



SPRINTER PHEV Battery Testing Project

July 2006 – Project Update



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So. Cal. Edison – Electric Transportation

- Partners:
EPRI, DaimlerChrysler and SCE
- Primary objective:
To determine PHEV Sprinter environmental benefits and lifecycle operating costs
- Two Phases:
 - Battery evaluation to assess the performance and cycle life of selected batteries under Sprinter PHEV test profiles
 - Vehicle testing (Not discussed in this presentation)

- **VARTA NiMH Pack**

- Seven 48V blocks
 - 40 cells per block, 280 cells total
- 40 Ah per block
- 14.4 kWh
- 70 kW (peak power)
- 1 block being tested



- **SAFT Li-Ion Pack**

- Seventeen 21.6V modules
 - 6 cells per module, 102 cells total
- 39 Ah per module
- 15.5 kWh
- 87 kW (peak power)
- 3 modules being tested



PHEV Test Profile Development

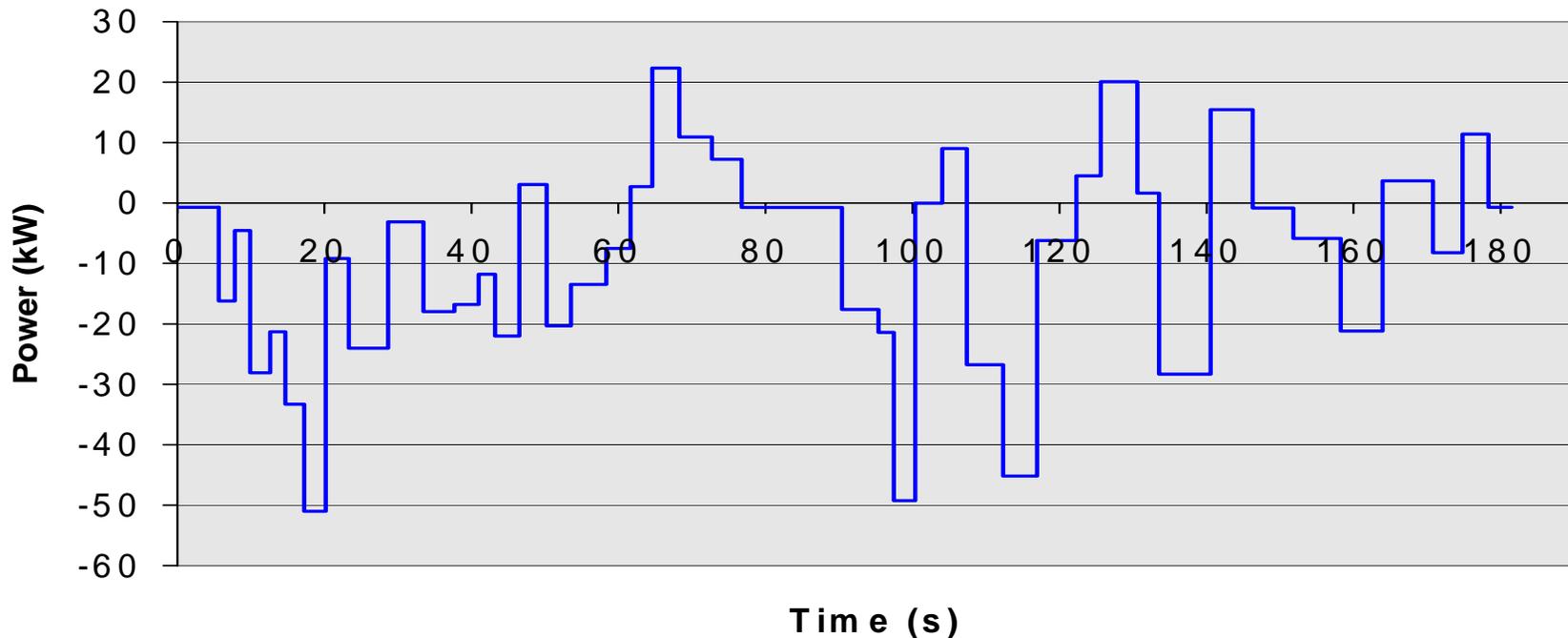
- Derived from a dynamic vehicle-level simulation
- Based on the final portion of the INRETS URB1 vehicle test cycle
- Replicates the urban driving conditions likely to be the most demanding to the battery (low speed, high acceleration and charge-sustained HEV mode at low battery SOC)
- Uses a combination of both HEV and EV driving modes to represent greater than 50% of statistical daily trips

PHEV Test Profile Overview

- Test profile composed of three main modes
 - Charge depletion mode, simulating the EV operation
 - Charge sustained mode, simulating the hybrid operation (HEV mode)
 - Regular charge mode, simulating the vehicle being recharged from an outlet

