Advanced composite materials: designing real cars with carbon fiber bodies today

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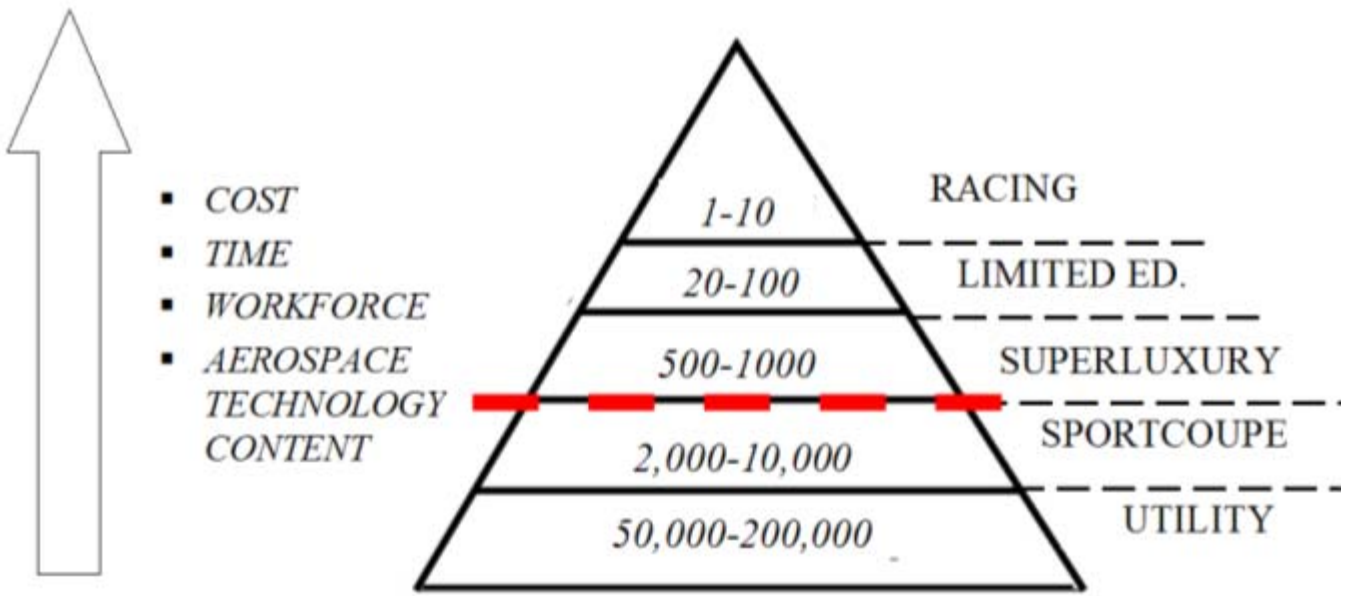
Many different composites

- Superluxury industry vs. mass automotive — Volume issue
- Structural composites vs. body panels — Structures issue



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Reasons for accident fatality:

- Contusion.
- Excessive deceleration.
- Fire and smoke.

Conditions for survivability – a systems approach:

1. maintaining sufficient occupant space
2. providing adequate occupant restraint
3. employing energy-absorbing devices
4. and allowing for a safe post-crash egress from the craft.

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CFRP monocoque:

- Expensive material & process deriving from racecar technology and suitable for limited production
- Designed to provide undeformable, survivable space: operates mostly in linear-elastic range
- Prepreg technology (autoclave and vacuum bag)
- 24K tow fabric (2x2 twill) with toughened epoxy

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CFRP monocoque but metallic crash-box:

- Ferrari Enzo (Ferrari F50, Maserati MC12)
- Bugatti Veyron
- Porsche Carrera GT
- Mclaren F1
- Pagani Zonda

