# *Composites Crashworthiness Energy Absorption*

*Or the long and winding road toward Standardization*

A Center of Excellence
AMTAS
Advanced Materials in Transport Aircraft Structures

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# Ground and Air vehicles alike


## *What is Crashworthiness?*

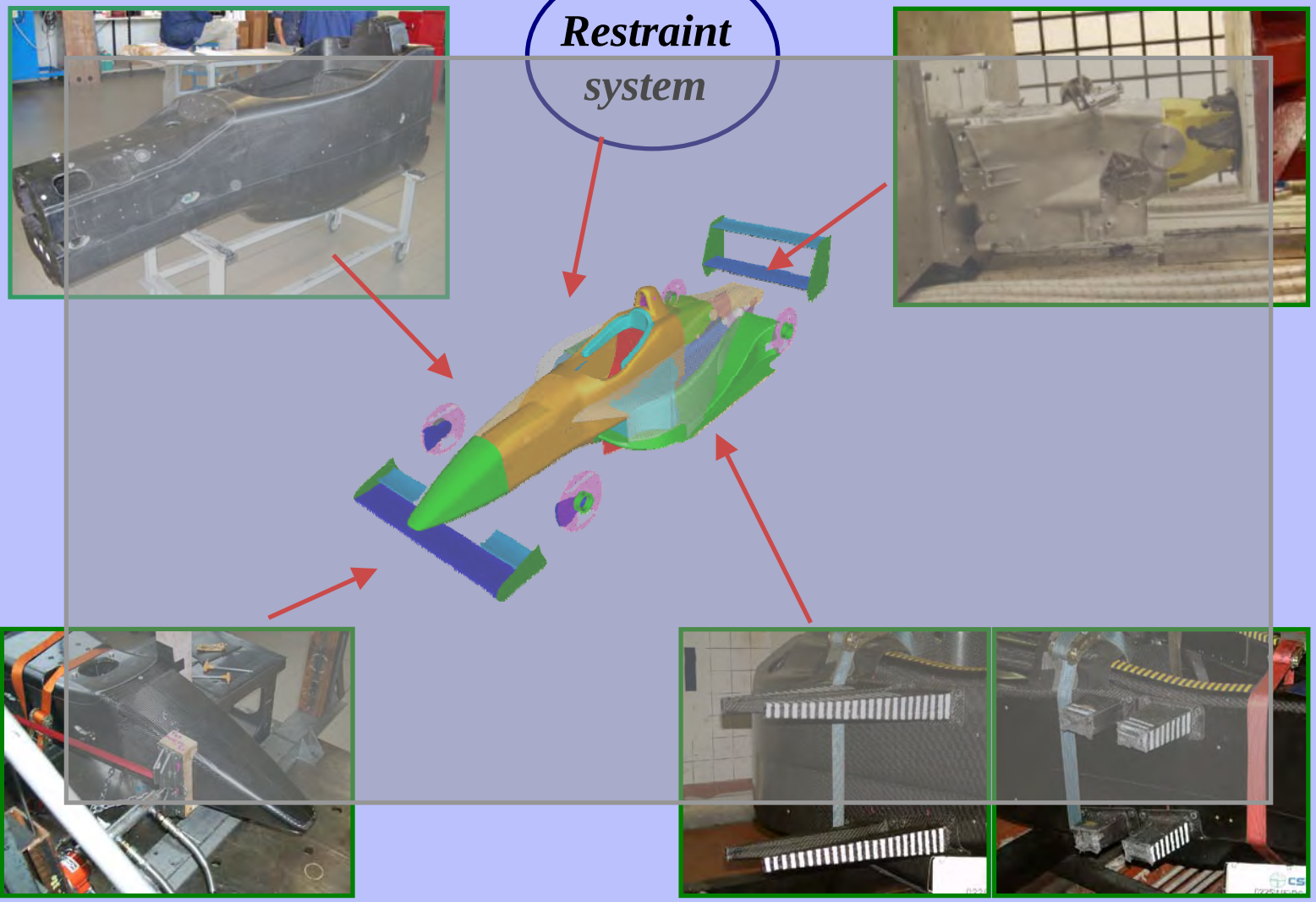
***Reasons for accident fatality:***

- *Contusion against objects.*
- *Excessive decelerations.*
- *Fire.*

***Conditions for survivability:***

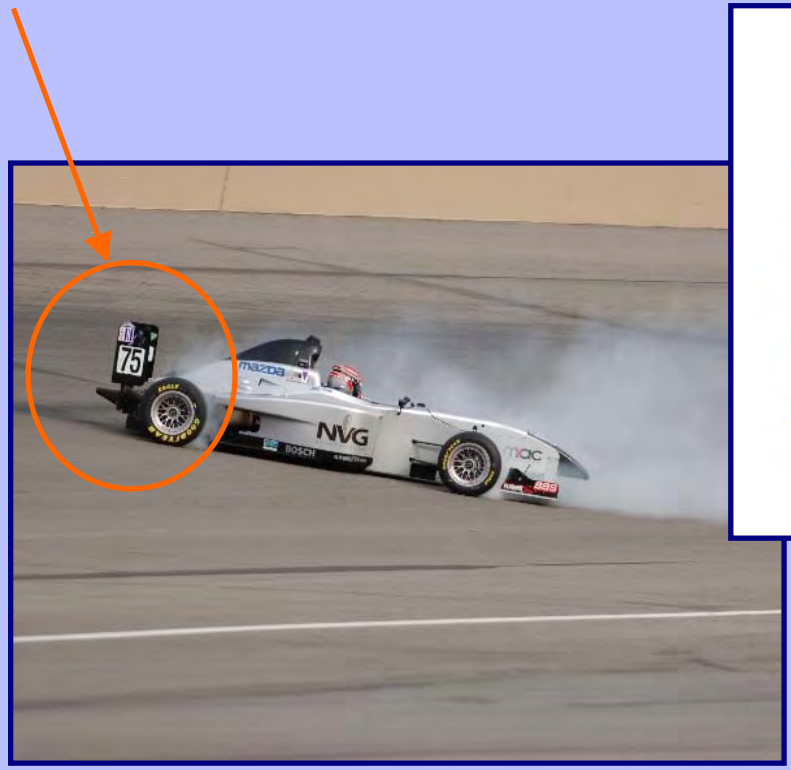
1. *maintaining sufficient occupant space*
2. *providing adequate occupant restraint*
3. *employing energy-absorbing devices*
4. *and allowing for a safe post-crash egress from the craft.*

