



Reverse Building Block Testing for Production-Relevant Scaling Effects

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➤➤ Often building block test programs carried out early stages may not be representative of final product

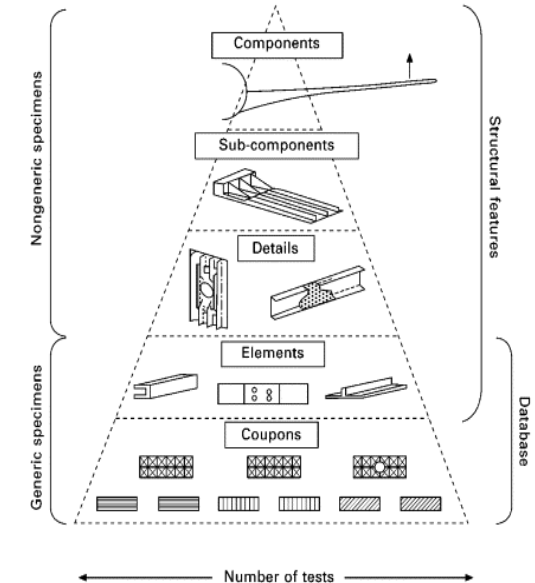
- Analysis/validations are done to meet schedule target(s)
- Planning for factory design

➤➤ Once the design is fully defined/optimized, reverse building block testing can be carried out with more representative data

- Manufacturing representative test articles

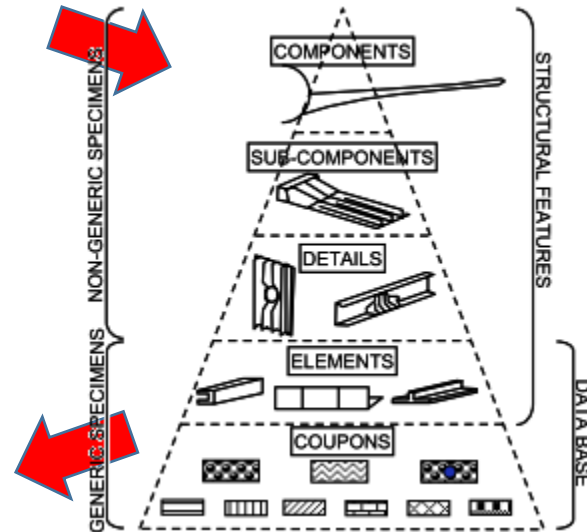
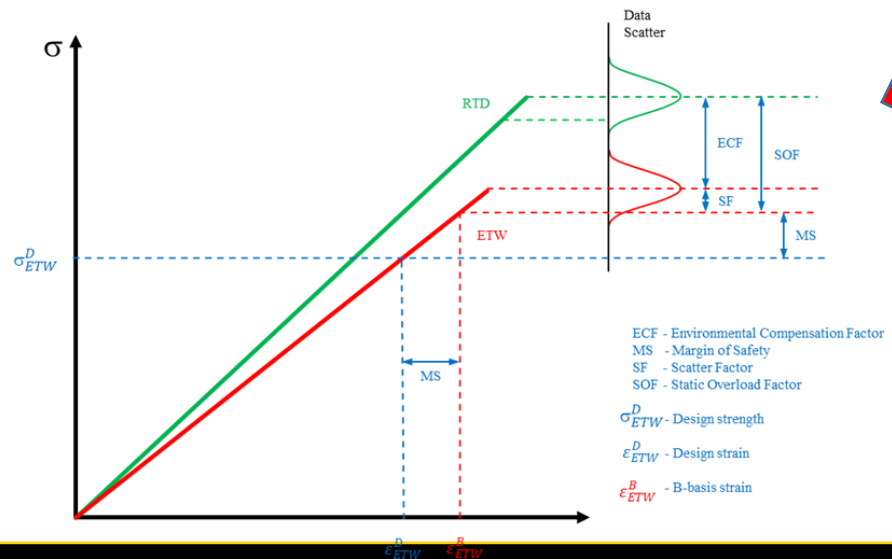
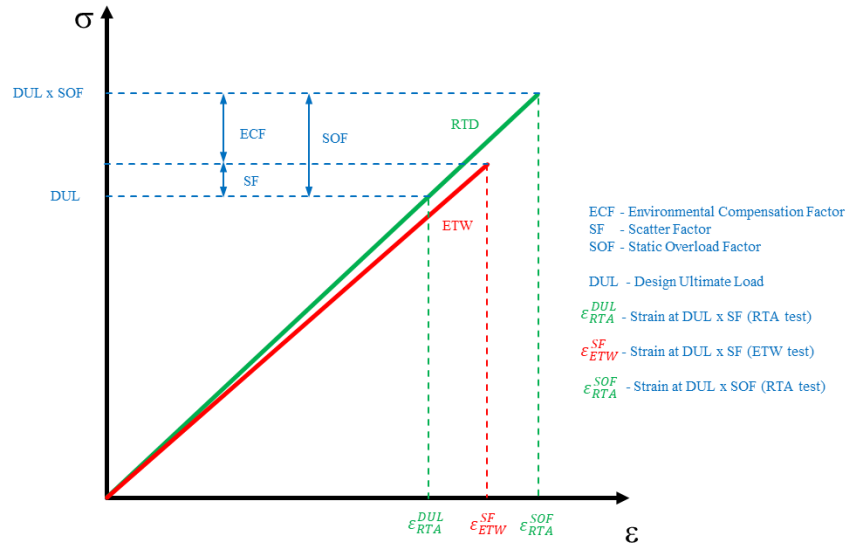
➤➤ Determine a reasonable mid-level element test for interrogating design envelop for new programs

- Scaling effects (conservatism)
- Analysis validation for detailed design



Investigate reverse building block approach to evaluate scaling effects in composite damage tolerance and to establish a mid-level test element for design developments