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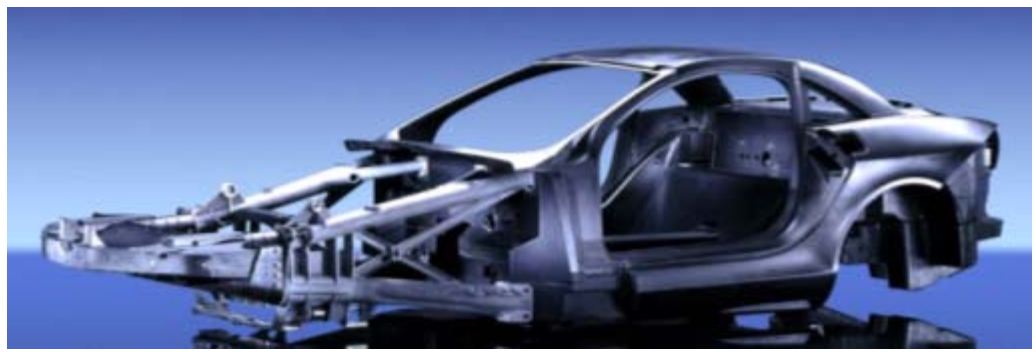
Mercedes/ Mclaren SLR composite technologies:

- 3.5 BIW per day/ 700 vehicles per year/ Total production 3000 vehicles
- Upper safety cell (Roof structure) – RTM
- Quarter panels (body panels) - Low density Advanced SMC
- Tub (passenger compartment) – RFI
- Most body panels (hood, rear, etc.) - Liquid infusion
- XMC (CF molding compounds) - Rear lid
- Doors - Carbon Fiber Prepreg with steel intrusion beam
- Crash box (2 cones) – braided preforms for RTM infusion



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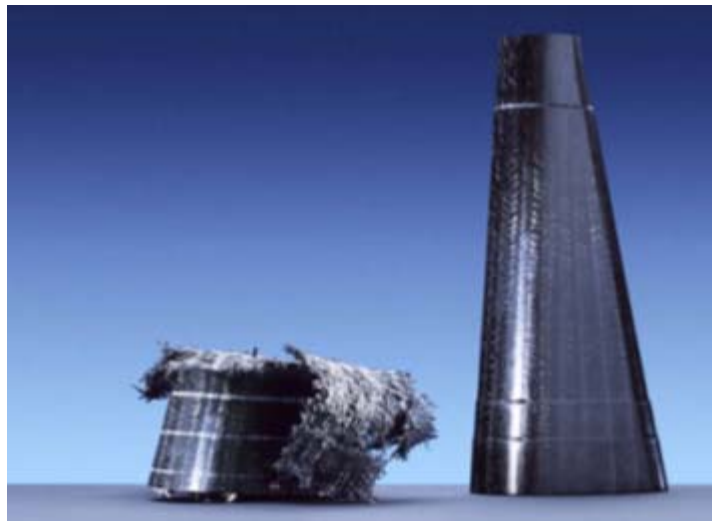
Front crash-box on the Mercedes / McLaren SLR:

- Weigh 7.5 lbs each
- Triaxial CF braids that are RTM
- Transverse prepreg member distributes load across the cones



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Problems unique to composites

- Composites are anisotropic
  - However lamination theory predicts well elastic response
- Composites are non-homogeneous
  - No accepted failure criteria!!
  - Damage progression is not self-similar
  - Difficulty modeling post-elastic behavior
- Scaling issues
  - Coupon to component differences
  - Macroscopic effects associated with length-scale of reinforcement