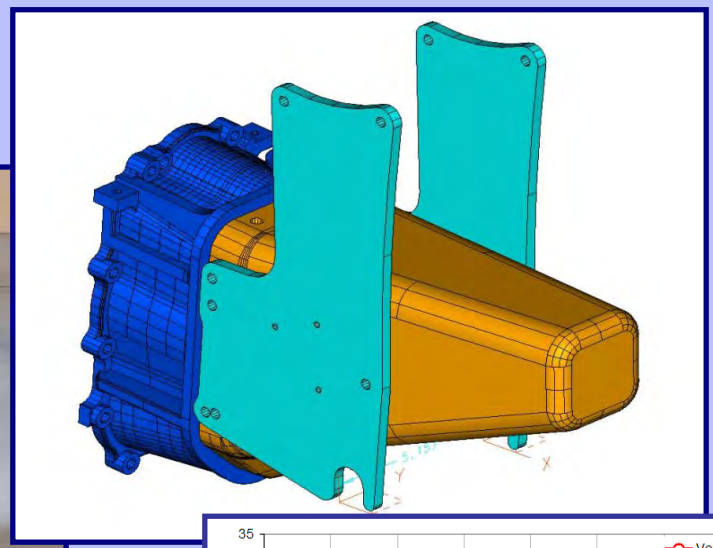
# *A systems approach*

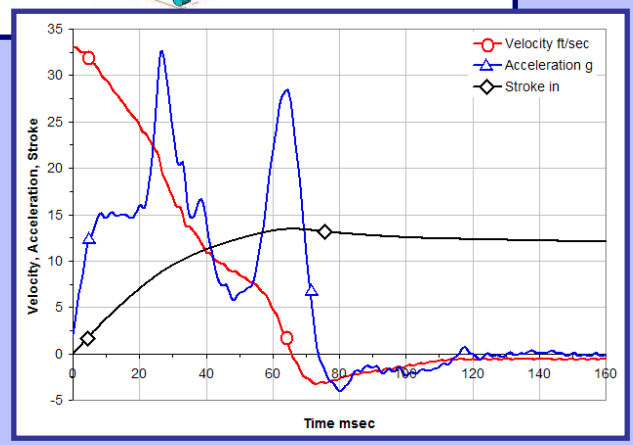


## *Star Mazda RIMP*

- *Design of the Rear IMPact structure (RIMP)*
- *Certification as per Formula 3 FIA guidelines*
- *Crash test against rigid barrier at 22.4 mph*

