



## **VERTICALLY INTEGRATED MASS PRODUCTION OF AUTOMOTIVE CLASS LITHIUM ION BATTERIES**

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Project ID: ARRAVT018**

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# Overview

## Timeline

- Project start date: 3 Dec 2009
- Project end date: 2 Dec 2014
- Percent complete: 60%

## Budget

- Total project funding: \$498.18M
  - DOE share: \$249,090,000
  - Contractor share: \$249,090,000

## Barriers

- Barriers addressed
  - + Cost
  - + Performance (energy density)
  - + Manufacturability

## Partners

- DOE – USABC
- Equipment and materials suppliers

# Objective

- The overall objective of this project is to establish the manufacturing capability in the US to produce at least 500 MWh of automotive lithium ion batteries per year by the end of 2014.
  - + A123 will build a vertically-integrated factory capacity that encompasses the full production process, including: the manufacturing of cathode powder, electrode coating, cell fabrication, module fabrication, and the assembly of complete battery pack systems ready for vehicle integration. Design and production validation will also be performed under this program, ensuring that the products meet customer specifications, and that the production lines conform to standard automotive practice.

# Relevance

- Establishing automotive lithium ion battery manufacturing directly addresses the VT Program goal to develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum.
- The batteries manufactured under this program will provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment.

# Approach/Strategy

- The general philosophy of manufacturing expansion is to cost-effectively meet the rapidly escalating customer volume needs while managing operational risk. This approach will begin with low-risk, mature process technologies, improve the processes, and systematically increase throughput and lower costs over time. The first portion of the build-out involves the rapid deployment, using a “Copy Identical” approach wherein the initial Site 1 (Livonia) cell and module/pack factory capacity will be installed with the same processes and equipment currently used in the Recipient’s Asian factories, while increasing the level of automation for material movement and process control to increase output and boost productivity. Site 2 (Romulus 1) was completed in 2011 providing a fully automated coating capability.

# Approach/Strategy, continued

- The second portion of the build-out uses nearly identical equipment as what is used in the Site 1 production, but with increased throughput at specific operations that are at low risk. This “Copy Improve” high volume manufacturing (HVM) capacity will further reduce cost and headcount through additional automation, data collection and improved manufacturing execution platforms. Although this work started in 2010, the production facilities will be fully operational in 2011, with additional capacity being brought online in 2012 through 2014. Sites 2 and 3 of the manufacturing plan will use this “Copy Improve” philosophy. The Recipient will continue to improve specific operational output in powder, coating and cell assembly, as part of an ongoing effort to continuously improve productivity.
- The build-out of the manufacturing capability will occur in three (3) years, each corresponding to a specific location.

## Approach/Strategy, continued

- The build-out of the manufacturing capability will occur in five (5) years, each corresponding to a specific location.
- **Site 1 – Cell Plant and Module/Pack Assembly Plant (Livonia)**
- **Site 2 – Powder Plant & Coating Plant (Romulus 1)**
- **Site 3 – Cell Manufacturing & Module/Pack Assembly (Romulus 2)**

# Site 1 – Cell and Module/Pack Assembly Plant Livonia



- Site 1 focuses on the Low Volume Manufacturing plant using the “Copy Identical” approach and represented the bulk of the work of the project for 2010. These activities include Site 1 (Livonia) installation of cell assembly equipment, construction of dry rooms and validation testing.



# Site 2 – Powder Plant & Coating Plant (Romulus 1)



- Sites 2 and 3 use the “Copy Improve” approach, which uses nearly identical equipment as what is used for Site 1 production, but with increased throughput at specific operations that are at low risk. This “Copy Improve” high volume manufacturing (HVM) capacity will further reduce cost and headcount through additional automation, data collection and improved manufacturing execution platforms. Site 2 represents the first portion of powder and coating manufacturing on this program.

## Site 3 – Cell Manufacturing & Module/Pack Assembly (Romulus 2)



- Site 3 represents additional cell manufacturing and the first module/pack assembly facility on this program.

# Design and process validation

- Cell Design Validation (DV) is used to ensure that the cell meets specification and is accomplished through a Design Verification Plan and Report (DVP&R) process, which includes cell-level performance, life, environmental, and abuse testing.
- Production Validation (PV) testing is used to determine whether the process is capable of producing consistent product, while meeting the demands during an actual production run at quoted production rate.
- The Production Part Approval Process (PPAP) process includes many elements to ensure that specifications and requirements are understood and that the production process has the capability to consistently meet the requirements at production rate. Examples of PPAP elements include: design records, engineering change documentation, Engineering Approval, Design Failure Mode and Effect Analysis (DFMEA), Process Flow Diagram, Process Failure Mode and Effect Analysis (PFMEA), Control Plan, and Measurement System Analysis (MSA) Studies.