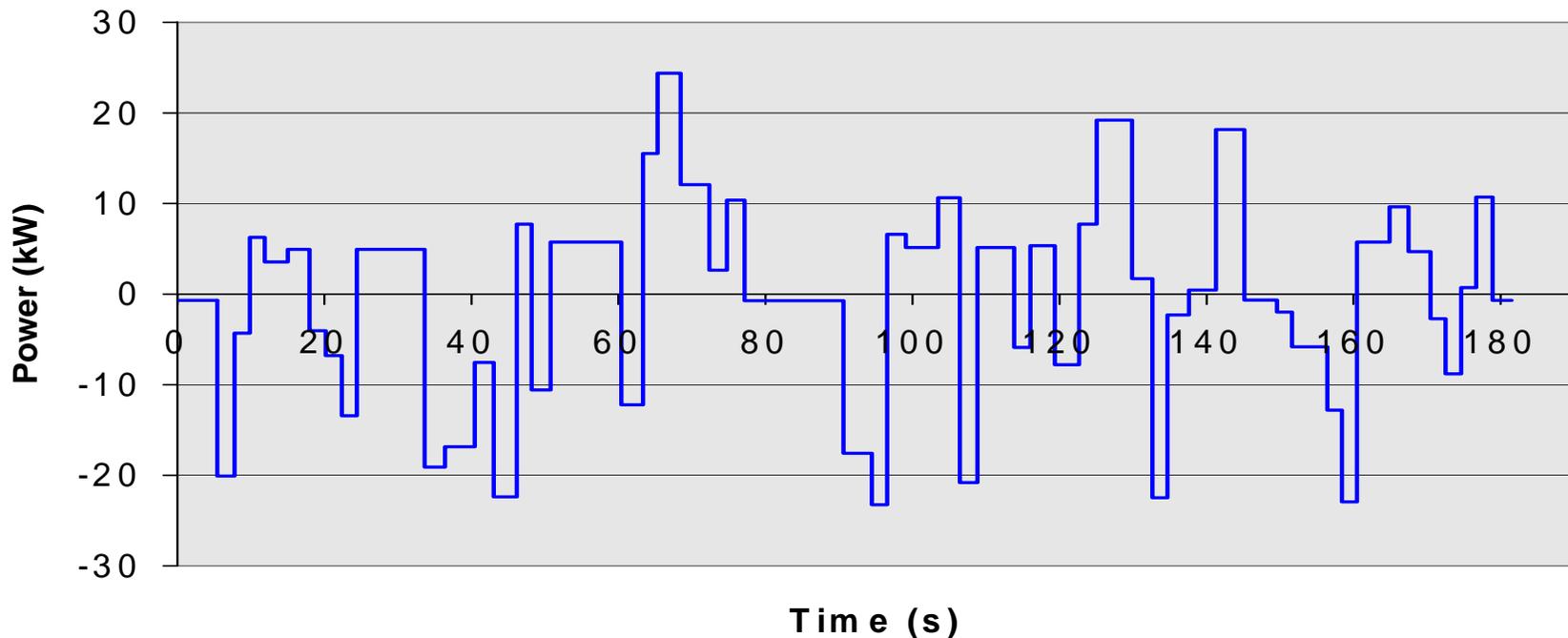
(Equivalent to a 2.6 hours / 50 miles drive)

Charge Depletion Mode



- 180 sec test cycle
- Run from 100% SOC down to approximately 25% SOC
- Mode ends when the battery voltage stays below a pre-defined threshold for more than 10 sec

Charge Sustained Mode



- 180 sec test cycle
- Run at approximately 25% SOC
- Mode ends when the duration of the charge depletion mode plus the duration of the charge sustained mode reaches 2.6 hours

