

# Status of Lithium Ion Production, Life Testing and Development

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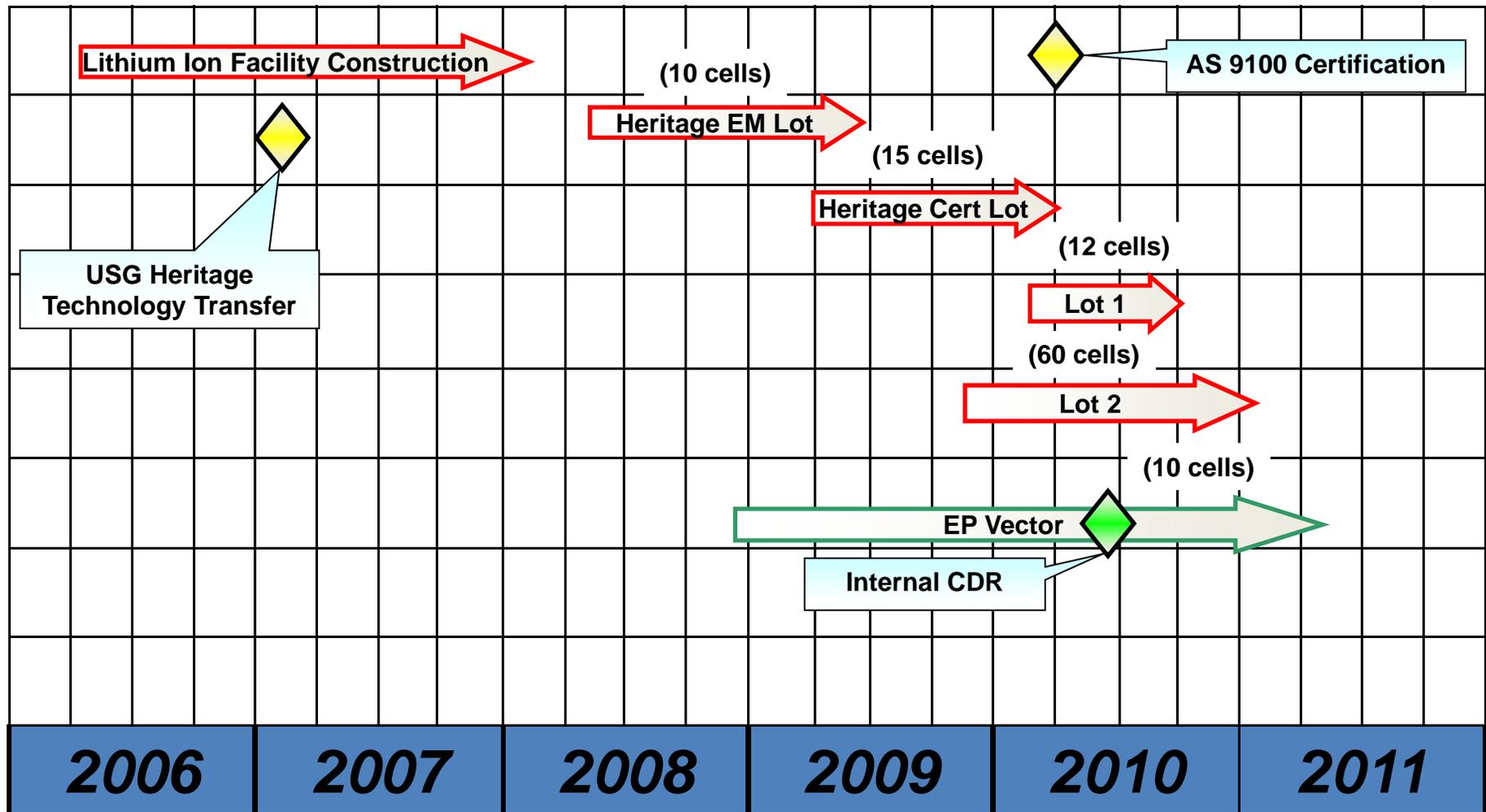
Engineering Lead, New Product Development



- **Introduction**
- **Current EPT Li Ion Life Testing Assets Summary**
- **EPT Engineering Models E2 and E3 LEO Testing**
- **USG and EPT(USG) Heritage Certification GEO Testing**
- **EPT Next Generation Space Cells (Vector)**
- **Summary**