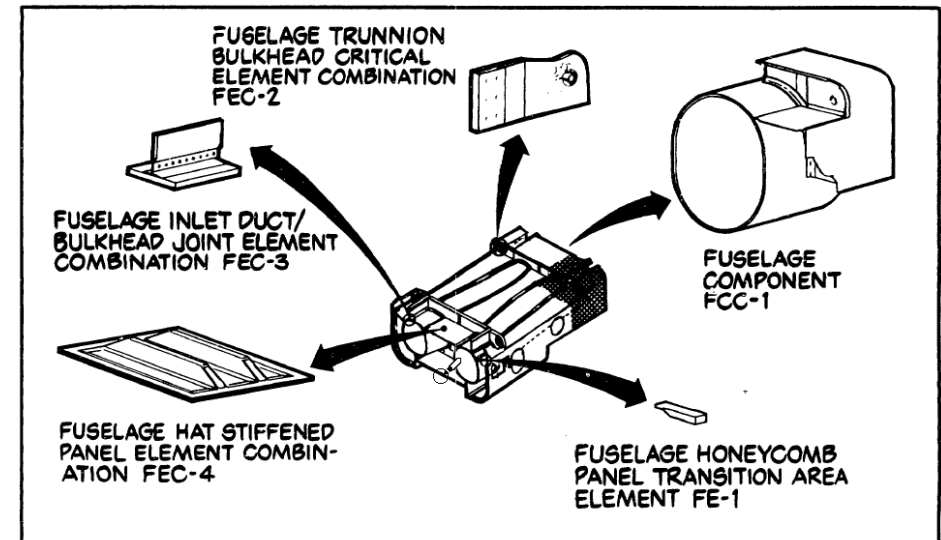
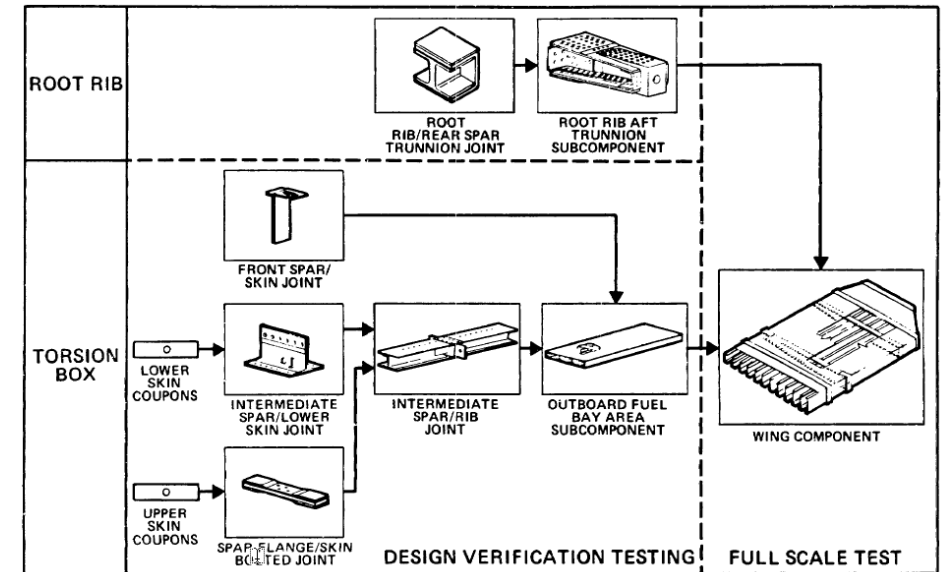
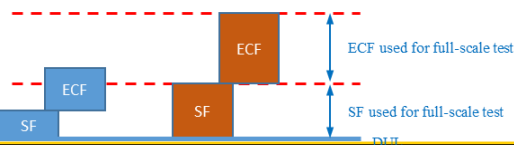
Static Overload Factor (ECF+SF)



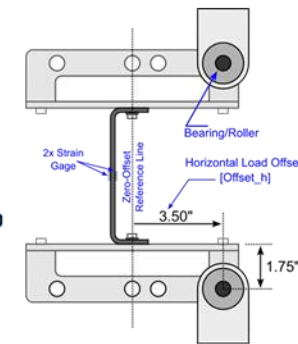
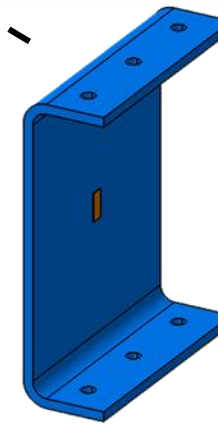
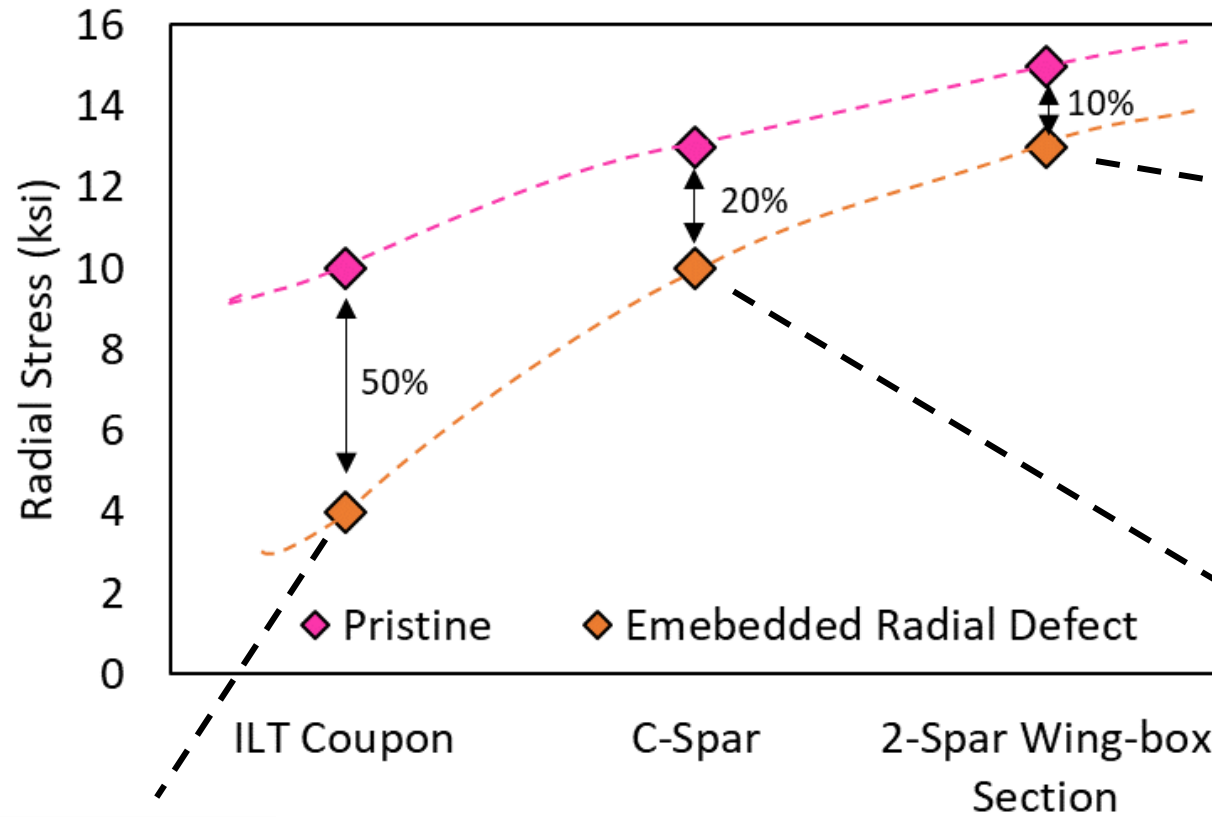
Hybrid

