ANTEC® 2024
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Cost-Effective Automotive Body Structures

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WEAV3D Inc.

#ANTEC24

Outline

- About WEAV3D® and Rebar for Plastics®
- Composite Door Design Challenge and Redesign Objectives
- Project Overview
  - Material Benchmarking
  - FEA Optimization
  - Parametric Cost Modelling
  - Prototype Manufacturing
- Experimental Results
- FEA Validation
- Summary

About WEAV3D®

Manufacturer of composites lattice materials for automotive and construction applications

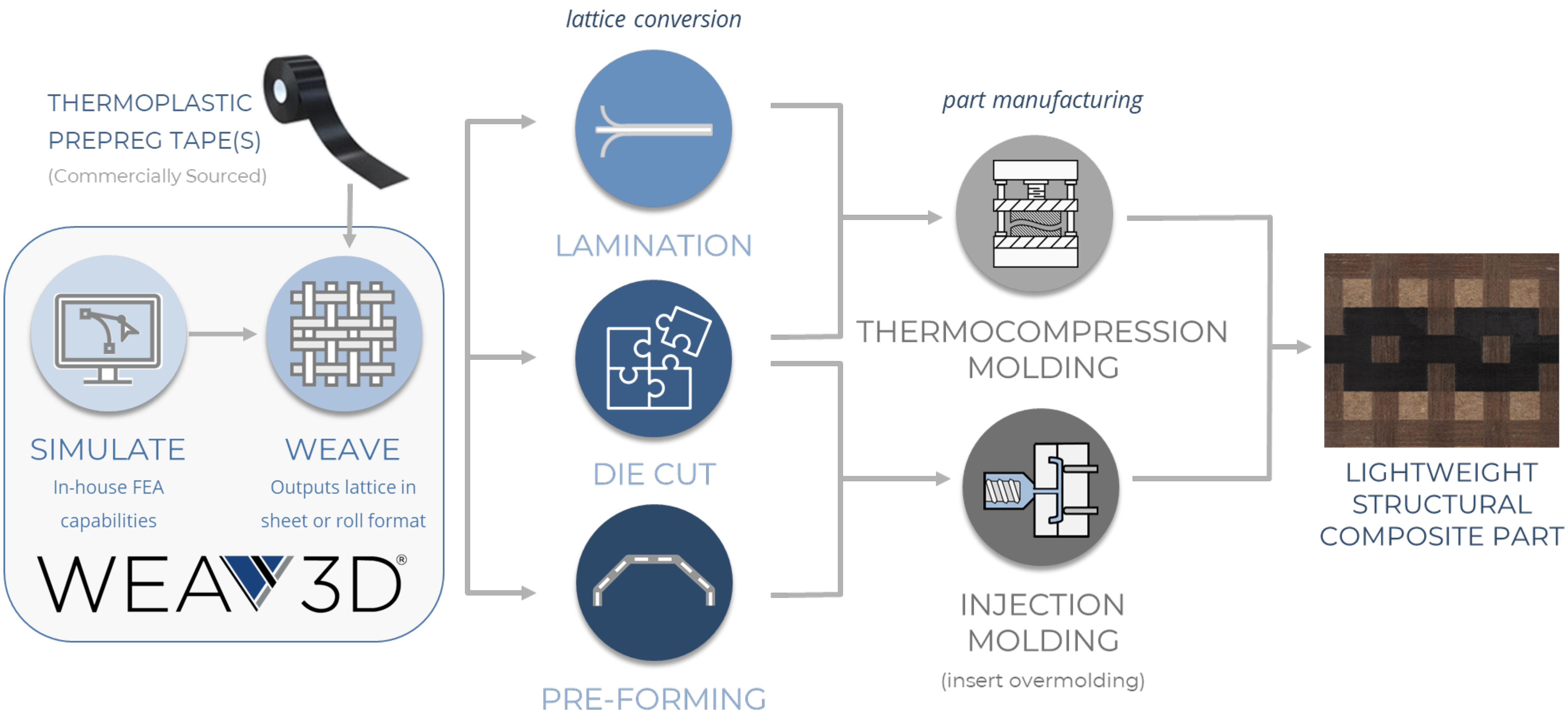
2014
Technology invented

2017
WEAV3D founded out of Georgia Tech

TODAY
Headquartered in metro Atlanta, Georgia

WEAV3D's patented **Rebar For Plastics®** solution enables cost-effective, scalable, locally tunable composite lattices for mass production.

