

# **Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts**

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Materials Innovation Technologies LLC

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Project ID #  
LM047

# Overview

## Timeline

- Start – October 2010
- Finish – September 2013
- 15% Complete

## Budget

- Total project funding
  - DOE - \$2,999K
  - Contractor share - \$1,500K
- Funding received in FY10
  - \$289K
- Funding for FY11
  - \$1,000K

## Barriers

- Barriers addressed
  - Cost
  - Manufacturability
  - Inadequate Supply Base

## Partners

- Proterra – bus exterior panel
- IAC – automotive interiors
- MFG – Corvette body part
- ICS – Materials/process evaluation
- MIT LLC - Project lead

# Objectives/Relevance

- Explore the use of virgin and reclaimed carbon fiber to produce both preforms and rollgoods for use in lower cost lightweight automotive components
  - MIT LLC's patented 3-DEP™ process for making complex net shape preforms addresses both Cost (lower material usage, less process waste and faster cycle times) and Manufacturability (fast cycle time and excellent part-to-part and within-part variation)
  - MIT LLC's development effort for producing rollgoods made from carbon fiber as well as carbon fiber-thermoplastic polymer Co-DEP materials addresses the same Cost and Manufacturability barriers identified by DOE
  - The use of MIT LLC's reclaimed carbon fiber addresses both Cost as well as Inadequate Supply Base through the reuse of currently landfilled materials

# Milestones

Month/Year	Milestone or Go/No-Go Decision
Jun-11	Milestone: Demonstrate Co-DEP rollgoods composition(s) and manufacturing processes. Complete, but additional work will be conducted with additional compositions.
Jun-11	Milestone: Large 3-DEP™ machine installed and ready for shakedown and startup. Behind schedule by four months due to delays in raising internal capital to complete machine construction.
Dec-11	Milestone: Shakedown and startup of large 3-DEP™ machine complete. Also behind schedule due to delays in fully funding machine construction.
Jun-12	Milestone: Overhead bracket validation at IAC complete. On schedule.
Sep-12	Milestone: Rocker panel technology demonstration and validation at Proterra complete. Well ahead of schedule. Materials selection has been finalized and process selection is nearly completed. Flexible tooling has been ordered.
Sep-12	Milestone: Door trim validation at IAC complete. On schedule.

