Expanding U.S.-based Lithium-ion Battery Manufacturing

P.I.: Robert Kamischke
EnerDel, Inc.
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Project ID: ARRAVT003

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Overview

Timeline

- Start January 2010
- End April 2014
- > 91% Complete (Phase I)

Barriers

- Lagging Customer Demand
- Financing
- Long Development Cycle(s)

Budget

- Total Project Funding $236 M
  - DOE - $118 M
  - EnerDel - $118 M
- Funding Received FY 2012: $62 M

Partners

- Equipment Suppliers
- EV Partners (Volvo, HHI, ATC)
- Purdue University
- USABC

Objectives - Relevance

- Develop competitive mass production capability for Lithium-ion battery cells & battery pack systems
  - Vertically integrated cell fabrication through pack assembly
  - Create domestic manufacturing capacity & skilled workforce
- Enhance supply chain & competitiveness of base materials
  - Develop and qualify domestic & international material suppliers
  - Improve performance, cost, & availability

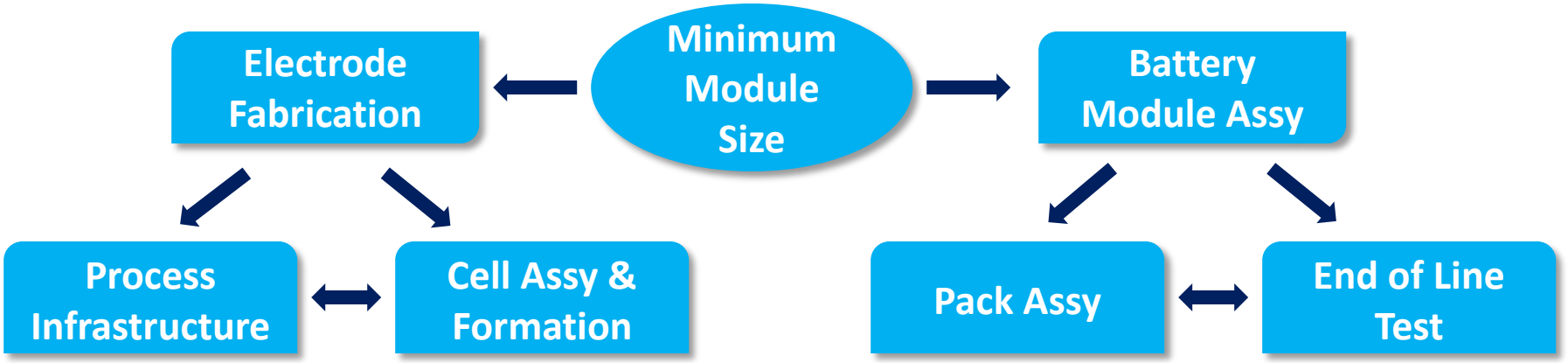
Objectives - Relevance

- Position EnerDel as a tier-one transportation supplier of advanced Lithium-ion battery pack systems
  - Implement APQP product development framework
  - Meet standards and acquire industry certification
  - Qualify manufacturing systems

Approach

- Scalable facility footprint
  - Adapt & upgrade existing cell fabrication site
  - Acquire a new mixed-use manufacturing facility
- Achieve maximum leverage of process infrastructure
  - Achieve break-through process cycle times to minimize equipment & people footprint

Approach



Approach

- “Seed” initial capacity installation; scale upon customer acquisition
  - Design-in batch & serial production build capability
  - Flex capacity with manpower/line-shifts
  - Address system bottlenecks as needed
  - Develop capability to process alternative source rolled or cut electrode materials
    - Develop material packaging & storage methods

Approach

- Layout and automation guidelines
  - Follow lean manufacturing principles
  - Focus automation on Key Product (KPC) and Special Process Characteristics (SPC)
  - Flex through-put with manpower +/-

Approach

- Tool to one standard form factor for cell
  - Adjust chemistry or electrode content to specialize cell characteristics
  - High capacity, mid-power, and high power models
- Tool to one standard form factor for battery module
  - Standardized stack-up from cell to element to module
- Customize for applications at pack level

