Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

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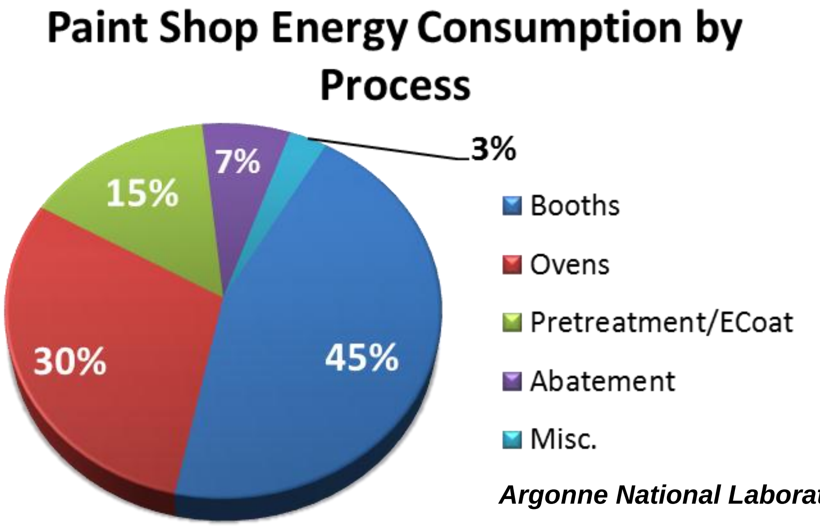
This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Project Objective

- Develop coatings, processes and facility design to reduce energy consumption in automotive OEM paint shops

70% of the automotive assembly plant energy is consumed in the paint shop



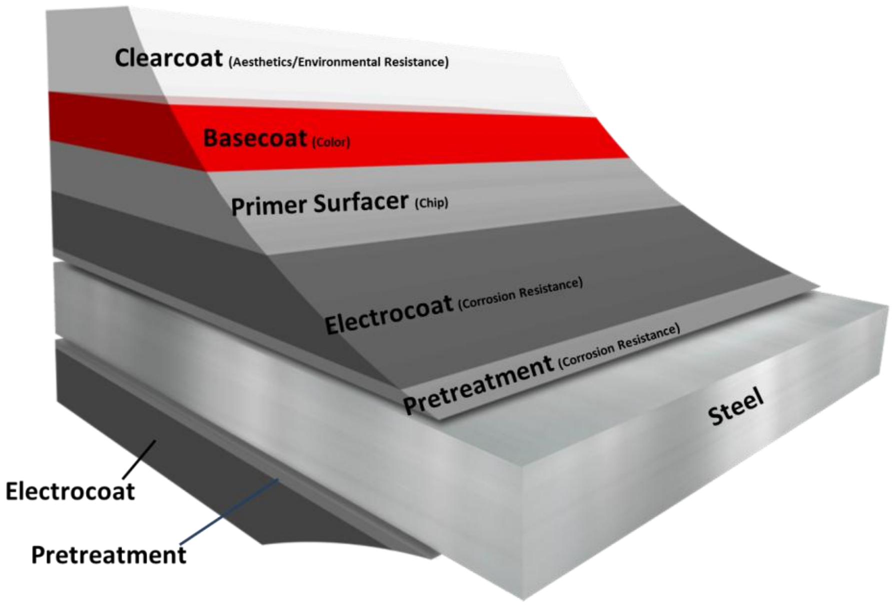
Argonne National Laboratory

- Technical Barriers
  - Maintaining coating properties at lower temperature cure
  - Low temperature cross-link chemistries not commercial
  - Adoption of waterborne technologies and VOC restrictions
  - Process optimization compatibility with "Brownfield" conversion

