



## **AMTAS Project:**

***“CERTIFICATION OF DISCONTINUOUS COMPOSITE MATERIAL FORMS FOR  
AIRCRAFT STRUCTURES”***

## **First year planning**

*April 23, 2009*

## ***Why doing this project?***

- **Discontinuous Fiber Composites (DFC) molded by compression molding are increasingly being used for structural parts of complex geometries in the new generation of commercial airplanes.**
- **Structural analysis of DFC parts is a challenge as DFC do not behave like traditional composites or isotropic materials. There are no standards for material allowable, design methods or analysis methods.**
- **As a result certification of DFC parts is done by testing a number of parts (“Point Design”). This is time consuming (and expensive) for the part manufacturer, the AC manufacturer and the FAA. It is also ineffective to optimize design (i.e. for lower weight)**
- **This AMTAS project is to help ease the path to certification of DFC parts of aerospace structural parts. Hexcel HexMC has been selected as a DFC for this project since HexMC is leading the way for use of DFC materials in primary and secondary structure applications.**

## What is HexMC<sup>®</sup> material?

HexMC  
Material,  
(450mm wide  
Roll),  
~2000 gsm,  
~2 mm thick



50mm x  
8mm 8552/  
AS4 UD  
150 gsm,  
38% RC,  
Controlled  
Random  
Distribution

**HexMC<sup>®</sup> is made from UD prepreg**

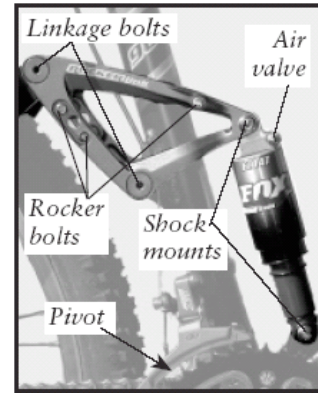
## ***Why HexMC<sup>®</sup> ?***

**HexMC<sup>®</sup> technology was developed to bridge the gap between low performance/low cost SMC and high performance/high cost pre-impregnated C/Ep.**

- Complex, structural 3D shapes possible**
- Net molding, fast cure, low labor content**
- High yield, high through-put**