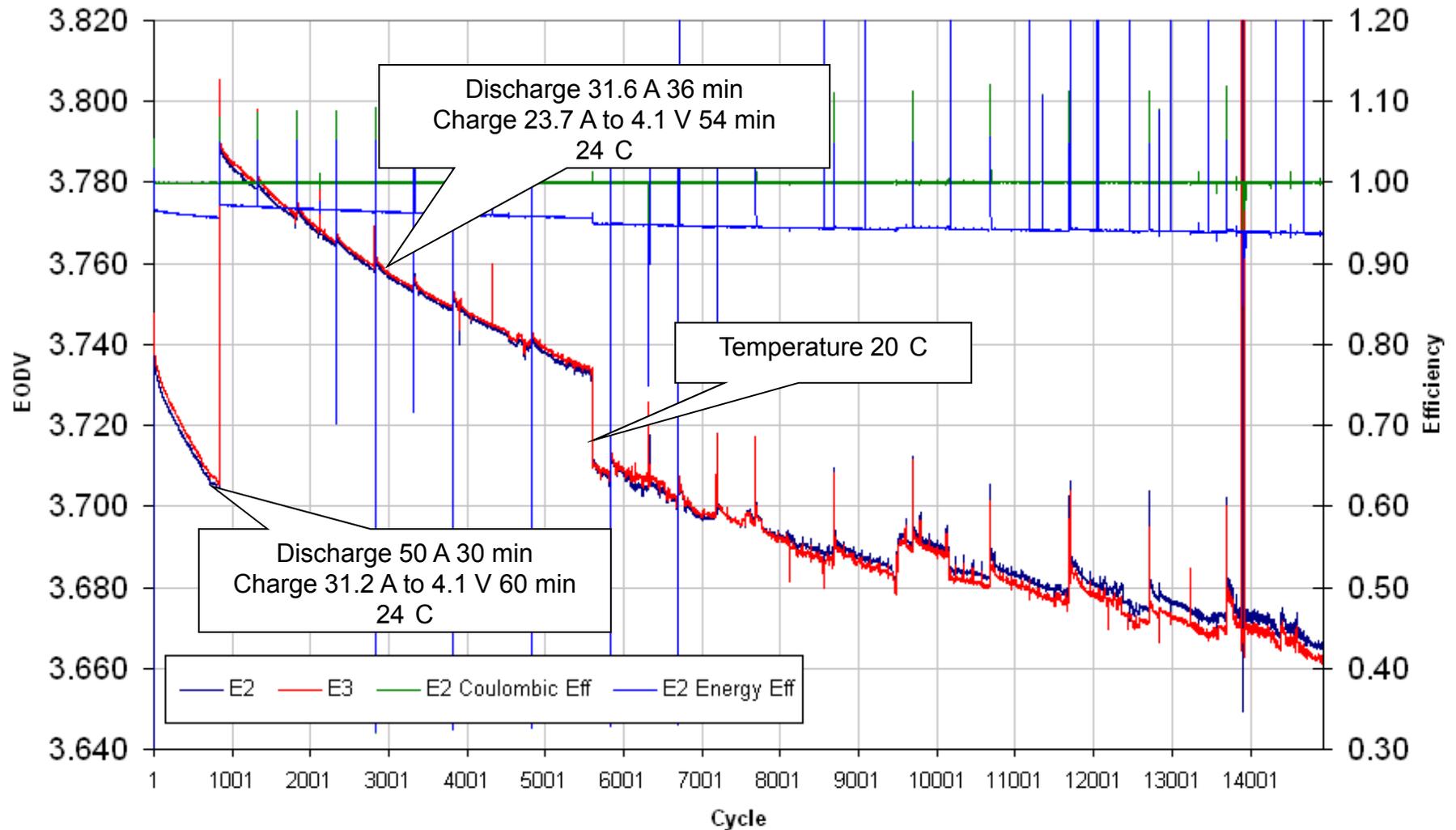
- **SLC-16050 – Heritage – EPT (USG)**
  - USG Gen 1.1 design
  - LCO cathode
  - Manufacturing technology transferred to EPT from USG
  - EPT production made E2, E3 and Certification cells
  
- **SLC-21060-001 – Vector– EPT (Vector)**
  - EPT designed electrodes
  - NCA cathode
  - Initial cells on life test