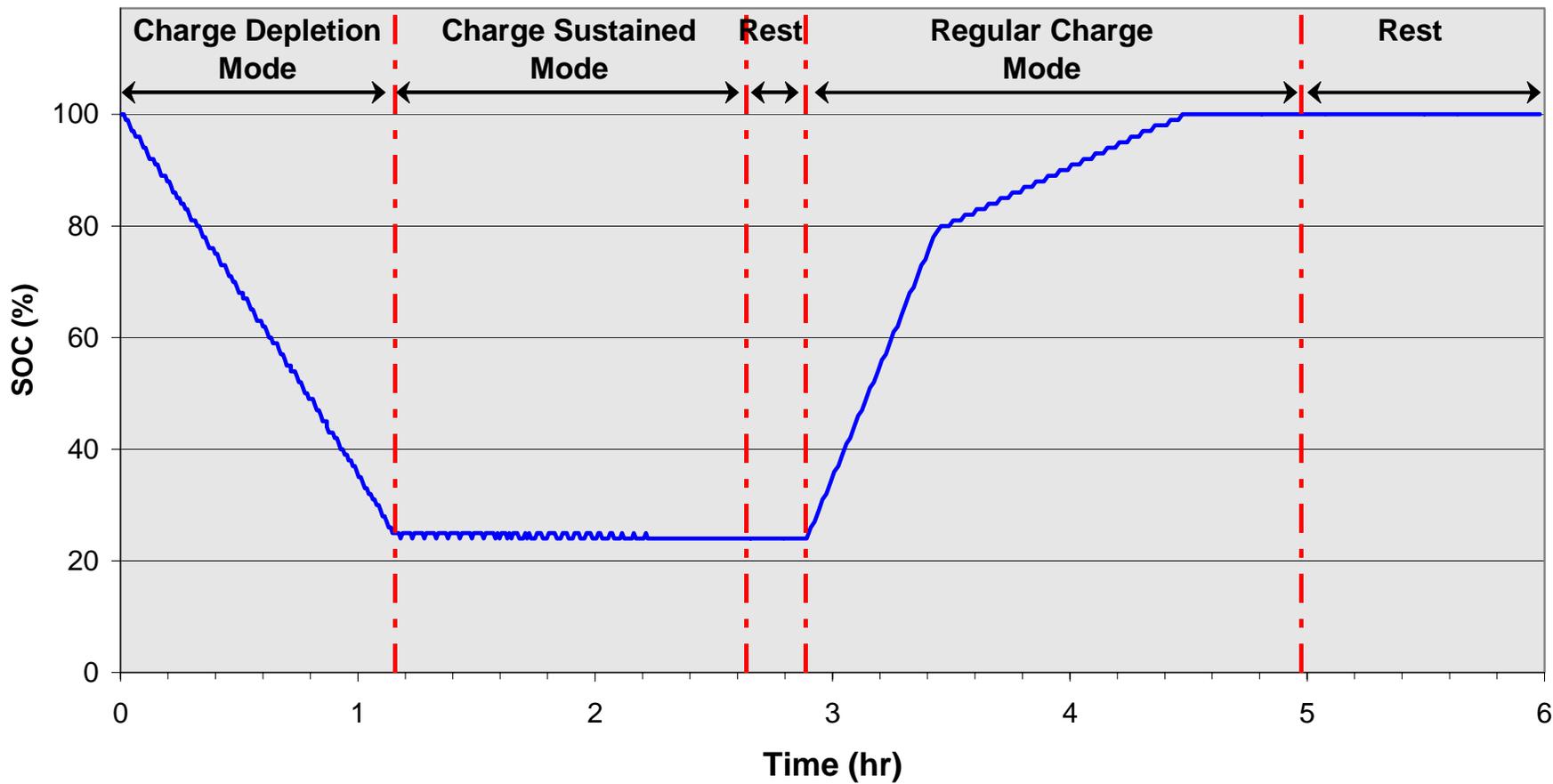
Regular Charge Mode

- A regular charge, following the manufacturer recommendation, is applied to the battery
 - Charge rate is C/1 for the VARTA NiMH battery
 - Charge rate is C/2 for the SAFT Li-Ion battery

PHEV Test Profile Summary

- Duration of the test profile (composed of the 3 described modes) is approximately 6 hours
- Approximately 4 cycles are applied per day
- Reference Performance Tests (RPT) are performed every 200 cycles

Actual Test Profile



- RPTs are performed every 200 cycles (approximately 50 days) and includes:
 - A C/1 Capacity Test
 - A C/3 Capacity Test
 - A Peak Power Test (USABC Test Manual)
 - An HPPC Test (Hybrid Pulse Power Characterization – PNGV Test Manual)

- VARTA NiMH Battery (DNP2)
 - Battery went through **1700** cycles – 16 Months
 - No significant capacity degradation
 - ~ 4% of power degradation
- SAFT Li-Ion Battery
 - Battery went through **1250** cycles – 14.5 Months
 - ~ 4% of capacity degradation
 - ~ 3% of power degradation