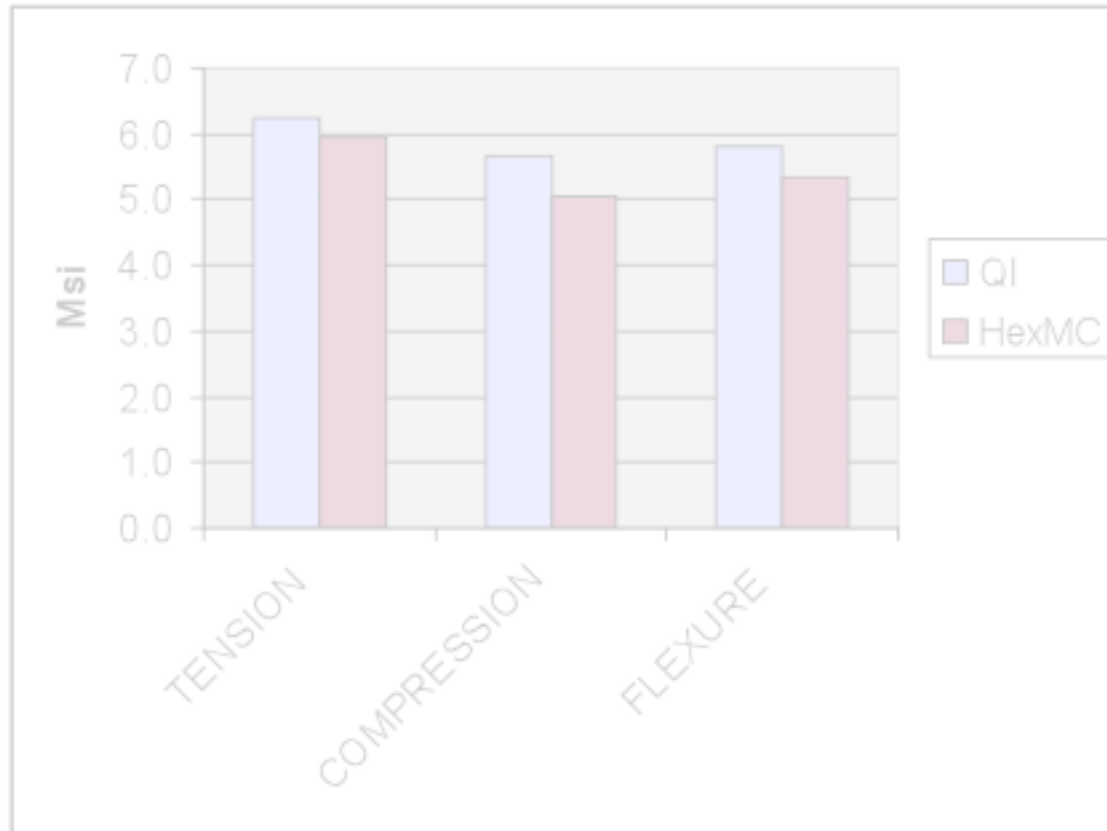


## Examples of HexMC<sup>®</sup> in non aero applications



# Typical HexMC<sup>®</sup> vs QI moduli (from same batches of UD)\*

\* Industrial HexMC<sup>®</sup> material