Technical Approach

Low Temperature Cure Coating Systems

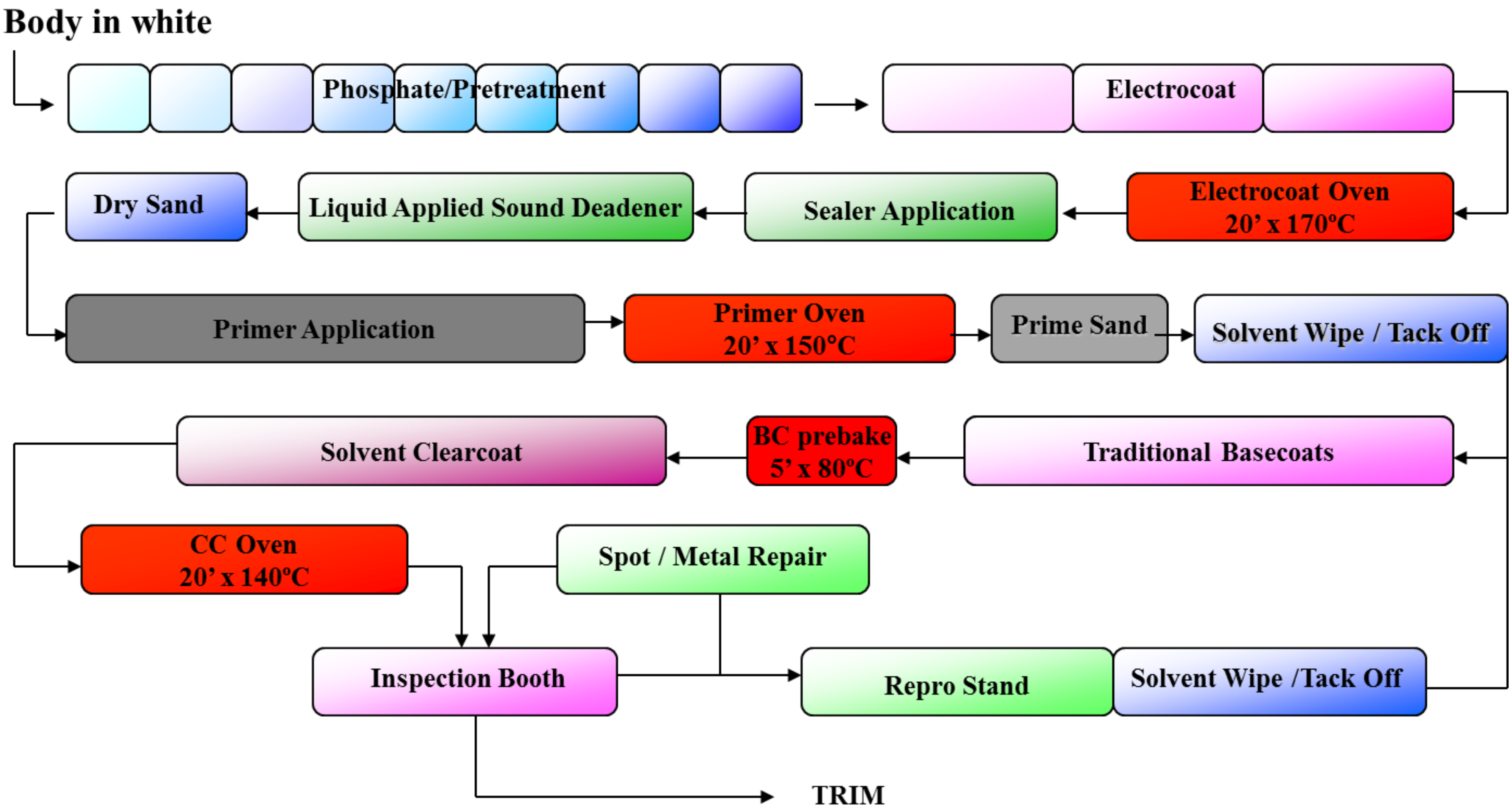
- Development of new low temperature cure polymers and formulas
- Five candidate chemistries identified
- Oven temperature reduction 140°C → <100°C
- Target layers include; Primer, Basecoat and Clearcoat