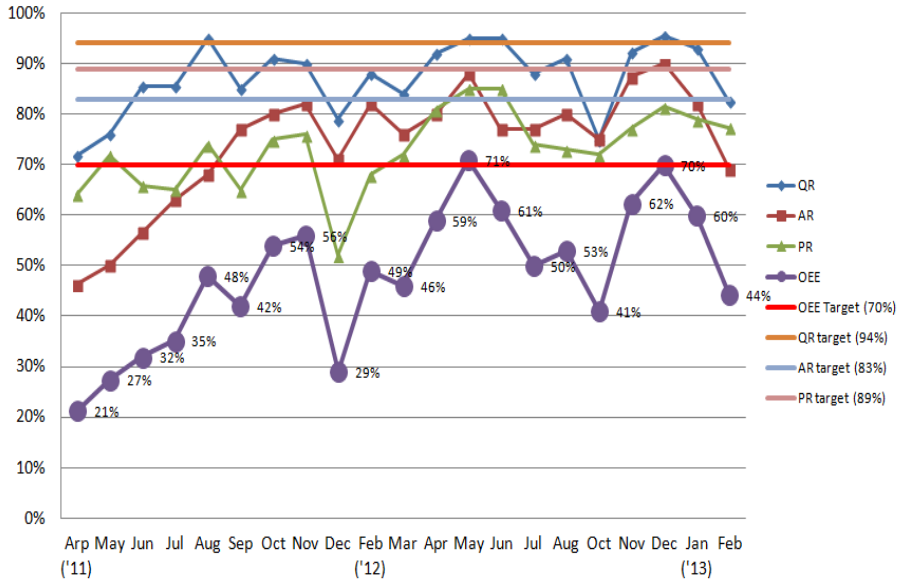
Technical Accomplishments/Progress

Facility II	3 mos.	1 mos.	2 mos.
Electrode	14 mos.	2 mos.	2 mos.
Cell Assy	7 mos.	2 mos.	7 mos.
Formation	9 mos.	3 mos.	3 mos.
Module/Pack	9 mos.	1 mos.	1 mos.

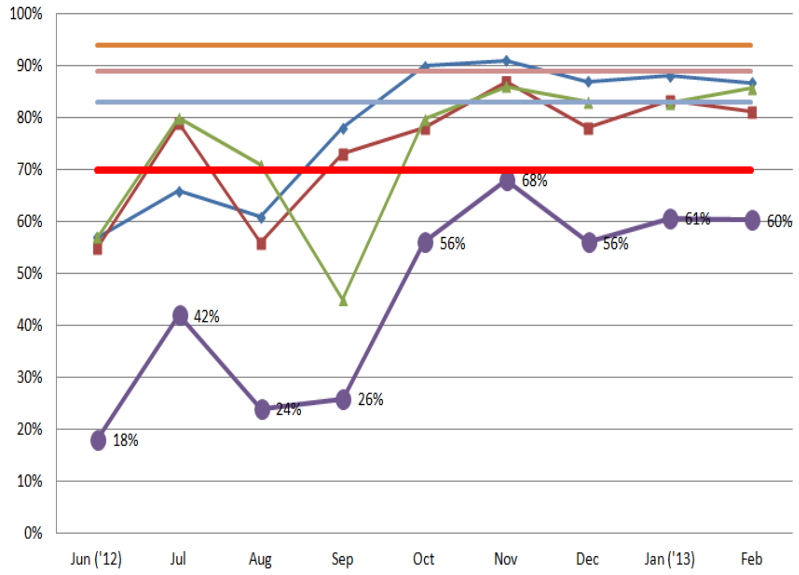
Technical Accomplishments/Progress

- Cell manufacturing
  - Production approval for EnerDel's first Lithium-ion cell mass production system
  - Cell Validation phase Overall Equipment Effectiveness (OEE) improvement