# Timeline of Space Lithium-Ion Activities

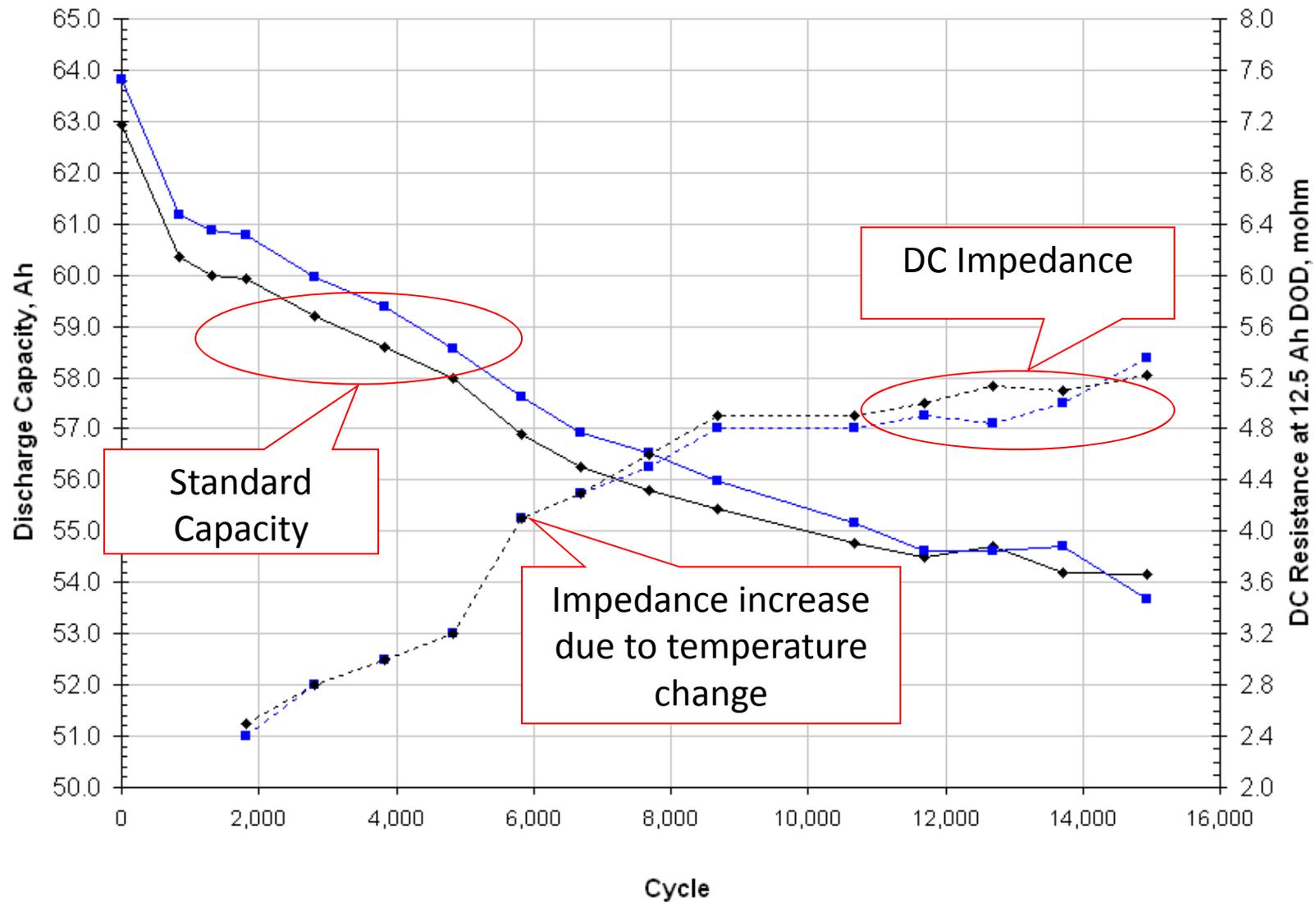


- **Two EPT (USG) engineering model cells, E2 and E3**
  - Placed in LEO cycling Dec 2008
  - 15,000 cycles
- **EPT (USG) Certification cells**
  - LEO testing, 4 cells 9,500 cycles
  - GEO testing, 4 cells 12 seasons complete
- **USG provided cells**
  - LEO testing, 1 cell 9,500 cycles
  - GEO testing, 3 cells 12 seasons complete
- **EPT (USG) cells provided to USG for independent testing**
  - Two cells placed in 40% DOD LEO testing
  - Two cells placed in 60% DOD LEO testing
- **EPT (USG) cell in storage at 0°C 22 months**
- **EPT Vector cells**
  - LEO testing, 5 cells 2000 cycles
  - GEO testing, 2 cells 3 seasons complete