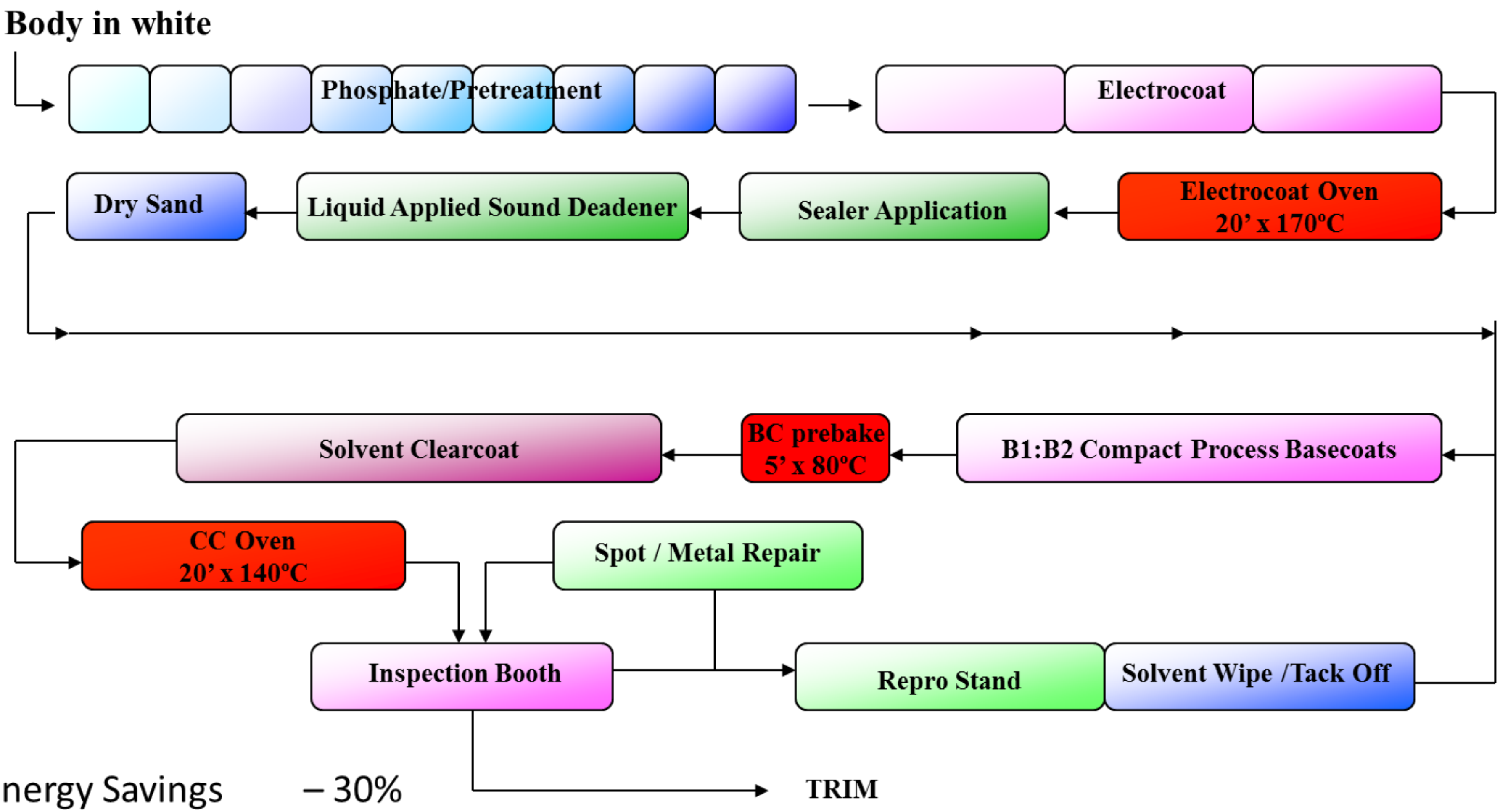
Energy Benefits

- Lower Oven Temperature
- Reduction in Waste Heat
- Faster Time Between Layer Applications
- Lowers Fresh Air Demand in Oven
- Reduced Temperature/Humidity Control Requirements
- Enable Lightweighting– Temperature Sensitive Substrates

