Why Advanced Composites?

- Light Weight
- Superior Strength
- Greater Fatigue Resistance
- Vibration Damping
- Chemically Inert
- No Body / Frame Rot
- Mechanical Stability
- Design Flexibility

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Composites Crossover to Land Transportation

- 1953 to Present
  - General Motors - Corvette
    - 100% Composite Body
- Over 150 different automotive applications in regular production
  - Prime Contribution
    - Weight Savings resulting in fuel savings
    - Freedom from Rust and Corrosion
    - Parts Consolidation
      - Elimination of separately formed pieces
    - Lower Tooling Cost
    - Design Flexibility
      - Complex geometry difficult in metal
      - High Strength and Good Durability
Composites Crossover to Land Transportation

One (1) piece all composite body-in-white electric vehicle
Carbon-E-glass sandwich construction
(FMVSS 30 mph frontal impact certified)
Composites Crossover to Mass Transit

Advanced Technology Transit Bus
40’ All-Composite Body

Tooling System
Composites Crossover to Mass Transit

40’ and 45’ All-Composite Body Assembly
27-33% body weight reduction
Altoona Tested - Certified (12yr, 500,000 mile, heavy duty cycle)
Composite Bus Body
Why Composite Bus Body?
(from owners perspective)

- Lighter than Steel Body Shell
- Lower Fuel Consumption
- Lower Emissions including CO$_2$
- Superior Corrosion Resistance
- ‘Easier’ Repairability
- Composite Technology becoming mature in Automotive, Aerospace and Windpower Industries

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Composite Bus Body Design Criteria

Different design criteria to develop all-composite bus body laminate with Finite Element Analysis (FEA), e.g.:

- Linear braking loading
- Linear acceleration
- Linear modal analysis
- Linear roof crush simulation
- Floor loading
- ....
Starting Point

Bus Body Solid Model (over Bus Suspension & Steering System)
- Application of laminates (ply-by-ply)

Finite Element Analysis:
- Predicts performance of materials and global structure
- Determination of first ply failure and mode of failure
- Result: Ply-by-ply / page-by-page laminate sequence for complete QA-fidelity

Visualisation of FEA Analysis Results
Bus Body Tooling

Use of 3D CAD Model to develop master plugs (body, small parts)

Complete body ➤ developed from separate upper & lower halves
Bus Body Tooling

Fiberglass polymer filled material for mold

Molds may be split into front, rear, sides, Chassis (5 parts) for easy part removal

Lay-up preparation (inspection, release agent, mould parts assembly, vacuum check)
Robust Manufacturing Process

- **Hand Lay Parts**
  - Front and Rear Fascias, Dashboards

- **SCM Molding**
  - Outer Body Panels

- **Filament Winding**
  - Tanker Trucks, CNG Fuel Tanks

- **VIP**
  - Body Shell, Chassis, Structural Components
Mold Lay-Up

Paint primer, skin-coat

FST layer

NCF fabrics

Core
VIP-Process

De-Molding
Component Integration & Final Shell Assembly
Testing

Depending on local regulations

Test of support structure

Test track for complete unit (Altoona, USA)
Body Weight Savings

9.1m Composite Bus ~ 2.25 ton savings

12.2m Composite Bus ~ 3 ton savings

13.7m Composite Bus ~ 3.7 ton savings
Summary

Esthetically pleasing
No geometry constraints as imposed by metal forming techniques

Scratch & dent resistant
Higher ultimate tensile elongation than metals
Traditional repair techniques (marine, automotive)

Rust & rot resistant
Non-corrosive, no metal
Impervious to chemicals
Summary

Lighter weight than metal
Self-supporting bus body without chassis

Designed to meet all transport rigors
Some models currently travelling over 1,100,000 miles

Can be packaged with all many types of drive systems
Diesel, bio-diesel, CNG, LNG, hybrid electric drive, fuel cell...
Thank you very much for your attention!