



**QUALLION**



**Quallion LLC Title III Project:  
Creating A Secure Domestic Source of Materials  
and Cells for USG Space Applications**

NASA BATTERY WORKSHOP  
November 2011

*Powering Life.*

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Power Group  
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- Employing a core strategy of leveraging R&D, niche focus, complementary and synergistic market entries
- One of the largest manufacturers of Lithium ion cells in the United States fortifies barrier to entry hampering potential competitors from entering the space
- Best-of-breed system level approach for advanced battery technologies that involves a core expertise beginning from material selection to cell design and final battery pack configuration

## ❖ IP Portfolio

- Zero-Volt™
- Matrix Battery™
- FLEX-Power™
- SaFE-LYTE™

## ❖ Products

- Materials
- Cells
  - Primary
  - Secondary
  - Polymer
- Batteries

## ❖ End Markets

- Defense
- Energy
- Transportation
- Medical

Headquarters  
Los Angeles, CA

Founded  
1998

Employees  
176

US Congressional Districts  
Buck McKeon (R)  
Howard Berman (D)  
Brad Sherman (D)

CA State Reps  
Senator Alex Padilla  
Assemblyman Felipe Fuentes



### Hisashi Tsukamoto

*CEO & CTO*

Served as the senior technology officer for Japan Storage Battery, over 20 years experience in the field of Lithium ion batteries.

### Paul Beach

*President, Business & Legal*

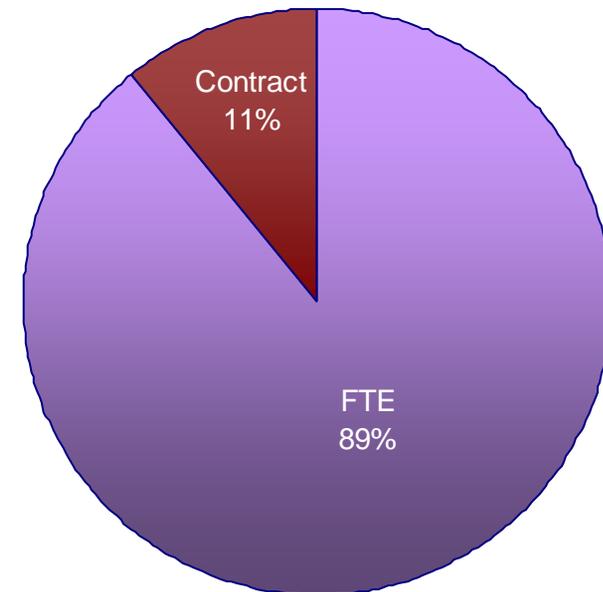
Key member of several start-ups and represented several large technology companies as an IP attorney.

### Robert Licha

*President, Operations & Finance*

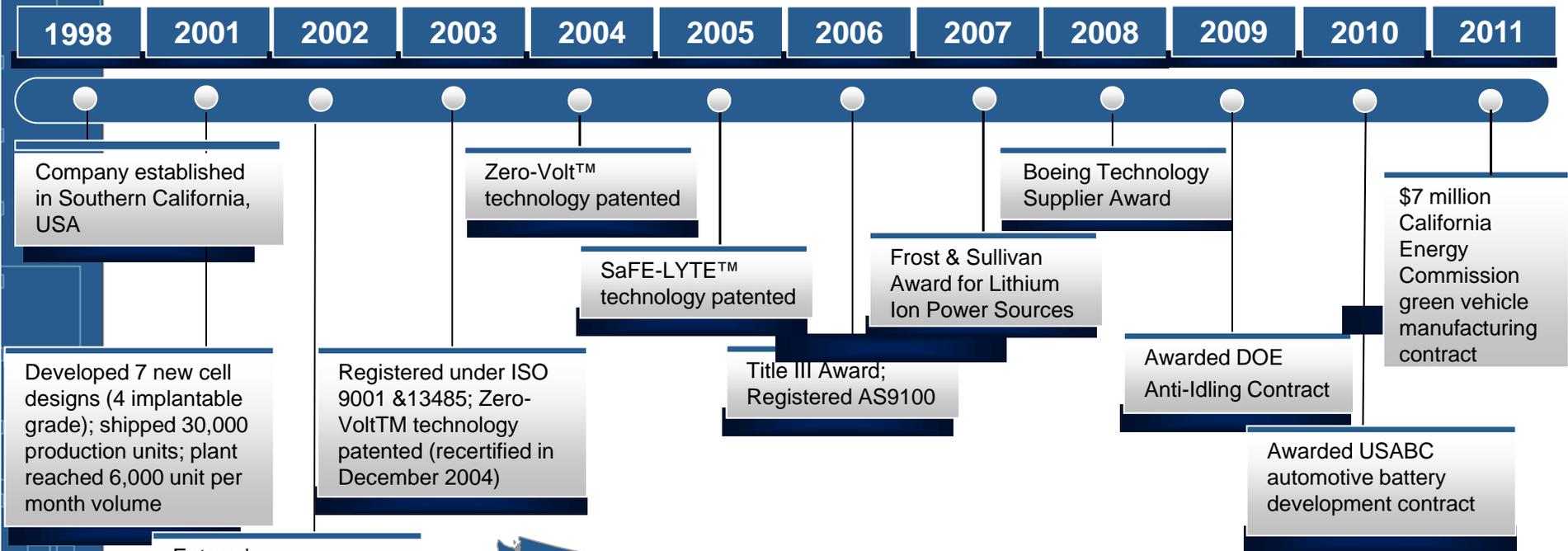
Extensive operations and finance experience in both public and private companies in the medical, telecommunication, electronics industries.

### Employee Breakdown

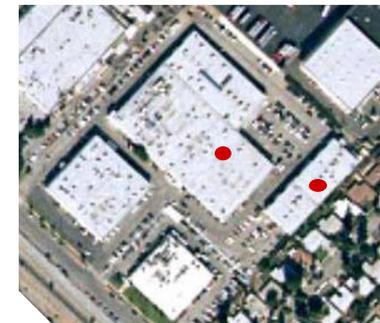


176  
Employees

# Company Milestones



Los Angeles County



## Configuration Control for Materials, Cells and Batteries



*(1) Cathode and Anode Materials Line: LCO, NCA and MCMB production (200kg/month)*



*(2) Coater: Precision-engineered to Quallion chemistry, roll to roll continuous coating.*



*(3) Die Cutters: Custom designed, fully automated dual lines with integrated inspection system (3,000 electrodes per day).*

*(4) Automated Stacker: High speed stacking, single button operation with separator bagging system and inline inspection.*



*(5) The Product: Up to 5,000 72Ah cells per year (single shift).*

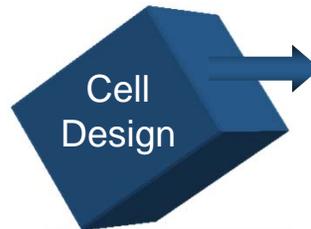
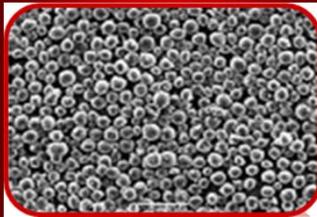


# Quallion Offers a Comprehensive Energy Storage Solution

## Battery Market Stratification



Domestic production of cathodes and anodes.