Technical Approach – Conventional Process



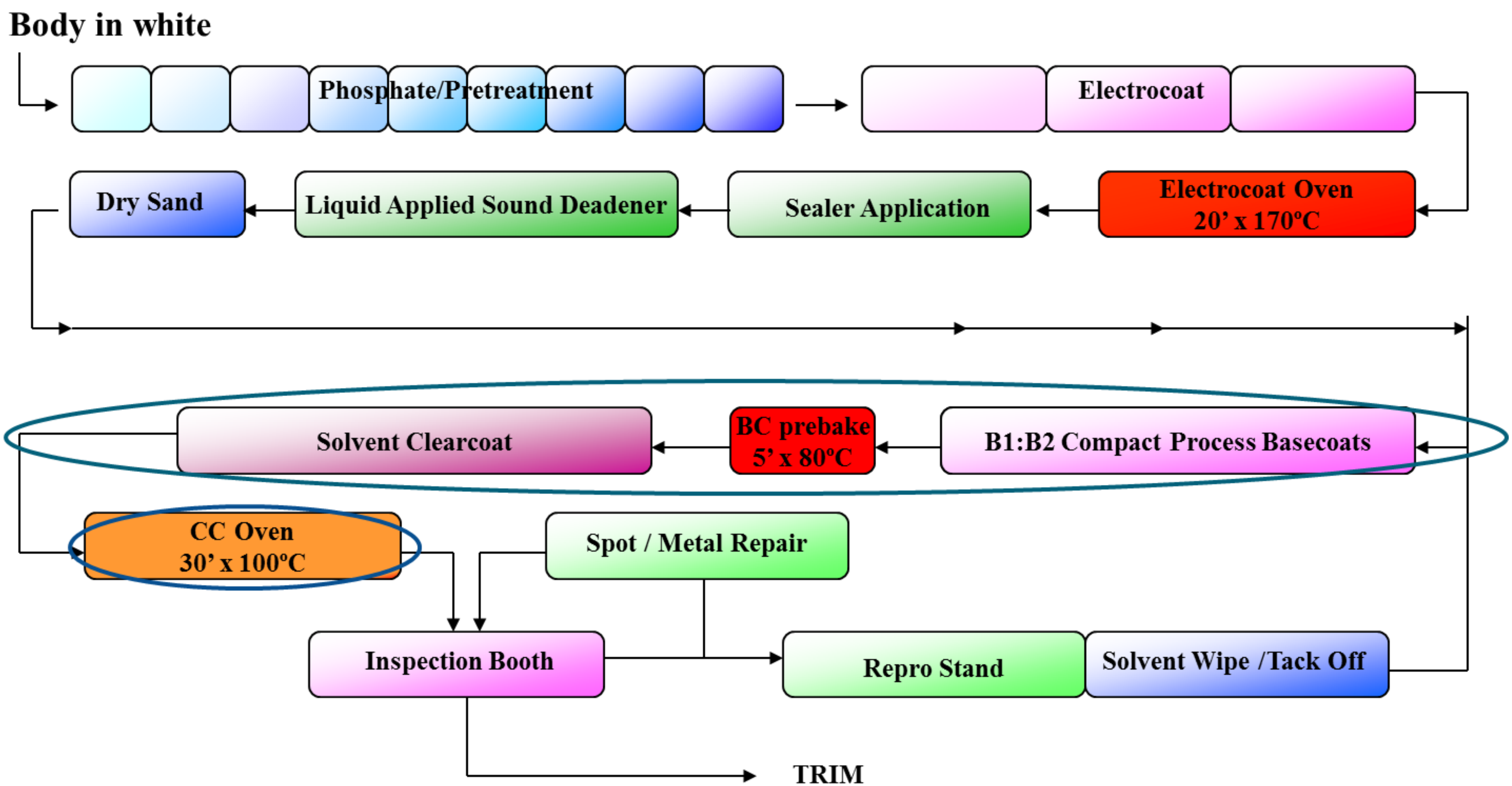
Technical Approach – PPG B1:B2 Compact Process