Metal

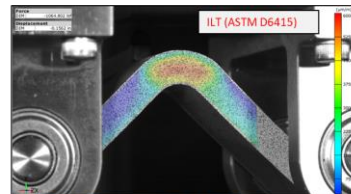
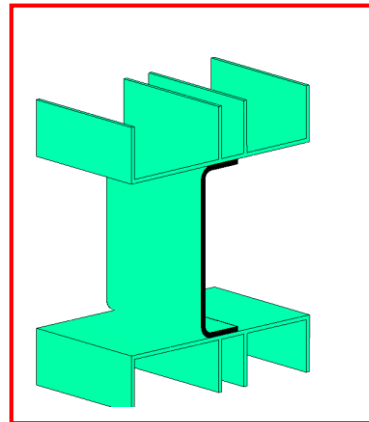
Composite



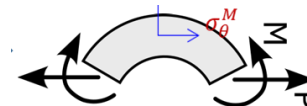
Scaling Effect: Skin-to-Spar Joint (Defect Sensitivity)



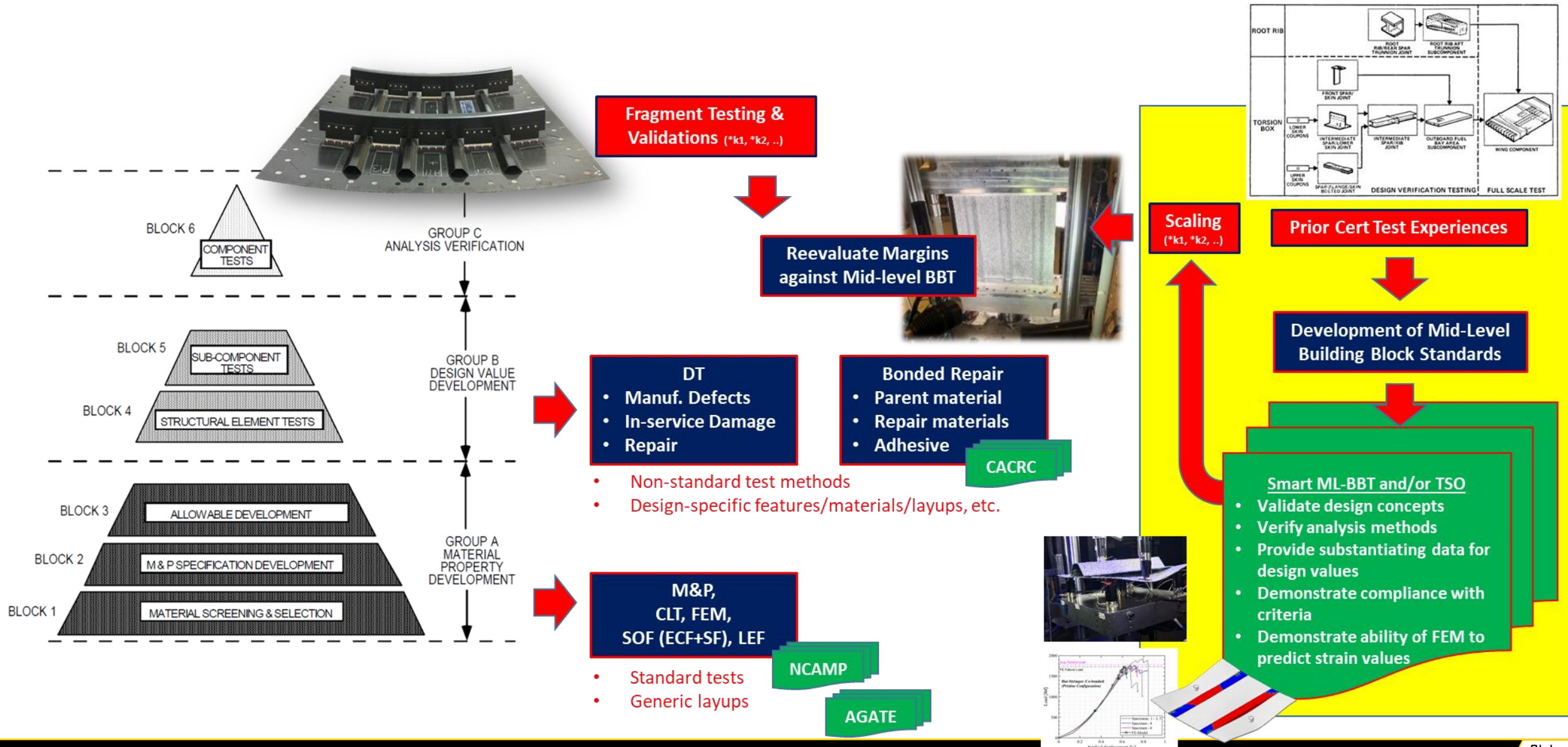
Material System	Horizontal Load Offset, Offset_h (in)			
IM7/5320-1	0.0"	1.0"	3.5"	-3.5"
IM7/5250-4	0.0"	1.0"	3.5"	N/A