High Capacity Cell

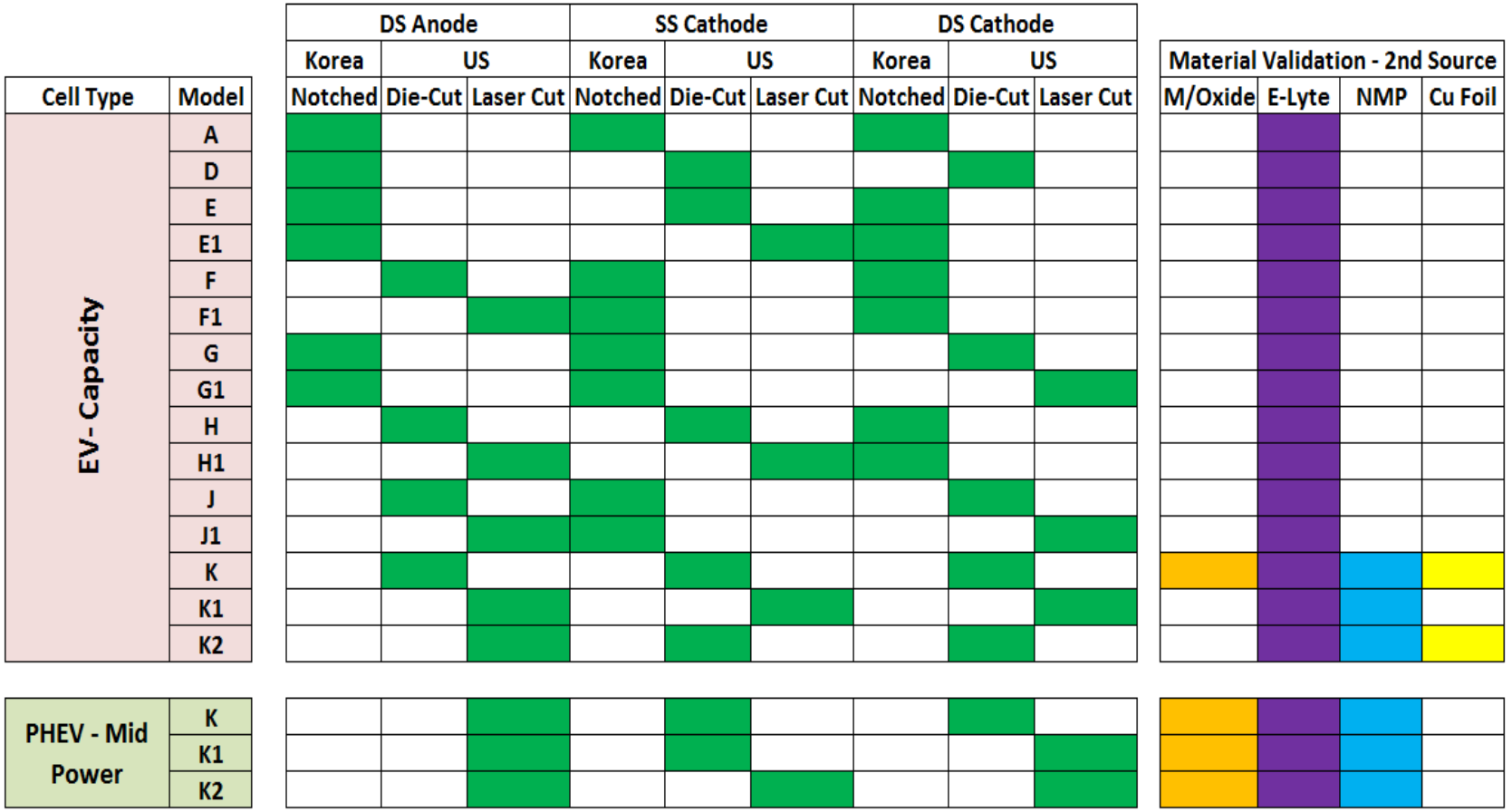


Mid-Power Cell



Technical Accomplishments/Progress

- Production Validation: Model Types & 2nd Material Sources



