PNGV
Partnership for a New Generation of Vehicles

Advanced Light Weight Body Structure Development
Phase II Report

(March 21, 1997)
(by Gerry Klees)

Excerpts from:
Hard copy, red-lined of final report presented to me by William Todd. General Motors, senior staff engineer. Member of the PNGV Vehicle Engineering Team. Immediately prior to his retirement

Advanced Light Weight Body Structure Development

- MSX (The Multimatic Technical Center) was engaged by the PNGV Vehicle Engineering Team to:
  - Conduct packaging studies utilizing aerospace design methods, and utilizing carbon and aramid fiber composites.
  - **Results**
    - Mass Reduction was significant (70%)
    - Structure stiffness was superior to the "Steel" reference vehicle
    - Structure crashworthiness was "projected" to be acceptable
  - **Issues**
    - Cost concerns and related issues stopped it from progressing

Structural Numbers

	Units	PNGV Ref. Veh.	ACC Prediction	Multimatic Prediction
Bending Stiffness	Lb/in	29,763	38,600	**29.895**
Torsional Stiffness	Ft-lb/deg	6,260	30,800	**9,998**
1st Global Bending Freq.	Hz	28.3	78.3	**56.2**
1st Global Torsion Freq	Hz	33.0	90.6	**47.5**
Mass	lb	645	285	**192**

Aerospace Design Methodology

- Aluminum sheet metal
- Aluminum honeycomb core with aluminum skins
- Aluminum honeycomb core with carbon/epoxy skins
- Aluminum honeycomb core with aramid/epoxy skins
- Multi-laminate carbon/epoxy composite sheet

The Issues

- Durability (unknown)
- Final (CF/resin) material (not selected)
- Panel breakdown (unknown)
- Coring for sandwich structure
- Bonding
- Assembly Fixtures
- Energy Management
- Thermal Factors
- Cost of Carbon Fiber
- Material Properties
- Processing costs
- Fiber Forms
- Joint designs
- Assembly Processes
- Process Capabilities
- Class A Surfaces

The Risks

- Process
  - The liquid compression molding (LCM) does not allow for the required cycle times necessary for high volume production
- Material Thickness
  - LCM currently allows for a minimum of 2.5mm thickness. An Assumption has been made that a 1.5 mm thickness can be achieved in the near future.
- Material Properties
  - Assumptions have been made as to the future development of carbon fiber composites. A Young's Modulus of 63 GPa is required to meet global performance targets with current design.

The Opportunities

- Unidirectional Fibers
  - The selective use of unidirectional fibers throughout the structure will allow for **"further"** mass reduction at a given performance level…
- Minimum Thickness
  - By selecting/investigating alternative processes, minimum thickness, currently at 1.5 mm, could be reduced. Given that the torsional stiffness… is over 300 percent stiffer… then it is possible to trade stiffness for decreased wall thickness thus reducing mass.

The Lessons Learned

- The design of an all-composites BIW structure requires the re-evaluation of packaging constraints in order to optimize the structure. Development of an all-composite structure based on an optimized steel BIW package has severe limitations.
- Fiber orientation of each particular member needs to be optimized to suit its specific load spectrum.

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Cost?

- As far as I can tell the "Projected" cost of the composite intensive structure was never provided.
- Concerns about production cost, high-volume capability, and carbon fiber cost declared too high (required additional study).

My Position?

- The PNGV Advanced Light Weight Body Structure Development
  - Verified my BIW Structure weight objective of 176 pounds as realistic!
  - Their weight projection was 192 pounds, but…
    - The structure was stiffer than required
    - They admitted a need to optimize (using uni-directional CF)
    - They were limited by LCM thickness limitation to 1.5 mm
  - We know that CF/E prepregs can be molded as low as 0.75 mm
    - Corvette Fenders in rocker area are at (or below) 0.75 mm
  - Manufacturing production and assembly high-volume capability "still is" the primary limitation, preventing body structure utilization of CF/E composites