Cell configurations include prismatic, cylindrical, flat stack, wound, large, small, polymer (pouch), hard case and COTS 18650s.



Cell and battery management, power, safety, interface, communication (e.g., SM/CAN), balancing, state of health monitoring, modeling, grade of board parts.



Pack design considerations: safety, interconnects, spacing of cells, thermal gradients, heat ejection, environmental requirements, interface to application.



Quallion is a full service provider with expertise at all stratifications of the battery market.

## Aerospace & Military Aviation Systems



**NASA Heavy Lift Vehicle:** Li ion battery for ARES I (batteries for crew Launch Abort System and other support systems).



**Launch Systems:** Li ion replacement batteries for launch vehicle flight termination, telemetry and on-board avionics.



**Boeing X-51 unmanned Scramjet “Waverider”:** First successful test flight May 26, 2010 (Mach 5), supported by USAF, NASA, DARPA.



**ISS:** Quallion down selected for ISS Li ion Battery replacement program. Project value \$20M. **Title III** materials and battery line key driver to down select.



**C-17 Globemaster:** Production contract for Li ion upgrade program on emergency back-up power. Project value \$40M.



**Predator:** Fleet Li ion battery upgrade program. Programmatic value \$36M every three years.



**U2 Spyplane:** Demonstrator project, flew test flight in 2009. USAF to fund full qualification and production effort to upgrade vehicle.



**Specials Ops Helicopter:** Li ion battery upgrade program.

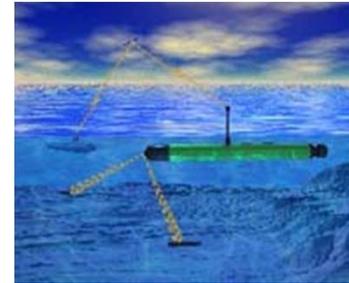
## Other Military Systems



**Marine Corp Vehicles:**  
Quallion under contract to qualify a Li ion upgrade battery system for all Marine Corp vehicle systems including HMMWV, light armored vehicles, amphibious assault vehicles, and others.



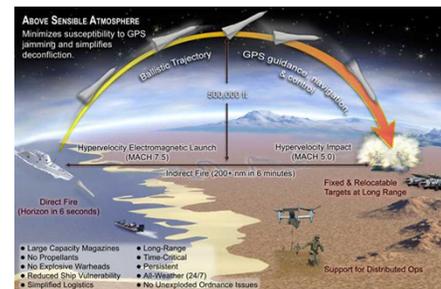
**Bradley & Abrams:**  
Quallion developed and tested with BAE and TARDEC a Li ion battery replacement for the Bradley and Abrams systems.



**UUVs:** Quallion developed a 5Kwh battery test module with General Atomics and ONR.



**Directed-Energy Weapon (DEW):** Weapon system that delivers various levels of energy with lethal and non-lethal effect. Li ion battery systems offer concentrated energy storage solutions enabling compact, portable options.



**Railgun:** A railgun uses electric energy to conduct a projectile over extremely long distances. Large Li ion battery systems can replace bulky capacitors.



## Key 2011 Space Activities

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- NRL TacSat IV – Launched September 2011 – 28V-30Ah
- NASA ISS – Downselected as a cell supplier. Key discriminator over our competitors drove NASA to this decision:
  - Deep LEO discharge capability (greater than 40%)
  - Zero-Volt technology
  - Quality in cell manufacturing capability
  - Cathode and anode control through our Title III project
  - Extensive LEO/GEO life testing at USG, primes and in-house
  - Cells may not need cell balancing
- Other Major Programs and Platforms
  - Ares Heavy Life
  - Scramjet Builds
  - Launch Systems



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## Title III Status

# Manufacturing Line Status and Relative Complexity

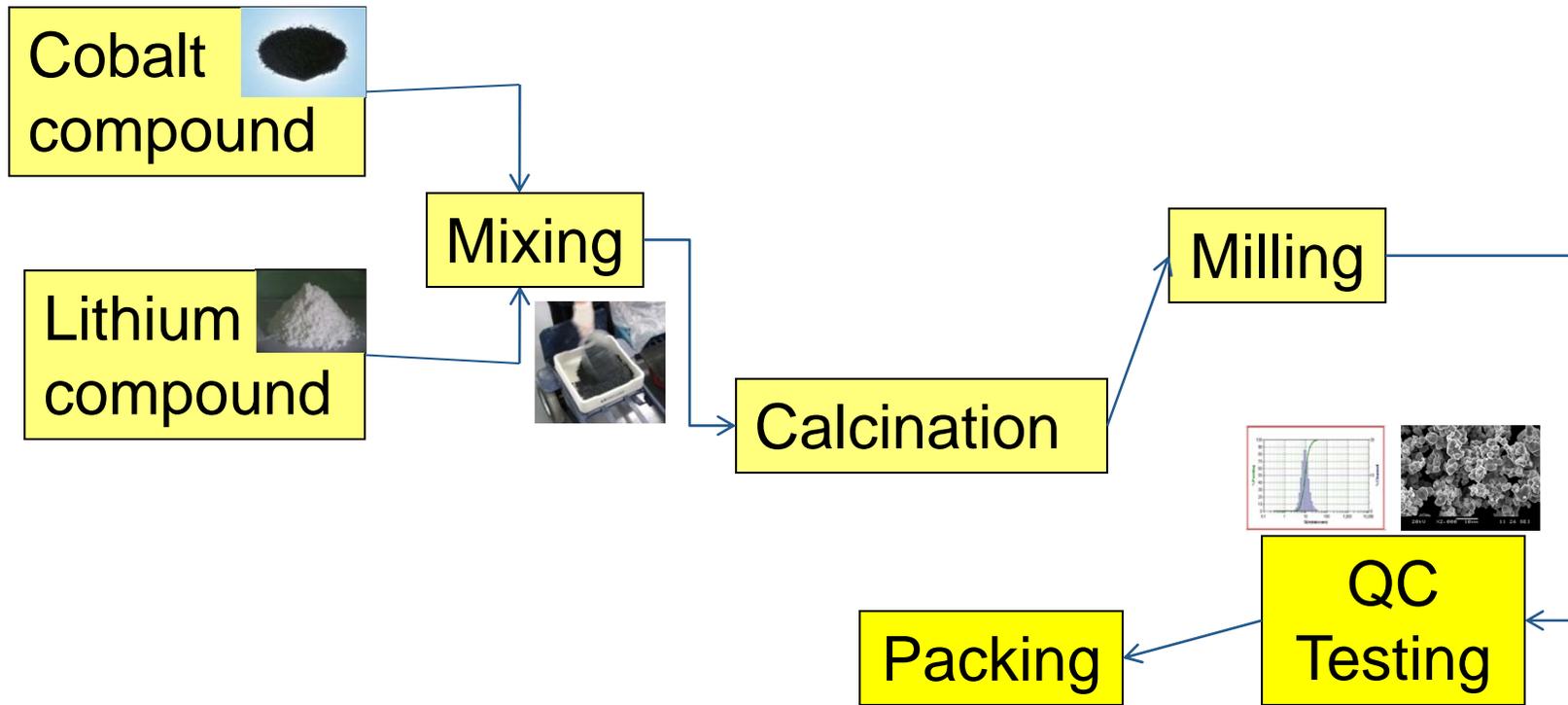
Title III Manufacturing Lines	Status	Relative Complexity					
Description	% Complete	1	2	3	4	5	6
<b>Design/TT</b>							
Cathode Gen 1	100%	■	■				
Anode	100%	■	■	■	■	■	■
Cell	100%	■	■	■			
Cathode Gen 2	85%	■	■				
Precursor	70%	■	■	■			
<b>Facility Modification</b>							
Cathode Gen 1 "Sylmar"	100%	■	■				
Anode "Santa Clarita"	55%	■	■	■	■	■	■
Cell "Sylmar"	100%	■	■	■	■		
Cathode Gen 2 "Sylmar"	0%	■	■				
Precursor "Santa Clarita"	0%	■	■	■			
<b>Line Installation and Verification</b>							
Cathode Gen 1	100%	■	■				
Anode	10%	■	■	■	■	■	■
Cell Electrode	100%	■	■				
Cell Sub-assembly	98%	■	■	■	■		
Cathode Gen 2	0%	■	■				
Precursor	0%	■	■	■			