**HexMC<sup>®</sup> Moduli are >90% of Quasi-Isotropic UD**

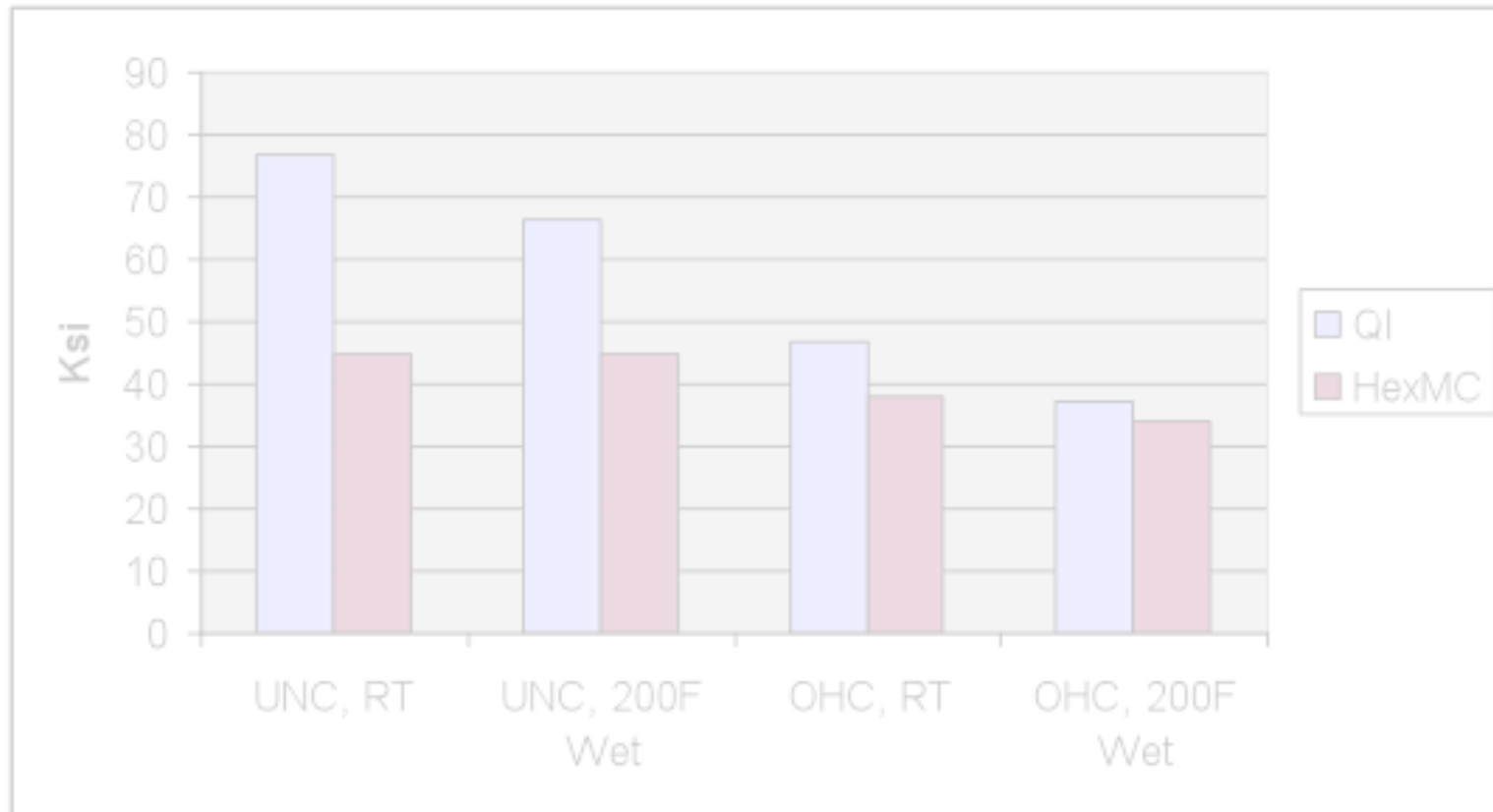
## Typical HexMC<sup>®</sup> vs QI Strengths (from same batches of UD)\*