# E2 and E3 LEO Testing EODV



# E2 and E3 Capacity and DC Resistance



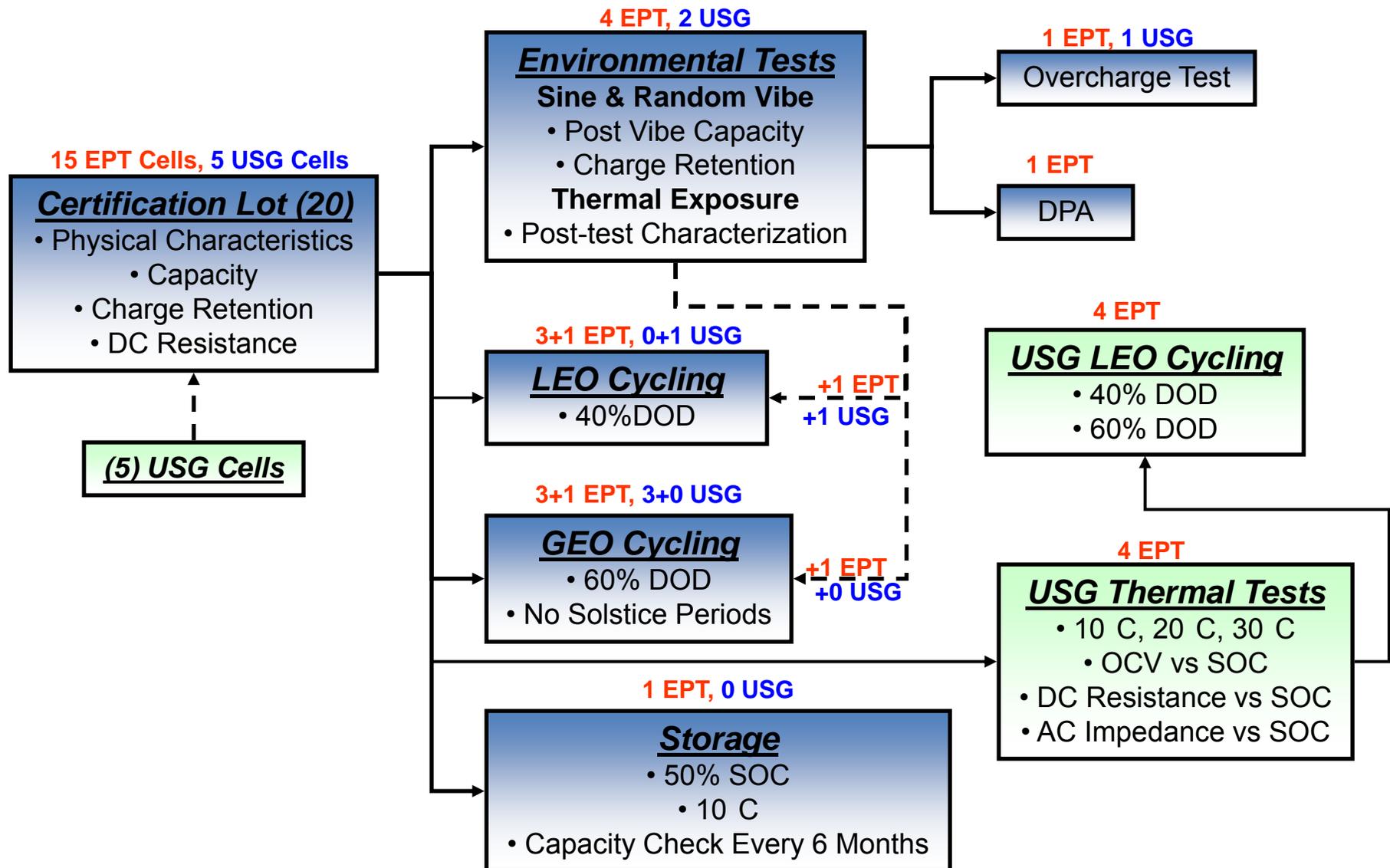
# E2 E3 LEO Summary Results

End of Life Predictions for 7 year LEO mission at 30% DOD

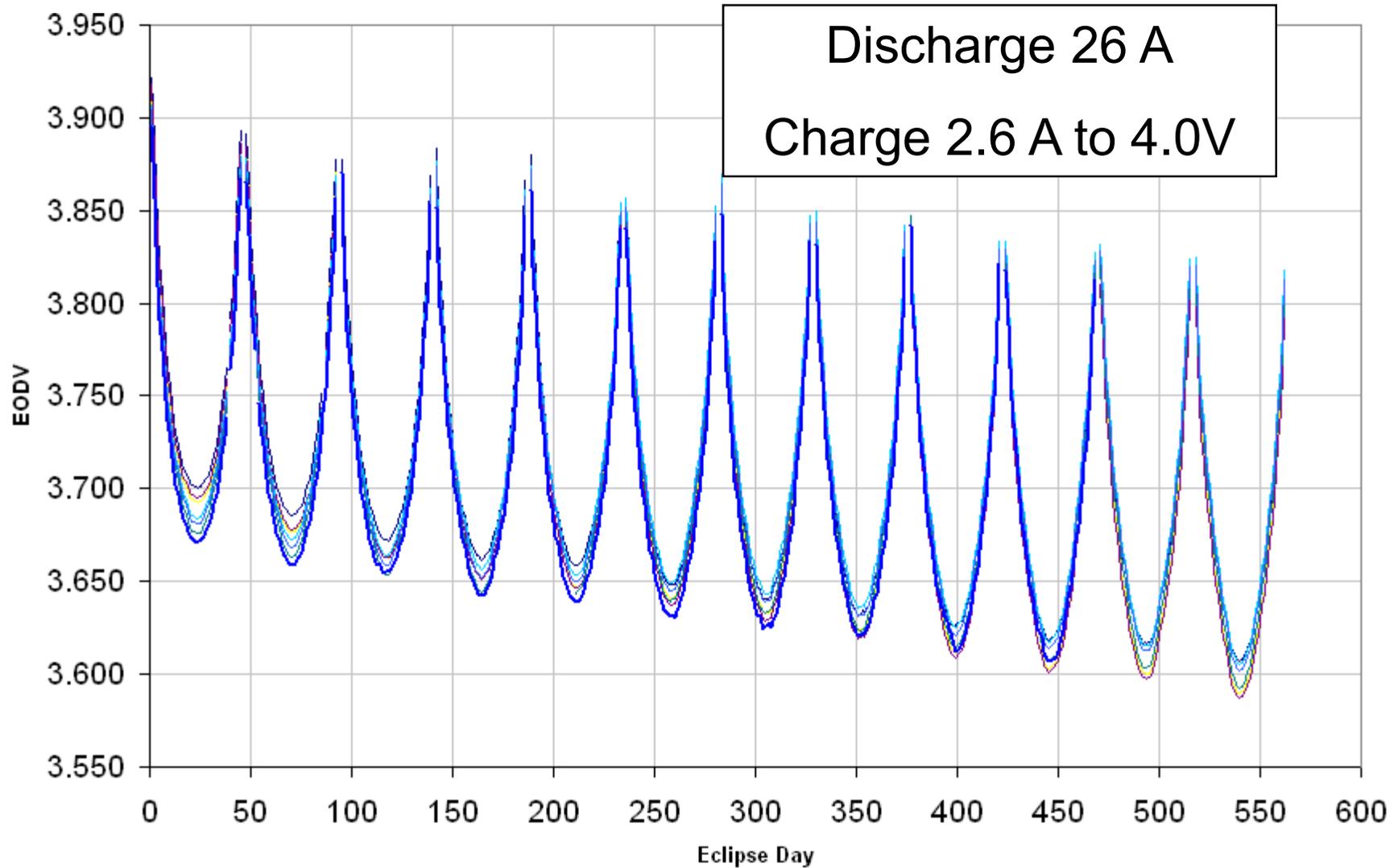
	Cell E2	Cell E3
End of Discharge Voltage	3.487 V	3.478 V
Charge energy efficiency	86.4%	85.8%
Standard Capacity	43.7 Ah	43.7 Ah
DC Impedance	10.8 mΩ	10.9 mΩ