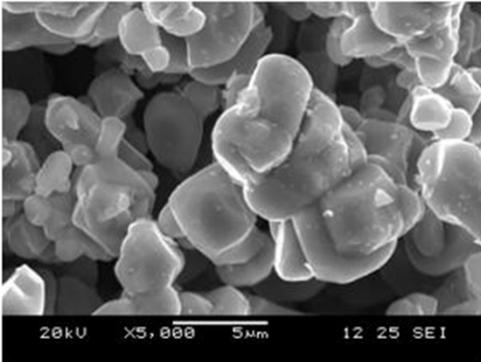
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## Gen 1 Cathode Material Characteristics and Manufacturing Line

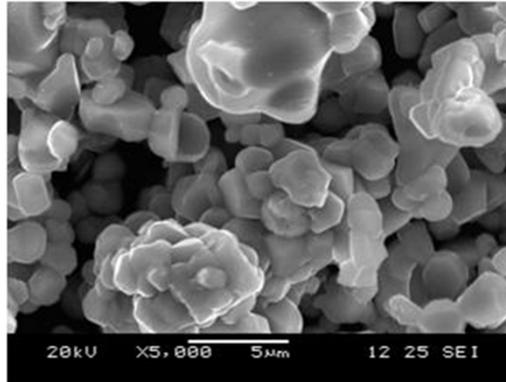
# Gen 1 Cathode Manufacturing Process Overview



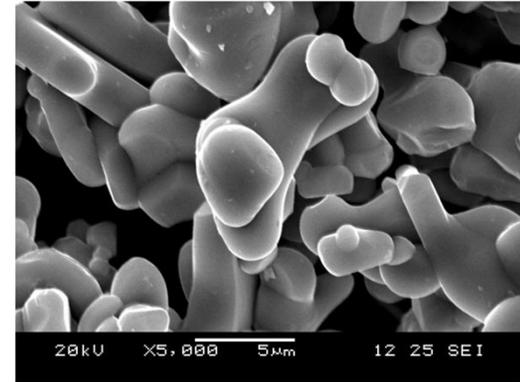
# SEM Images of Multiple Quallion Gen 1 Lots



