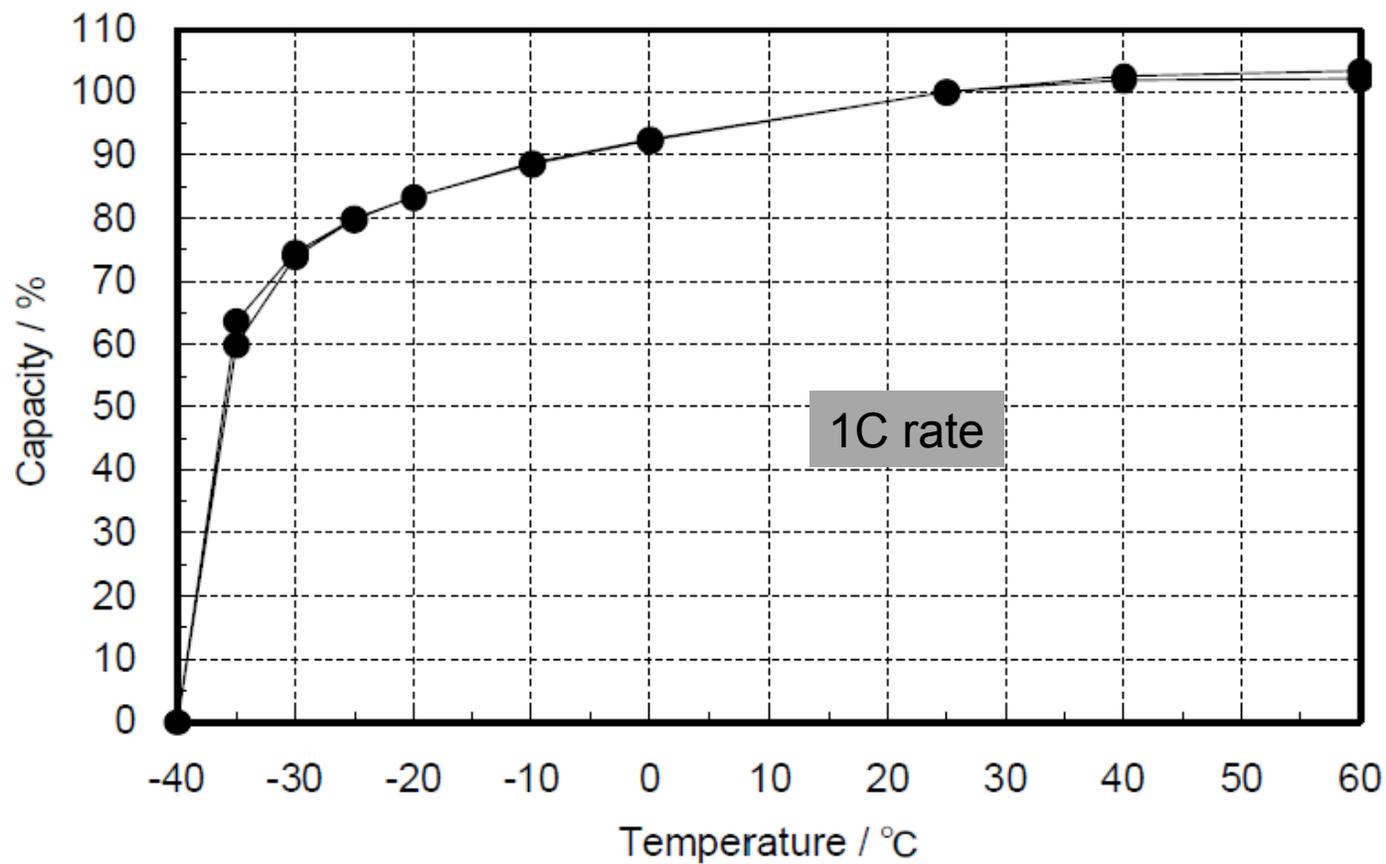
- “The three overarching needs (of the US military) are in **advanced power sources**, command control computer and intelligence and ‘signature management.’”*

*Source. Chandler, Richard, Head of Directorate Advanced Technologies in Special Ops. Magnuson, Stew. “Special Ops Technologist Have Unique Wish List.” Editorial. *National Defense*, April 2008, page 27.

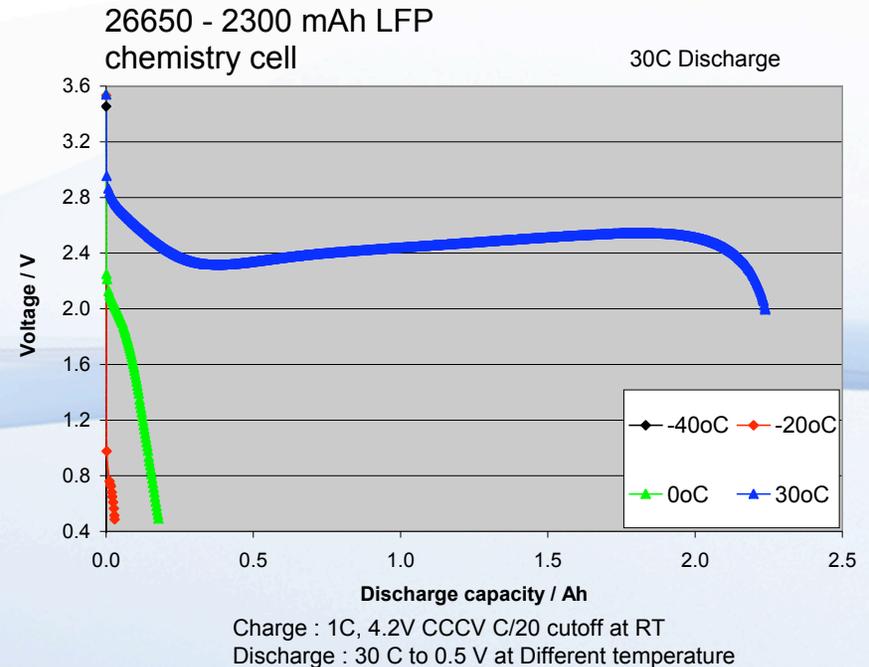
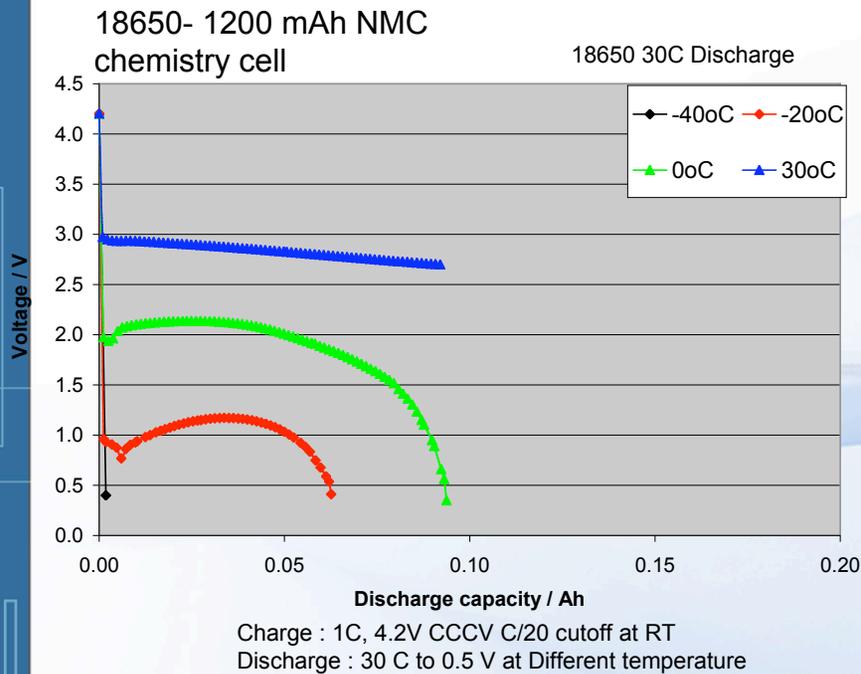


Powering Life.

COTS cell solution is an inexpensive solution, but it has limitation-
“Low Temperature Capability”.