Uniform Strain distribution in typical ILT Specimen under bending. Centrally aligning peak ~ 30% though thickness (Hard Layup IM7/5250-4)



Reverse Building-Block Testing for Development

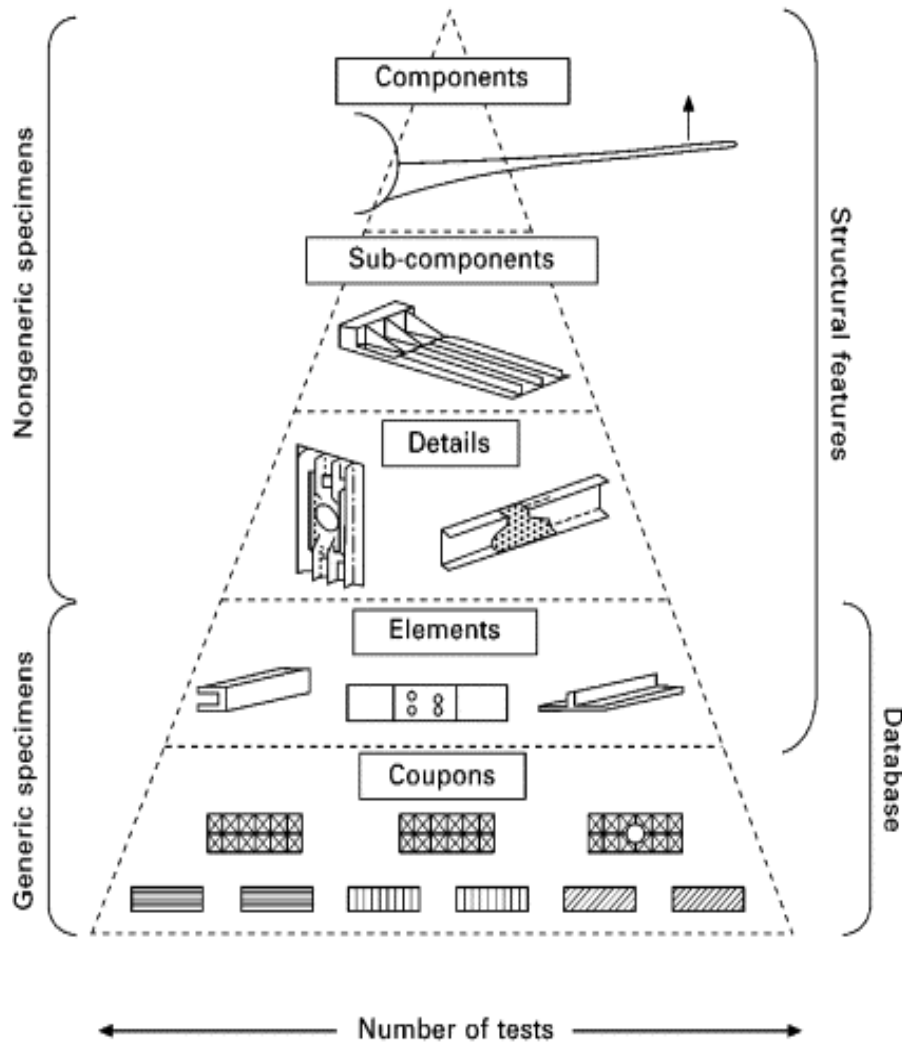
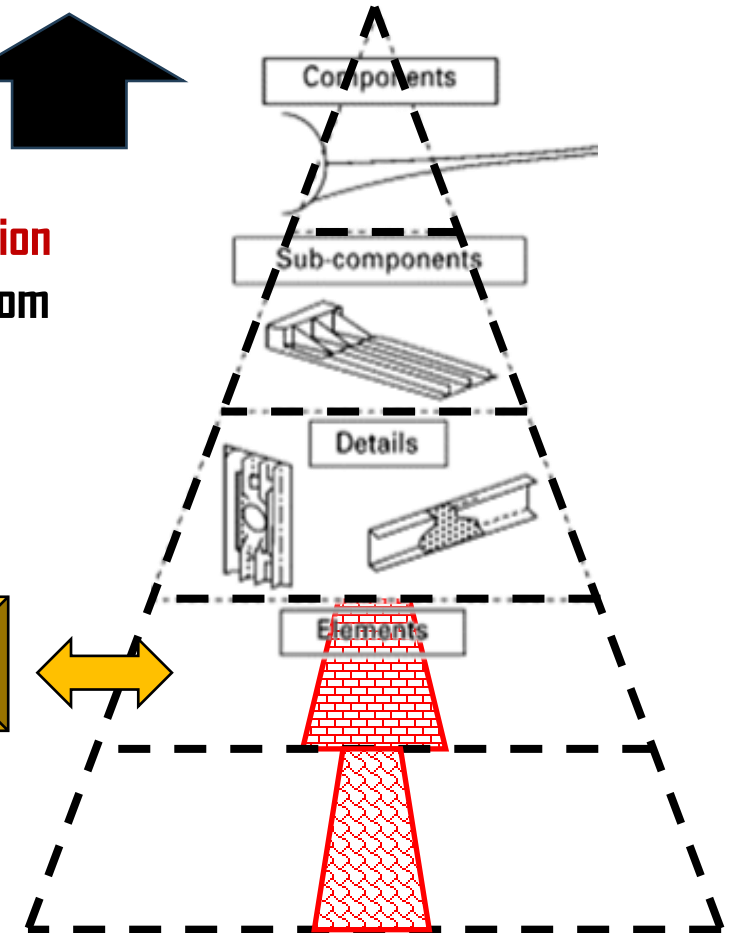
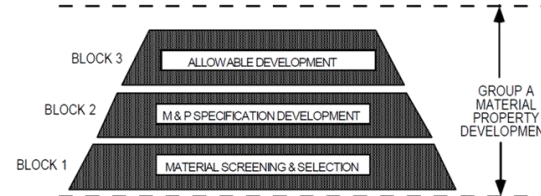