Rebar for Plastics® - Process Overview



Design Challenge – Automotive Door

Background

- Clemson University led a Department of Energy funded project to design an ultralightweight composite door, based on the 2016 Acura MDX.
- Carbon fiber/PA6 organosheet used for the inner frame and inner beltline stiffener, augmented with metal
- Clemson design achieved 45% weight reduction and 64% parts consolidation

Excerpt from 2021 DoE Vehicle Technologies Office Annual Merit Review

Inner frame
- **Manufacturing:** *Thermoforming*
- **Material:** *PA 6 + 50 % wt. Woven CF*

Anti-intrusion beam assembly
- **Manufacturing:** *Hot Stamped and Welded*
- **Material:** *Ultra high strength steel*

Inner beltline stiffener
- **Manufacturing:** *Thermoforming*
- **Material:** *PA 6 + 50 wt % Woven CF*

Outer beltline stiffener
- **Manufacturing:** *Extrusion and Welded*
- **Material:** *Aluminum 6061*

Lower Reinforcement
- **Manufacturing:** *3D Printing Dies + Stamping*
- **Material:** *Aluminum 6061*

Despite meeting performance and weight objectives, the cost of the composite door assembly was twice that of the original steel door, driven by the high cost of the carbon fiber organosheet.

Redesign Objectives

Beltline Stiffener Demonstrator Goals

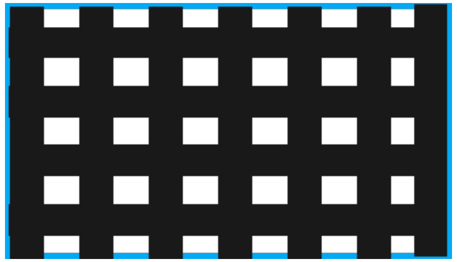
1. Reduce cost from current CF/PA6 organosheet design
2. Achieve comparable performance under side impact load case
3. Maintain weight savings
4. Maintain organosheet part geometry and thickness to utilize existing tooling

In Partnership with:

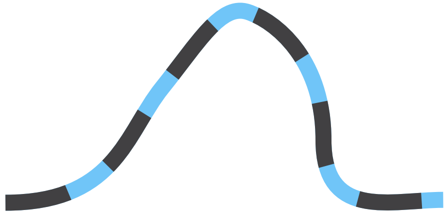
WEAV3D®
Braskem
CLEMSON® COMPOSITES CENTER
ALTAIR

Project Overview

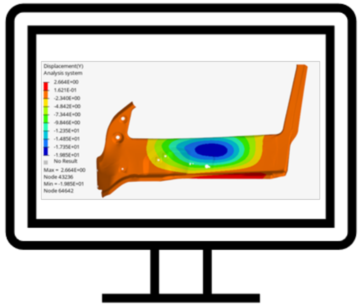
PHASE 1 → **PHASE 2** → **PHASE 3** → **PHASE 4**