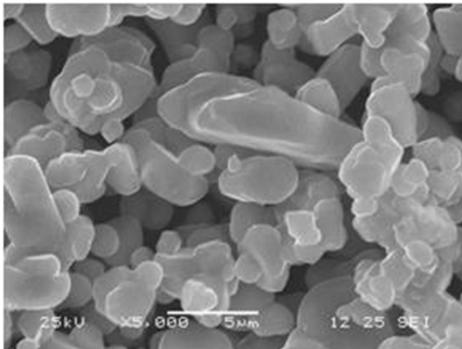
Control



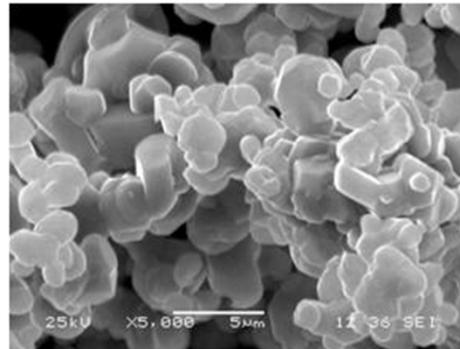
T10E105



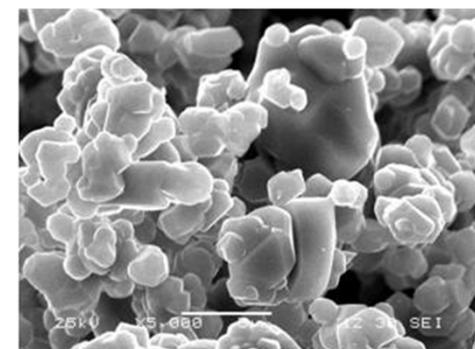
T10E229



T10G099

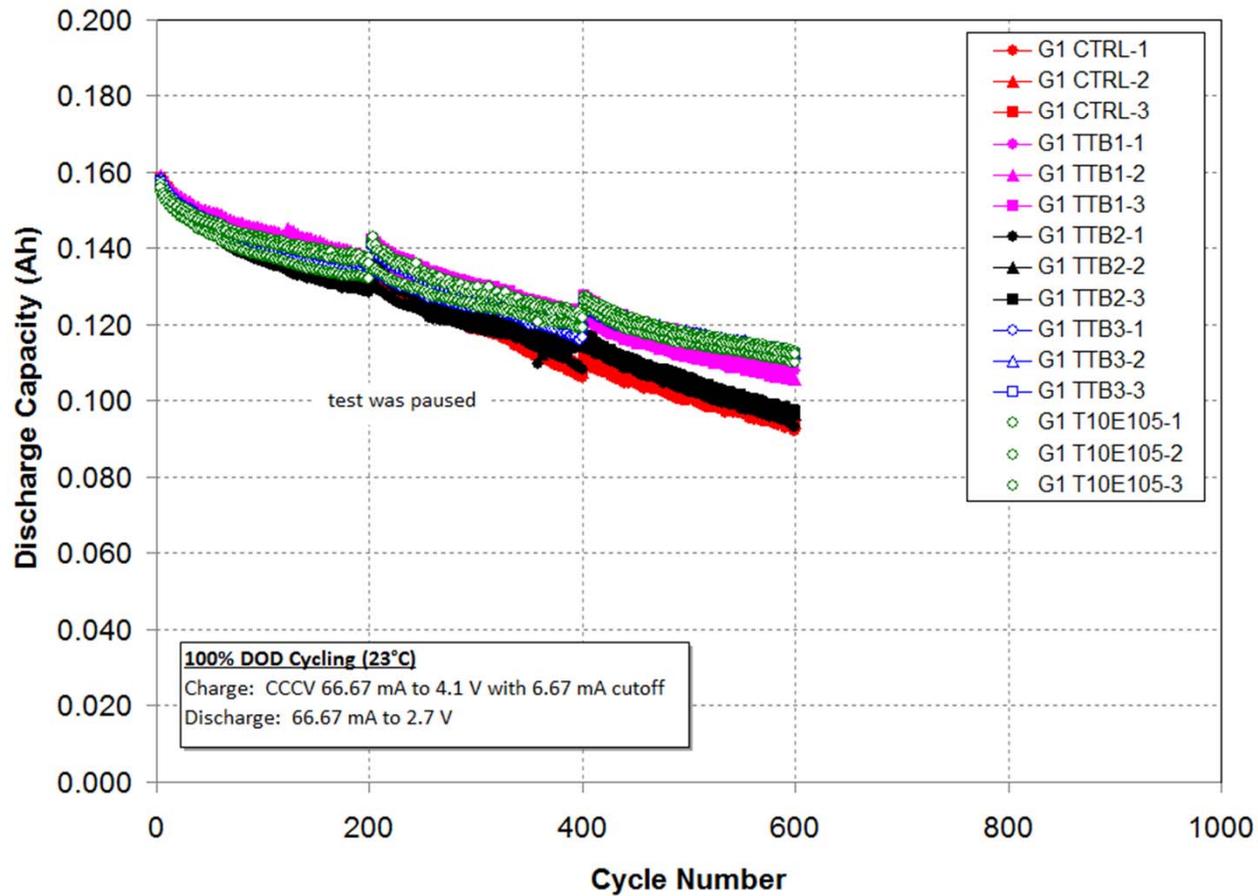


T10G334

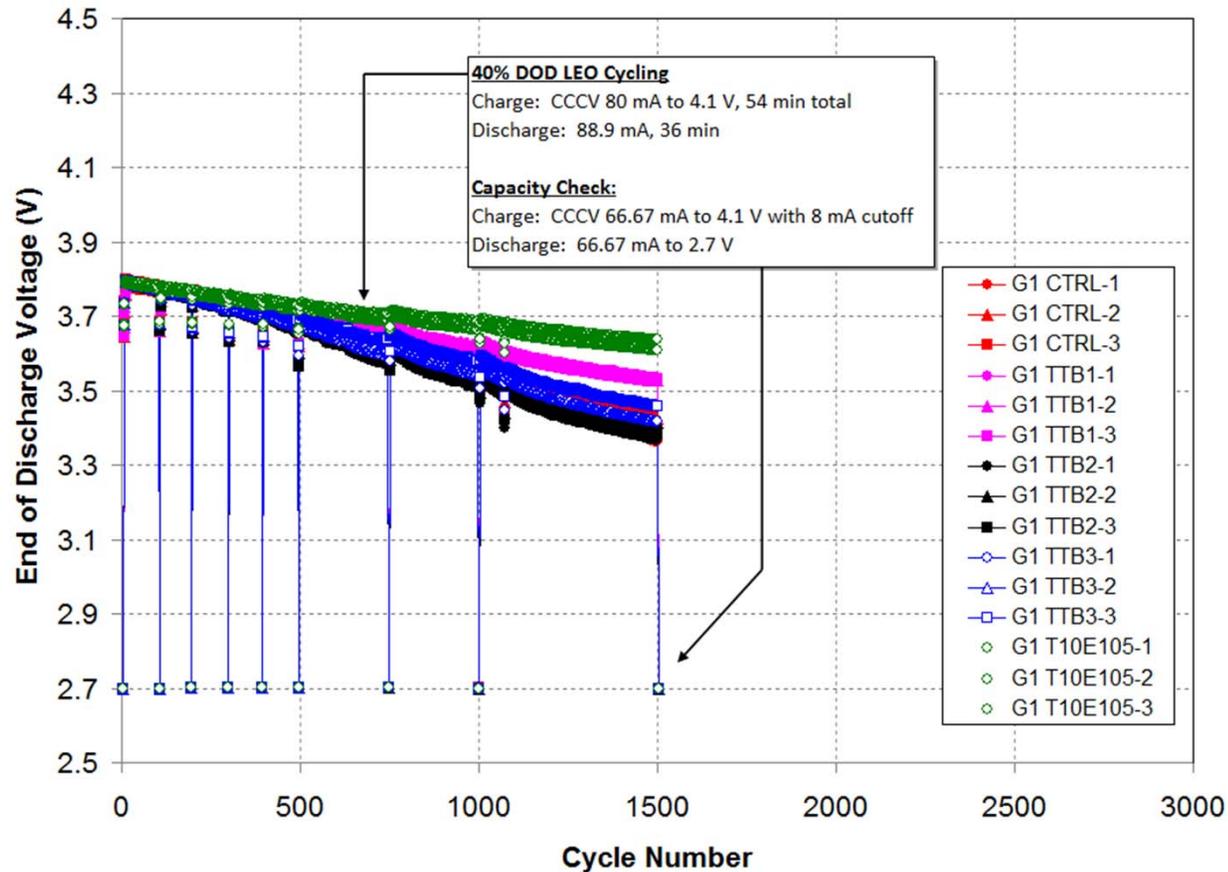


T10G582

## DOD 100 % Cycle Life at R.T.



## DOD 40% Cycle Life at R.T.



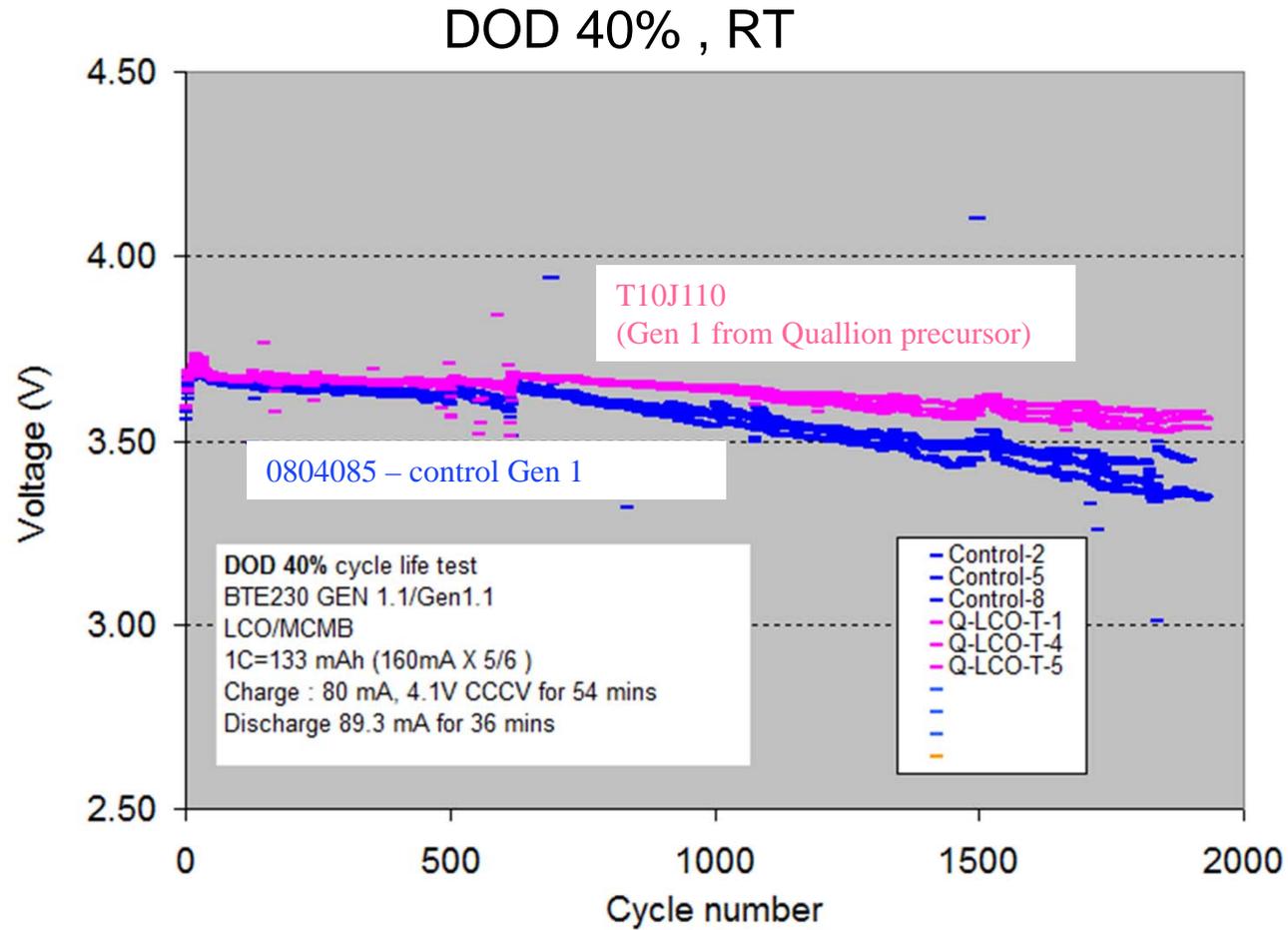


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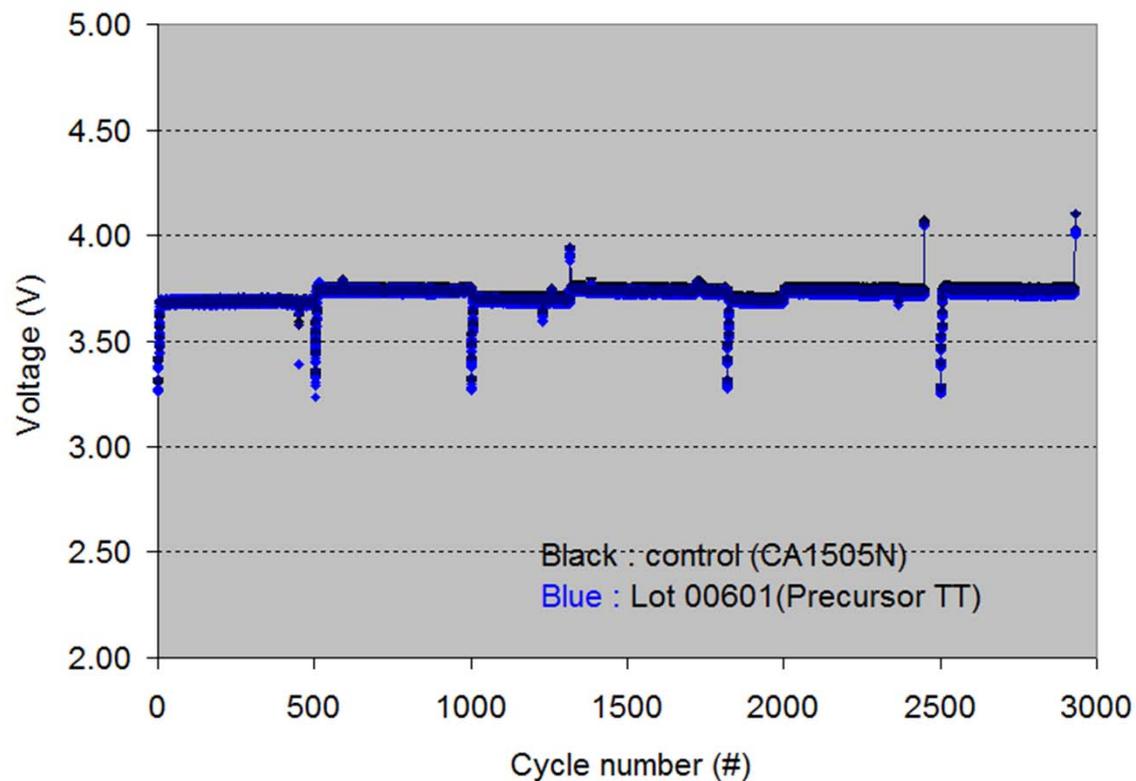