Predictions based on linear extrapolation after cycle 834

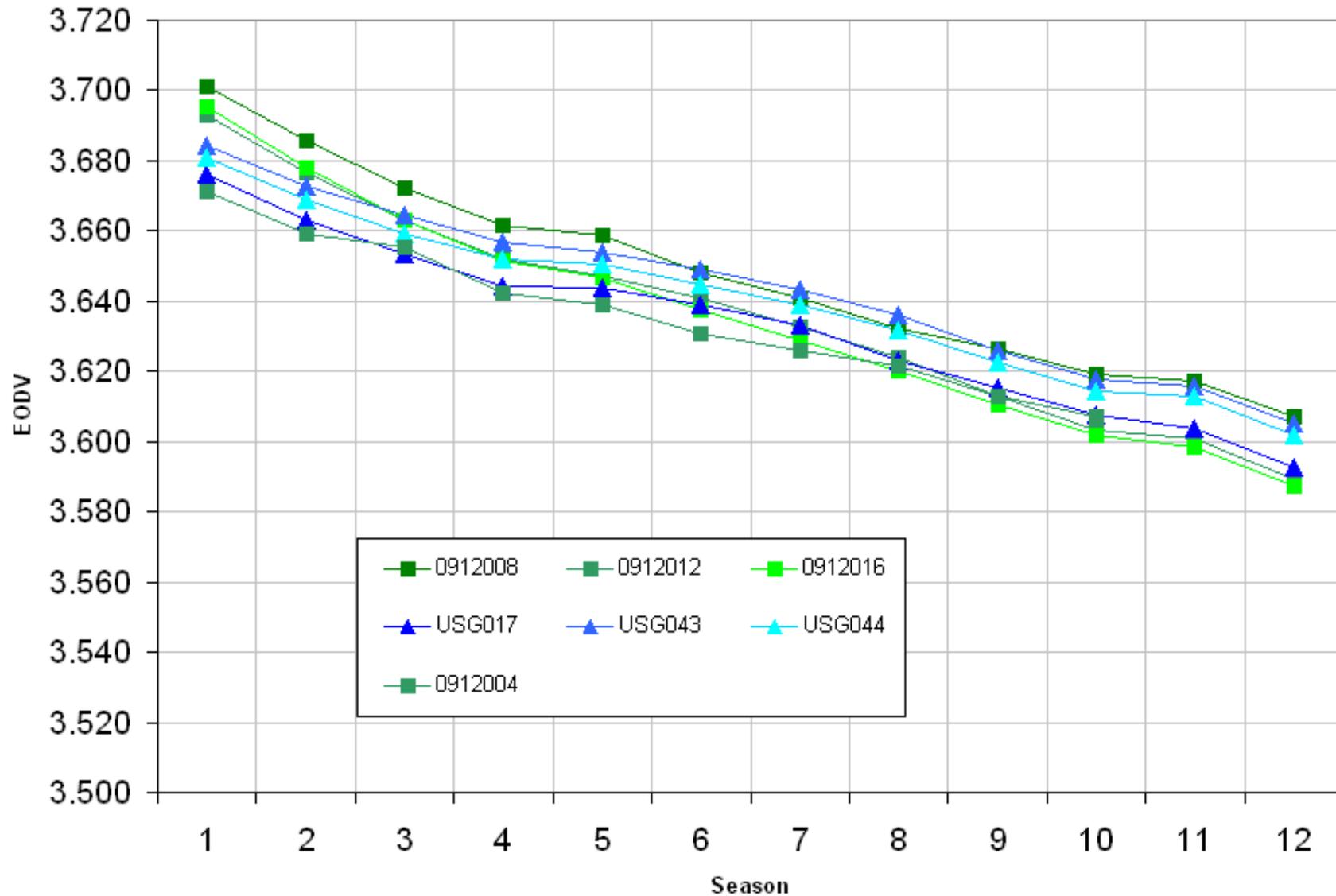
# Heritage Certification Test Plan



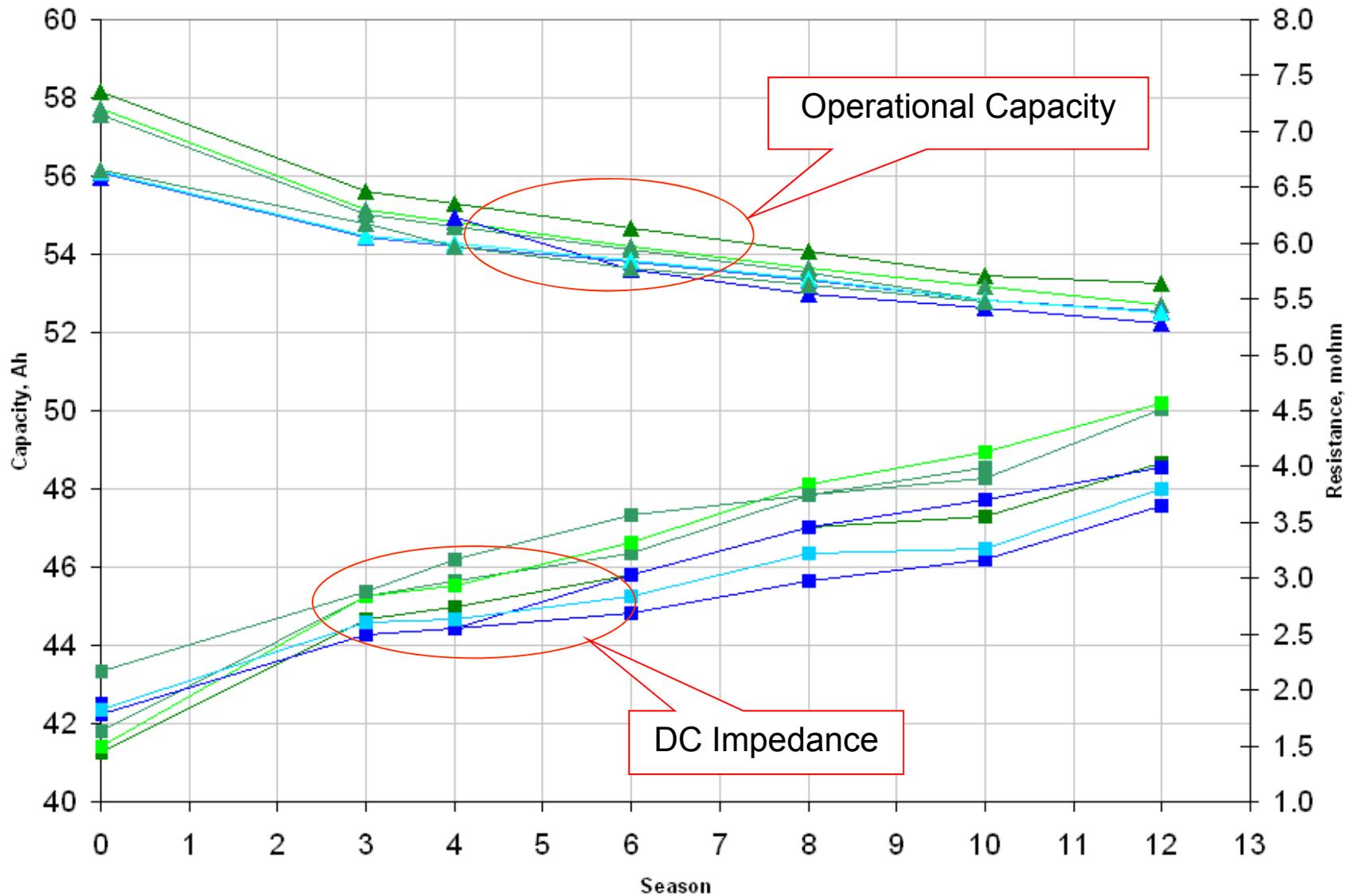
# Certification GEO Eclipse Seasons



# Certification GEO Day 23 EODV



# Certification GEO Capacity