30C rate discharge curves at various temperature



- Almost no capacity was delivered below -20 °C

Quallion 18650 HP

At -40°C, 30C rate discharge capable

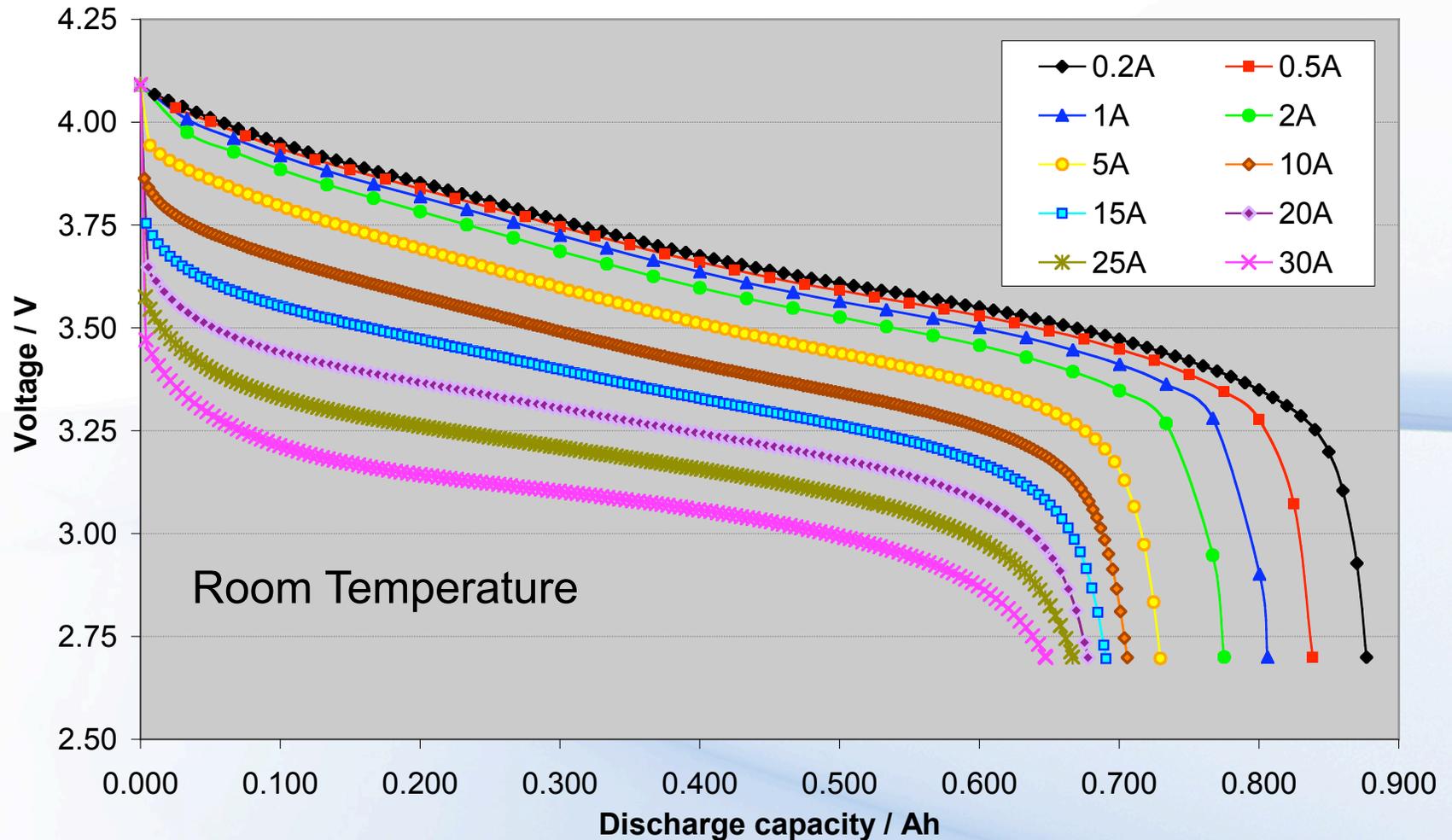


- Electrical Characteristics
 - Nominal Capacity = 900 mAh
 - Operating Range = -40°C to +71°C
 - Chemistry = NCA/MCMB
- Physical Characteristics
 - Diameter = 18.1 mm
 - Height = 65.4 mm
 - Volume = 66.7 cc
 - Weight = 39 g
- Heritage Materials
 - Active materials are the same as Quallion SATELLITE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

Powering Life.

Discharge Rate Data of Quallion HP Cell

Discharge of Q18650 HP

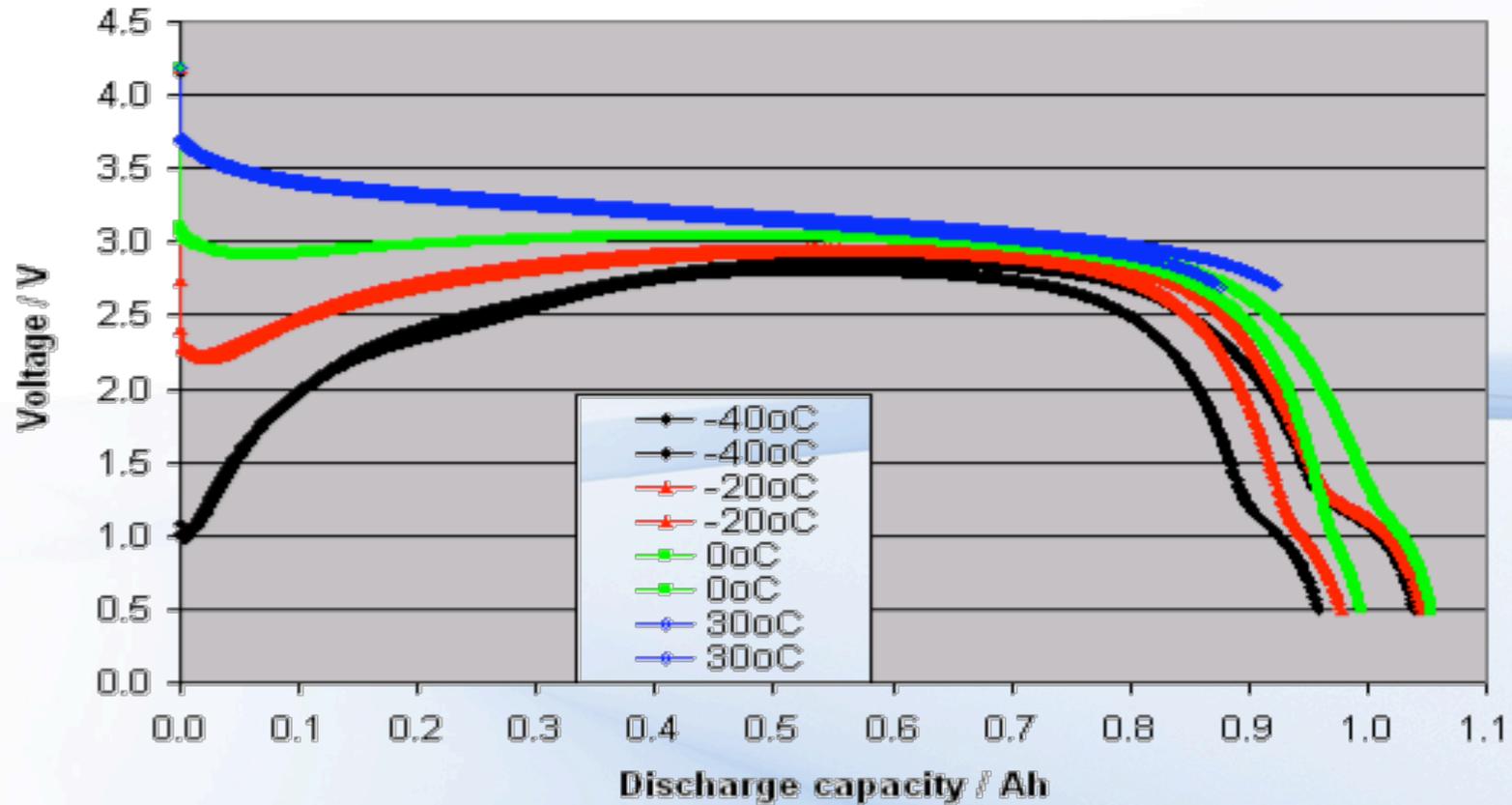


Charge : 1.0A, 4.1V CCCV C/20 mA cutoff at RT

Discharge : 0.2, 0.5, 1, 2, 5, 10, 15, 20, 25, 30A to 2.7 V at RT

Powering Life.