## Gen 1 & Gen 2 Precursor



# Quallion Precursor for Gen 1 Cathode Electrochemical Performance



## Quallion Precursor for Gen 2 Cathode Electrochemical Performance



### DOD 40% Cycle Life

- Quallion NCA exhibits similar electrochemical performance to control CA1505N



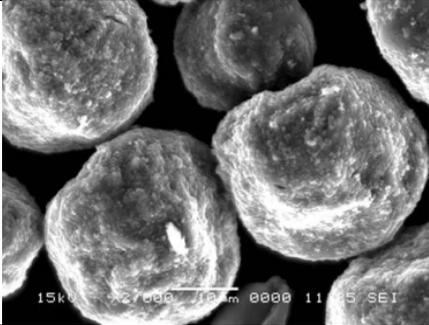
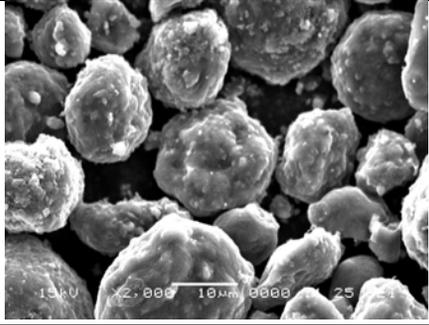
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## Anode Table Top Material Evaluation & Line Construction



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# Quallion Anode (Table Top Test) and Control Anode