Accelerate Design Developments

Focused Reverse Building Block Testing

Structural Analysis for
Weight/Performance Optimization
→ Scale Factor Determined from
Fragment Testing

Analysis/Validations



Ultra-High-Rate Manufacturing



sampe
Conference & Exhibition

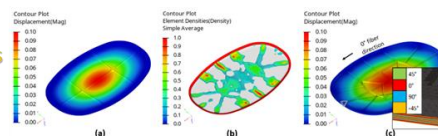


CAMX
THE COMPOSITES AND ADVANCED MATERIALS EXPO
CAMX AWARDS



Product Development

- Part Design for Manufacturing
 - New Products
 - Material Changes
 - Metal-to-Composite Conversions
- Structural Analysis

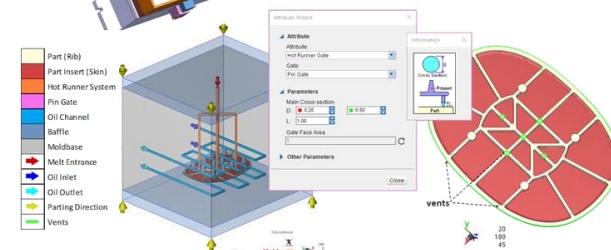
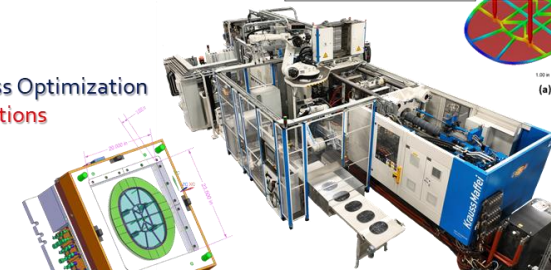
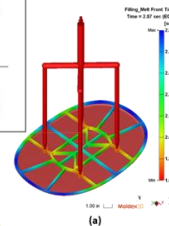
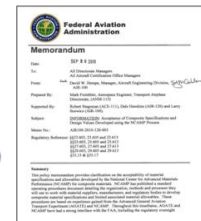


Manufacturing Process Development

- Material Screening & Compatibility
- Process Modeling
- Multi-Physics High-Fidelity Analyses
- Model Validations
- Manufacturing Tool Design

Building-Block Certification

- Material Characterization
- Design Allowables (NCAMP)
- Element to Component Testing (Full-Scale)
- Flight Testing
- Certification



MASc Injection Overmolded Rib



NIAR

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD • DISCOVER • DEVELOP • DELIVER

Office of Naval Research
ONR
Science & Technology

KraussMaffei
Pioneering Plastics

Joby

victrex

TOYOTA

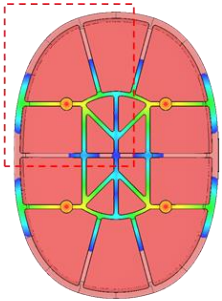
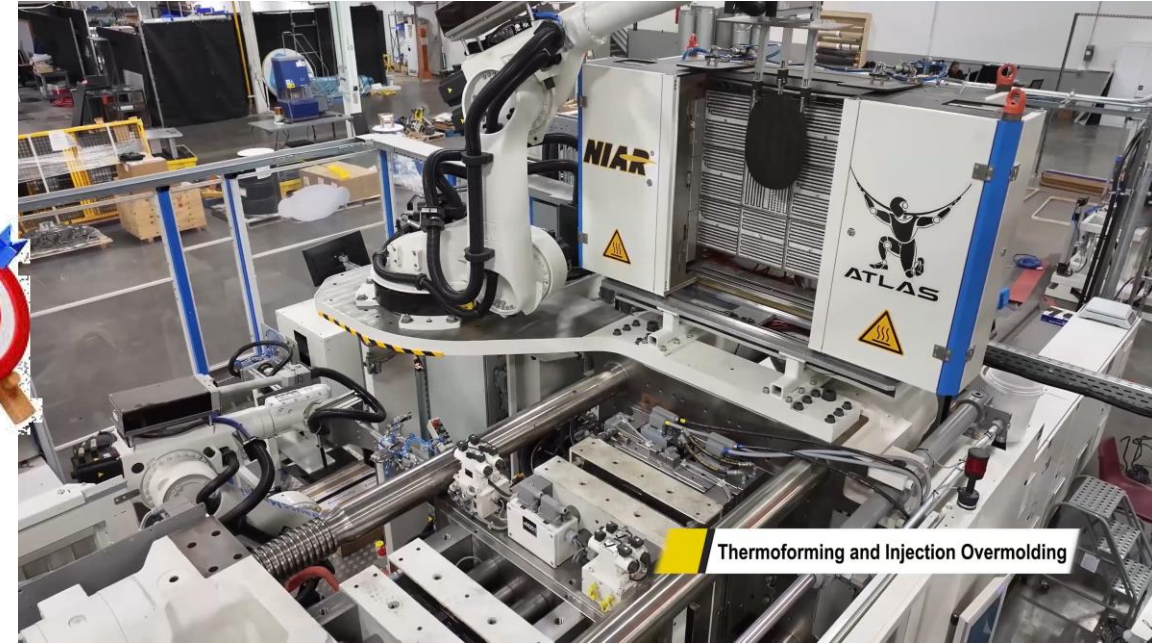
PROSPECT

Window Plug Certification

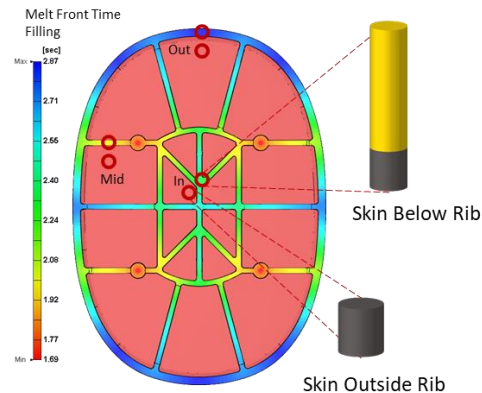
- **20-40% lighter** than the metallic counterpart.
- **Ultra-high-rate cycle times of ~ 90s (40 parts/hr).**
- **3-4x cheaper** compared to metallic counterpart.