\* Industrial HexMC<sup>®</sup> material



## Typical HexMC<sup>®</sup> vs QI: Un-Notched and Open Hole Compression\*

\* Industrial HexMC<sup>®</sup> material



Holes and hot/wet environment have a small effect on HexMC<sup>®</sup>

□

## Comparison of UD QI and HexMC® (8552/AS4) in UNC and OHC

	UD QI (45,90,-45,0)3s Ksi	HexMC Ksi	% of HexMC/UD QI
UNC - RT	92.60	54.70	59%
OHC - RT	49.06	37.95	77%
OHC - 200F Wet	37.42	34.12	91%

**HexMC “knock down” becomes smaller for “real” design conditions**

## ***HexMC<sup>®</sup> product form properties highlights***

- **HexMC is transverse isotropic shown by testing laminates at 0°, +/- 45°, 90°**
- **Moduli close to Quasi Isotropic laminates**
- **Low in plane (tensile and compression) strength compared to QI laminates in pristine condition, but UD or fabric can however be added if required**
- **Flexure strength > Compression strength > Tension strength**
- **Very damage tolerant as seen through OHT, OHC, Compression After Impact, fatigue and thermo-cycling and on hundreds of parts tested with defects and after damage**
- **Good bearing strength**
- **Good resistance to fatigue**