Cycles



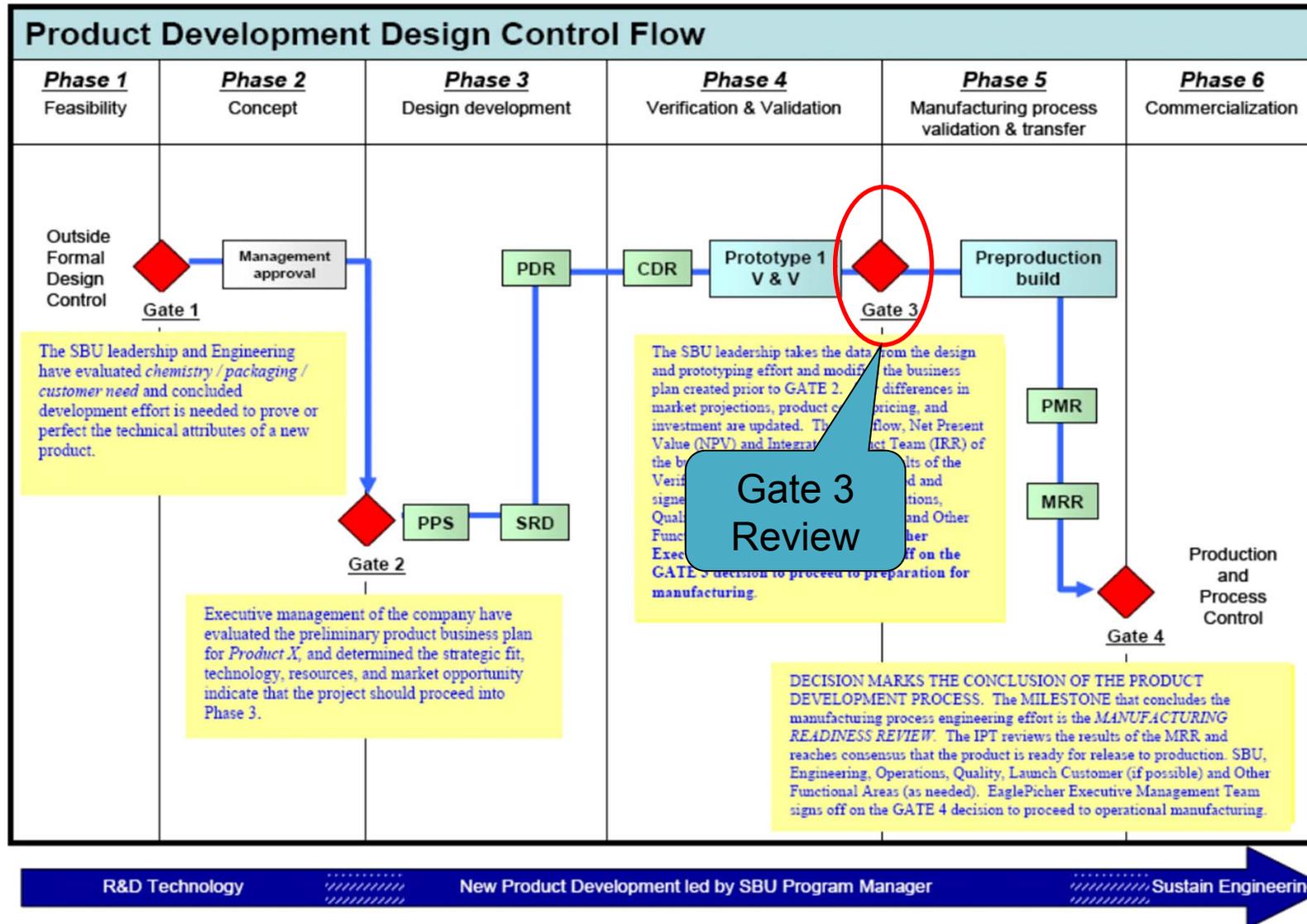
## End of Life Predictions for 15 GEO mission at 60% DOD

	Cell 0912008	Cell 0912012	Cell 0912016
Capacity	41.8 Ah	40.9 Ah	42.0 Ah
Day 23 EODV	3.452 V	3.426 V	3.411 V
Day 23 % DOD	75%	76%	74%
DC Impedance	7.9 mΩ	8.4 mΩ	9.4 mΩ