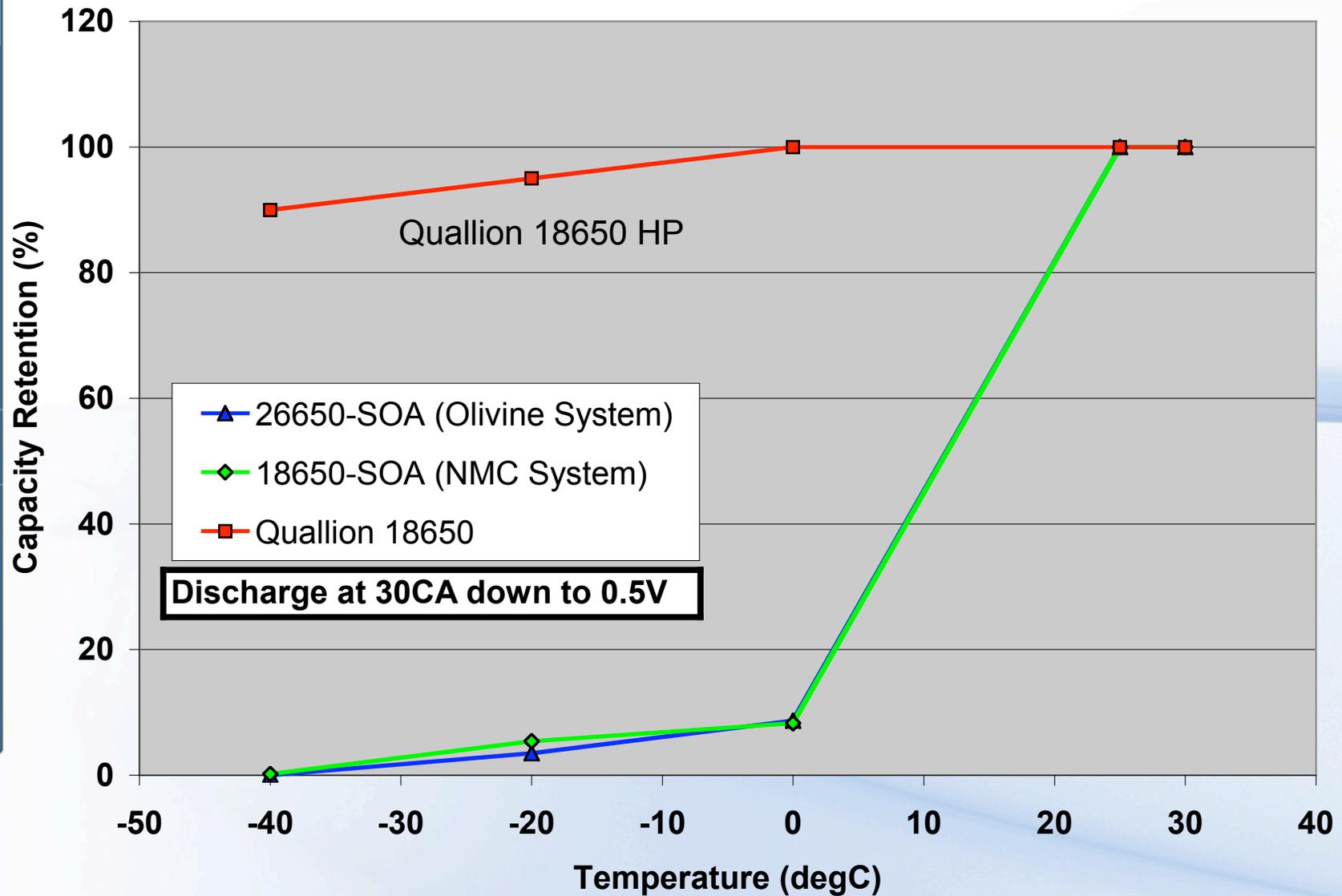
Discharge Temperature data of Quallion HP Cell at 30C Rate



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

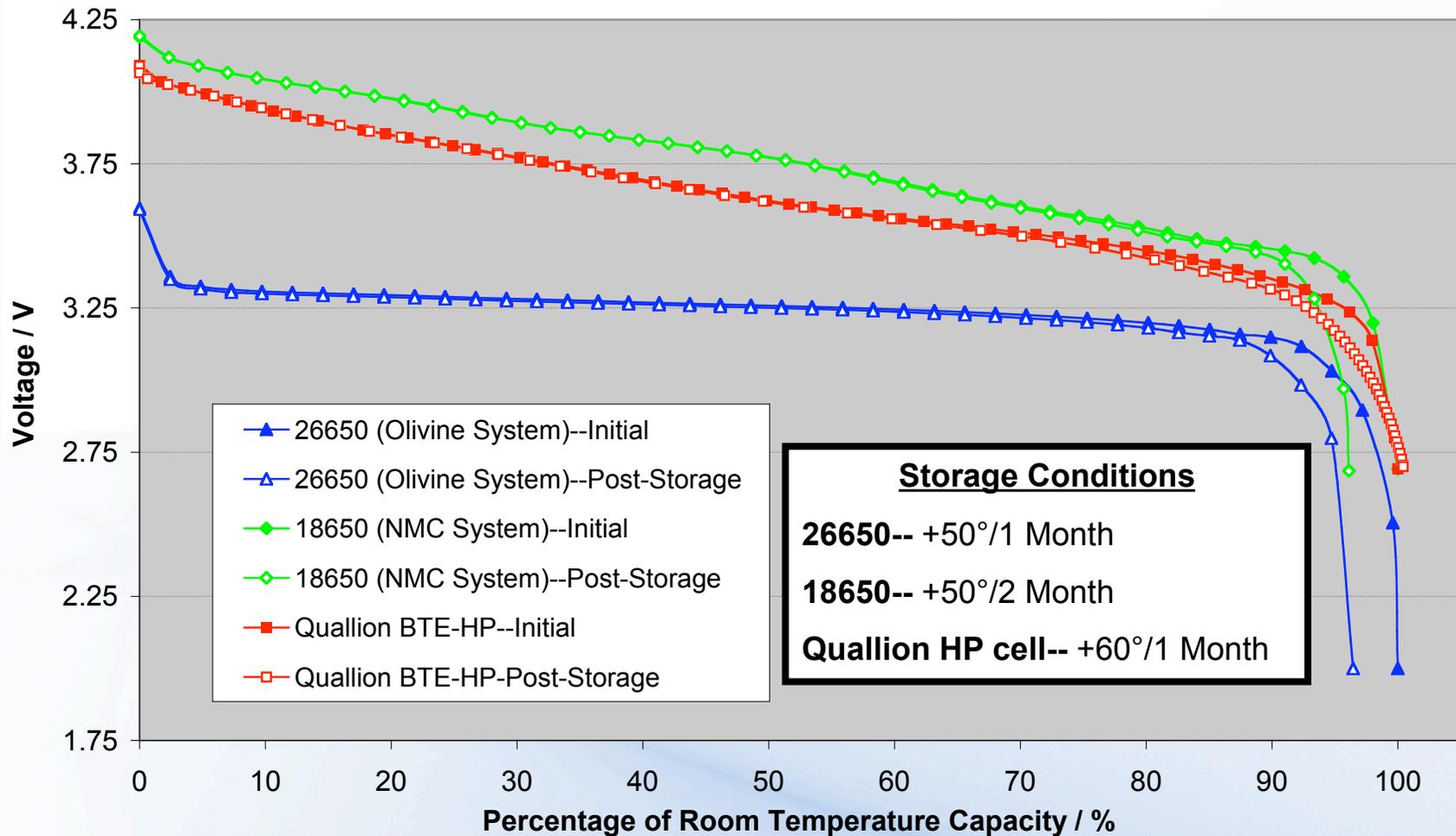
Powering Life.

30C Discharge Data Comparison



Powering Life.