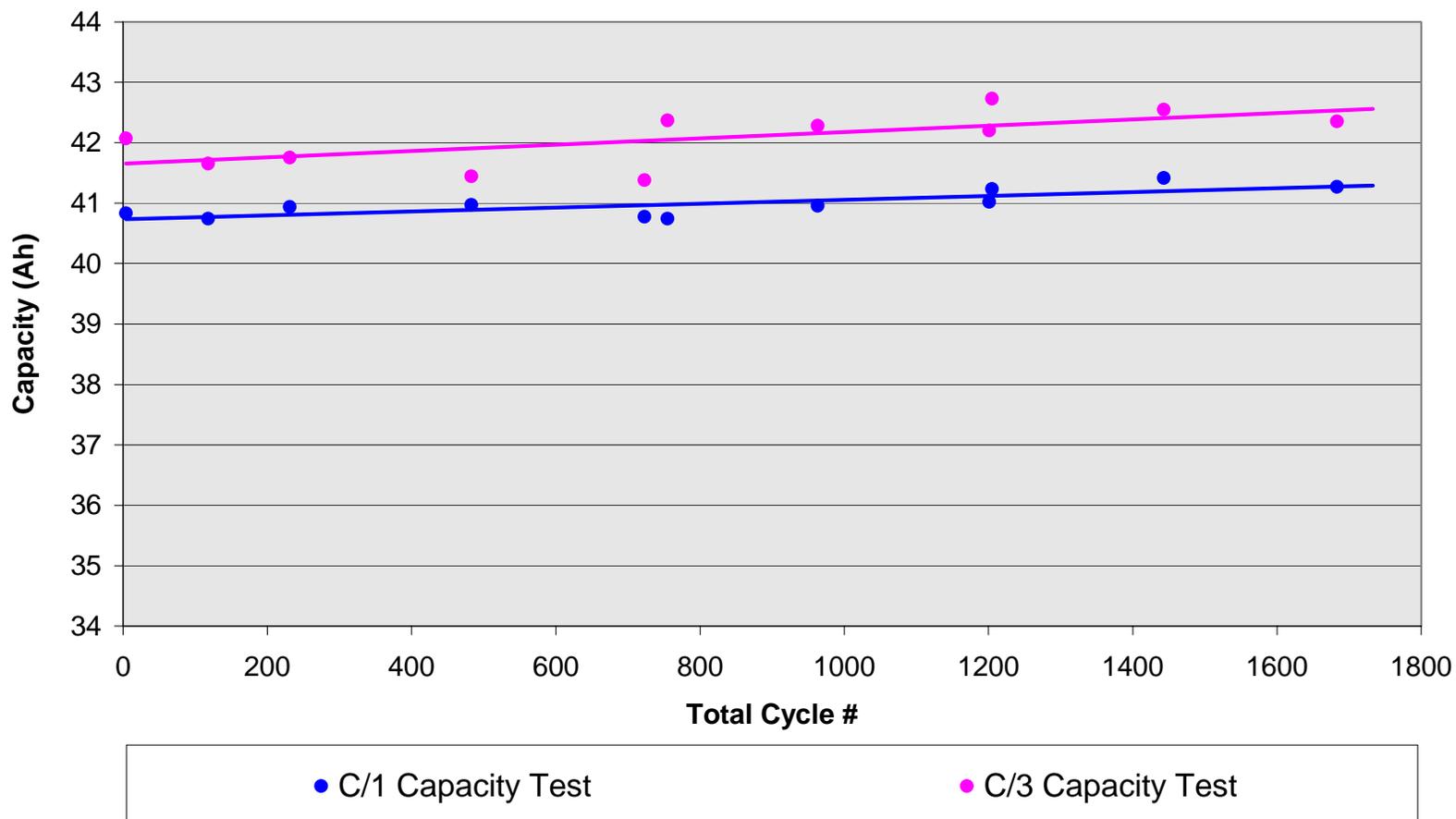


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