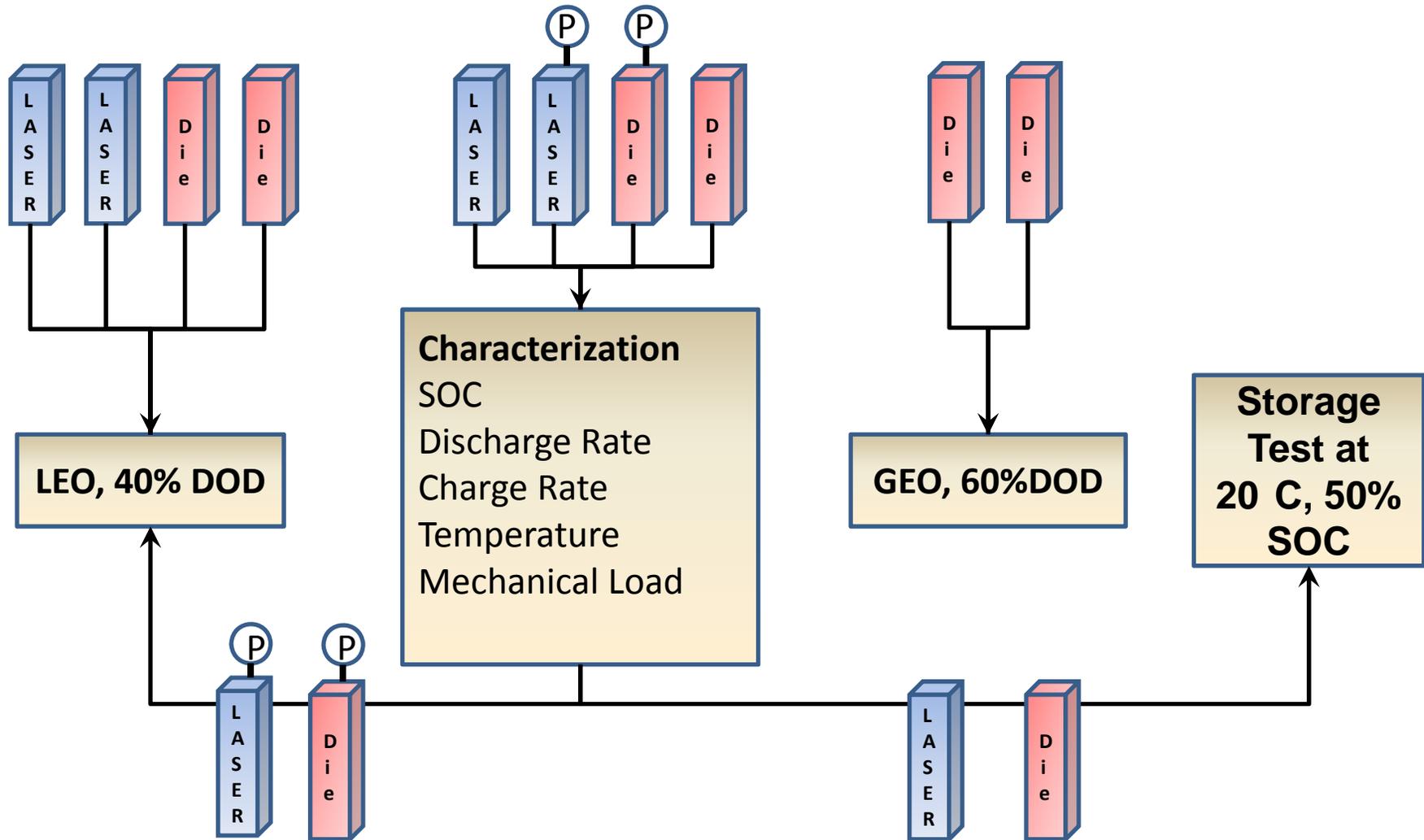
Predictions based on linear extrapolation after Season 1