➤➤ Final part for

- Process model validations
- Material compatibility from extracted specimens from various locations
- Full-scale window plug GAG testing



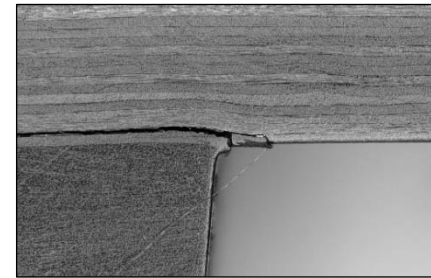
Process Model Validation



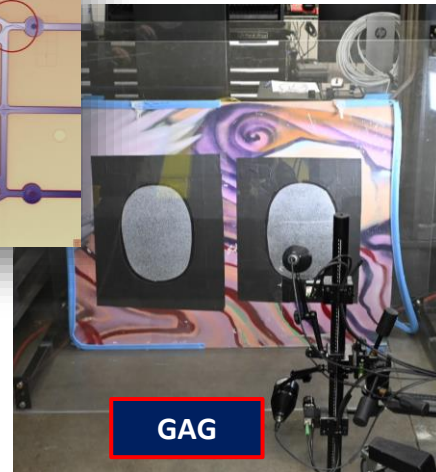
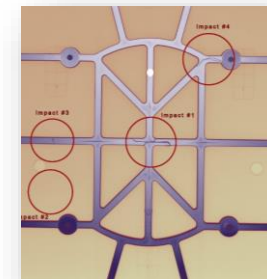
Thermal/Physical/Mechanical Testing