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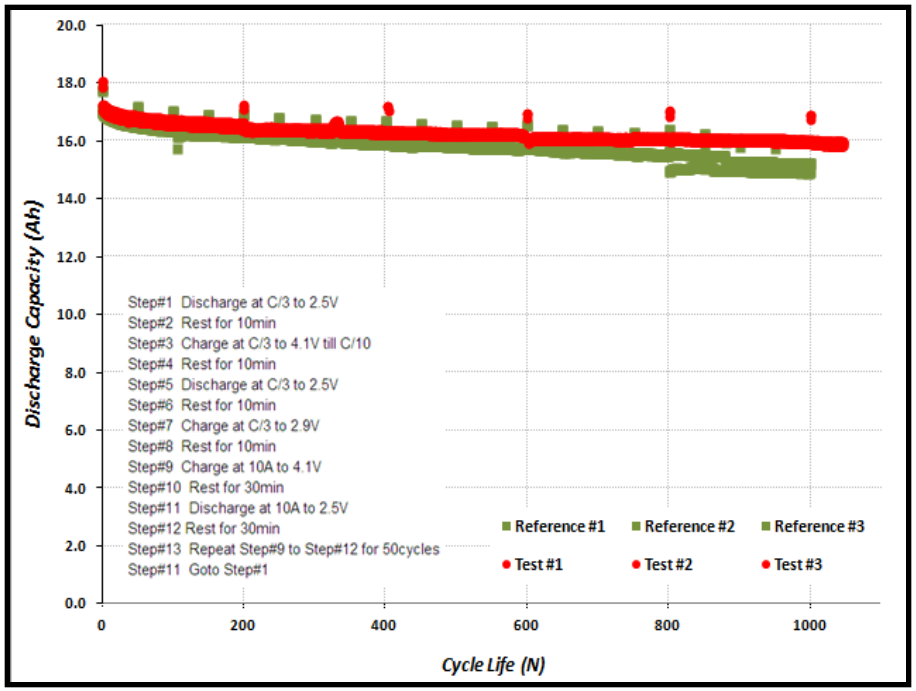
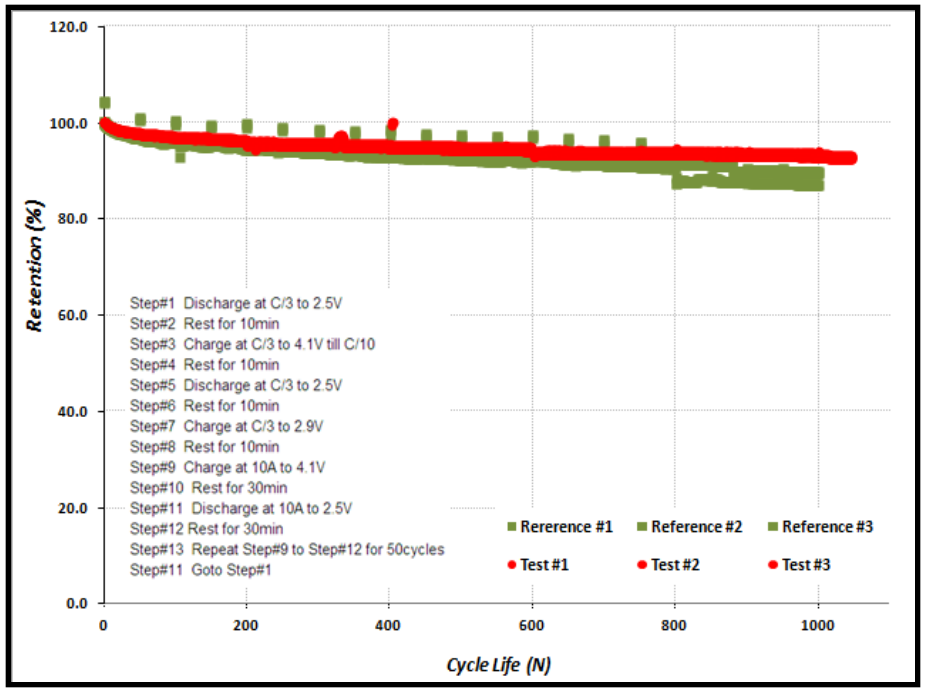
Technical Accomplishments/Progress