# Processing consideration: High versus Low Flow

## High Flow

No strand definition

Low Burst Pressure 287 PSI



**High Flow Molding:  
60% stronger than the best C/Ep SMC**

## Low Flow

Strand definition

Low Burst Pressure **530 PSI**



**Low Flow Molding:  
85% stronger than High Flow Molding**

NOTE: best C/Ep SMC failed at 180 Psi

## Processing consideration: HexMC<sup>®</sup> Low Flow Molding



Rule Die Kit and Stage



Lay-in L-shaped Front and Back Rib Plies



De-mold Net Shaped Part



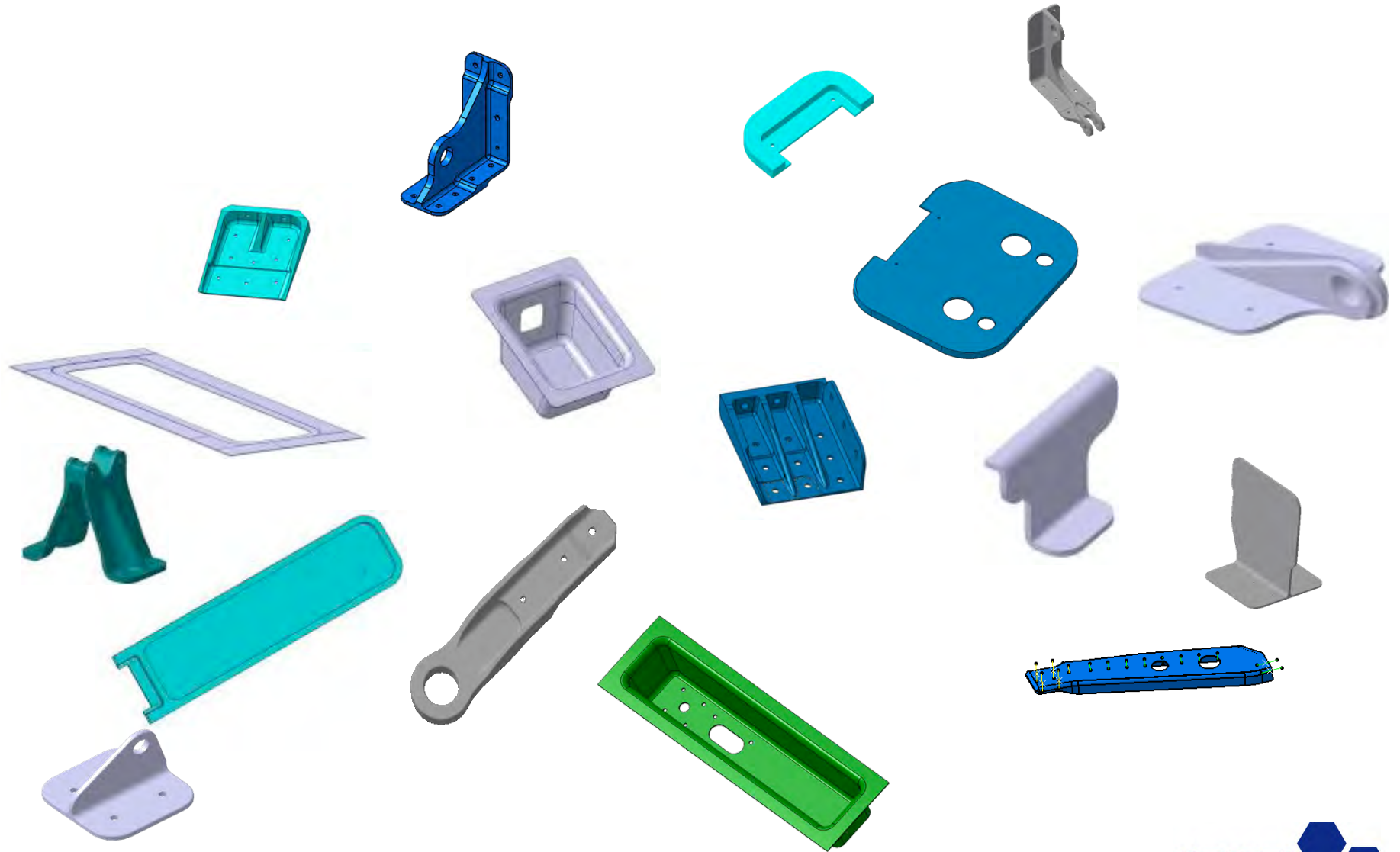
Prep and Heat Mold



Lay-in Flange Plies

- Low flow molding maintain isotropy
- UD or fabric prepreg can be added

***Examples of geometries molded with HexMC®***



*HexMC® Aerospace Grade*



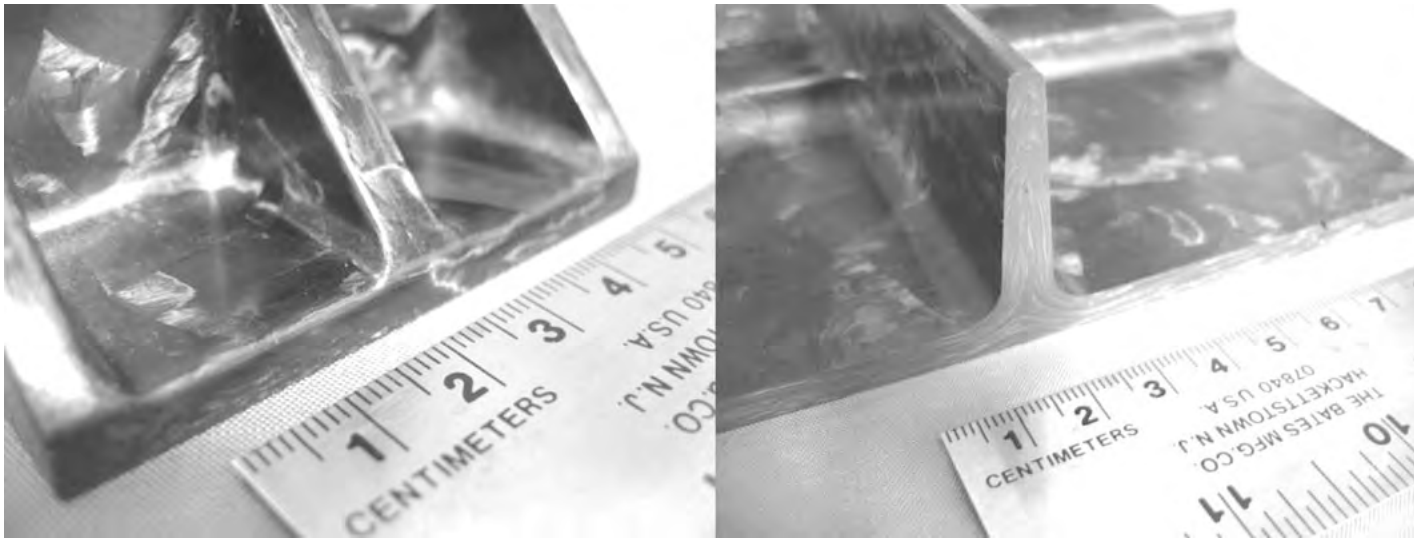
## *Examples of aerospace HexMC<sup>®</sup> parts*