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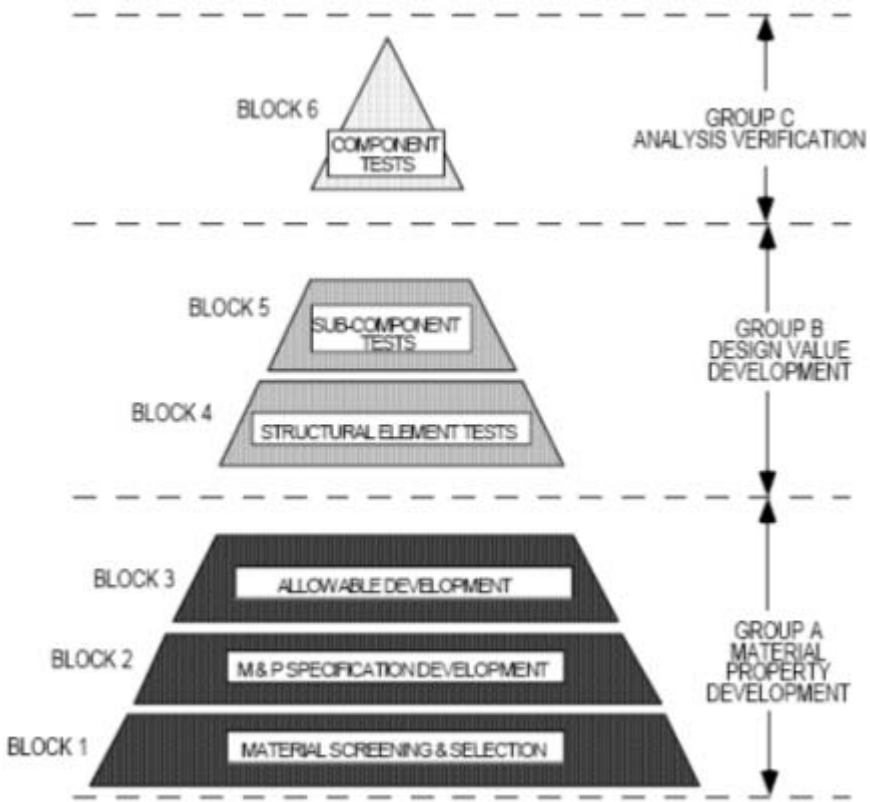
Building Block Approach

- As per CMH-17 (former MIL-HDBK-17) Volume 3
- Lead in to Prof. Lagace's presentation



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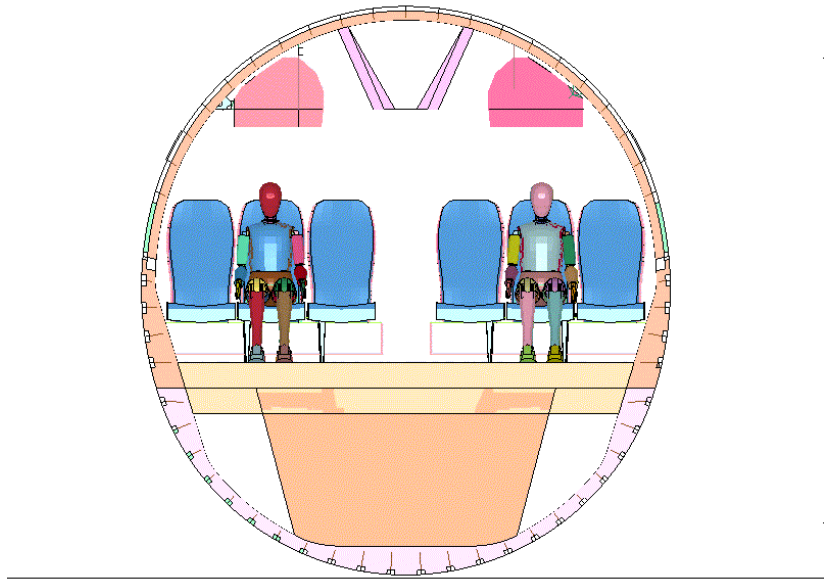
Boeing 787 first CFRP crushable subfloor

- Certification by analysis supported by test evidence (Standard FAA FAR Part 25)
- Aerospace building block approach needed



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Current needs

- Need for specialized test standards
- Need for suitable analysis tools and guidelines
- Need for lower-cost materials and processes
- Need for shared databases

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CMH-17 (former MIL-HDBK-17) effort

- Crashworthiness Working Group founded in March 2004
  - Current Chaired in conjunction with Mostafa Rassaian (Boeing Phantom Works) and Xinran Xiao (General Motors)
- Currently funded by FAA through Joint Advanced Materials Structures (JAMS) Center of Excellence at UW
- Develop coupon level test standard for crushing composite structures
  - Self-supporting specimen, possibly not tubular
- Review state-of-the-art FEA modelling practices and develop guidelines
  - Several approaches are phenomenological or otherwise semi-empirical
  - While waiting for truly predictive FEA tools, need to develop sensitivity about the effectiveness of the current crashworthiness modelling strategies

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Concluding remarks

- CFRP crashworthiness is a young field
- Composite education needs to increase at all levels
- Research in this field needs to be fostered
- Need for standardization and guidelines

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