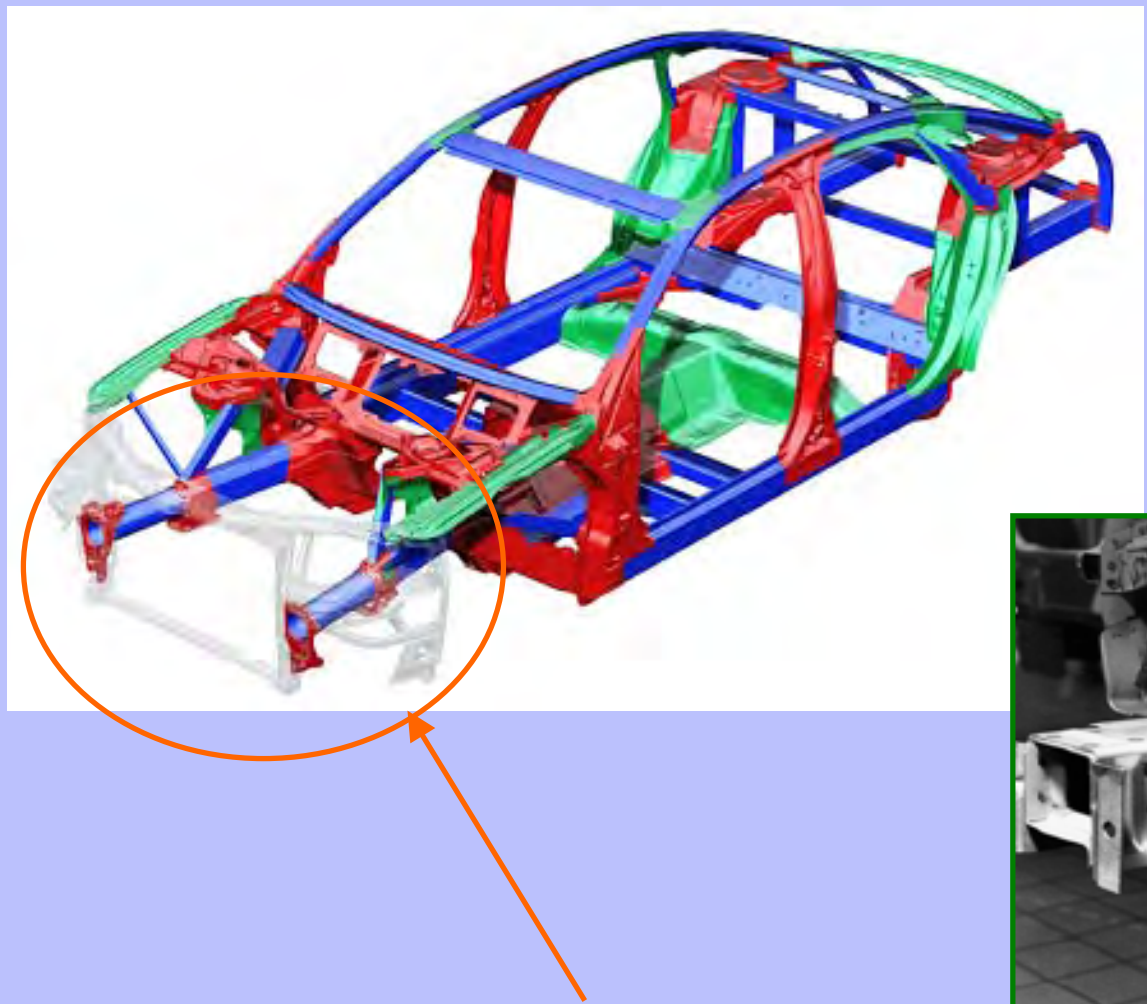


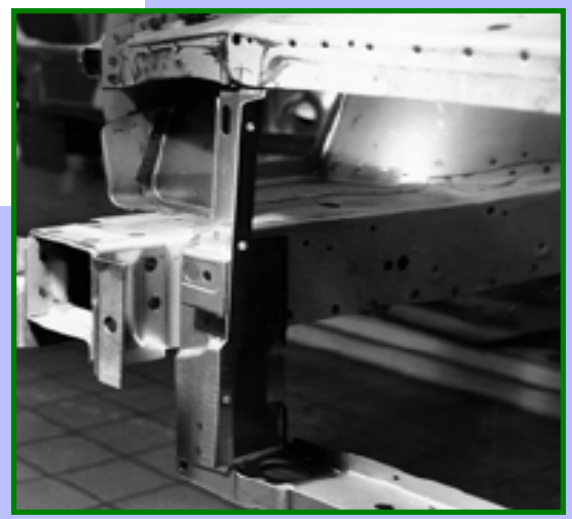





## *Passenger cars*

- *Front Crumple zone.*
- *Tubular mentality.*

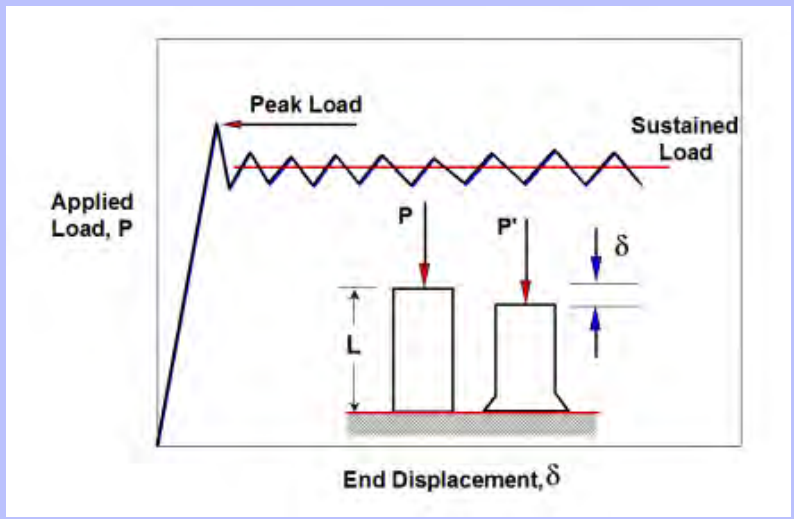


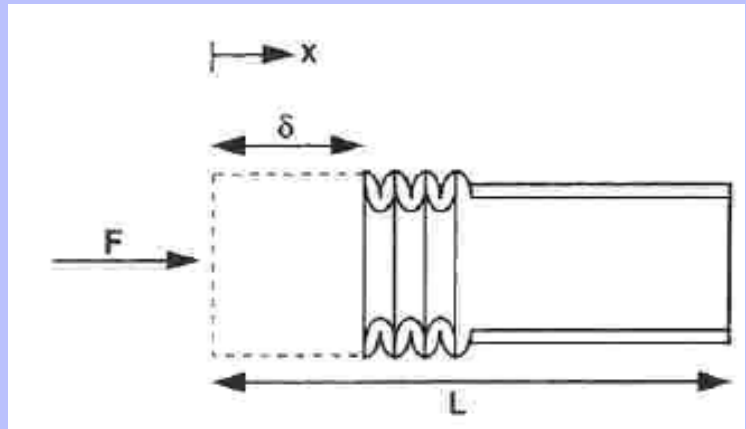


## *Measuring Energy Absorption:*

- *Specific Energy Absorption (SEA) is the Absorbed Energy per unit mass of crushed structure,*
- *Absorbed Energy is the total area under the Load-Displacement diagram*