## ***Examples of aerospace HexMC<sup>®</sup> parts***



## ***Examples of molding details***

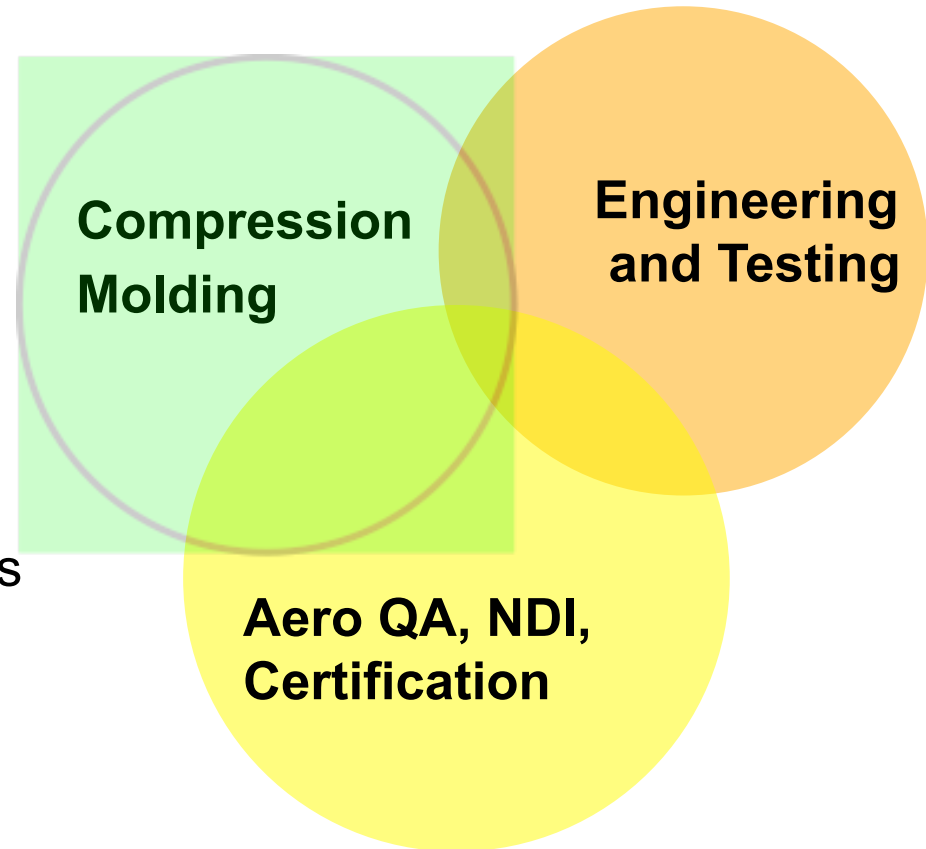


Tight radii and small geometric details are possible with HexMC, without resin rich areas

□

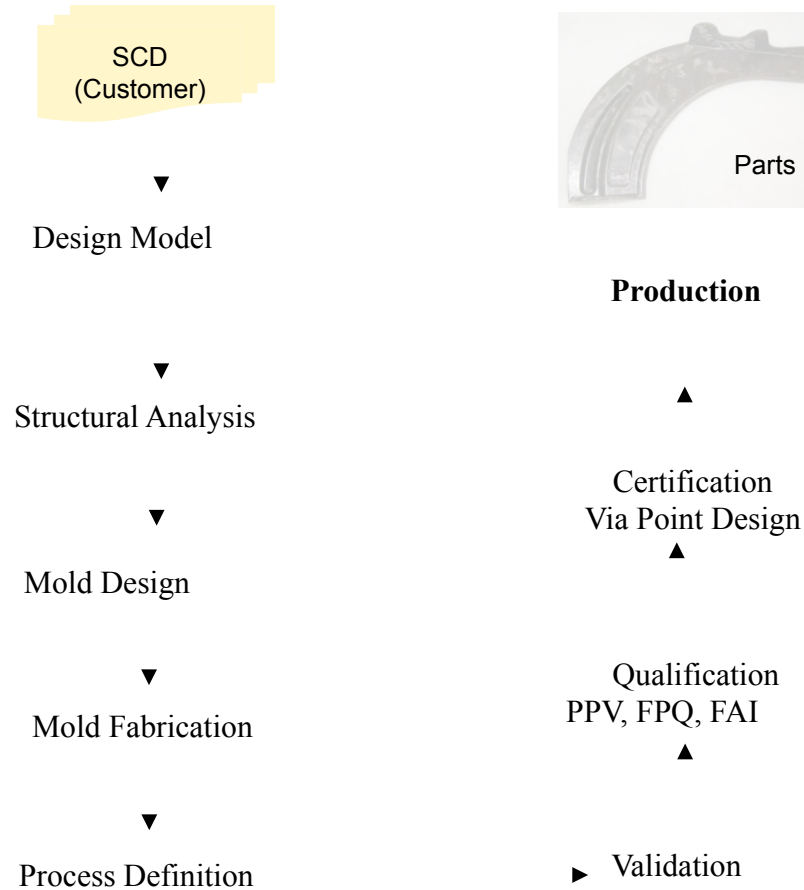
## ***Experience needed to produce HexMC<sup>®</sup> structural parts for aerospace applications***