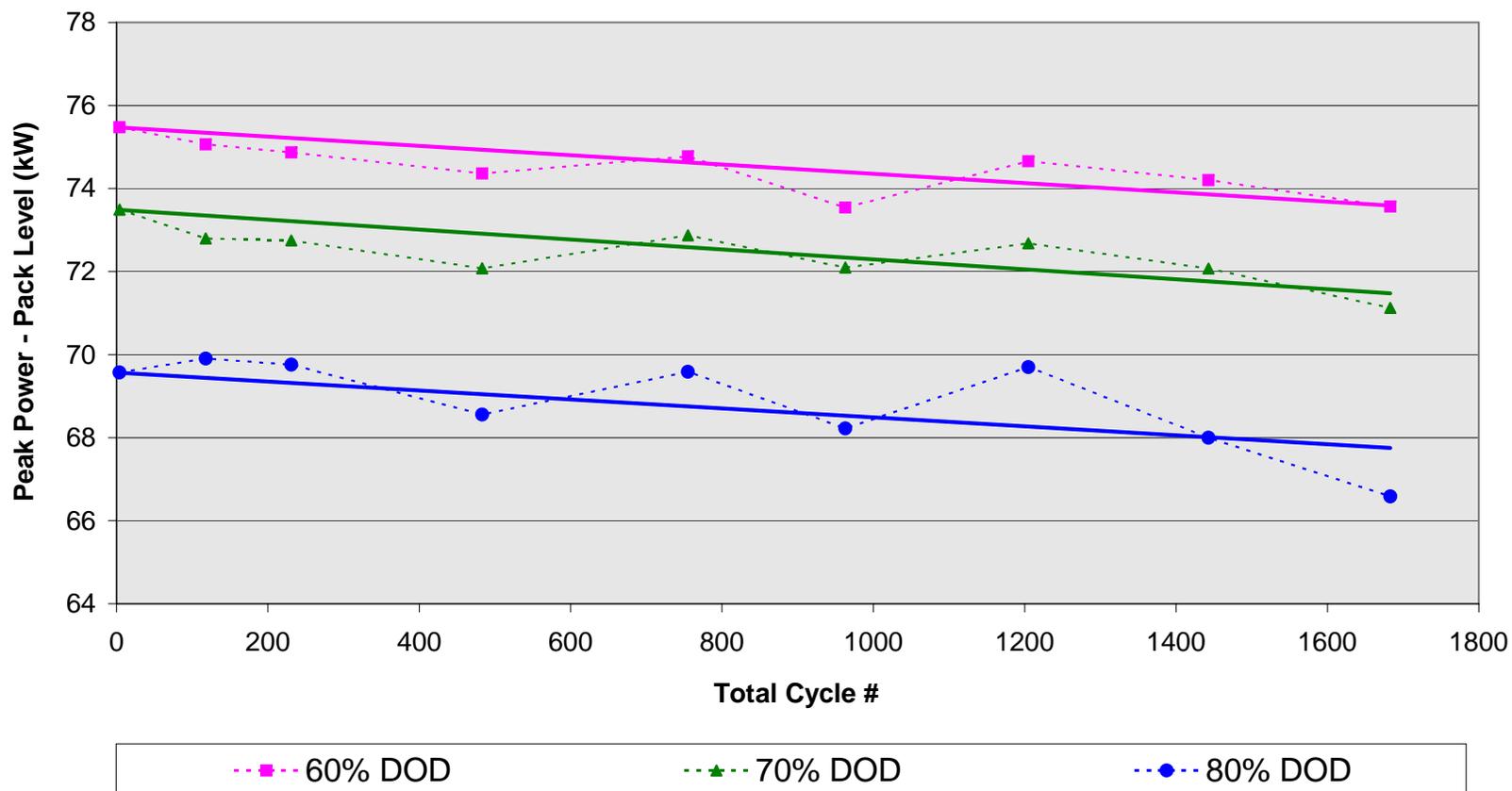
VARTA Battery Test Results