Post-Storage Capacity Check



18650 & 26650

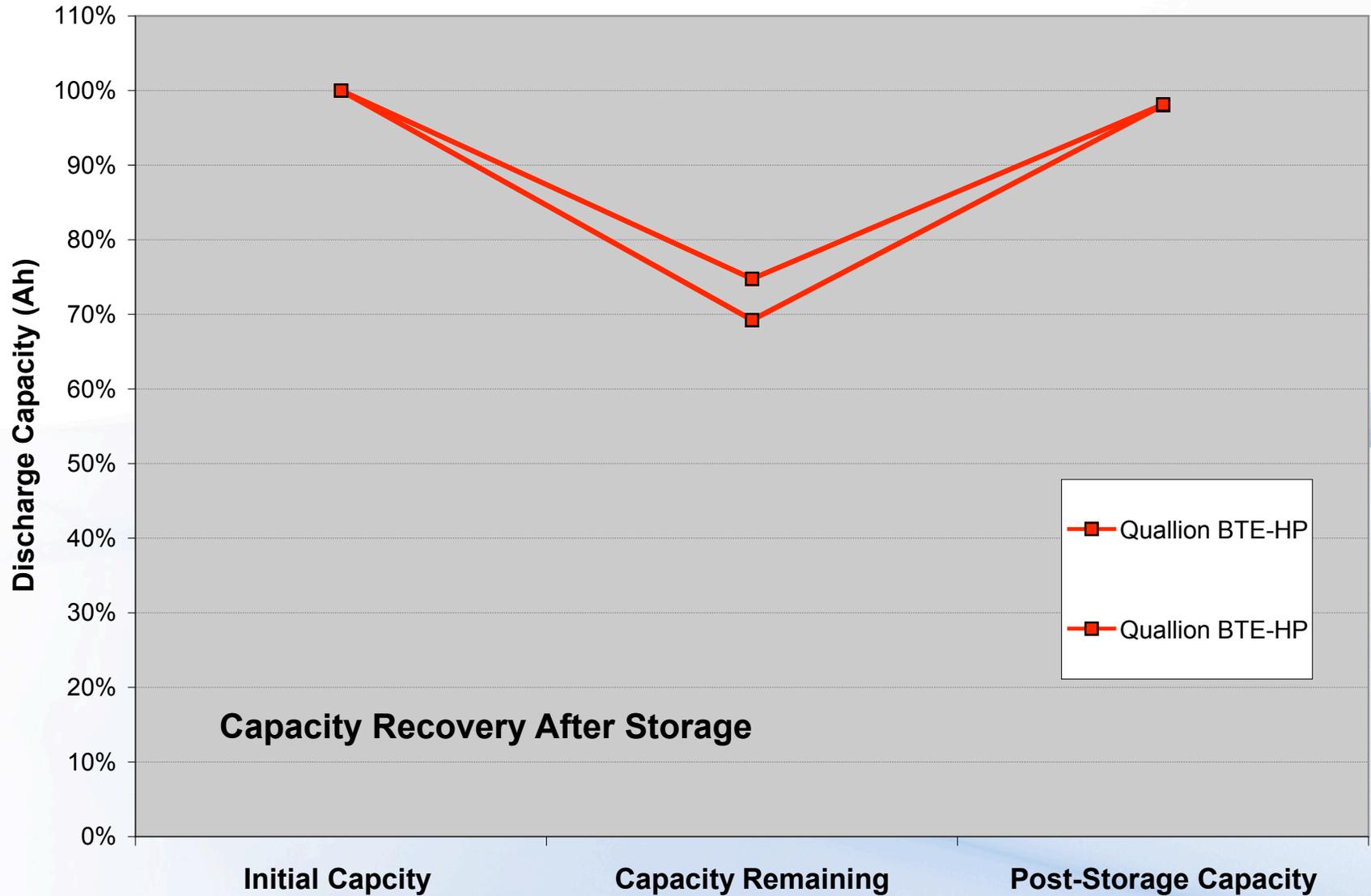
Charge : 0.5 CmA, 100% SOC CCCV C/20 mA cutoff at RT
 Discharge : 0.5 CmA to 100% DOD at RT

Quallion BTE-HP

Charge : 1.0 CmA, 100% SOC CCCV C/20 mA cutoff at RT
 Discharge : 1.0 CmA to 100% DOD at RT

Powering Life.

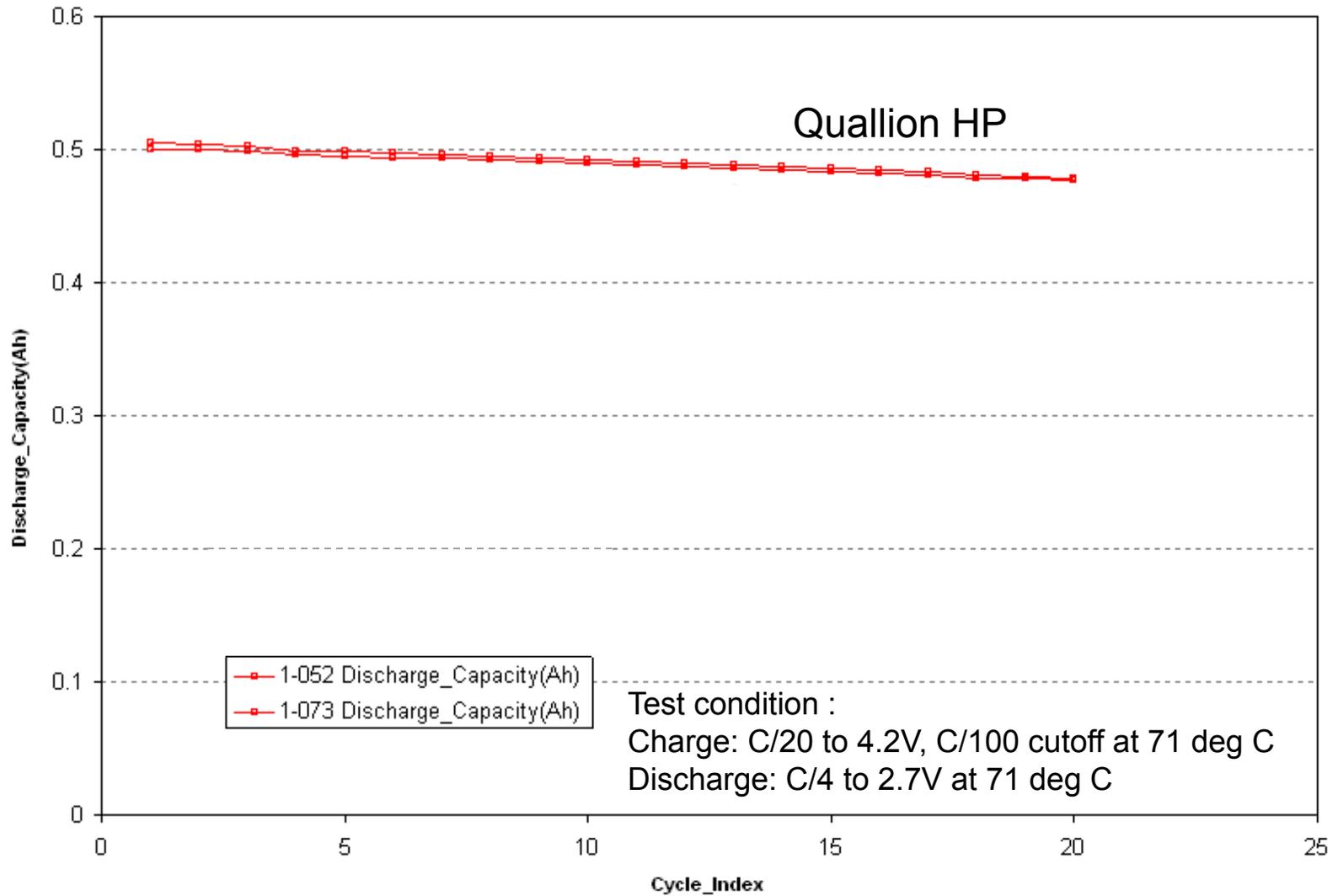
Storage of Quallion HP Cell at +71°C/2 Weeks