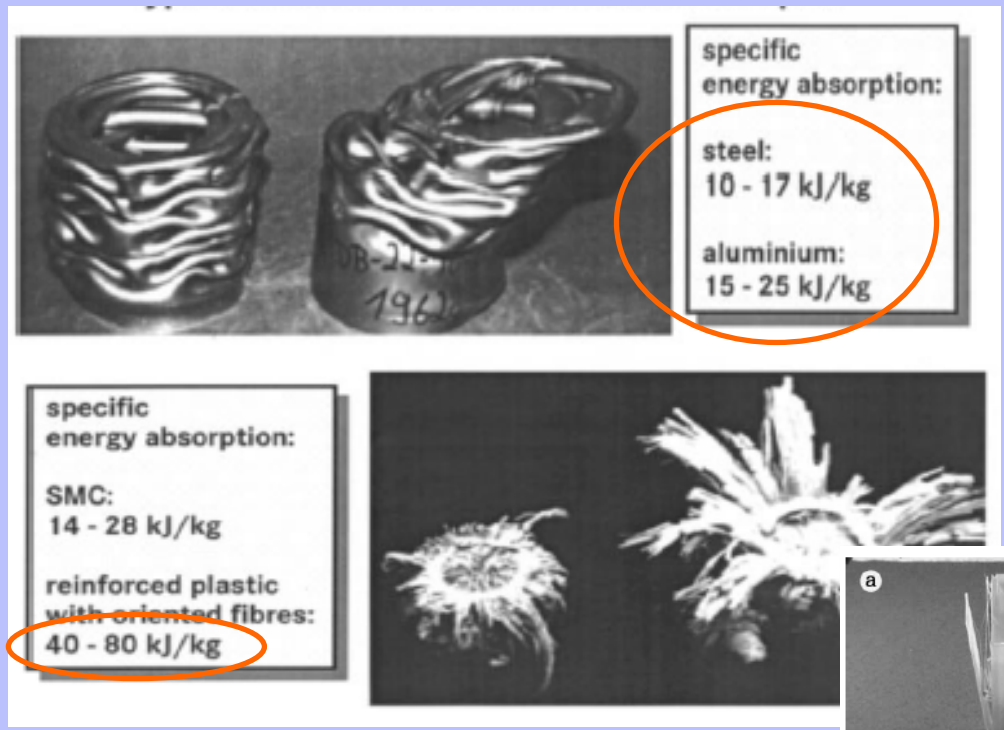
$$SEA = \frac{EA}{\rho \cdot A \cdot \delta} = \frac{\int_0^{\delta} F \cdot dl}{\rho \cdot A \cdot \delta}$$

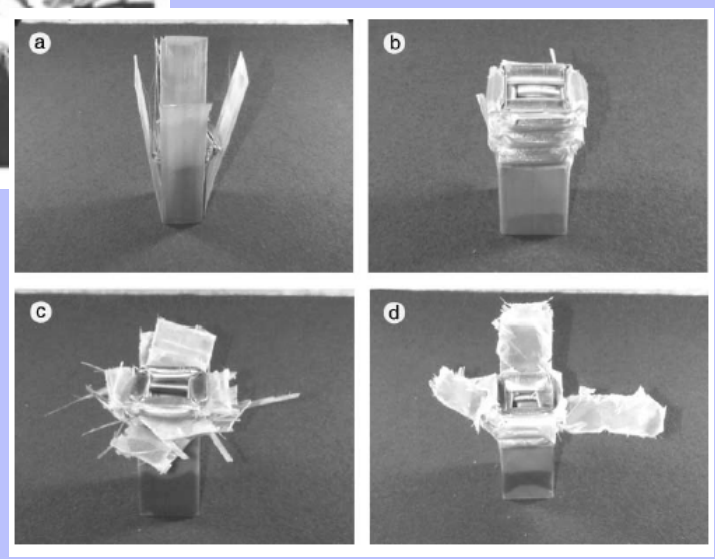


**SEA:**

- *In general composites have a greater SEA potential*
- *but need to be carefully studied and understood.*