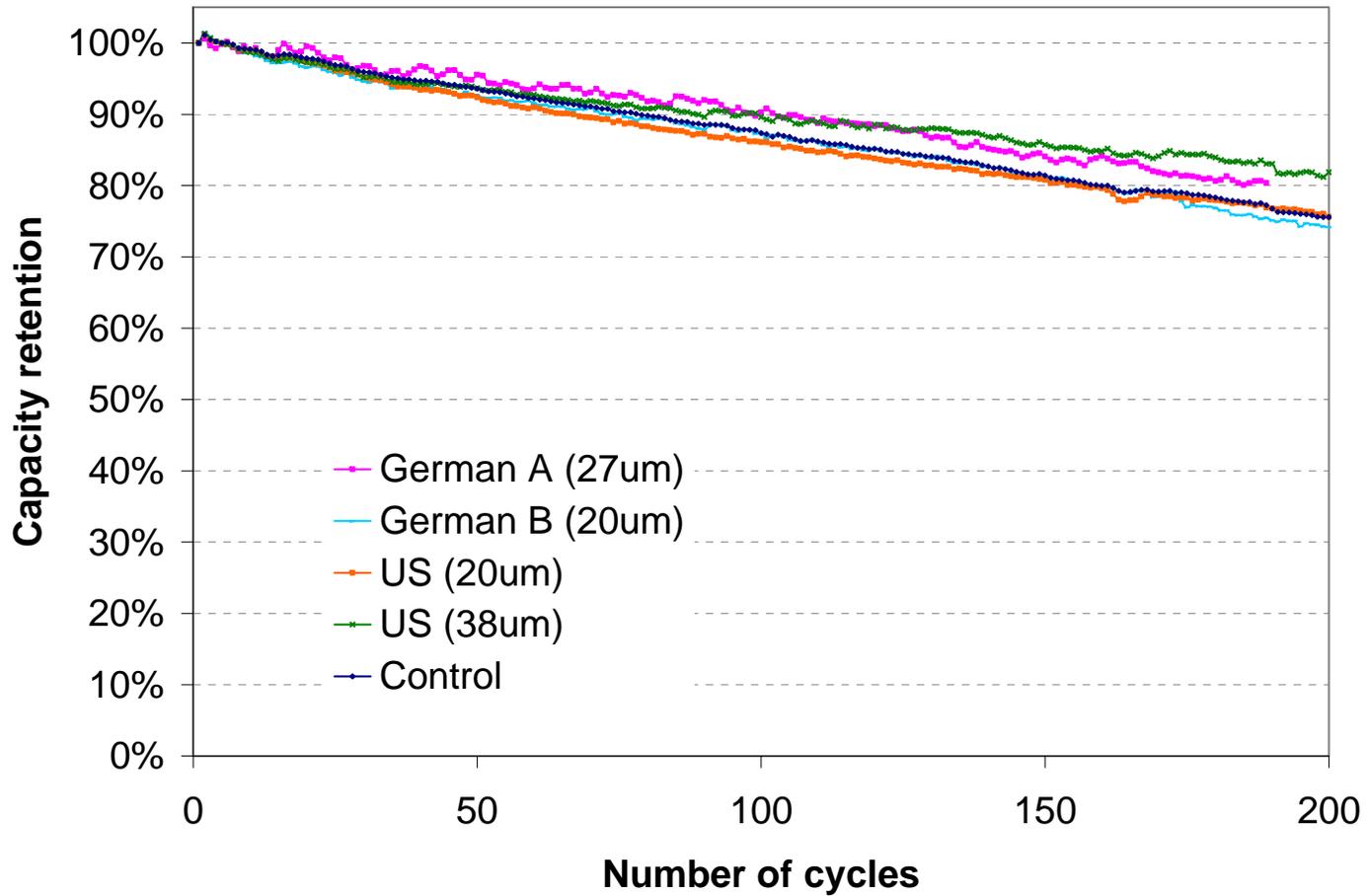
MCMB		Quallion MCMB	Control MCMB
Real Density	g/cc	2.27	2.15 - 2.28
Tapping Density	g/cc	1.37	1.39 - 1.42
D50	μm	26.32	20 - 30
XRD C <sub>0</sub> (002)	nm	<b>0.3360</b>	<b>0.3359 - 0.3361</b>
XRD Lc(002)	nm	<b>112.3</b>	<b>110 - 124</b>
Surface Area	m <sup>2</sup> /g	0.60	0.50 - 0.92
SEM			
Capacities	mAh/g	290-330	280-305
Irreversible capacities	mAh/g	14-24	20-25
Pouch cell cycle performance		80% retention after 200 cycles	80% retention after 200 cycles

Quallion Anode (table top test) meets all the specification of the control MCMB



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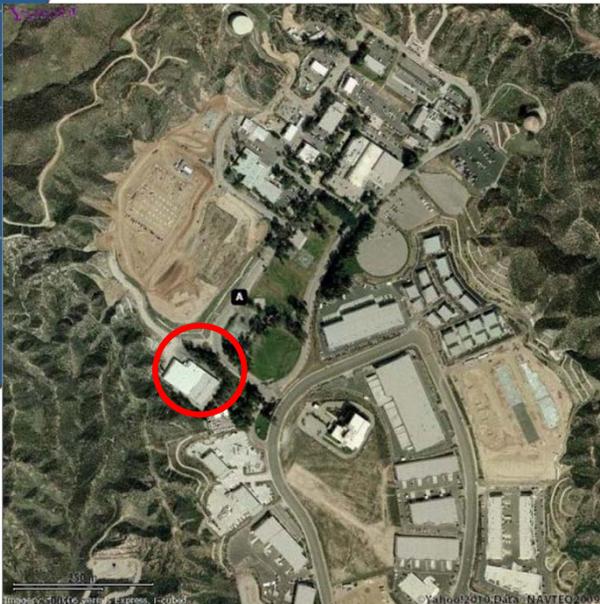
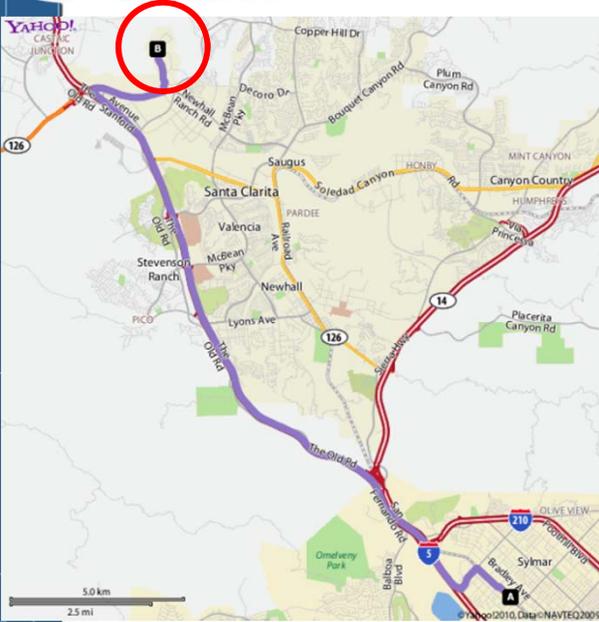
# Pouch Cell Performance – Capacity Check (DoD 100%)



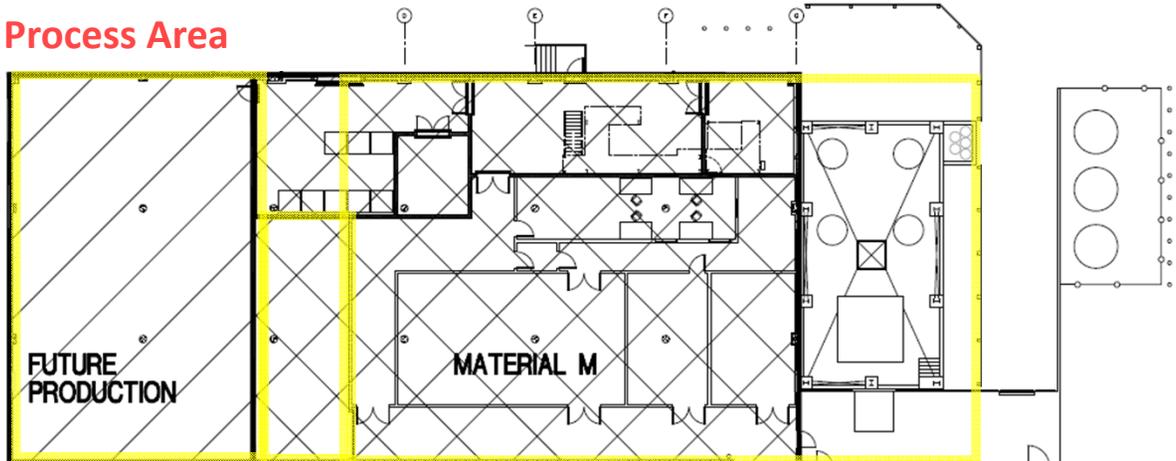
Cells prepared from Quallion Anode (table top test) meets or exceeds the control MCMB