Capacity Recovery After Storage

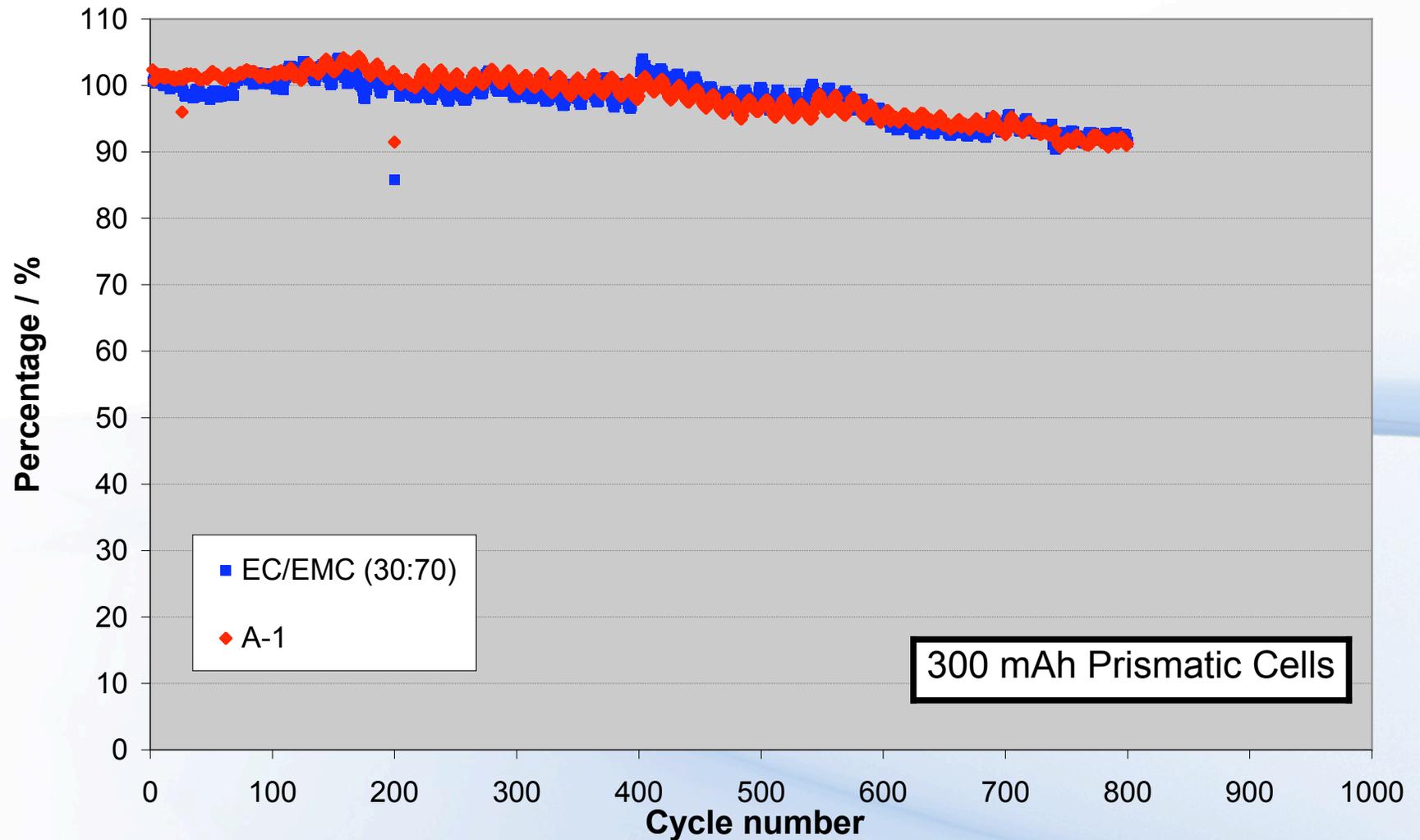
Powering Life.

Cycle Life of Quallion HP Cell at +71°C



Powering Life.

5C Discharge Rate Cycling at Room Temperature

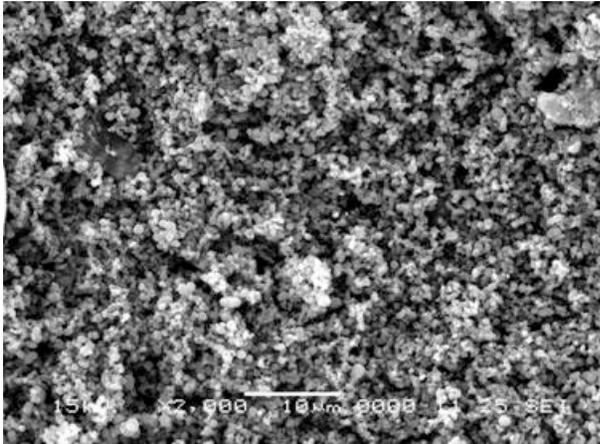


Charge : 1.0 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 5.0 CmA to 2.7 V at RT

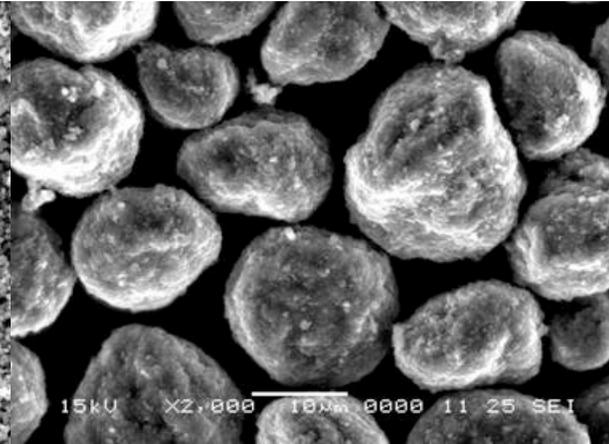
Powering Life.



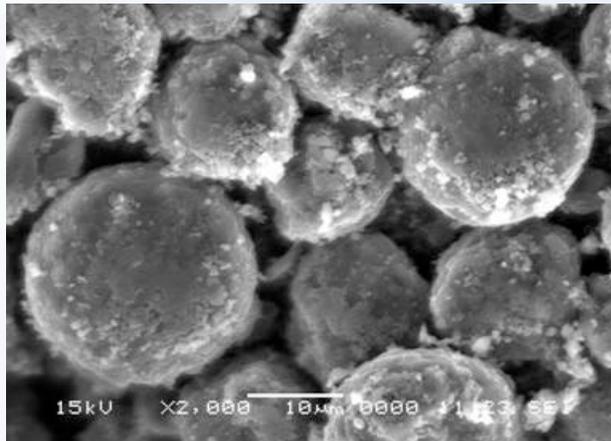
Further Enhancement Possible by using Quallion Original nano-MCMB



Run23-16 Q-nano-MCMB



Typical Q-MCMB



Osaka Gas (Lot#6162-S70614)

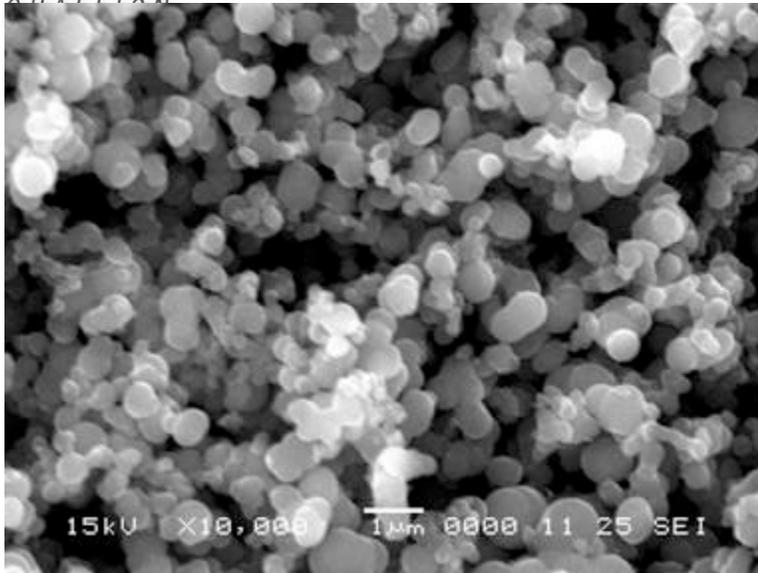
SEM x2000 Magnification

Quallion is installing cathode precursor, cathode and anode material production capability to support Aerospace community needs