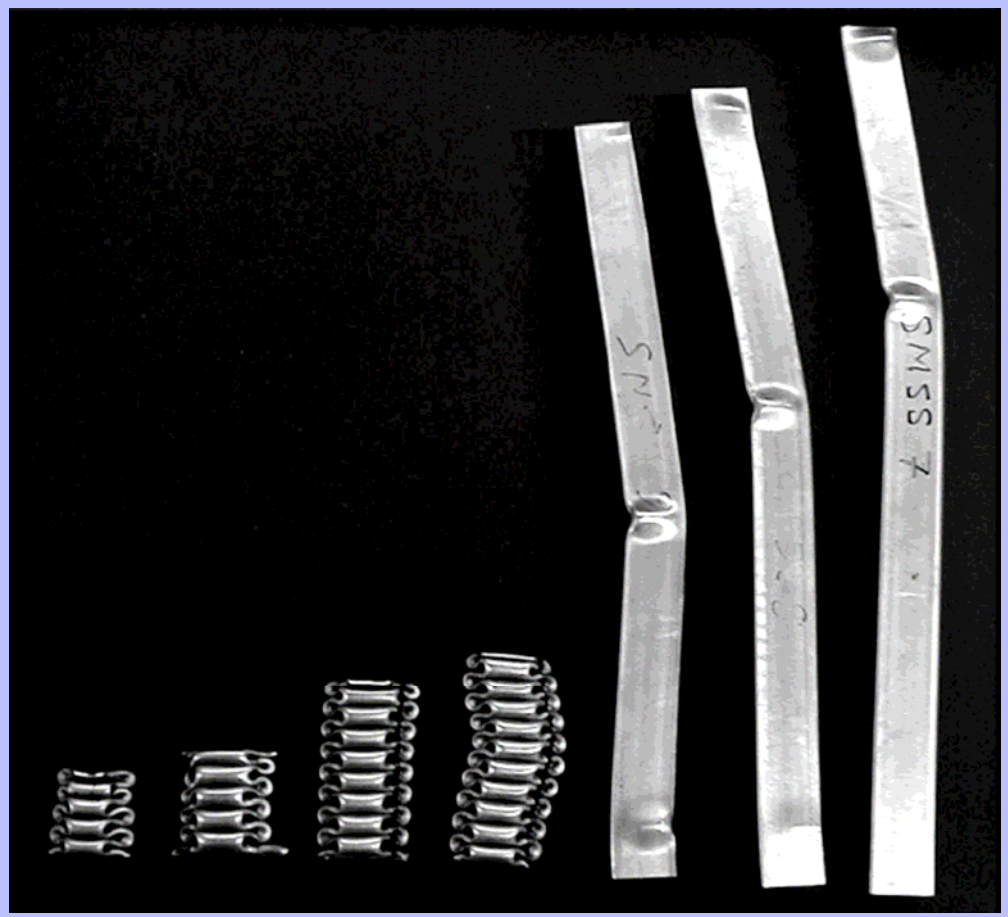



- *a. $[0]_n$*
- *b. $[90]_n$*
- *c. $[0/90]_n$*
- *d. $[\pm 45]_n$*

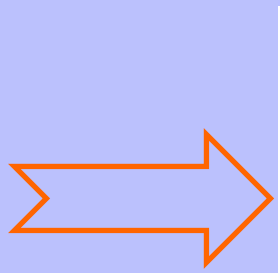
***Failure modes:***

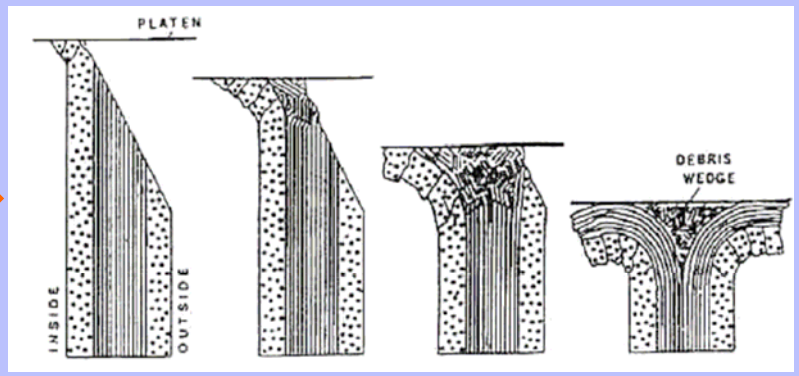
- *Metal structures collapse by plastic folding/ hinging.*
- *Buckling is only danger.*



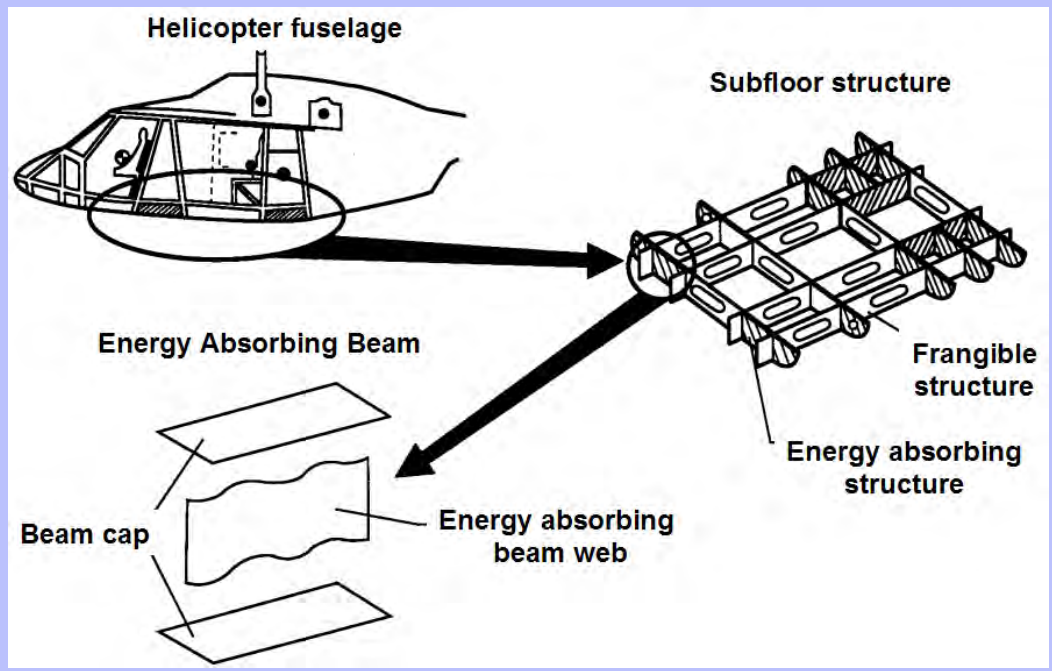
## *Fragmentation/ splaying:*

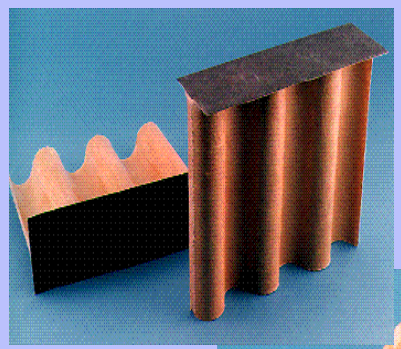
- *fracture and bending of the lamina bundles, and interlaminar crack growth*