Flat Panels



Complex Shape

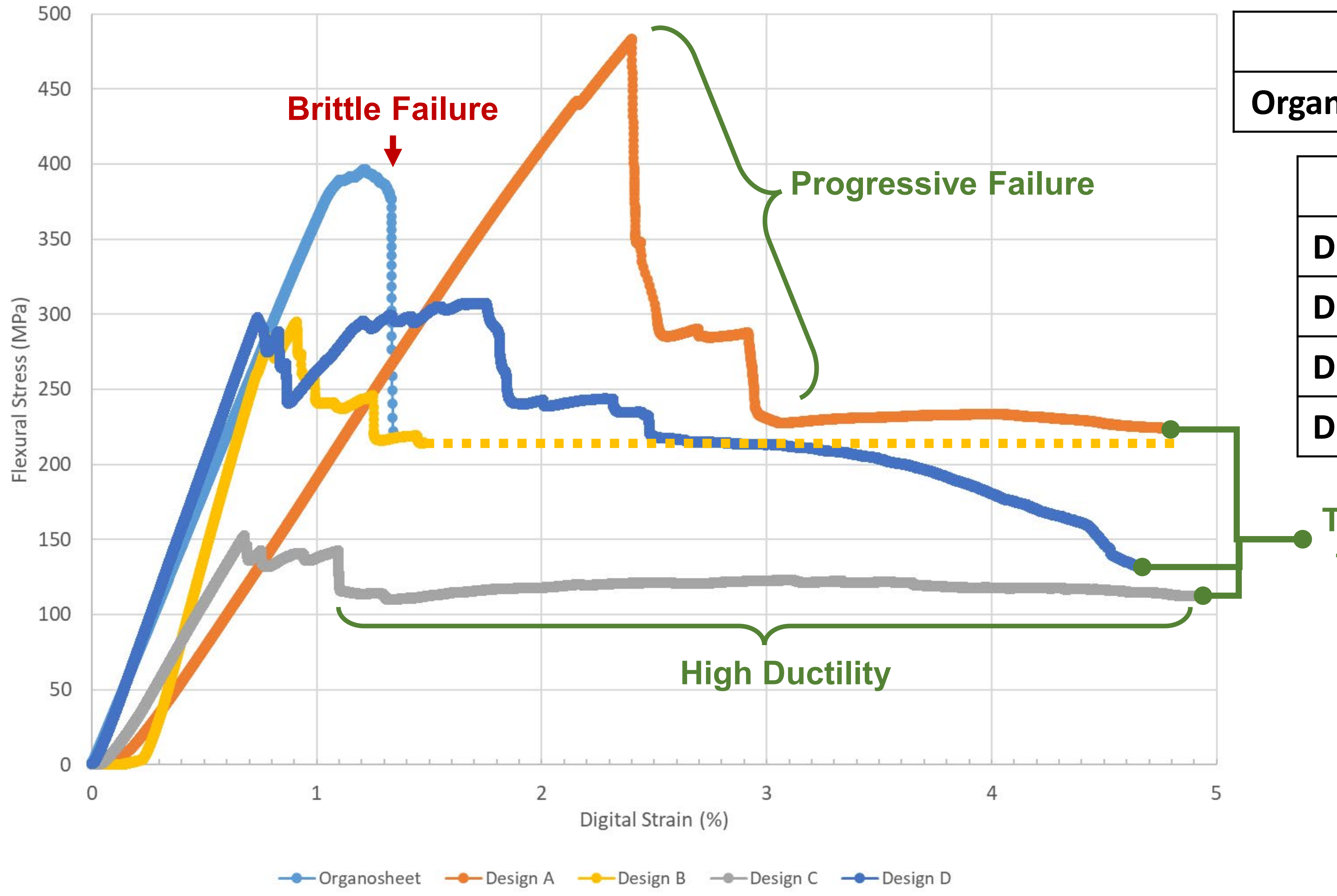


FEA Optimization

Part Prototyping

Material Benchmarking

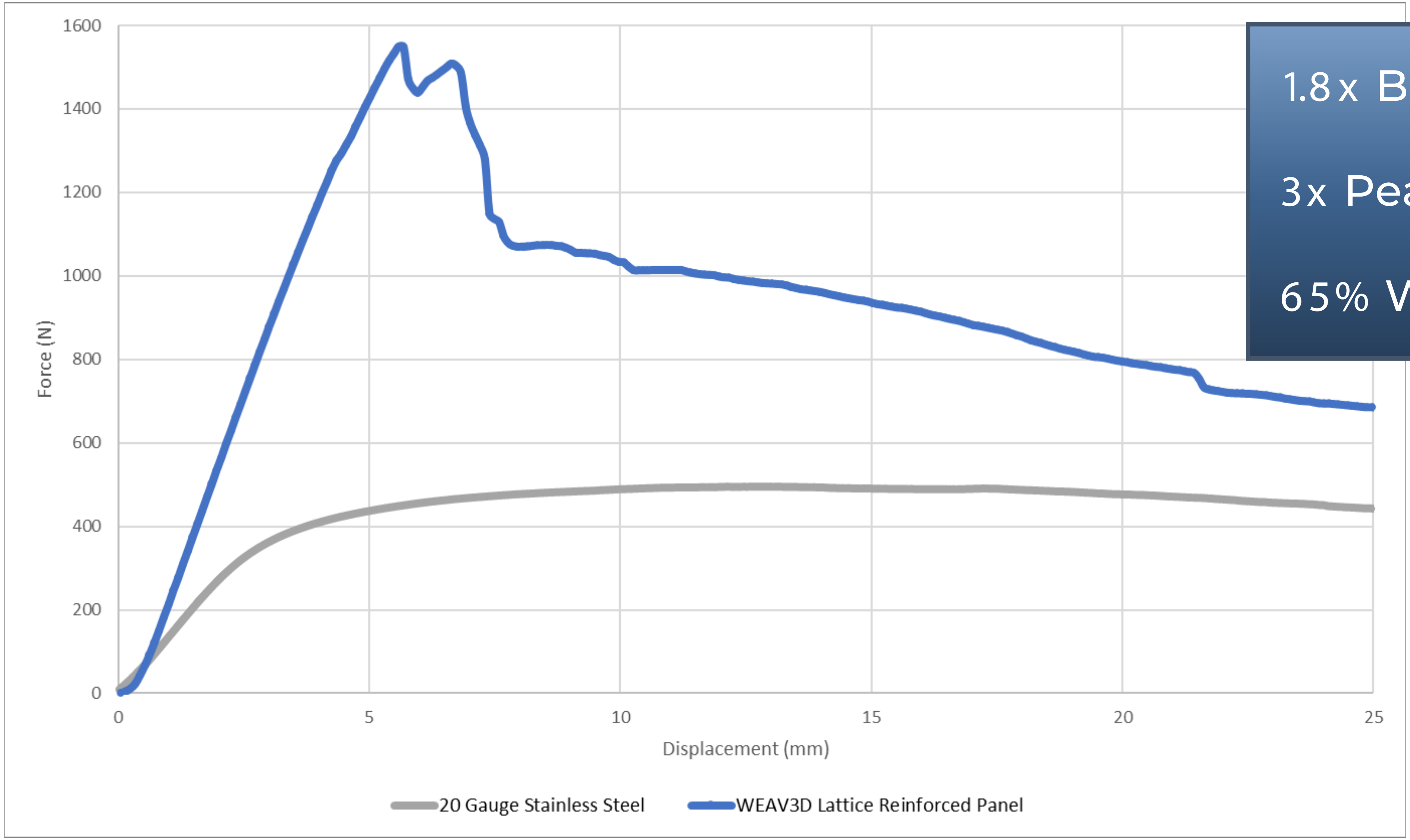
Material Benchmarking



	Material
Organosheet	2/2 Twill Laminate – CF/PA6

	Bulk	Lattice
Design A	Unfilled T14003F PP	GF/PP
Design B		CF/PP
Design C		CF/PP
Design D		GF/CF/PP