Failure modes away from the interface → **strong fusion**



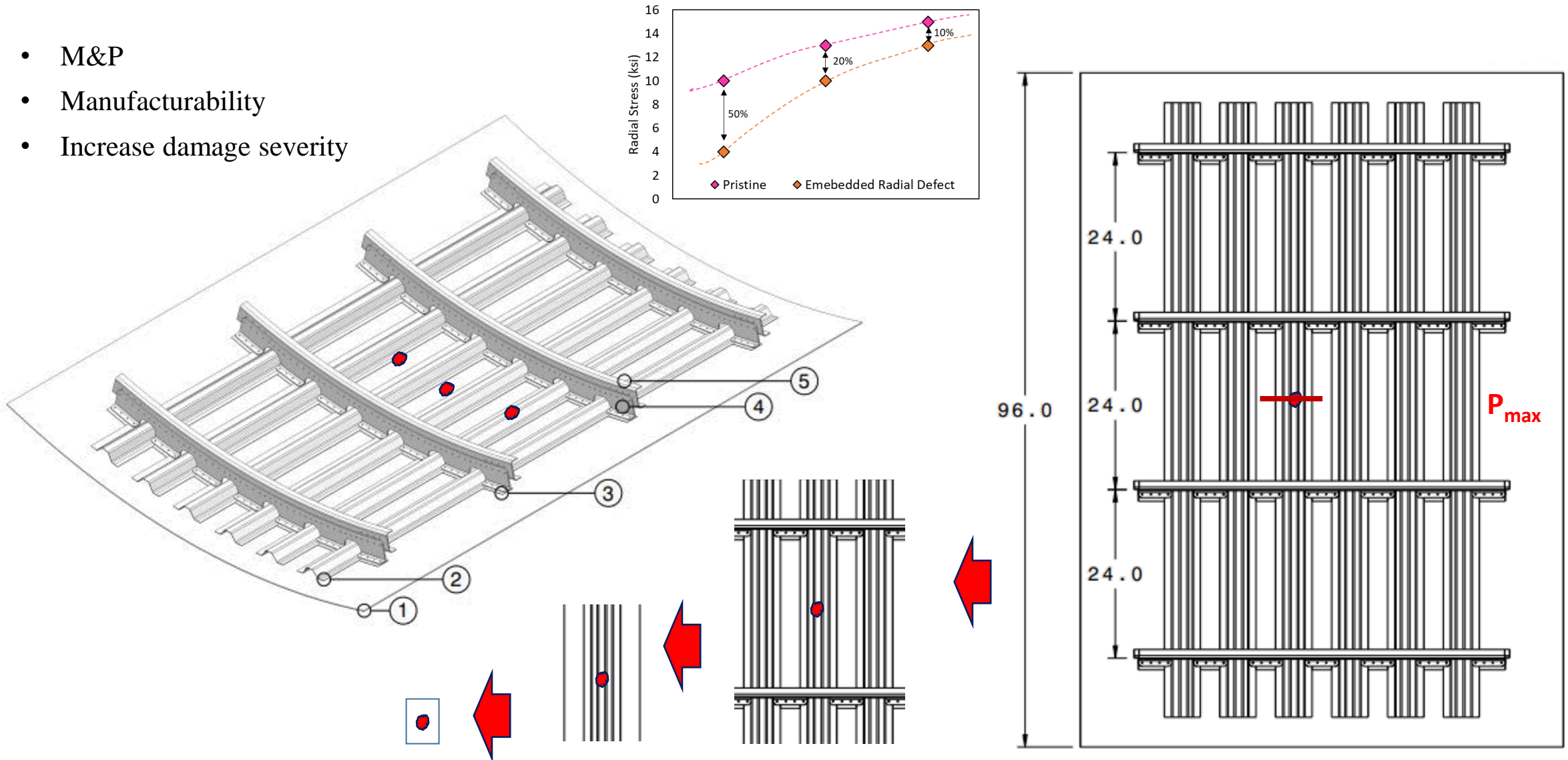
Material Compatibility



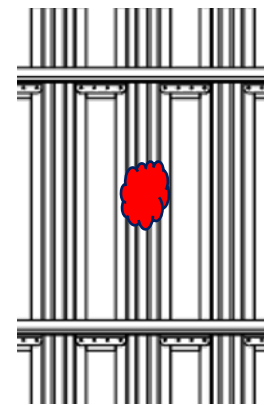
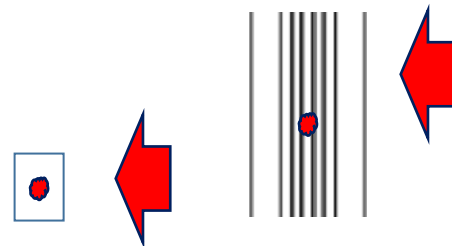
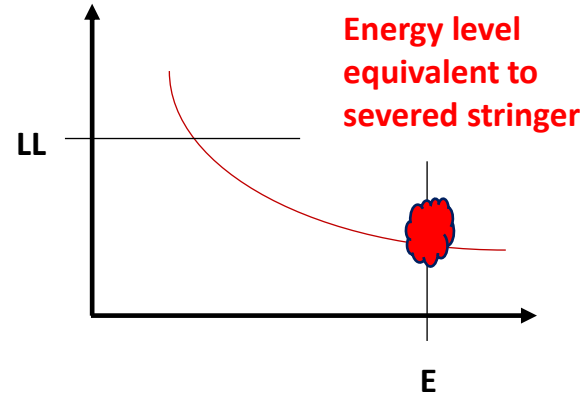
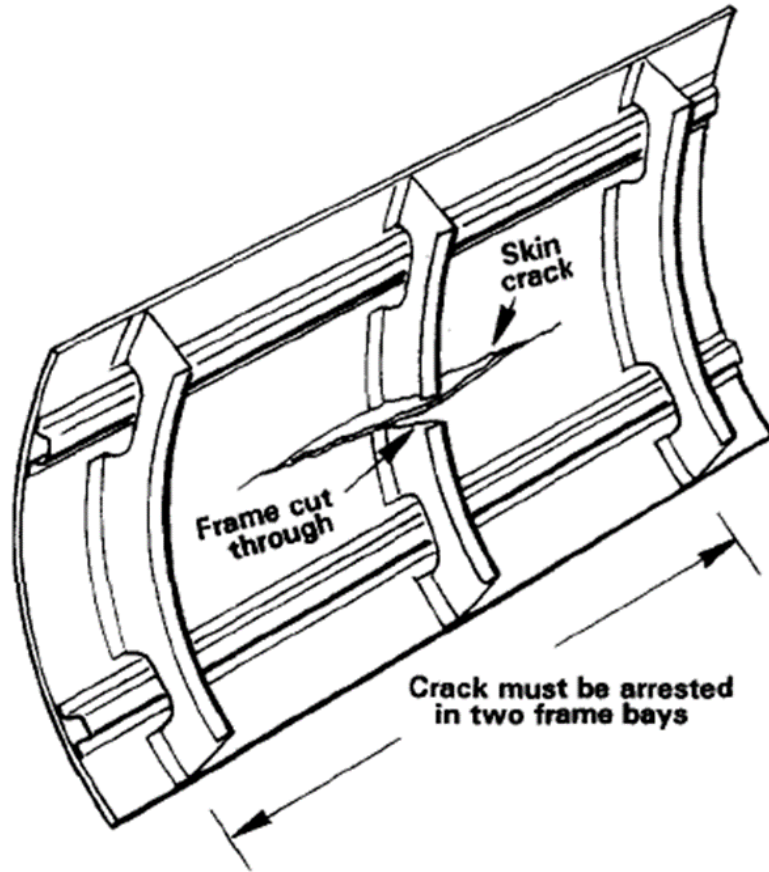
GAG

Large-Scale Damage Capability (Fragment Testing)

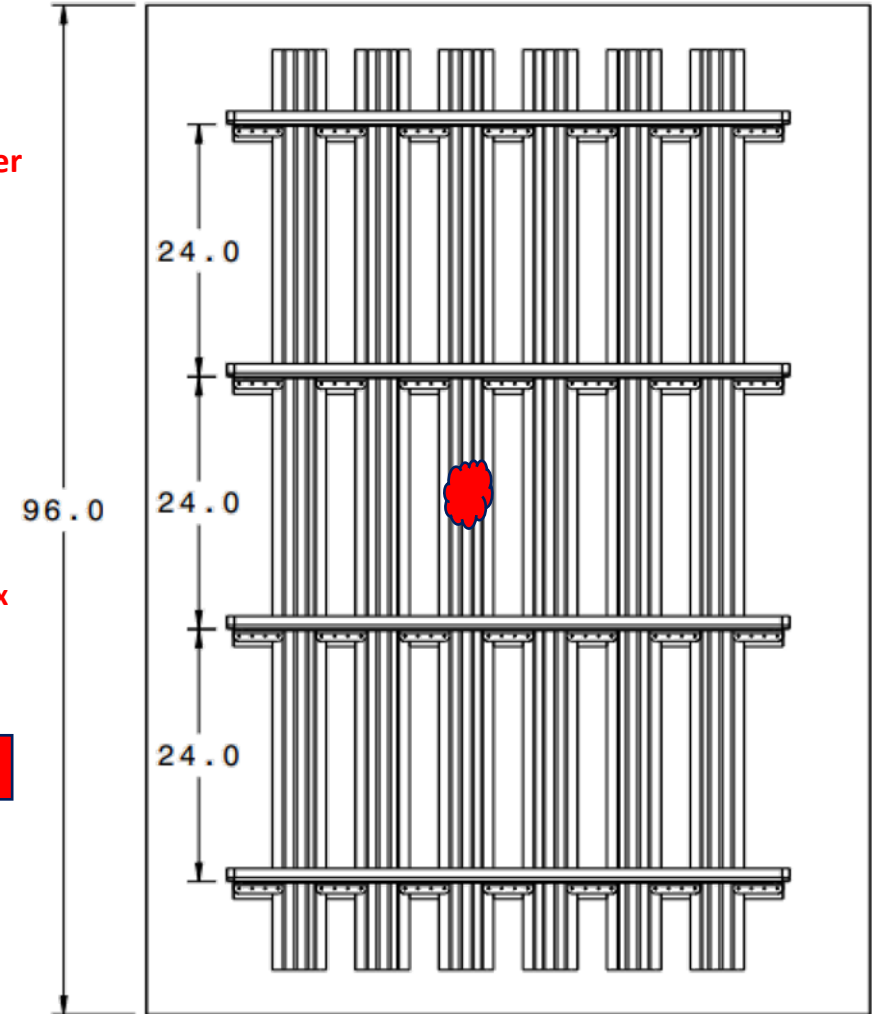
- M&P
- Manufacturability
- Increase damage severity