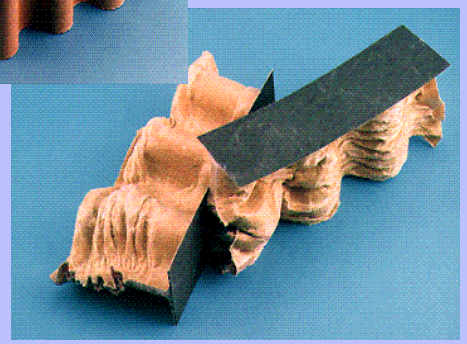


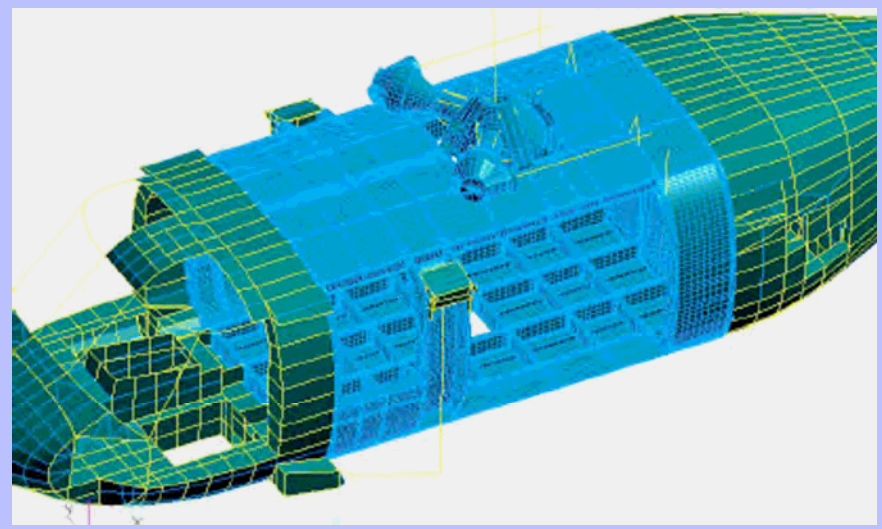



# Rotorcraft subfloor

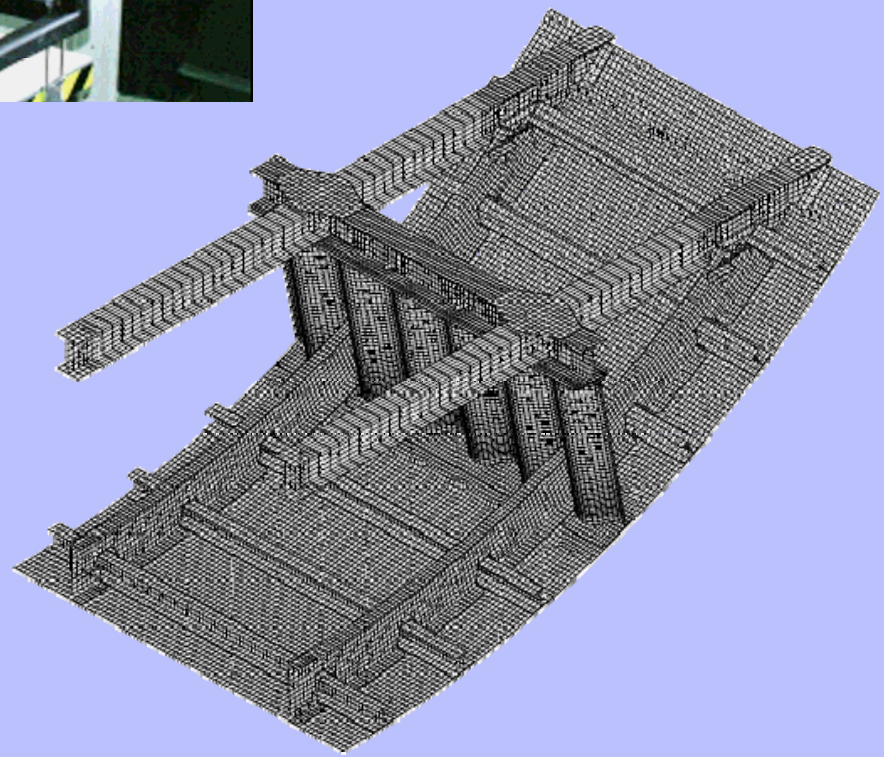


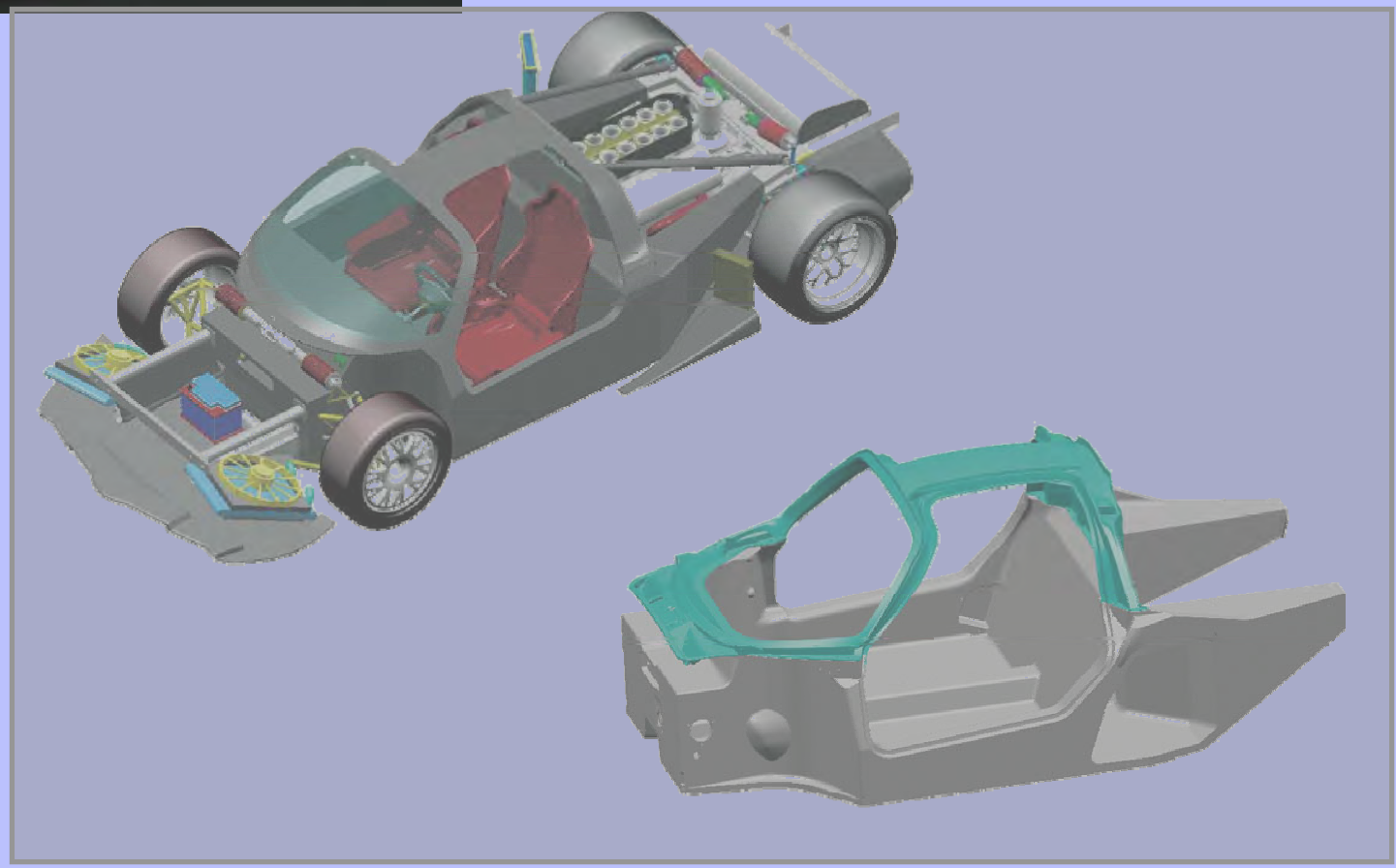




# *Commuter Aircraft cargo floor supports*



# *Superluxury car*



## *Or not….*

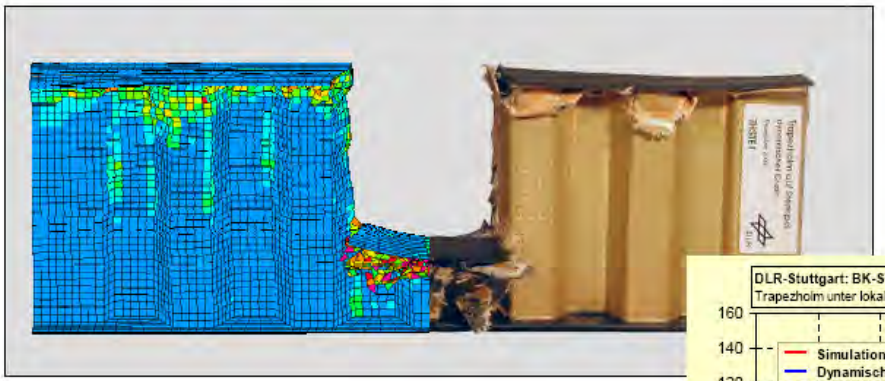
## *CMH-17 Crashworthiness Working Group*

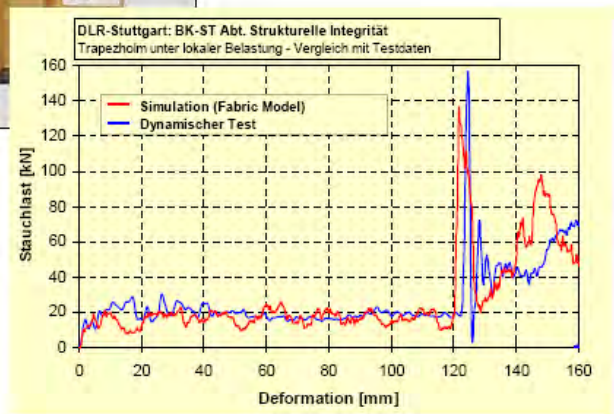
- *Numerical standardization*
  - *Current FE modeling strategies are not predictive*
  - *Round Robin is beginning, and it involves major FE explicit dynamic codes to validate existing material models and modeling strategies*
  - *Goal is to develop guidelines for "plug-and-play" capabilities*
- *Experimental Standardization*
  - *No existing test standard to determine SEA*
  - *No way to screen material systems/ forms/ lay-ups*
  - *Material suppliers, OEM's and engineers need to speak one language*
  - *Proposed corrugated specimen to be compared with flat channels and tubular specimens*

***Numerical Standardization:***

- *Use for crash applications is still not mainstream due to difficulty in predictability.*
- *Predicting failure is very difficult in composites (see SIFT presentation)*
- *Crashworthiness modeling requires explicit, dynamic, non-linear (post-failure) modeling*