Energy Savings – 30%
CO_2 Reduction – 43%
VOC Reduction – 7%
Cycle Time Reduction – 15 minutes

BMW Spartanburg

Technical Approach

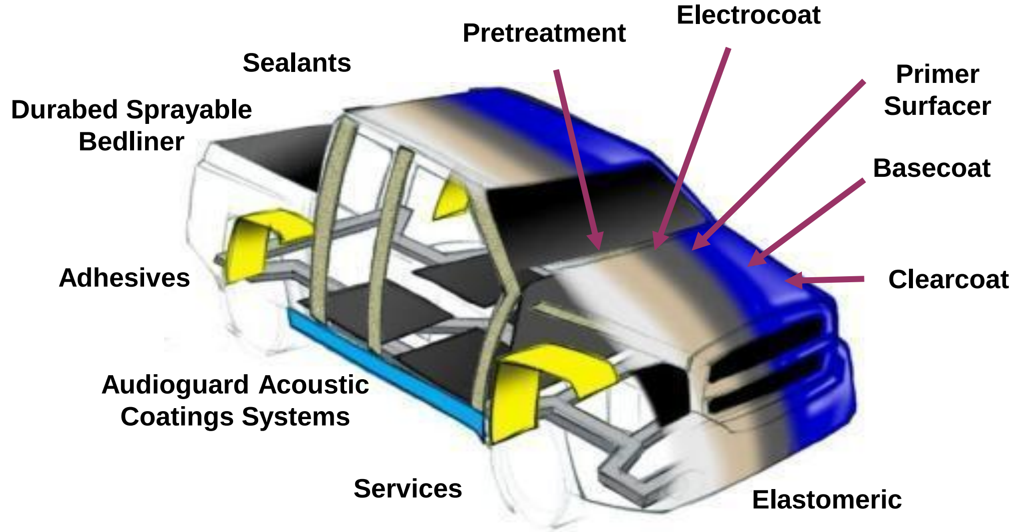


- Smaller manufacturing footprint
- Lower energy demand for conditioned air
- Lower capital cost

Transition and Deployment

- Automotive Industry

  PPG Innovations
  - ❖ Cationic Electrodeposition
  - ❖ Powder Clearcoat
  - ❖ B1:B2 Process



- Enable application temperature sensitive substrates and lightweighting

- Staged commercialization to manage risk
  - Low temperature application on existing lines
  - Monobooth conversion in target plant
  - Implementation dependent on automotive facility capital depreciation plans

Measure of Success

- Development of low temperature cure topcoat systems that meet performance property milestones
- Lab scale prototype validation of a consolidated topcoat booth design and associated energy saving
- OEM briefings are included in budget period go/no-go decisions and final deliverables
- Identification of an OEM partner for continued development and commercialization

- Project proposal identified 18 Tbtu/year savings based on 2012 US vehicle projection
- Dürr Systems will quantify energy calculations of material and process improvements relative to current baseline

Measure of Success - Go/No Go Criteria

Budget Period 1

1) Formulation <100°C cure
   Hardness- 75
   Solvent double rubs – 85
   Longwave – 25
   Shortwave - 35
   Flop index – 7.0
   DOI – 65