Steel Equivalence Comparison

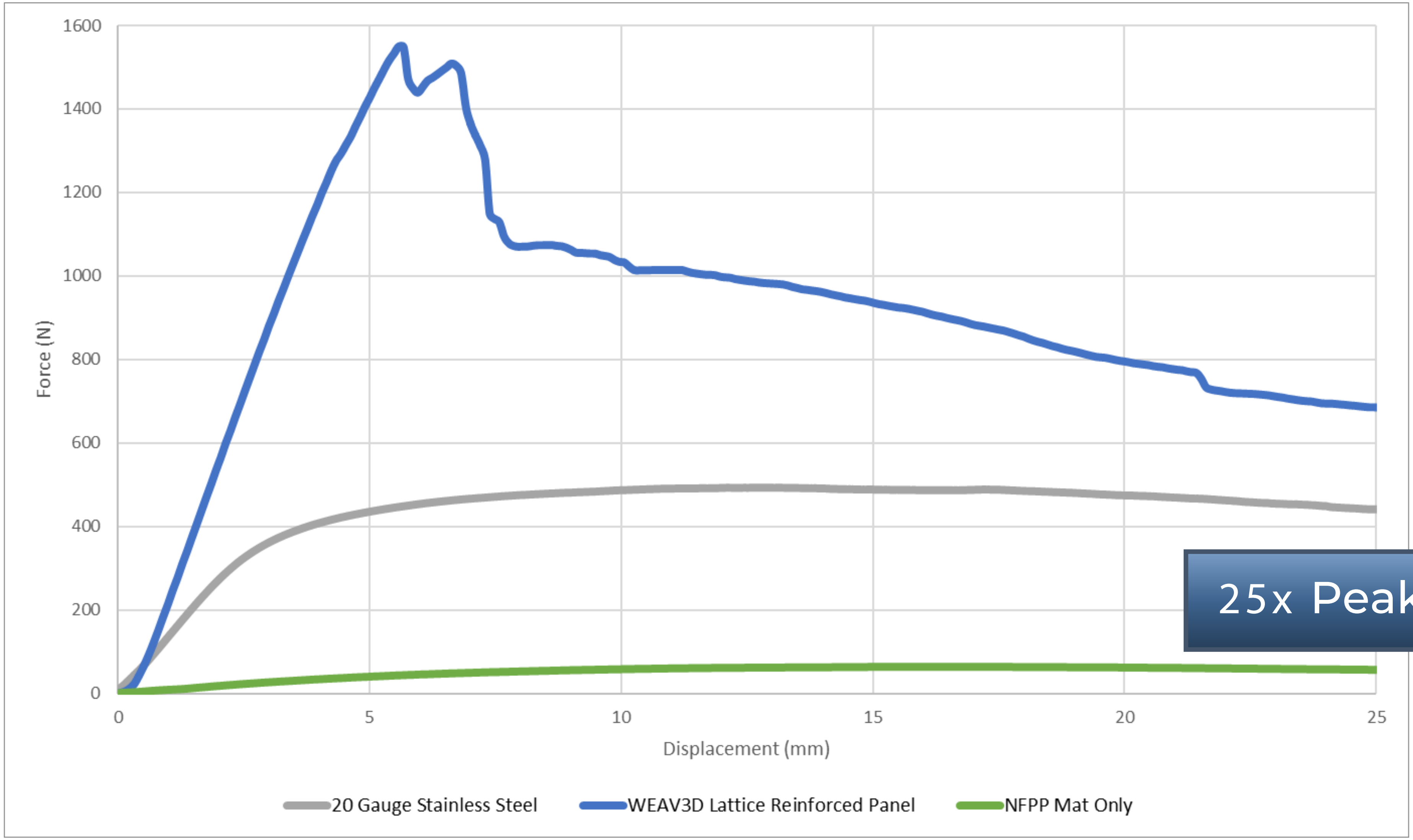


1.8 x Bending Stiffness

3x Peak Load

65% Weight Reduction

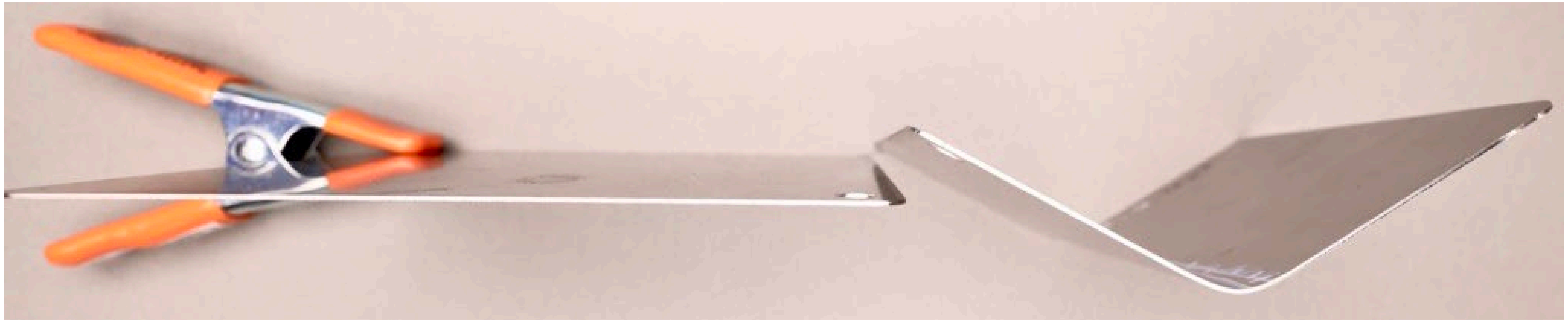
Steel Equivalence Comparison