# General Arrangement of Facilities and Location



Cathode Precursors  
anode Process Area  
Process Area

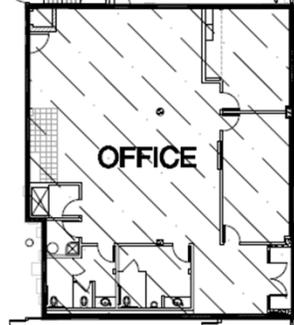


Warehouse

13,000 SQ FT



OFFICE





## Summary of Key activities to date

- Design Phase Completed Nov 2009
- Construction Permits Finalized/Submitted Dec 2010, Rec'd Feb 2011
- Construction Commenced Mar 2011
- Most Long Lead Equipment Received & Installed (Reactor, Centrifuge, Bag Unloader, Cake Hopper, Tanks, Cat. Ox., Chiller)
- Building Modifications Nearly Complete (dry wall, structural steel, pipe racks, roof insulation/penetrations, etc.)
- Air permit received on May 2011
- Process Piping, and Electrical Continues & awaiting receipt of furnaces & distillation system



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# Equipment - Quallion

Reactor  
23 Aug 2010 Delivery



Centrifuge  
17 June 2010 Delivery



Carbonization Furnace

Assembly Complete – Scheduled Deliver July 2011

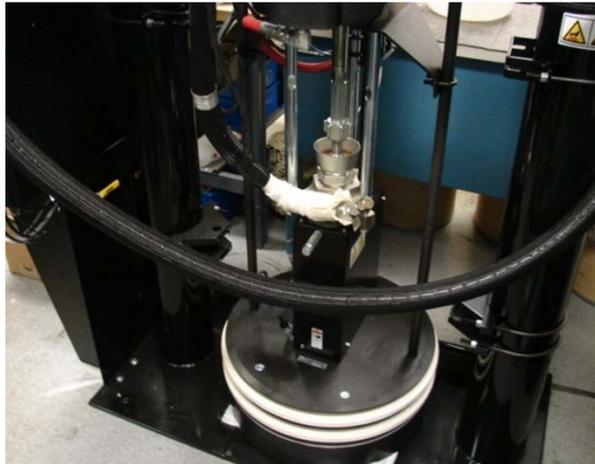


Graphitization Furnace

Assembly Complete – Scheduled Deliver July 2011



Pitch Melter



Solvent Tanks



Catalytic Oxidizer



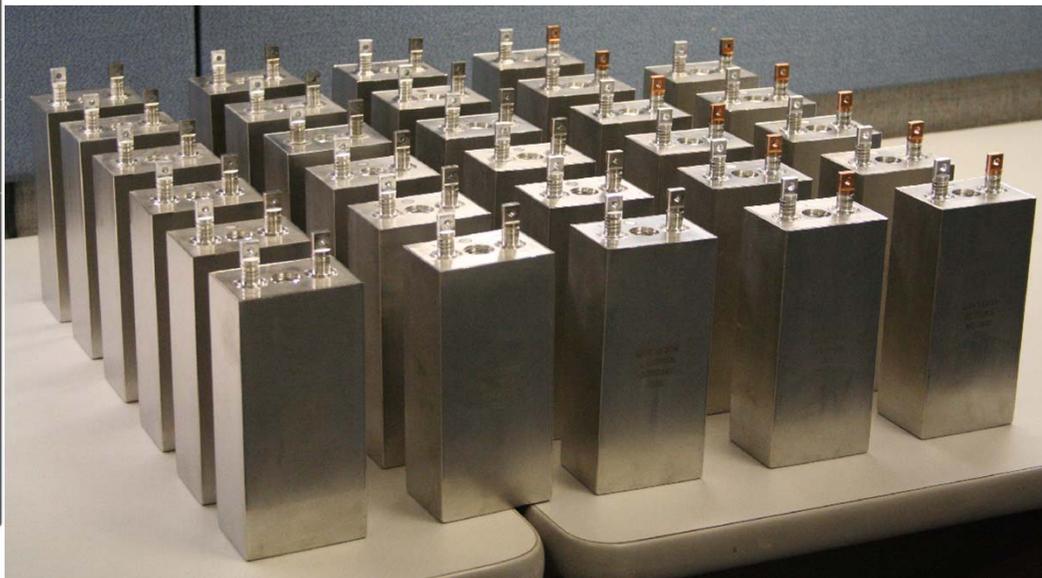
Air Compressor



Cake Hopper



## 72 Ah Cell (QL075KA) Line

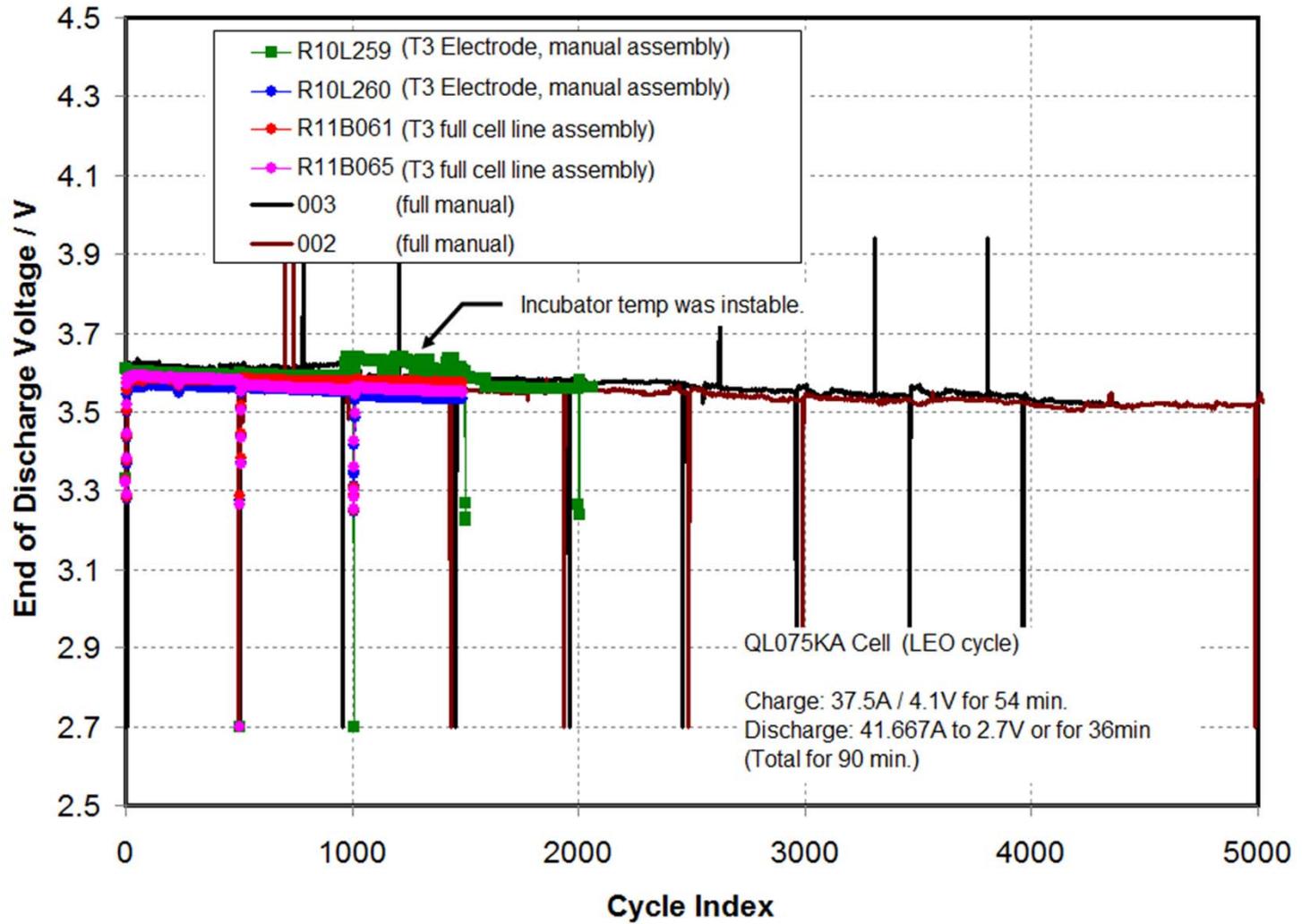


- Gen I and Gen II Chemistry
- True-Prismatic
- Zero-Volt™ enabled
- Line Capacity of over 4,000 72 Ah Cell/year



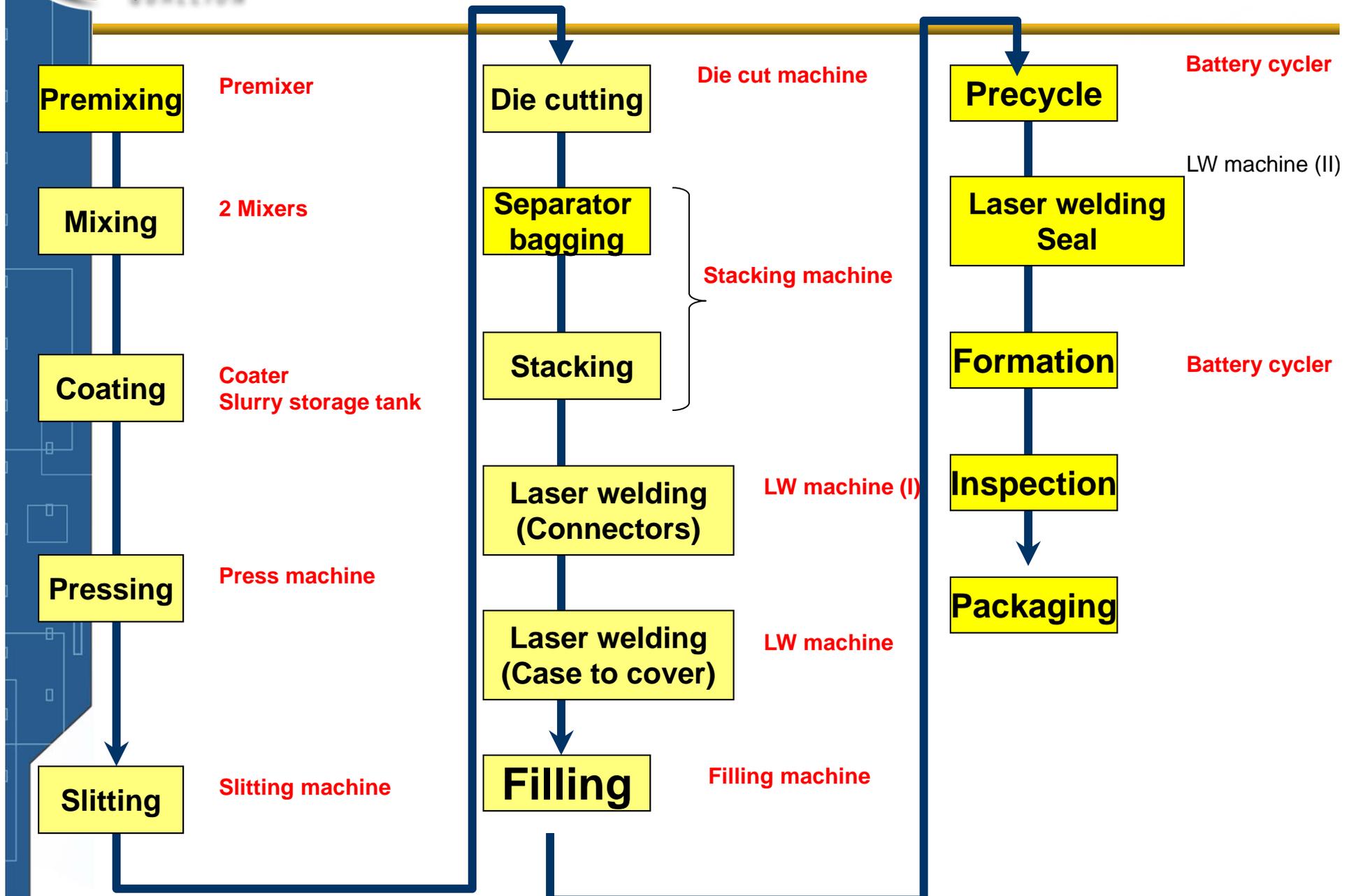