- Production validation cell cycling test results

High Capacity Cell – Standard Cycling



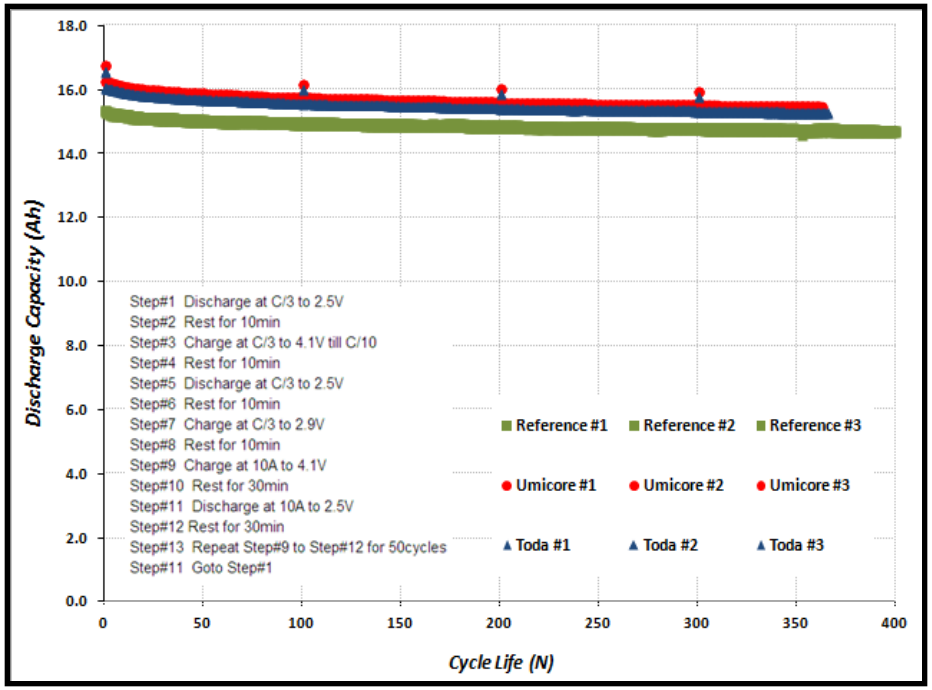


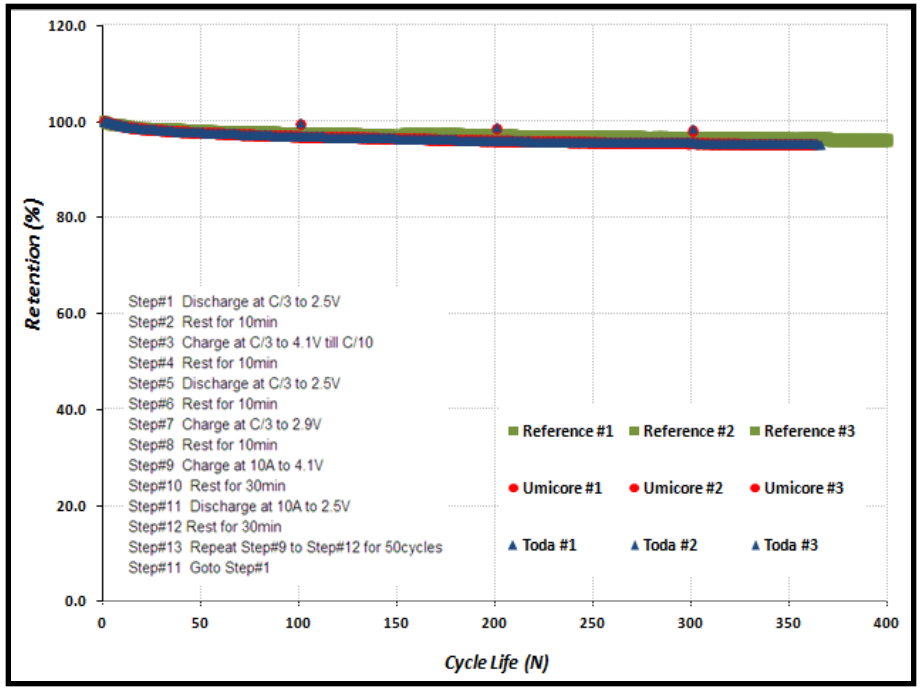
- Passed cycling test acceptance criteria

Technical Accomplishments/Progress

- Production validation cell cycling test results

Mid-Power Cell – Standard Cycling





- Acceptance pending test completion – on track

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Technical Accomplishments/Progress

- Module & pack manufacturing
  - Capacity ramped in 6 months to 17k equivalent EV Packs
  - Packs in customer use

Collaborations/Partnerships

- Strategic alliances result in the most advanced solutions as technology and infrastructure evolve