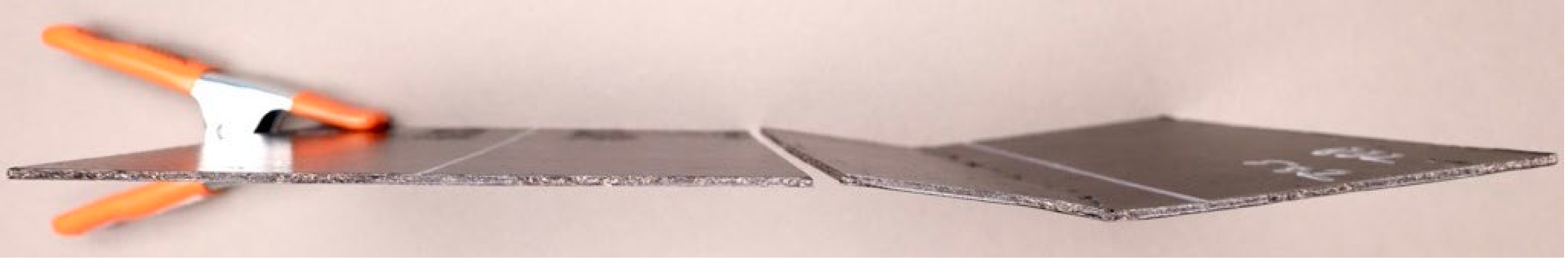
25x Peak Load vs. NFPP

Steel Equivalence Comparison

20 Gauge Stainless Steel (0.95mm)



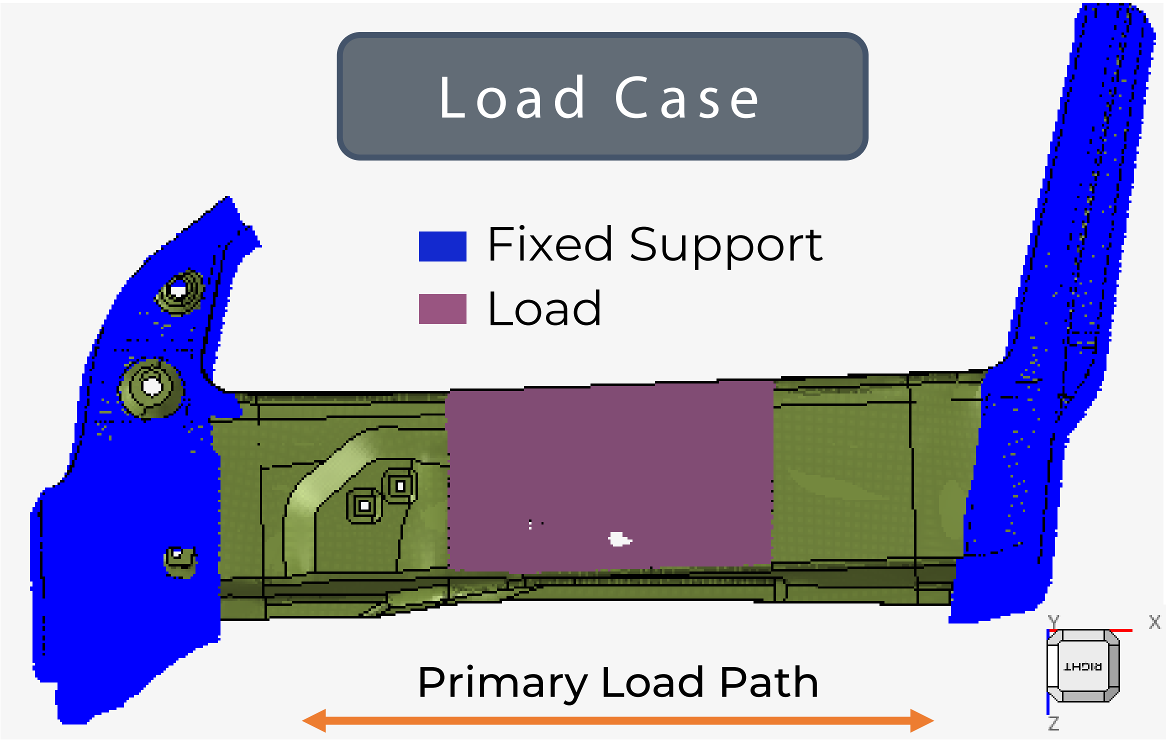
WEAV3D Reinforced (2.1 mm)