# Vector Program

# Vector Design Status



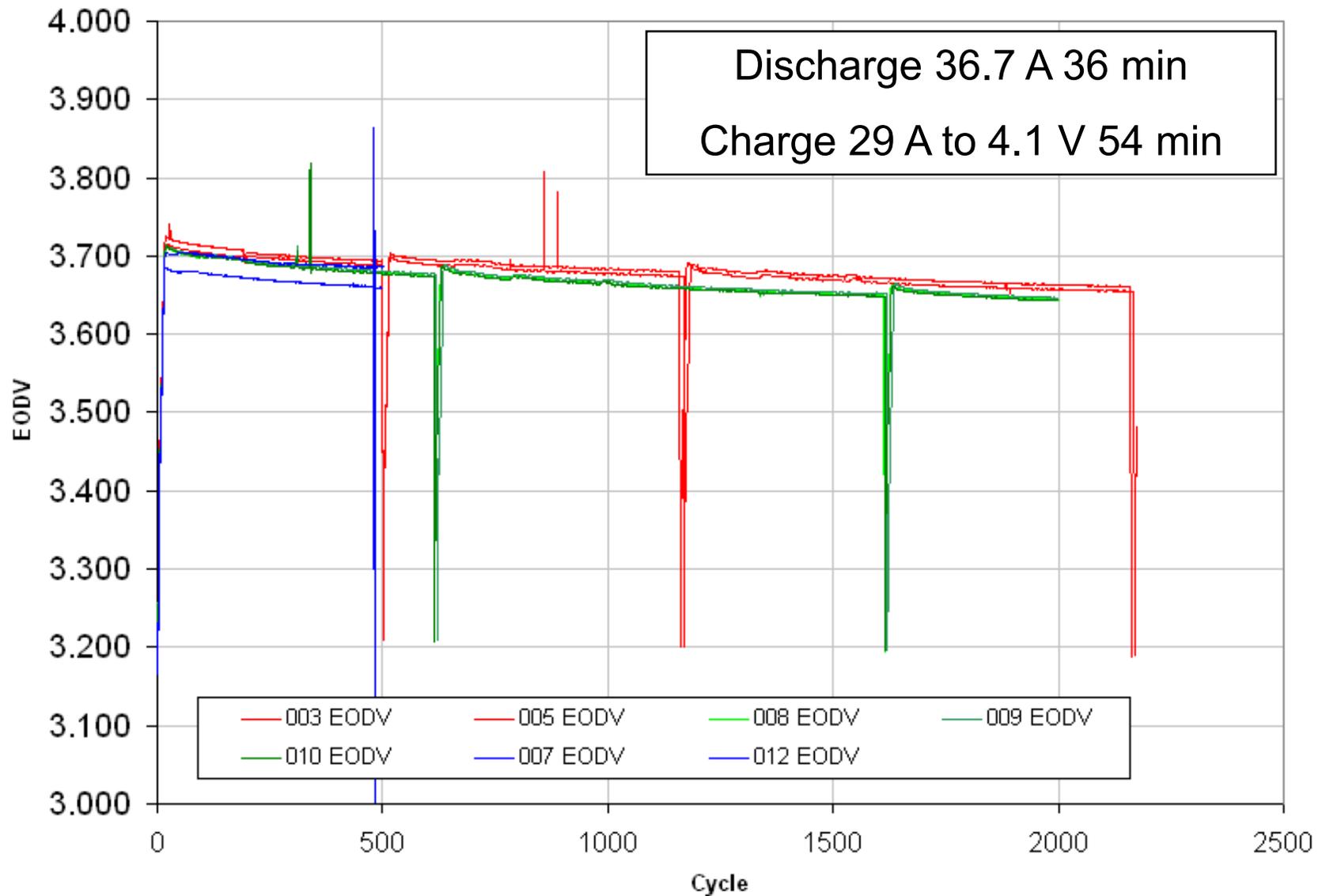
# Vector Test Plan



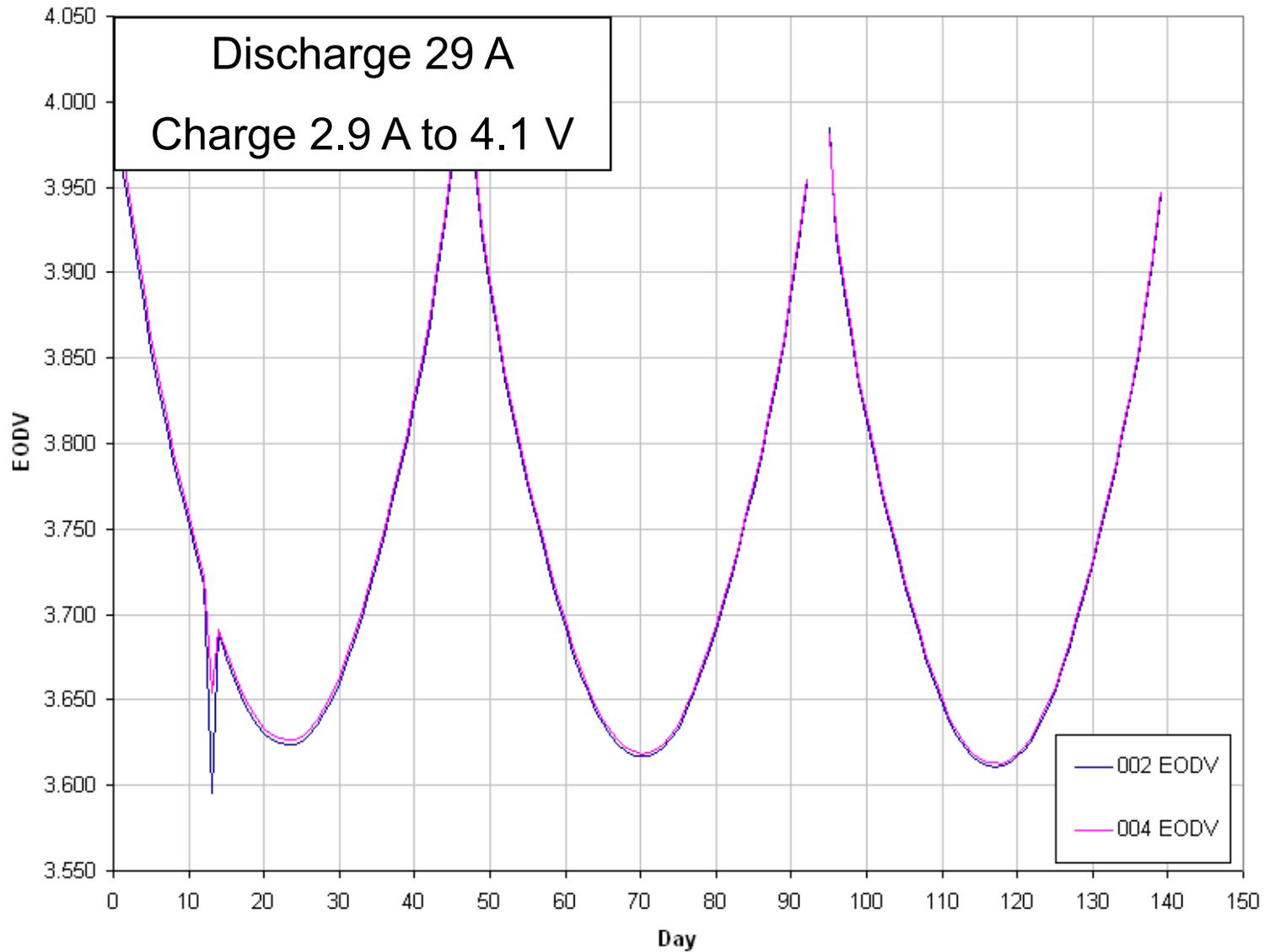
# Cell Comparison

	<b>Heritage EPT(USG)</b>	<b>Vector</b>
Cathode Material	LCO	NCA
Anode Material	MCMB	MFG
Mass, g	1967	1974
BOL Capacity, Ah	62.5	73
Volume, (L X W X H) inches	7.9 x 3.2 x 2.2	7.9 x 3.2 x 2.2
Specific Energy, Wh/kg	122	139
Energy density, Wh/l	257	295

# Vector LEO Test Data



# Vector GEO Test Data



- Heritage technology transfer successfully completed
  - EPT (USG) cells have over 15,000 LEO cycles to date
  - Heritage EPT(USG) cells have completed 12 GEO seasons to date
- EPT Vector cell design is in initial life testing
- Crossroads facility is AS9100 certified and qualified for space cell production