- Very few companies have sufficient expertise in all 3 key areas
- A lot of specific know-how in part and mold design, processing, NDI inspection, testing and certification are needed to produce quality parts consistently
- **Hexcel decided to sell parts rather than materials for aerospace applications**



**Hexcel is a one stop shop for HexMC<sup>®</sup> aero parts**

# HexMC<sup>®</sup> in aerospace applications: typical steps



## ***Hexcel on-going development of material properties and design methods***

### **1. Material Allowable and Generic Design Values**

- a) Using industry standard methods or Hexcel developed methods
- b) Generic Design values include particularities of HexMC molding such as Low and High Flow, Overlaps or Weight Balancing

### **2. Analysis Methods**

- a) Based on current experience, including comparing analysis and certification part test results
- b) Developing close form solutions for typical types of parts seen so far

### **3. Verification and Validation**

- a) Compare part test results with analyses using results from Material Allowable, Design Values and Analysis Methods
- b) Refine as required

**These 3 project elements are iterative and interactive**



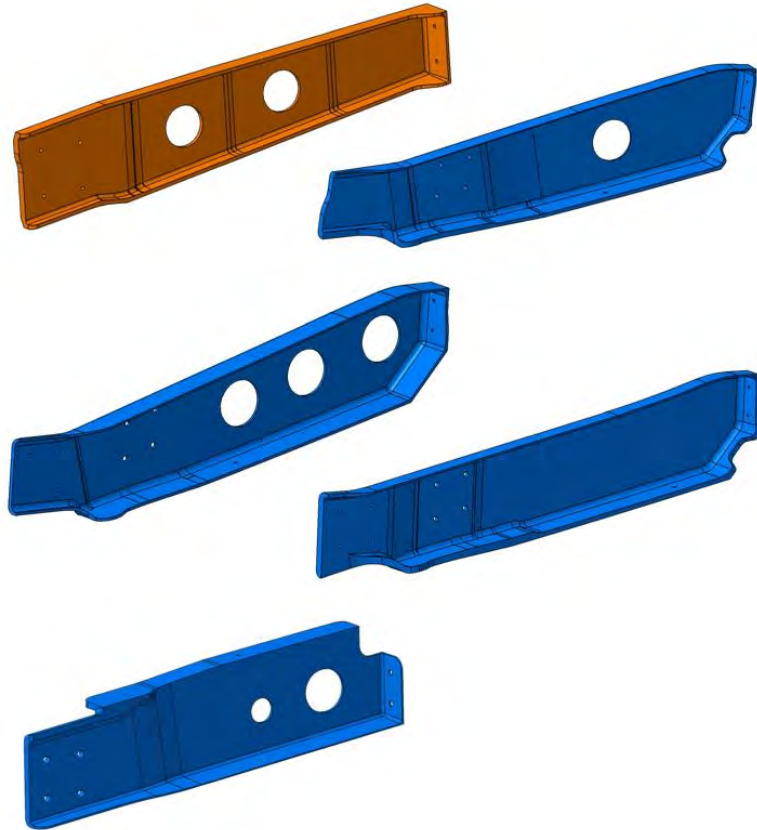
# ***AMTAS PROJECT OUTLINE***

❑ **Project Goal: Simplify certification of HexMC parts.**

❑ **Project Tasks:**

1. Pick a production part to relate lab tasks and results throughout the whole project. The project tasks defined so far are to evaluate and understand:
2. Effect of ply drop offs
3. Load redistribution and failure at or near part fastener or lightening holes
4. Load redistribution and failure at or near damaged areas
5. Load redistribution and failure near part features (e.g. radius bend areas).
6. Effect of NDI indications on properties

***PAX Intercostal was selected as the production part***



**UW is now developing a Statement Of Work with all the project steps to conduct tasks 2-6 and to link them to actual production PAX Intercostal**