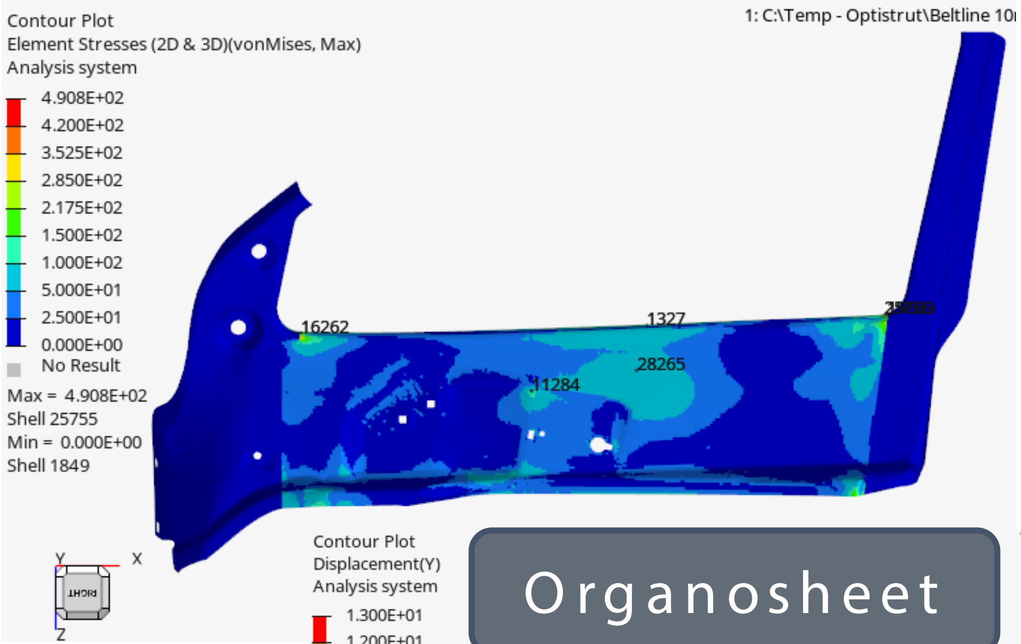


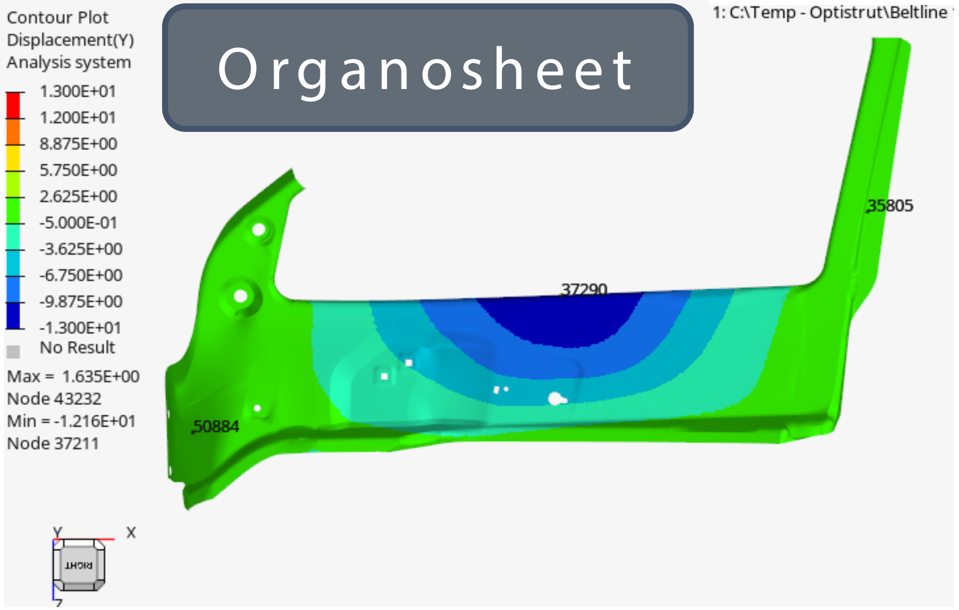
Before Test

After Test

FEA Optimization - Baseline







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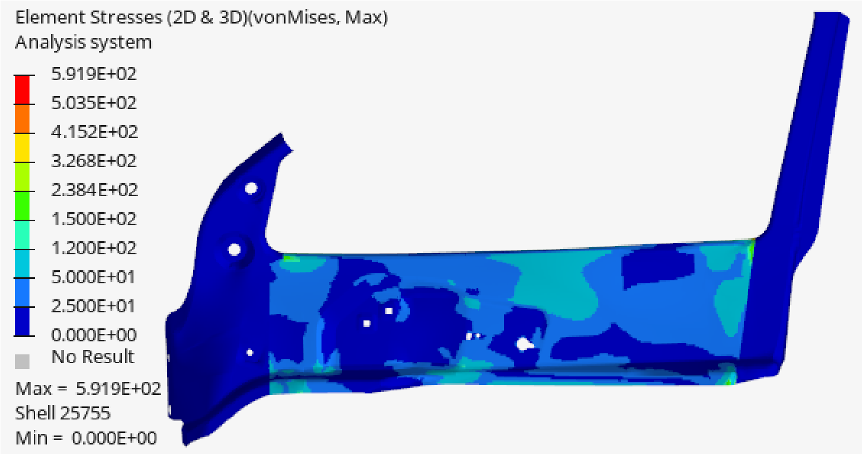
FEA Optimization - Baseline