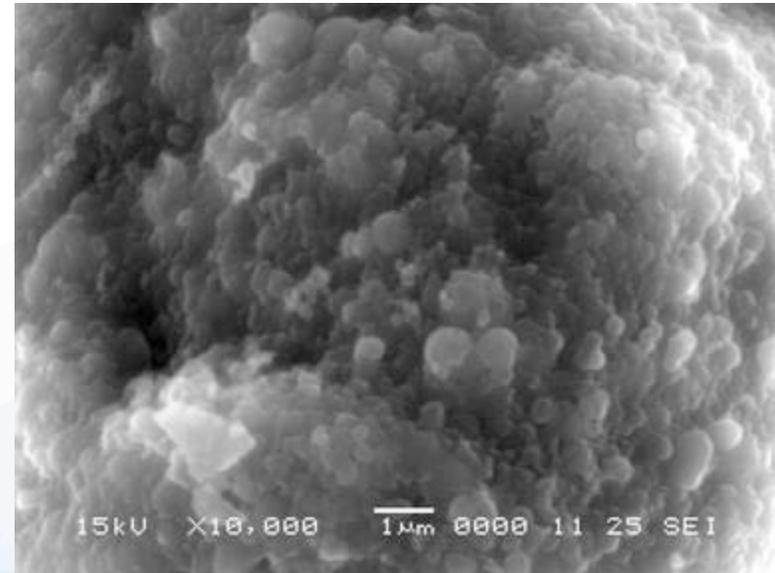
Powering Life.



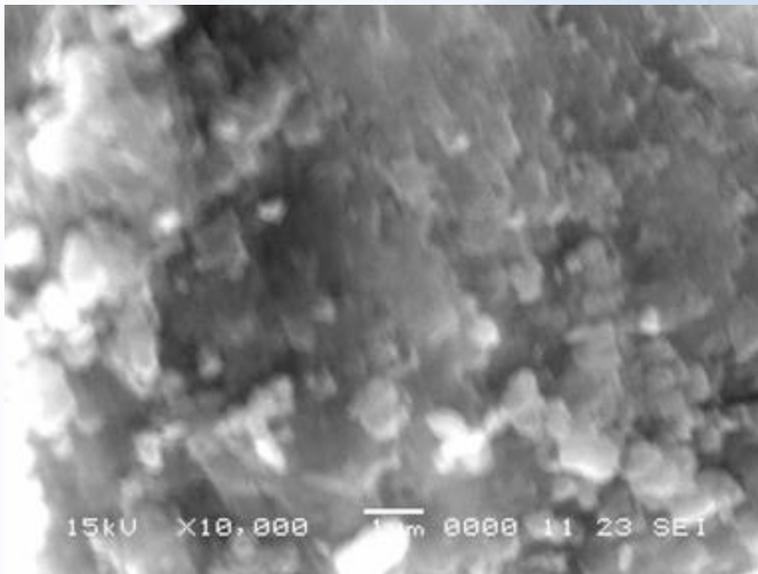
SEM x10000 Magnification



Nano-Size (Run23-16)



Typical Quallion MCMB



Osaka Gas (Lot#6162-S70614)

Powering Life.

Application for Quallion Wide Temperature Chemistry

- Soldier-Worn Power
- Portable Power
- Vehicle APUs and Start-Up Power (Silent watch)
- Aircraft
- Helicopters
- UUVs
- UAVs



Powering Life.



Quallion Wide Temperature Primary Battery with 966 Wh/L Capability

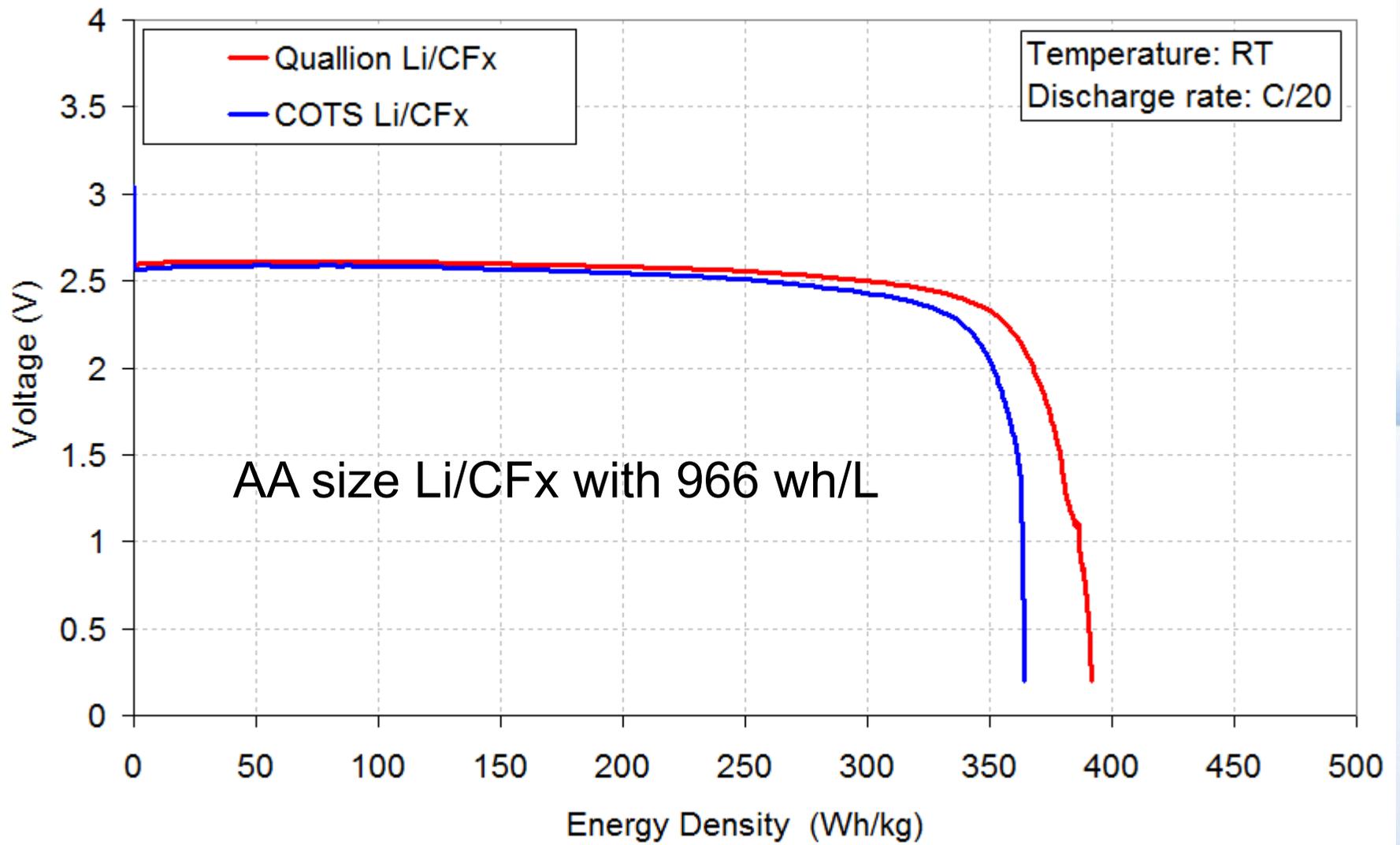
Cell type	Li/CFx AA
Nominal Voltage	3V
Nominal Capacity	2.5Ah
Standard Discharge Current	2.5mA
Weight	16g
Electrolyte	Quallion Low Temperature electrolyte