# QL075KA Quallion Gen 2 Cell Assembled with T3 Cell Line

## LEO 40% DOD Cycle at R.T.





# Title III 72 Ah Li Ion Cell Manufacturing Process Flow





- Premixer
- Mixer
  - Two mixers dedicated for positive and negative slurries

## Coating Process



- Accurate coating thickness
- Roll to roll continuous coating
- Patch coating
- Stripe coating
- Flexible width coating

## Press Machine



- Roll to roll continuous process



- Roll to roll continuous slitting process
- High speed production rate
- Highly engineered slitting cutters designed for electrode cutting
- Precise air friction rewinding technology for the following process



- Custom designed electrode cutting system
- 2 dedicated machines for positive and negative
- Provides high quality cut electrodes
- Integrated electrode inspection system
- Electrode cleaning system



- Custom designed electrode / separator stacking system
- High speed stacking
- Single button operation
- Separator bagging system
- Stack inspection feature

## Laser Welding (I)



- Copper weld capable
- Variable pulse shaped laser power output capable

## Laser Welding (II)



- Programmable 3-dimensional welding path
- Variable pulse shaped laser power output capable



- Custom designed electrolyte filling system
- Accurate electrolyte dispensing amount
- Corrosion free design
- One button operation

## X-Ray Inspection



- Automated X-ray inspection system
- High power X-ray source
- Improved parallelism image
- Integrated motion system allowing detailed inspection