- Capacity Test
- Peak Power Test
- HPPC Test

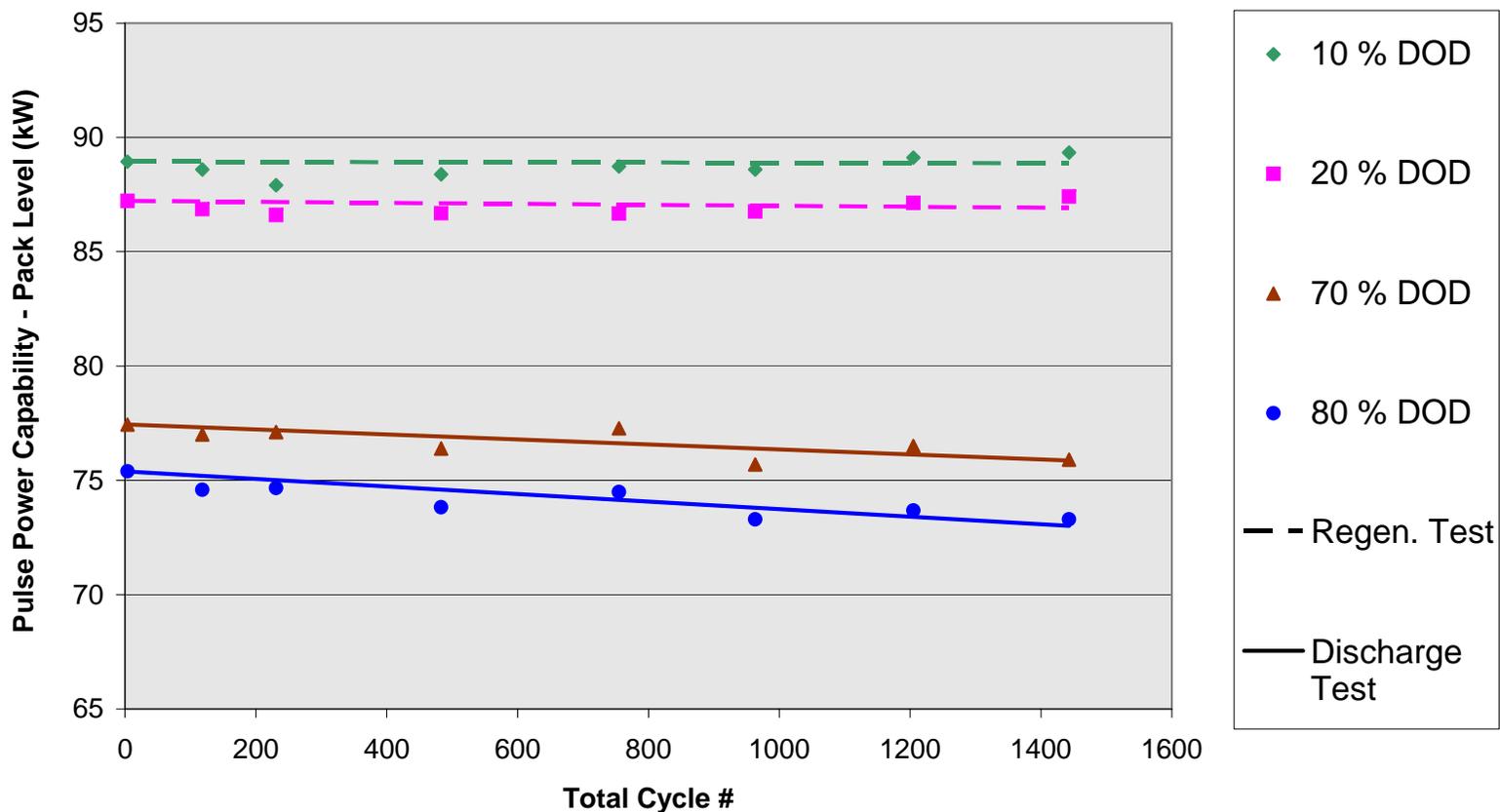
VARTA – Capacity Test Results



VARTA – Peak Power Test Results



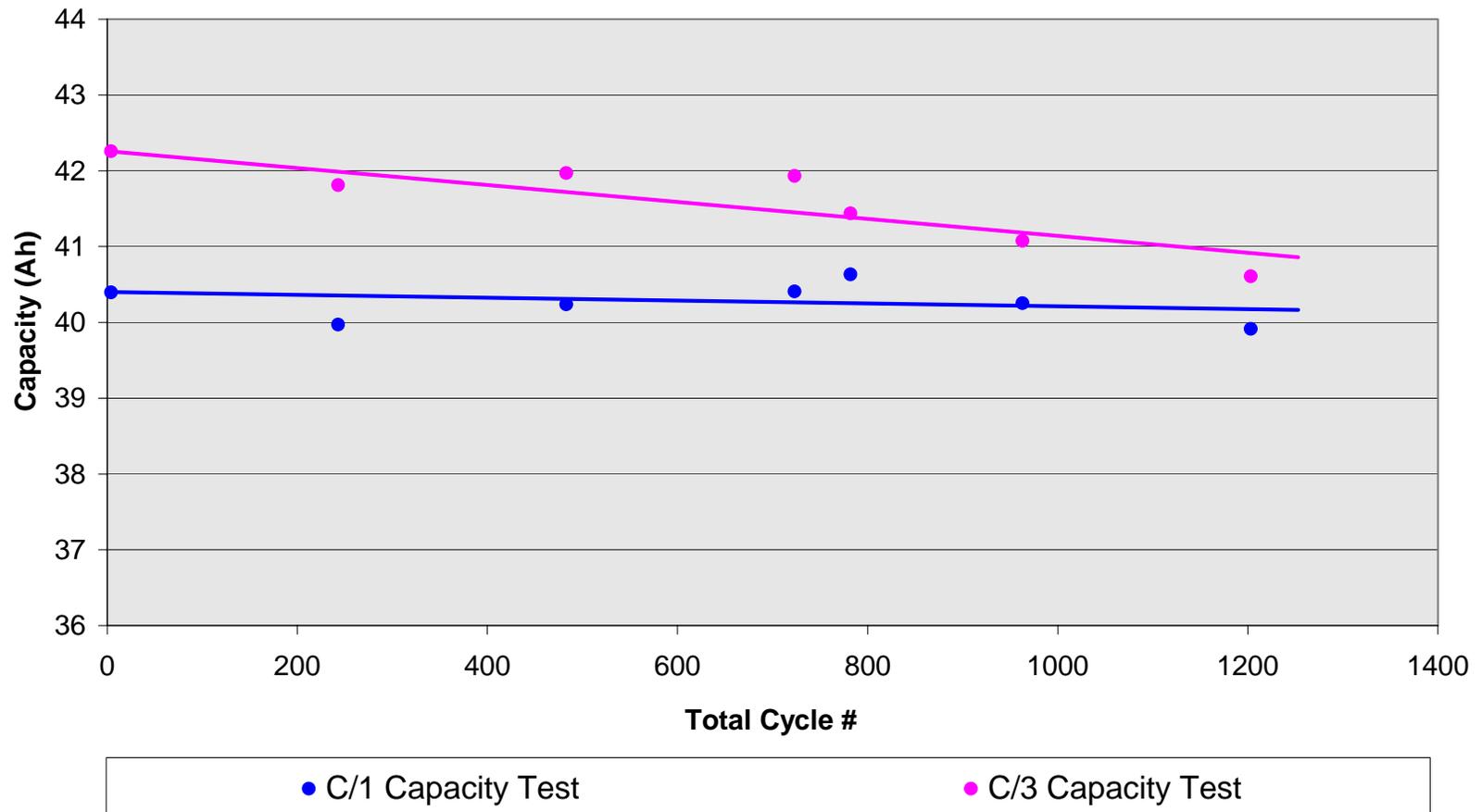
VARTA –HPPC Results



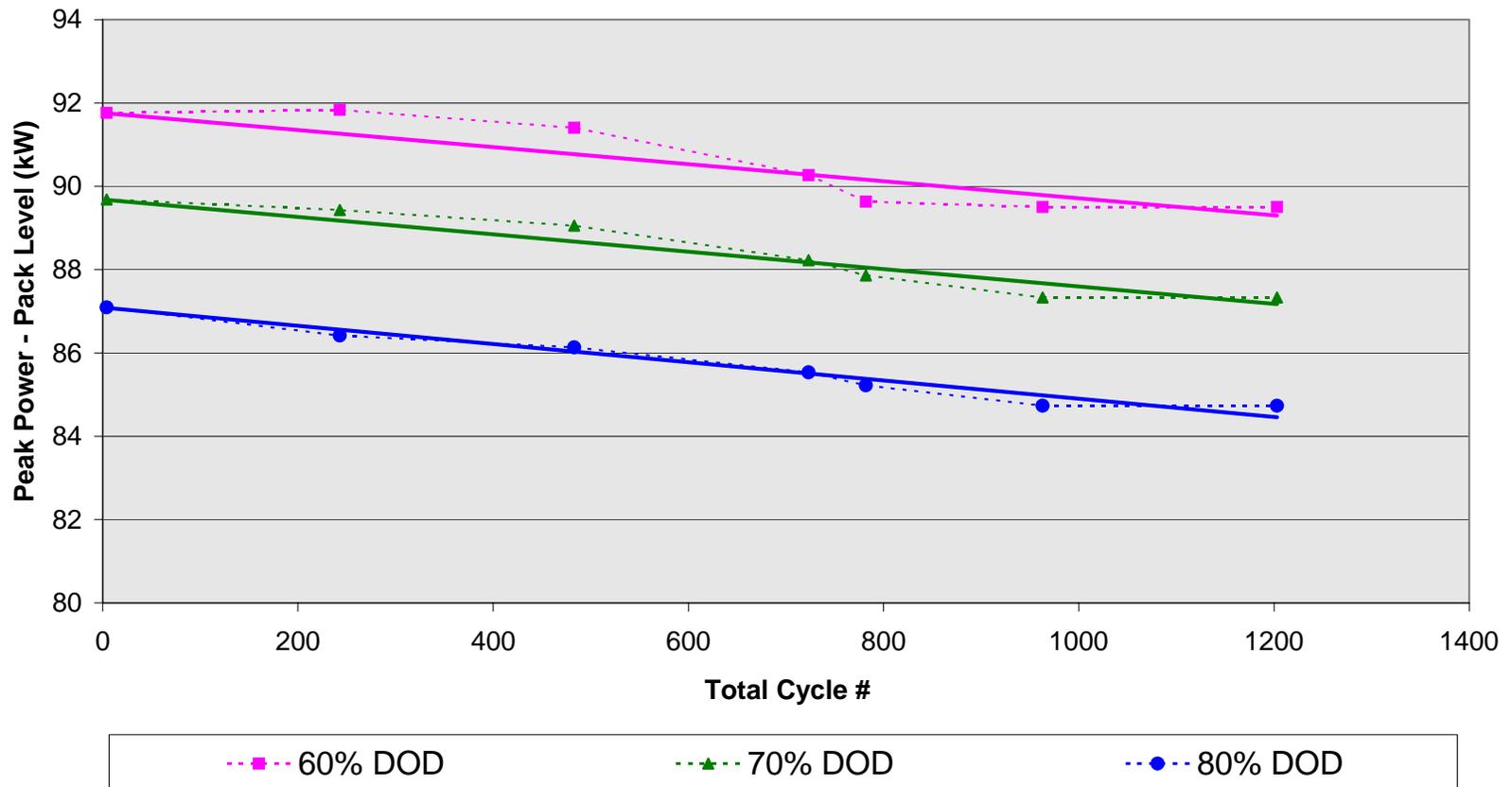
SAFT Battery Test Results