# Task 1 subtasks

## Establish Cell manufacturing in Site 1 (Livonia), the Low Volume Manufacturing facility.

- Subtask 1.1 Revise and maintain Project Management Plan; Report on activities
- Subtask 1.2 Hire engineering and manufacturing core team leaders. Complete factory design, layout, cost estimate, schedule and permits. Complete construction of all non-Manufacturing areas of building and order long lead facilities equipment.
- Subtask 1.3 Order, install and qualify equipment for cell design validation (DV) for cells. Start cell DV for cells made in existing plants as baseline for DV from US plants..
- Subtask 1.4 Order cell manufacturing line equipment and dry rooms. Begin construction of manufacturing areas and environmental mitigation equipment areas.
- Subtask 1.5 Complete construction; Install and qualify dry rooms and cell manufacturing line equipment.
- Subtask 1.6 Ramp-up of labor hiring to support manufacturing capacity
- Subtask 1.7 Complete Production Validation (PV) and Device Validation (DV) of cell manufacturing lines
- Subtask 1.8 Complete Production Part Approval Process (PPAP) for cell manufacturing lines

### Milestones Stage Gate Review 1

The Stage Gate Review will be used to assess whether the goal of establishing Pcell manufacturing was achieved. Completion of Production Part Approval Process (PPAP) for the cell manufacturing is the key criterion for successful completion of the Site 1 activity.

# Task 2 subtasks

## Task 2.0 – Establish one powder and coating manufacturing at Site 2 (Romulus 1)

- Subtask 2.1 Revise and maintain Project Management Plan; Report on activities
- Subtask 2.2a Hire engineering and manufacturing core team leaders. Design powder manufacturing line, layouts, cost estimate , schedule, permits and begin construction
- Subtask 2.2b Hire engineering and manufacturing core team leaders . Design coating line, layouts, construction drawings, cost estimates, schedule, permits and order long lead facility systems. Begin construction of all non-manufacturing areas.
- Subtask 2.3a Order powder manufacturing equipment and environmental mitigation systems. Begin construction of manufacturing areas.
- Subtask 2.3b Order coating manufacturing equipment and environmental mitigation systems. Begin construction of manufacturing areas.
- Subtask 2.4a Complete construction; Install and qualify powder manufacturing equipment
- Subtask 2.4b Complete construction; Install and qualify coating manufacturing equipment
- Subtask 2.5 Ramp-up of labor hiring to support manufacturing capacity
- Subtask 2.6a Complete production validation (PV) of powder line
- Subtask 2.6b Complete production validation (PV) of coating line
- Subtask 2.7 Complete Production Part Approval Process (PPAP) for powder and coating lines

# Task 3 subtasks

## Task 3.0 – Establish additional cell/module/pack manufacturing at Site 3 (Romulus 3)

- Subtask 3.1 Revise and maintain Project Management Plan; Report on activities
- Subtask 3.2a Hire engineering and manufacturing core team leaders. Design cell manufacturing line, layouts and construction drawings. Complete cost estimate, schedule, permits and begin construction. Order long lead facilities equipment.
- Subtask 3.2b Hire engineering and manufacturing core team leaders. Design module/pack manufacturing line, layouts and construction drawings. Complete cost estimate, schedule, permits and begin construction. Order long lead facilities equipment and begin construction of non-manufacturing areas.
- Subtask 3.3a Order cell manufacturing equipment and begin construction of manufacturing areas.
- Subtask 3.3b Order module/pack manufacturing equipment and begin construction of manufacturing areas.
- Subtask 3.4a Complete construction; Install and qualify cell manufacturing equipment.
- Subtask 3.4b Complete construction; Install and qualify module/pack manufacturing equipment.
- Subtask 3.5 Ramp-up of labor hiring to support manufacturing capacity
- Subtask 3.6a Complete production validation (PV) of cell manufacturing line
- Subtask 3.6b Complete production validation (PV) of module/pack manufacturing line
- Subtask 3.7 Complete Production Part Approval Process (PPAP) for cell and module/pack lines

# Milestones

- *Milestones      Stage Gate Review 1*  
The Stage Gate Review will be used to assess whether the goal of establishing Pcell manufacturing was achieved. Completion of Production Part Approval Process (PPAP) for the cell manufacturing is the key criterion for successful completion of the Site 1 activity.
- *Milestones      Stage Gate Review 2*  
The Stage Gate Review will be used to assess whether the goal of establishing powder and coating manufacturing was achieved. Completion of Production Part Approval Process (PPAP) for the powder and coating lines is the key criterion for successful completion of Site 2.
- *Milestones      Stage Gate Review 3*  
The Stage Gate Review will be used to assess whether the goal of establishing cell and module/pack manufacturing was achieved. Completion of Production Part Approval Process (PPAP) for the cell and module/pack manufacturing is the key criterion for successful completion of Site 3.

# Technical Accomplishments and Progress

- **Project 1 – Livonia – Cell Assembly**
  - + ASG Labs construction and equipment installation completed and operational
  - + Dry Room construction completed
  - + First Cell Assembly equipment delivered and installed
  - + Automated Formation and Aging systems installed
  - + Cells being produced and validated
- **Project 2 – Romulus 1– Powder & Coating**
  - + All construction activities complete
  - + Anode & cathode lines installed and being validated
  - + Pack assembly work commencing
- **Project 3 – Romulus 2 – Cell Assembly**
  - + Started final lease negotiations
  - + Preliminary design in progress



# Collaboration and Coordination with Other Institutions



- A123 has been working closely with equipment suppliers to ensure timely delivery
- The products to be made on this program have been developed, in part, through DOE-funded USABC programs
- A123 has been working closely with the Michigan Department of Natural Resources and Environment (MDNRE), formerly MDEQ

# Future Work

- Livonia
  - + Complete cell validation process
- Romulus 1
  - + Complete anode/cathode validation process
- Romulus 2
  - + Finalize design and construction documents
  - + Commence with building renovations