ESN ENERGY SYSTEMS NETWORK

Argonne NATIONAL LABORATORY

ITOCHU

PURDUE UNIVERSITY

PROJECT PLUG-IN

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

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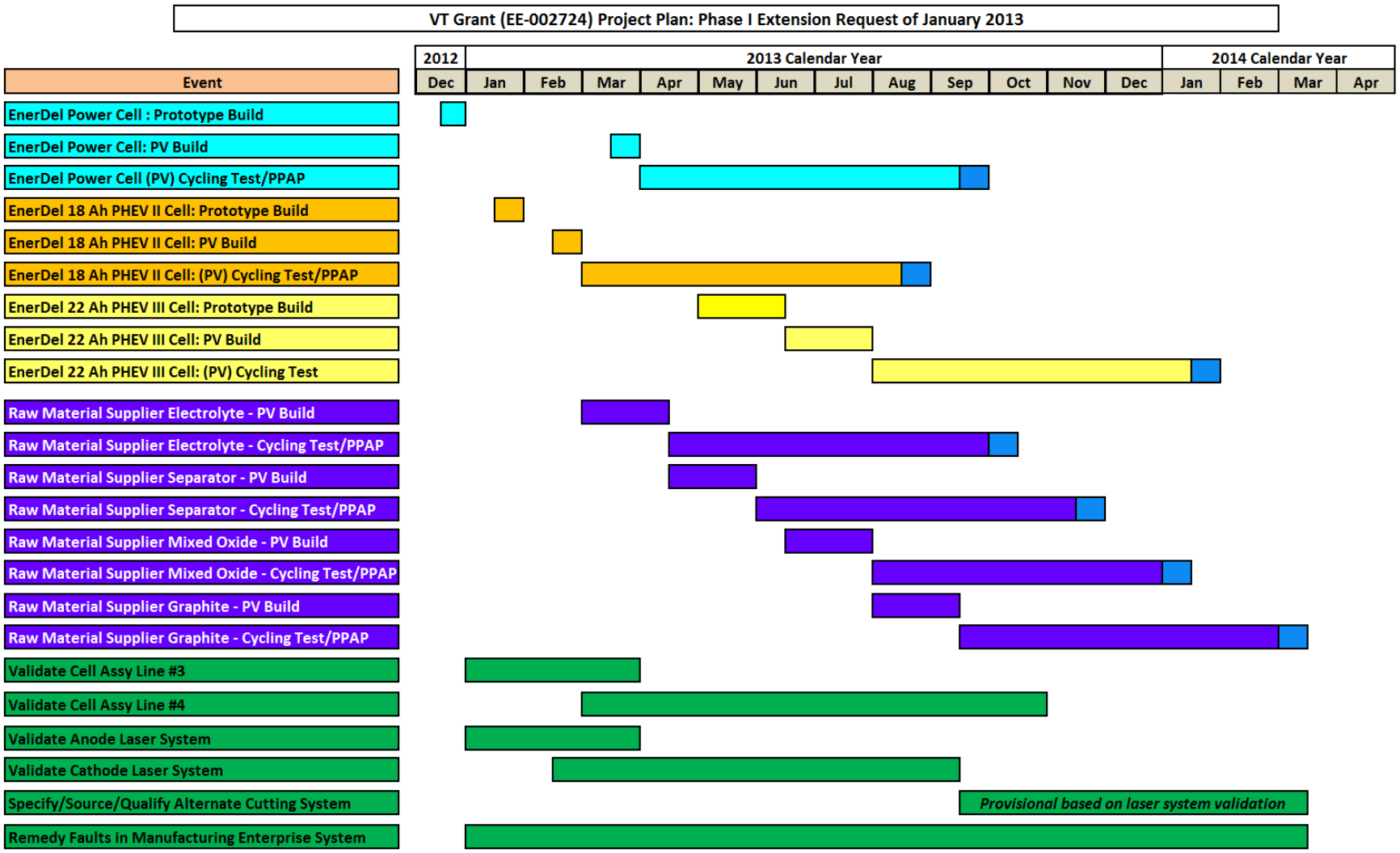
Future Work


VT Grant (EE-002724) Project Plan: Phase I Extension Request of January 2013
Event
2012
2013 Calendar Year
2014 Calendar Year
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
EnerDel Power Cell : Prototype Build
EnerDel Power Cell: PV Build
EnerDel Power Cell (PV) Cycling Test/PPAP
EnerDel 18 Ah PHEV II Cell: Prototype Build
EnerDel 18 Ah PHEV II Cell: PV Build
EnerDel 18 Ah PHEV II Cell: (PV) Cycling Test/PPAP
EnerDel 22 Ah PHEV III Cell: Prototype Build
EnerDel 22 Ah PHEV III Cell: PV Build
EnerDel 22 Ah PHEV III Cell: (PV) Cycling Test
Raw Material Supplier Electrolyte - PV Build
Raw Material Supplier Electrolyte - Cycling Test/PPAP
Raw Material Supplier Separator - PV Build
Raw Material Supplier Separator - Cycling Test/PPAP
Raw Material Supplier Mixed Oxide - PV Build
Raw Material Supplier Mixed Oxide - Cycling Test/PPAP
Raw Material Supplier Graphite - PV Build
Raw Material Supplier Graphite - Cycling Test/PPAP
Validate Cell Assy Line #3
Validate Cell Assy Line #4
Validate Anode Laser System
Validate Cathode Laser System
Specify/Source/Qualify Alternate Cutting System
Provisional based on laser system validation
Remedy Faults in Manufacturing Enterprise System

Summary Performance

Objective	Status
• Physical Facilities for LIB Production	in-place
• Qualified LIB Mfg'ing System	on-track
• Qualified/Trained Mfg'ing Staff	on-track
• Domestic Raw Material Suppliers	on-track