- Capacity Test
- Peak Power Test
- HPPC Test

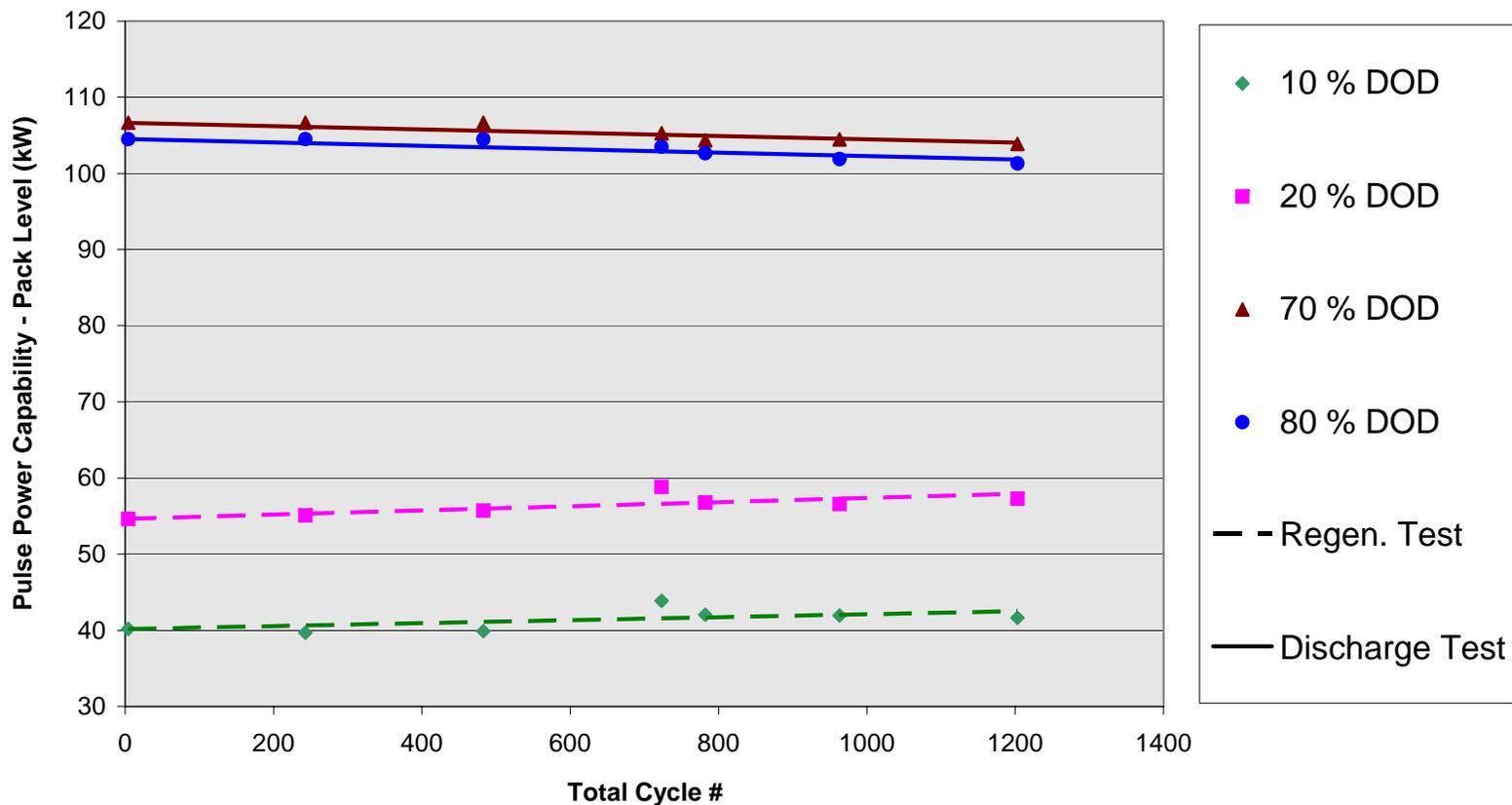
SAFT – Capacity Test Results



SAFT – Peak Power Test Results



SAFT – HPPC Results



- Continue battery modules testing for up to 3,000 cycles
 - Expected completion dates:
 - August 2007 for the VARTA battery pack
 - February 2008 for the SAFT battery pack
- Introduce full battery pack testing to validate sub-packs test results
 - Pending funding
- Three-year field evaluation of PHEV Sprinter battery systems (Phase 1 & 2 vehicles)



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