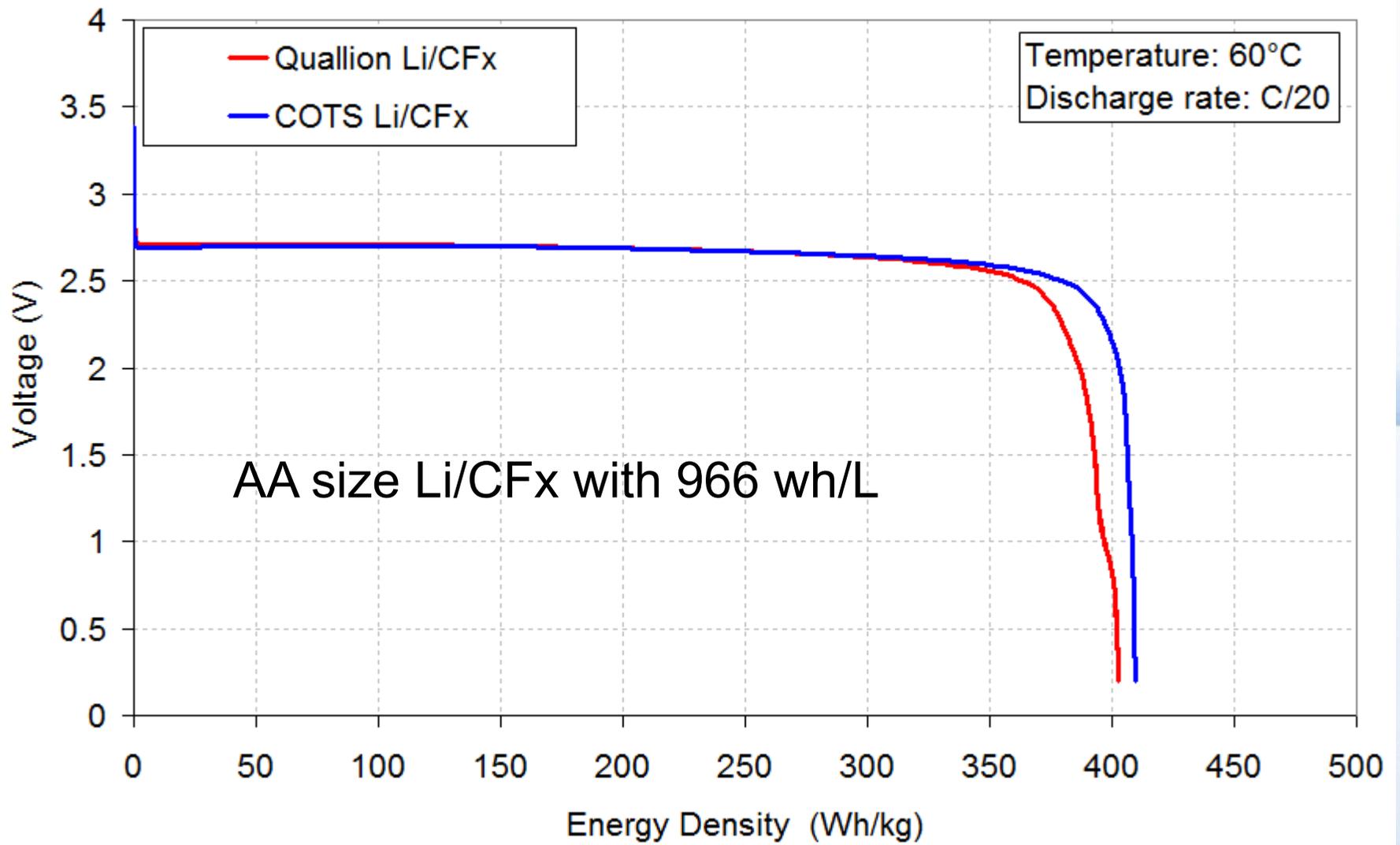
NOTE: D (D34.2 xH61.5mm) size Li/CFx cell with 15Ah has **798 wh/L** energy density. The 2.5Ah AA (D14x H50.5mm) size Li/CFx has 20% larger energy density than 15Ah D size Li/CFx.

Powering Life.