# Approach / Strategy

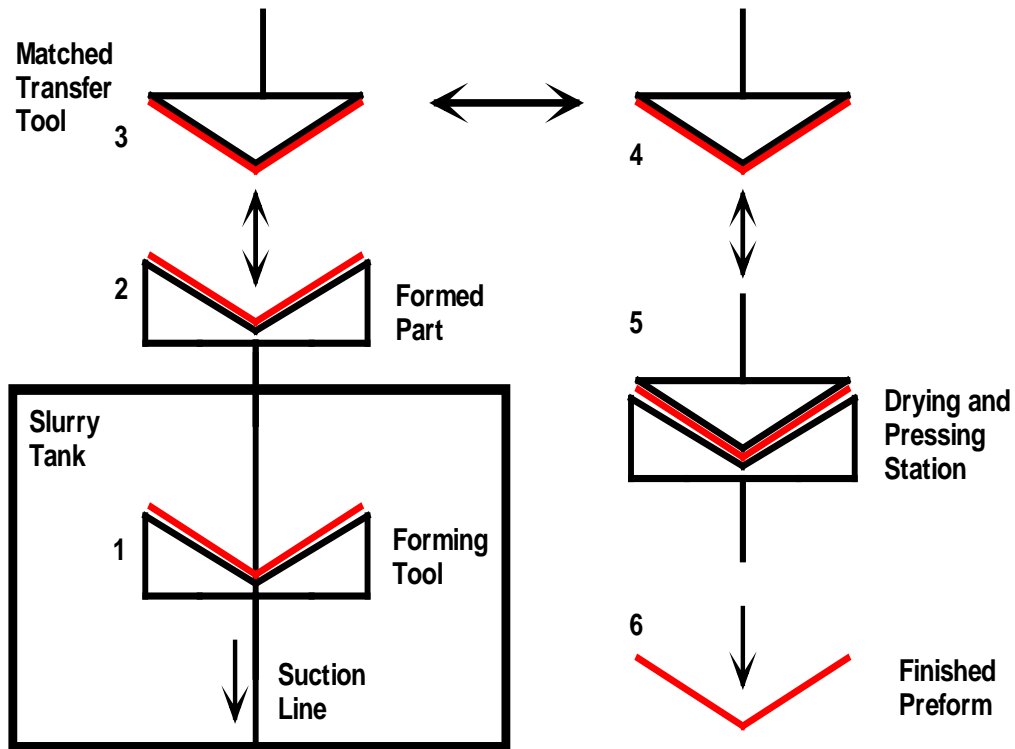


Figure 1. Schematic of traditional fiber slurry molding process.

(1) Fibers deposited on porous forming tool. (2) Formed part partially dried by vacuum. (3) Matched transfer tool picks up part from forming tool. (4) Partially dried part transferred to drying station. (5) Part dried using vacuum-assisted heating. (6) Finished preform.

# Approach / Strategy

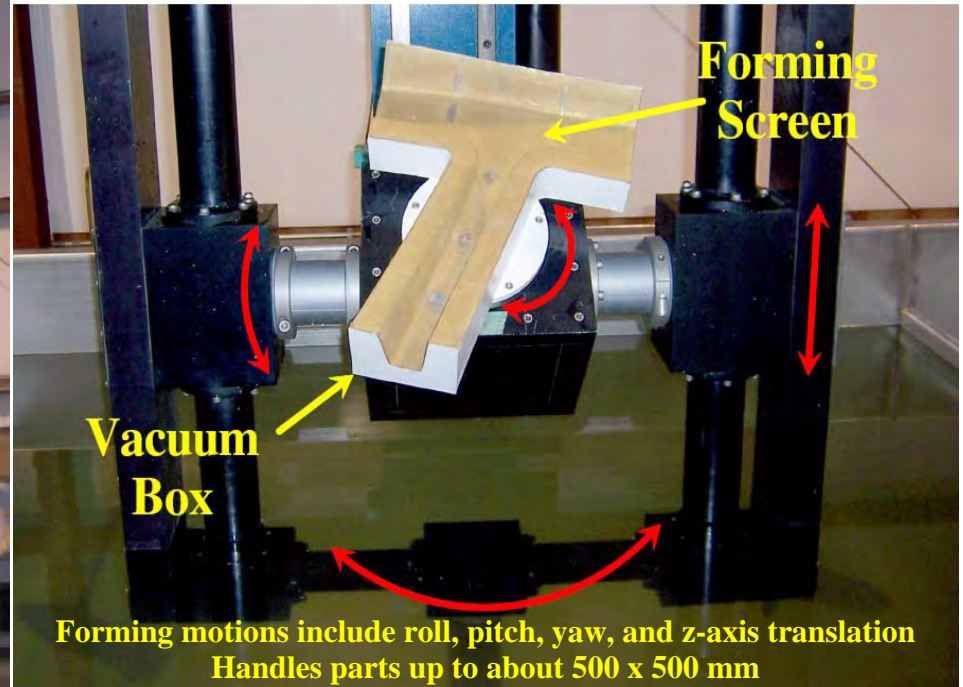


Figure 2. (A) Overview of the 20-foot tall, pilot-scale 3-DEPT™ machine. (B) Detail of the forming head of the 3-DEPT™ machine showing the forming screen for an automotive "B-pillar" (used in the Phase I project) and the four degrees-of-freedom (roll, pitch, yaw, and z-translation) that provide the unique forming capability of the 3-DEPT™ technology.