Large-Scale Damage Capability (Fragment Testing)



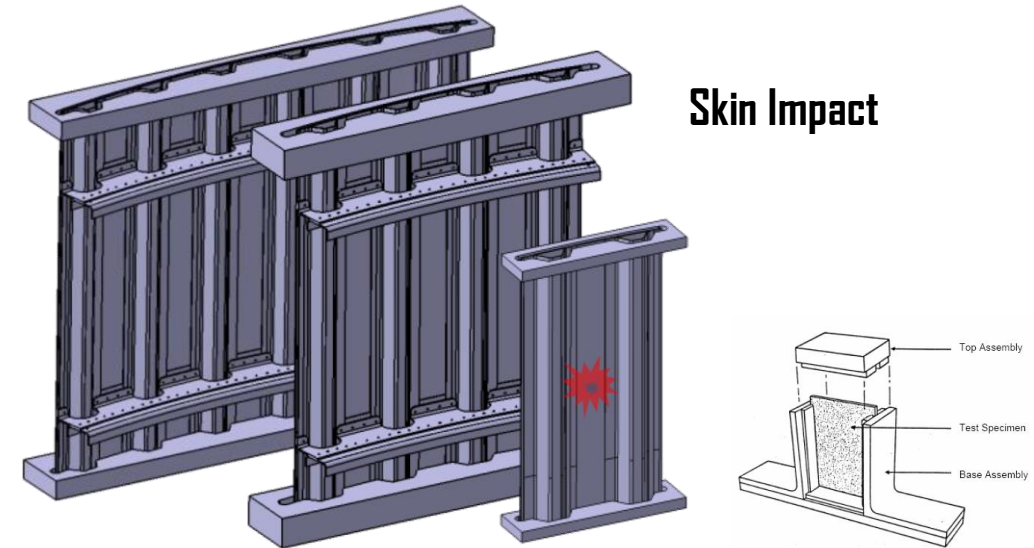
P^*_{max}



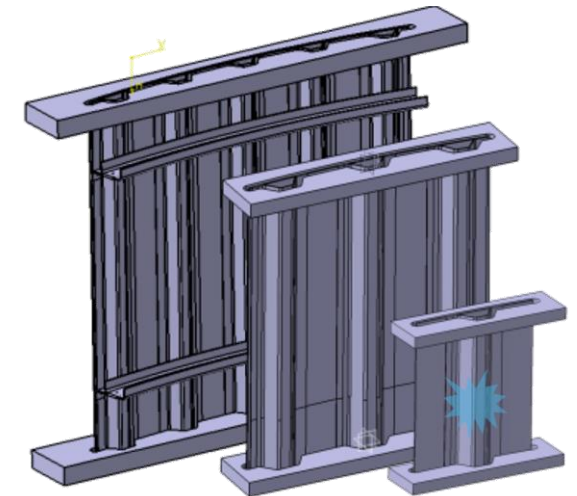
Test Element Extraction for Scaling Studies



- Thermoset (Bonded)
- Thermoplastic (Bonded & Welded)



Stringer Impact

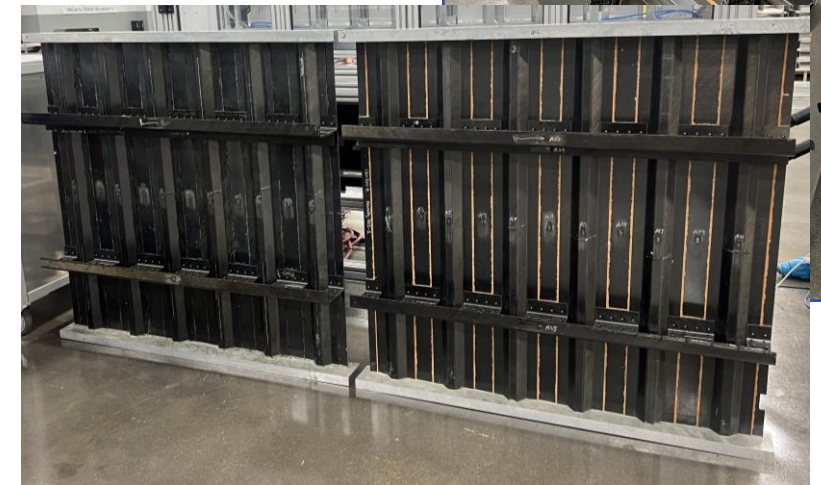


➤➤ Several thermoset panels (96"x70") panels were manufactured and elements were extracted for compression testing

➤➤ Thermoplastic panels

- Stringers are formed
- Skin panels are AFP'ed
- Ultrasonic welding will be used for assembly

➤➤ First round of testing is scheduled from June – August 2025



►► Enables comprehensive assessment of structural concepts, design solutions, and fabrication methods.

- Delivers accurate performance predictions.
- Integrates analysis across multiple length scales.
- Establishes clear linkages between material processing, microstructure, properties, and overall performance.

►► Employs advanced, validated numerical models to simulate the behavior and condition of composite materials in aircraft structures.

- Reduces the volume of physical testing required.
- Shortens the certification timeline.
- Enhances overall development effectiveness.

►► Digital engineering thread for structural concept evaluation in airframe safety management.

- Manage M&P changes