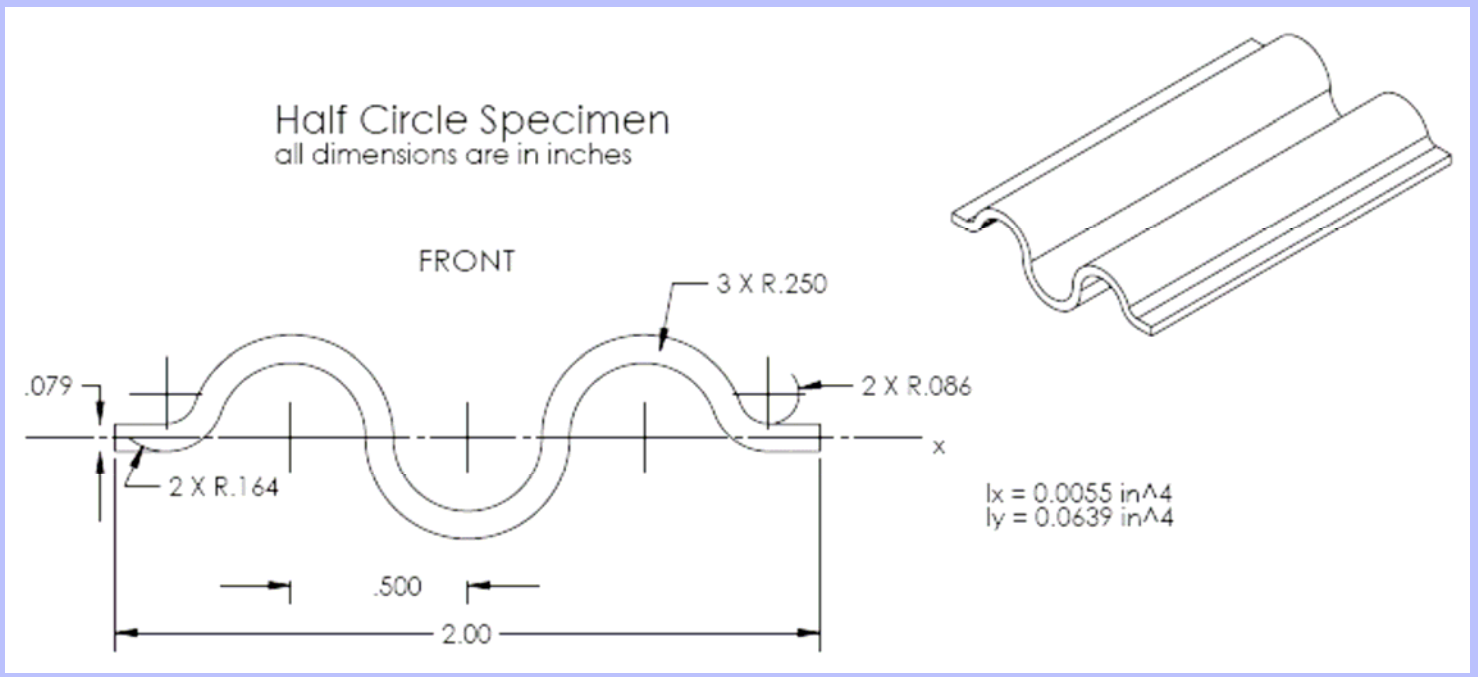
Test und Simulation of trapezoidal flooor beam under indenter loads





***Experimental Standardization:***

- *Self-stabilizing: no fixture necessary*
- *No autoclave or mandrel necessary*
- *<u>Less complexity, cost and uncertainty than tubular specimen</u>*

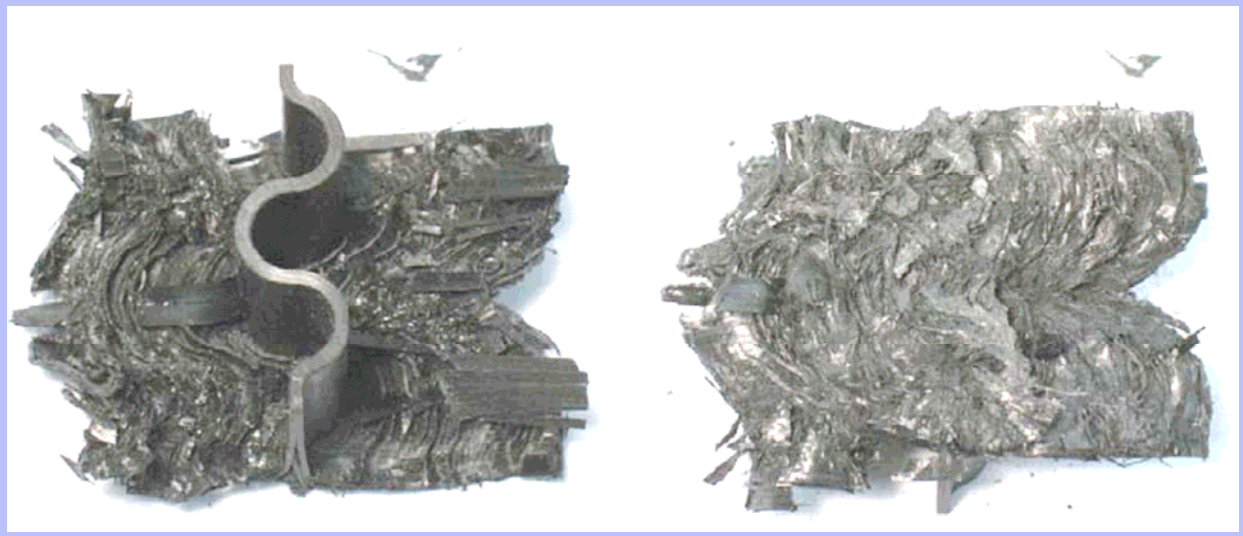


## *Corrugated Specimen:*

- *0/90 Tough Semicircle Slow*
- *0/90 Tough Sinusoid Fast*
- *Aluminum Short*

## *Corrugated Specimen:*

- *Specimen after testing, and Load, SEA, Total energy vs. stroke*



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