# Approach / Strategy

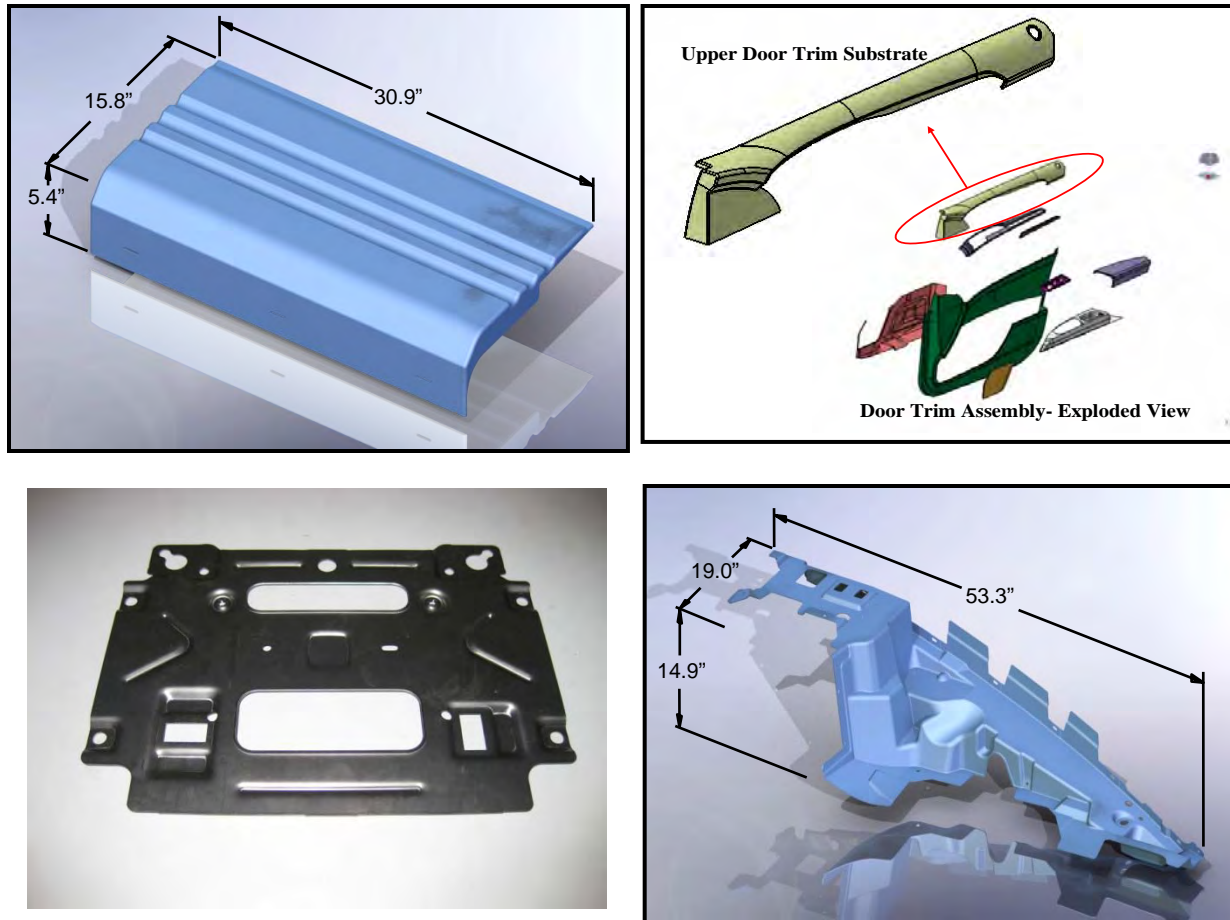


Figure 3. Overview of the automotive and bus components we plan to fabricate during the Phase III project. (A) side rocker panel for an electric bus - Proterra; (B) upper door trim substrate for the Ford Fusion/Mercury Milan - IAC; (C) overhead bracket for Chrysler Minivan - IAC; (D) front wheelhouse inner for the Corvette - MFG.