2) OEM project briefing

Budget Period 2

1) Formulation <100°C cure
   Hardness- 100
   Solvent double rubs – 100
   Longwave – 15
   Shortwave - 20
   Flop index – 8.5
   DOI – 80

2) OEM project briefing

3) Process conditions
   Fluid delivery rates equal current range
   Humidity range – 50% - 80%
   Temp. range - 70°C - 100°C

Budget Period 3

1) Formulation <100°C cure
   Hardness- 105
   Solvent double rubs – 100
   Longwave –12
   Shortwave - 20
   Flop index – 9.5
   DOI – 85

2) OEM project briefing

3) Process validation
   ull scale body panel application demonstrating prototype process and material improvements

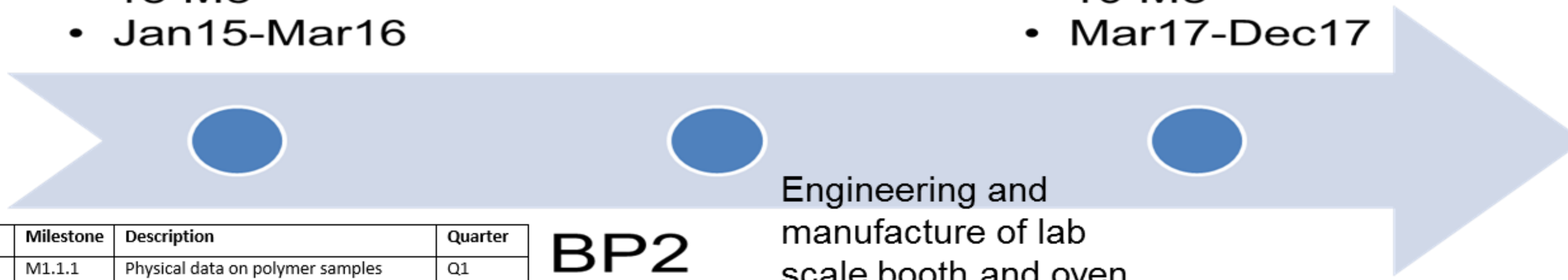
Project Management & Budget

BP1
- 15 Mo
- Jan15-Mar16

Develop low temperature cure polymers and formulas

BP3
- 10 Mo
- Mar17-Dec17

Lab scale validation of materials and process



BP2
- 11 Mo
- Apr16-Feb17

Engineering and manufacture of lab scale booth and oven designs

Title	Milestone	Description	Quarter
Synthesis	M1.1.1	Physical data on polymer samples	Q1
Initial Formulation	M1.2.1	Solid color basecoat/clearcoat application	Q2
Monobooth Coatings	M1.3.1	Metallic color basecoat/clearcoat applications	Q3
Monobooth Process	M1.3.2	Process variables defined	Q3
Combinatorial catalysts	M2.1	Catalyst investigations through combinatorial techniques	Q4
Design Principles	M3.3.1	Coating system design strategies communicated to equipment supplier	Q5
Chemistry Selection	M4.1	Coating chemistry down-selection	Q5
Combinatorial coatings	M6.1	Coating investigations through combinatorial techniques	Q6
Equipment Design	M7.4.1	Oven/booth equipment requirements defined	Q7
Equipment Fabrication	M7.5.1	Fabrication of lab scale equipment	Q8
Equipment Installation	M9.1	Equipment installation at PPG labs	Q9
Lab Scale simulations	M10.1	Demonstration using newly fabricated monobooth concept	Q10
System Optimization	M11.1	Coating systems demonstrated using optimized equipment and materials	Q11
Final reporting	M12.1	Final Reporting for entire project	Q12

Total Project Budget	
DOE Investment	$2,972,349
Cost Share	$1,273,722
Project Total	$4,246,071

Results and Accomplishments

- Project mobilization complete
- Lab studies of initial low temperature cure coating formulations demonstrating positive results