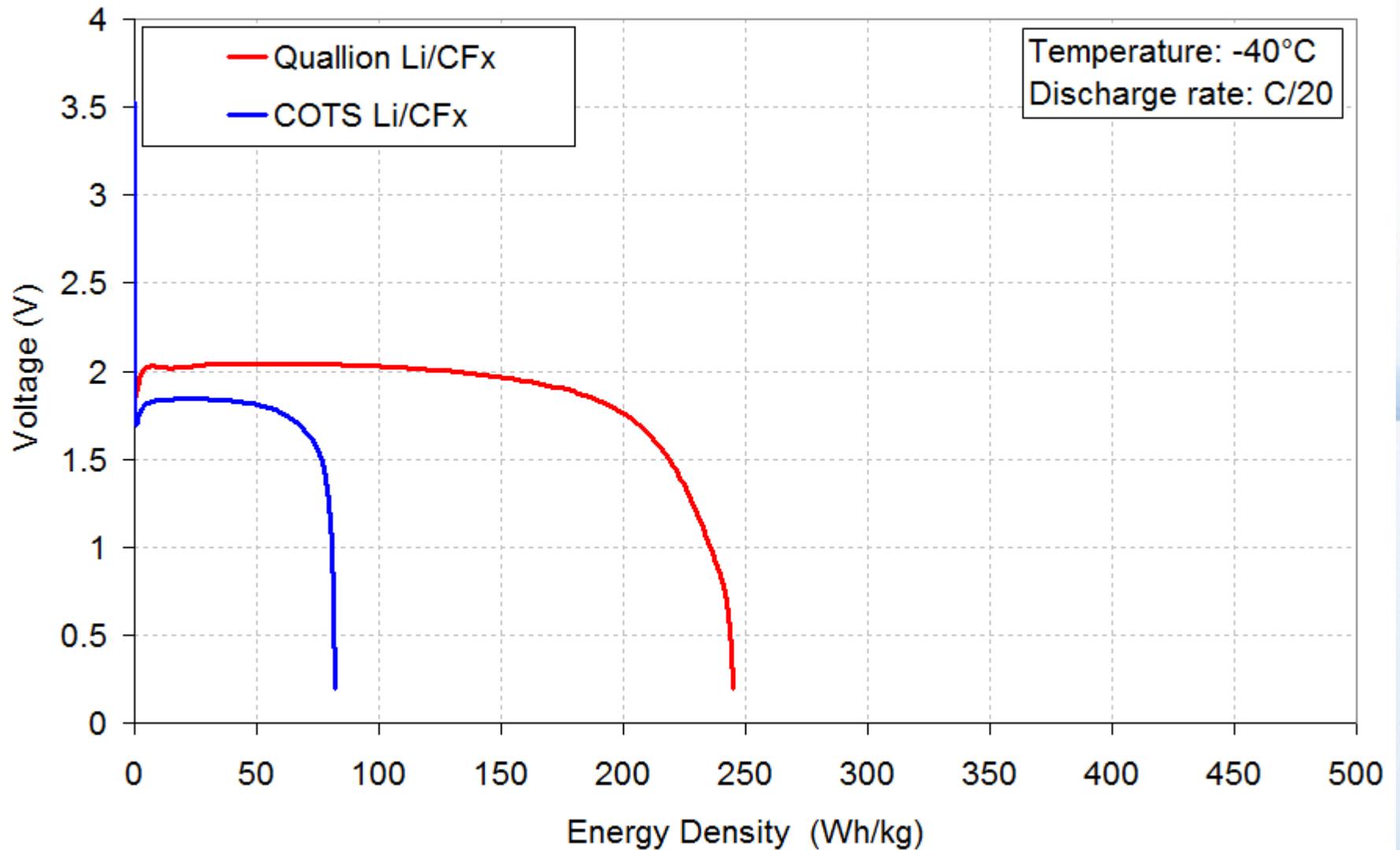
Quallion LLC Confidential

SBIR Data Rights Reserved—Agreement No. N081-098-1328

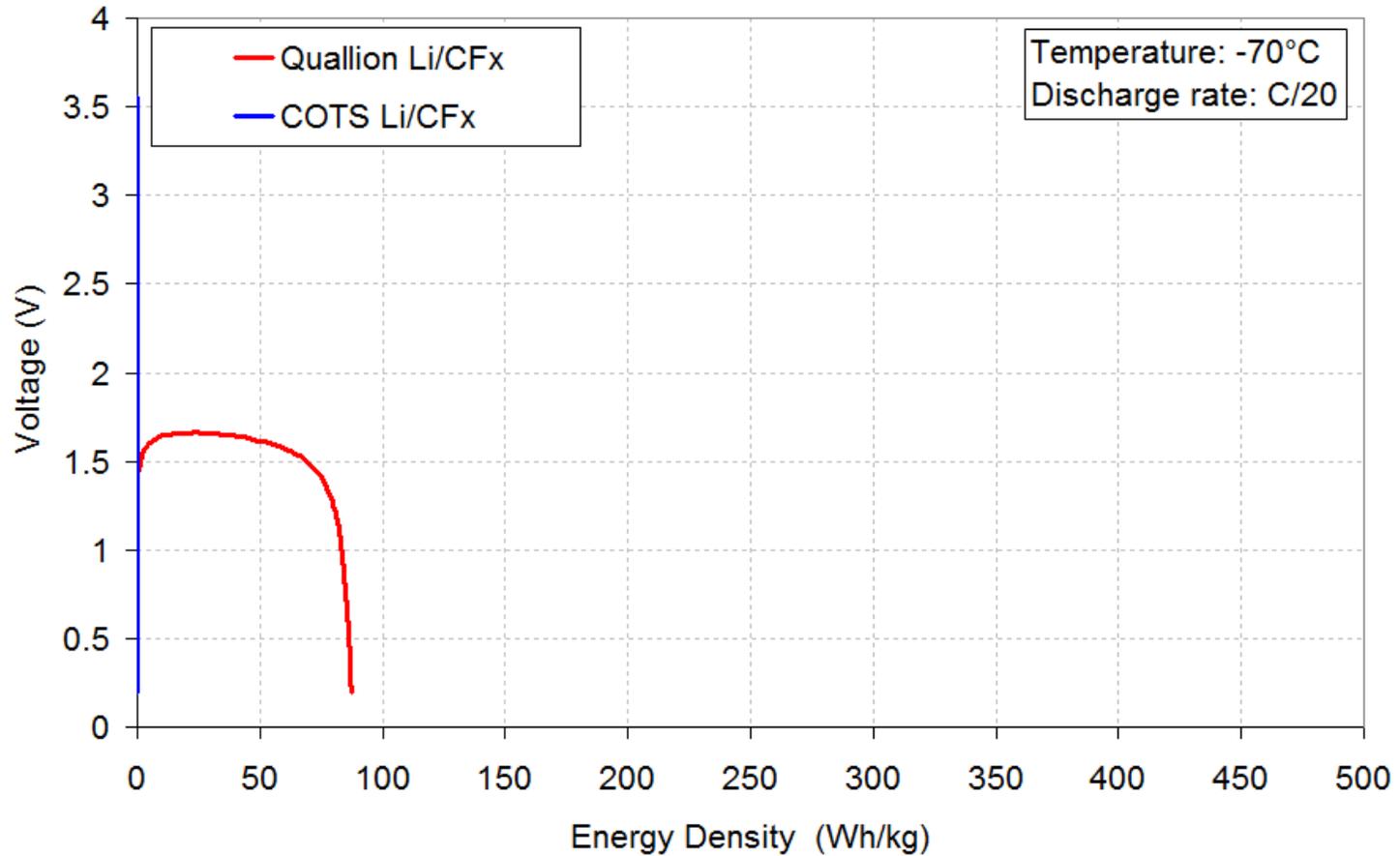




Comparison of -40C capability



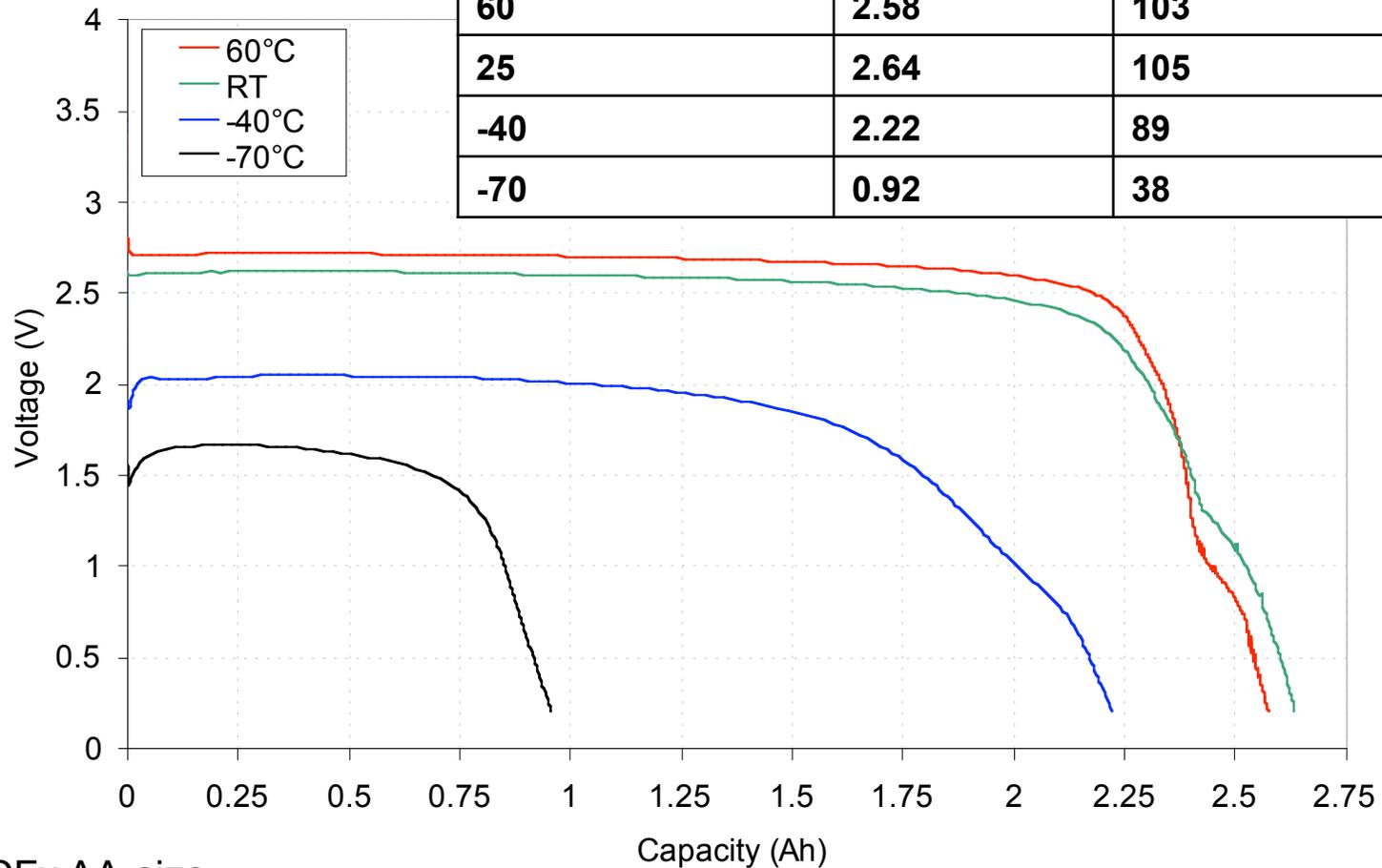
Comparison of -70C capability





Quallion Primary Battery : C/20 discharge

Temperature (°C)	Capacity (Ah)	Capacity (% of 2.5Ah)
60	2.58	103
25	2.64	105
-40	2.22	89
-70	0.92	38



Li/CFx AA-size
966 wh/L Primary battery Technology

Quallion LLC Confidential

SBIR Data Rights Reserved—Agreement No. N081-098-1328

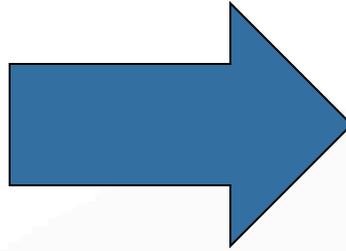
Powering Life.

One of applications for wide temperature technology SINGARS to JTRS Radio Transition

LEGACY SYSTEMS



- SINGARS (over 250,000 units produced)
- ASIP
- Falcon
- MBITR
- ATCS



JTRS Program: Produce a family of interoperable, affordable software defined radios to provide, secure, wireless, networking capabilities for Joint services.



- HMS (Handheld & Manpack Systems)
- GMR (Ground Mobile Radios)
- AMF (Airborne Maritime)

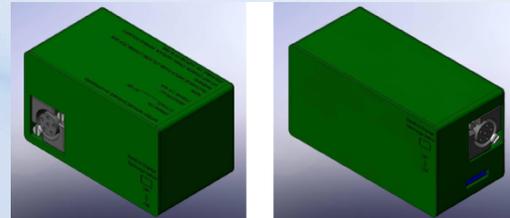
Li/SO₂ BA-5590

95% market saturation against primary and rechargeable solutions



Quallion Battery Solution

Reduced envelope, lighter weight with same mission profile
Quallion Li/CFx Half-5590



Powering Life.



Powering Life.