# Approach/Strategy

- Two processing routes are being explored
  - 3-DEP™ for producing preforms with 3-dimensional shape, deep molding draws or tight radii at short cycle times (1 minute)
  - Continuous rollgoods for use in relatively flat final part geometries
- Two main materials routes are being explored with each of the processing routes
  - Carbon fiber (for thermoset applications)
  - Co-DEP materials containing carbon fiber and one or more thermoplastic resins co-deposited into a felt-like material
  - A variety of thermoplastic resins are being studied including PPS, PA, PP, PE and PET
- Goal is to utilize the improved properties achieved by the introduction of carbon fiber to reduce the thickness and mass of current parts



# Technical Accomplishments



- Task 1: Rollgoods Development
  - Initial trials completed using Carbon Fiber alone along with Co-DEP rollgoods consisting of CF/PP, CF/PA and CF/PPS
  - 26" wide material made in roll form up to 200 ft. in length
  - Total length of rollgoods produced to date in excess of 1 mile
  - Further efforts will evaluate additional Co-DEP combinations of materials while improving material uniformity

# Technical Accomplishments



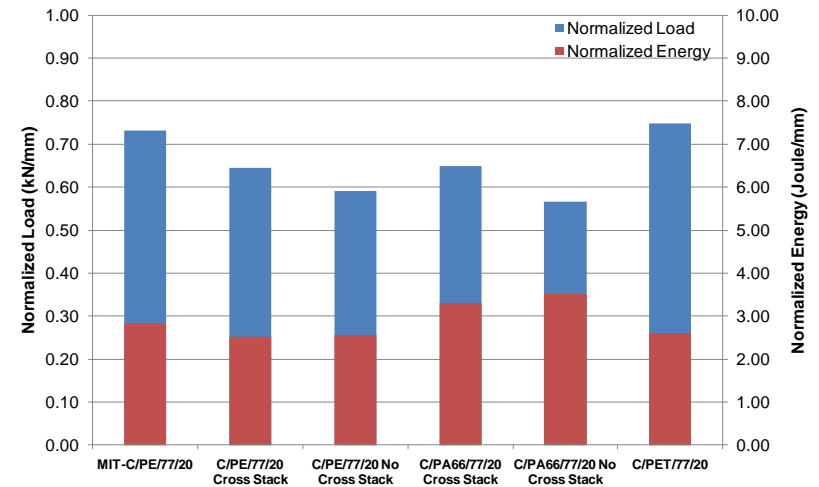
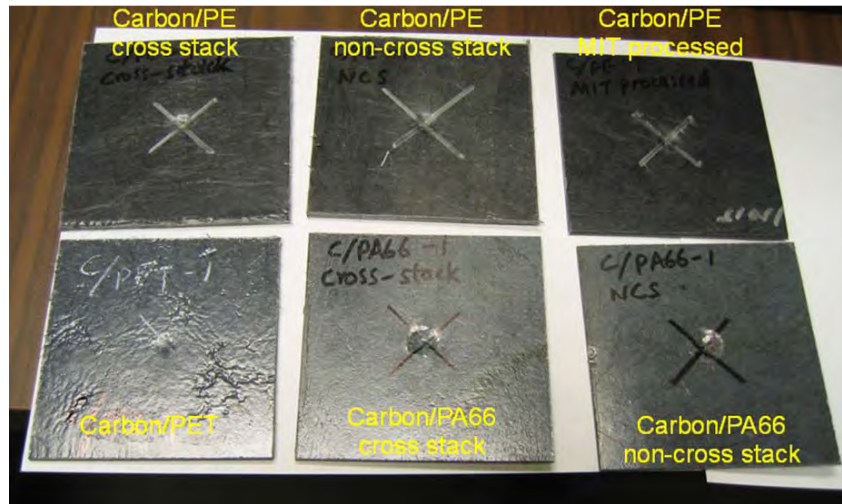
- Task 1: Rollgoods Development
  - Thermoforming was successfully demonstrated with CF/PPS rollgoods
  - An existing tool for an aircraft seatback was utilized to keep tooling costs down

# Technical Accomplishments



- Task 2: Rocker Panel (Proterra Bus)
  - A wide range of Co-DEP materials have been explored including CF/PP, CF/PA, CF/PE and CF/PET
  - Extensive materials property testing including low velocity impact testing has been completed
  - CF/PET offers the best combination of properties for this specific application – cost, strength, stiffness, impact strength, abrasion resistance, paintability

# Technical Accomplishments



- Task 2: Rocker Panel (Proterra Bus)
  - Materials property test results show that CF/PET offers a nice compromise between CF/PE or CF/PP and CF/PA
  - CF/PA66 exhibited the most brittle failure during impact testing - most likely due to the higher interfacial adhesion properties between the PA66 and the carbon fiber
  - CF/PET had high tensile properties (similar to CF/PA66) without the processing issues and moisture pickup of PA
  - PET polymer has an established recycling chain



# Technical Accomplishments



- Task 3: Door Trim Support (IAC)
  - Proof-of-concept compression molding trials have been completed in order to validate the development plan
  - Initial Co-DEP materials evaluation completed with several materials
  - IAC is moving forward with investments in advanced thermoforming tooling and processing equipment

# Technical Accomplishments



- Task 5: Large 3-DEP™ Machine – Build, Install, Shakedown
  - Equipment layout and infrastructure was completed ahead of schedule and on budget
  - Main stainless steel forming tank was fabricated and installed ahead of schedule
  - Machine design, construction bids and initial fabrication was completed ahead of schedule
  - Final construction is behind schedule due to internal capital funding issues, but completion is scheduled for December 2011

# Collaborations

- Partners
  - **Proterra Bus** (Industry): lightweight structures for use on their electric/hybrid bus
  - **International Automotive Components (IAC)** (Industry): lightweight interior components for a variety of automotive OEMs
  - **Molded Fiber Glass (MFG)** (Industry): lightweight automotive parts for GM/Corvette
  - **Innovative Composite Solutions (ICS)** (Industry): molding process evaluations
  - **University of Alabama at Birmingham (UAB)** (Academic): materials property testing

# Future Work

- Build prototype tooling for Proterra Bus rocker panel and evaluate vacuum molding, single diaphragm forming and compression molding with the goal of developing a cost model and business case leading to commercialization of a family of lightweight bus parts
- Continue development of the rollgoods manufacturing process with the goal of improved material uniformity as well as faster and more controlled drying
- Investigate a variety of pre-consolidation techniques for both rollgoods and 3-DEP™ applications
- Explore heated and cooled tooling for compression molding applications
- Complete large 3-DEP™ machine construction, start-up and shakedown
- Continue to investigate three-component Co-DEP systems including carbon fiber/natural fiber/thermoplastic resin systems for optimizing cost/properties
- Initiate Computational Fluid Dynamics (CFD) study of our patented 3-DEP™ process
- Produce large parts (up to six feet by six feet) and multiple parts on our large 3-DEP™ machine



# Summary

- The project focuses on commercialization of lightweight composites for the transportation industry
  - Necessary for meeting upcoming CAFE and Supertruck requirements
- Our approach utilizes thermoplastic materials reinforced with carbon and other structural fibers with the goal of decreasing existing part thickness and mass by 30 – 50%
- We are on or ahead of schedule in all areas except for the large 3-DEP™ construction schedule
- Compression molding trials have produced excellent looking parts with good mechanical properties and commercialization looks promising
- Market pull for lightweight parts for the transportation industry has been increasing since project inception and several new potential partners have expressed interest in expanding our scope of work