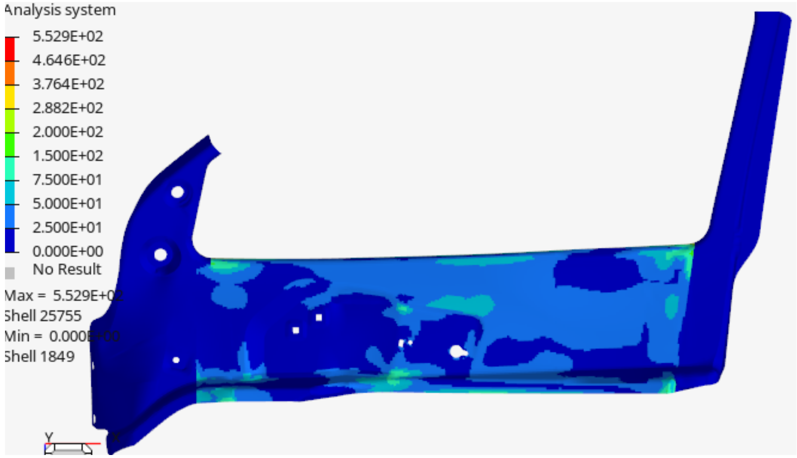
Design 7

2-Layer 100% Dense (Alternating) Glass and Carbon

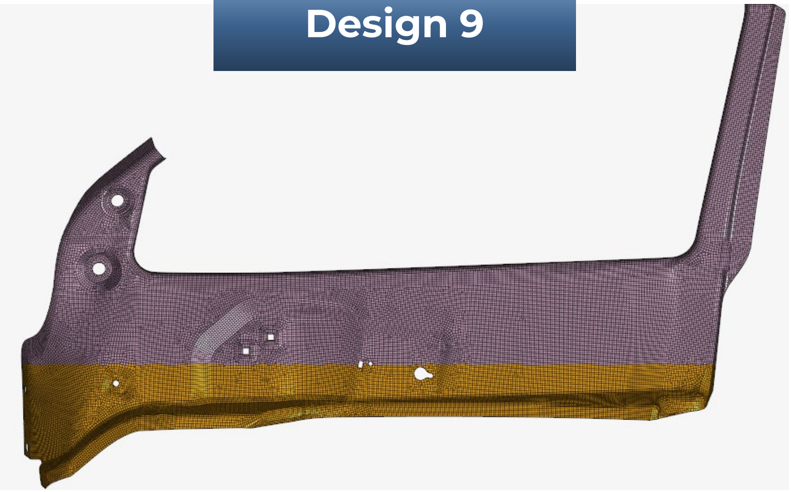


Design 8

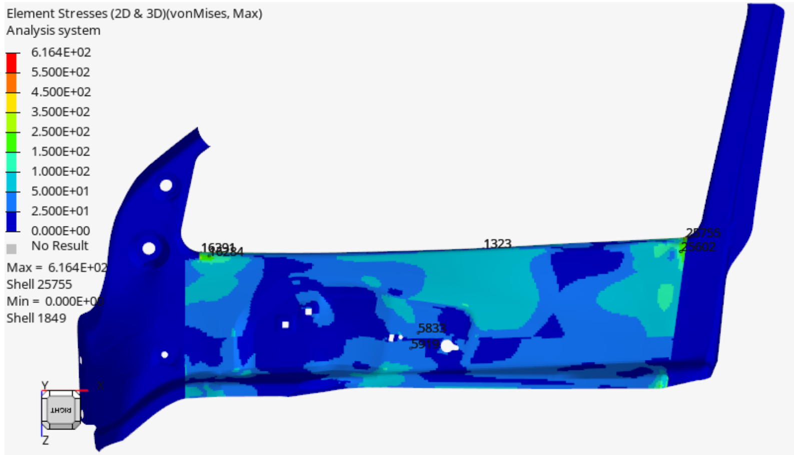
2-Layer 100% Dense Carbon Inner, Glass Outer



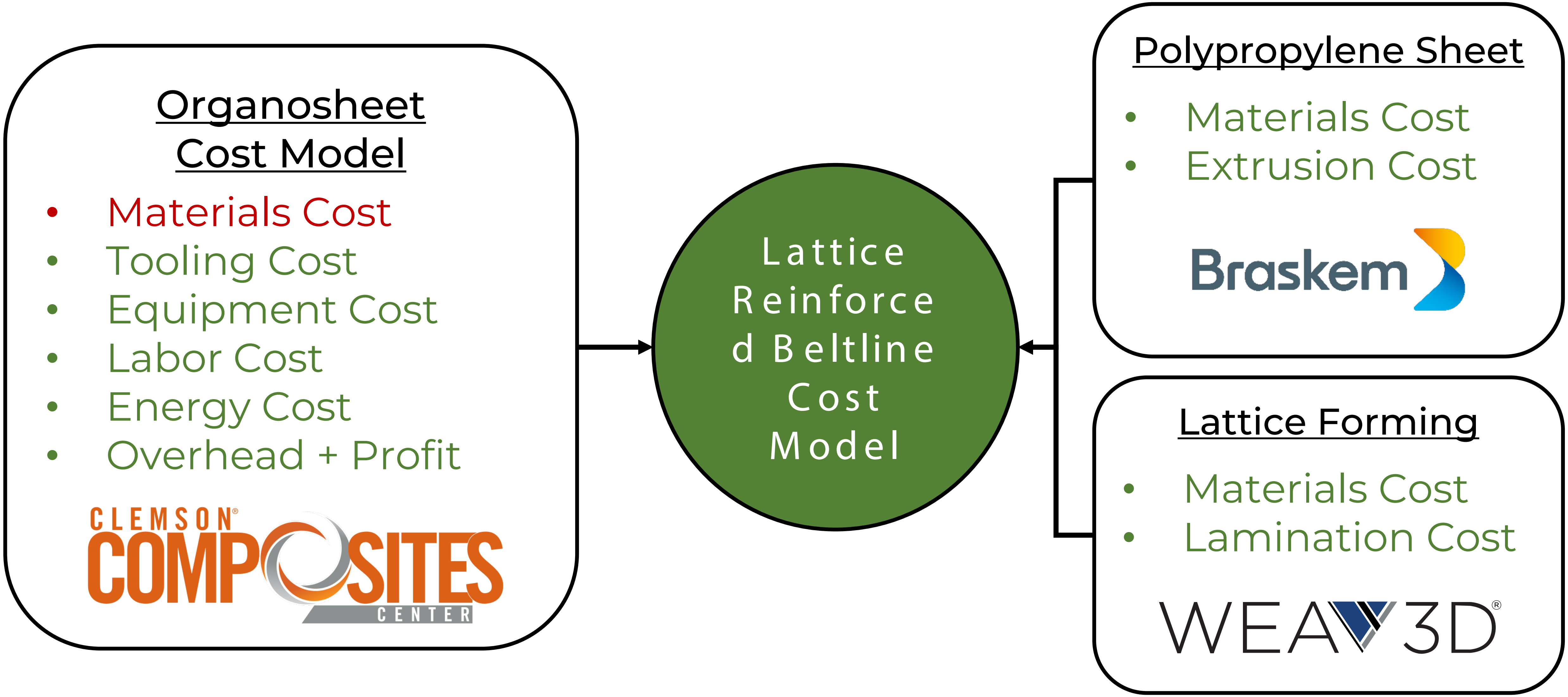
Design 9



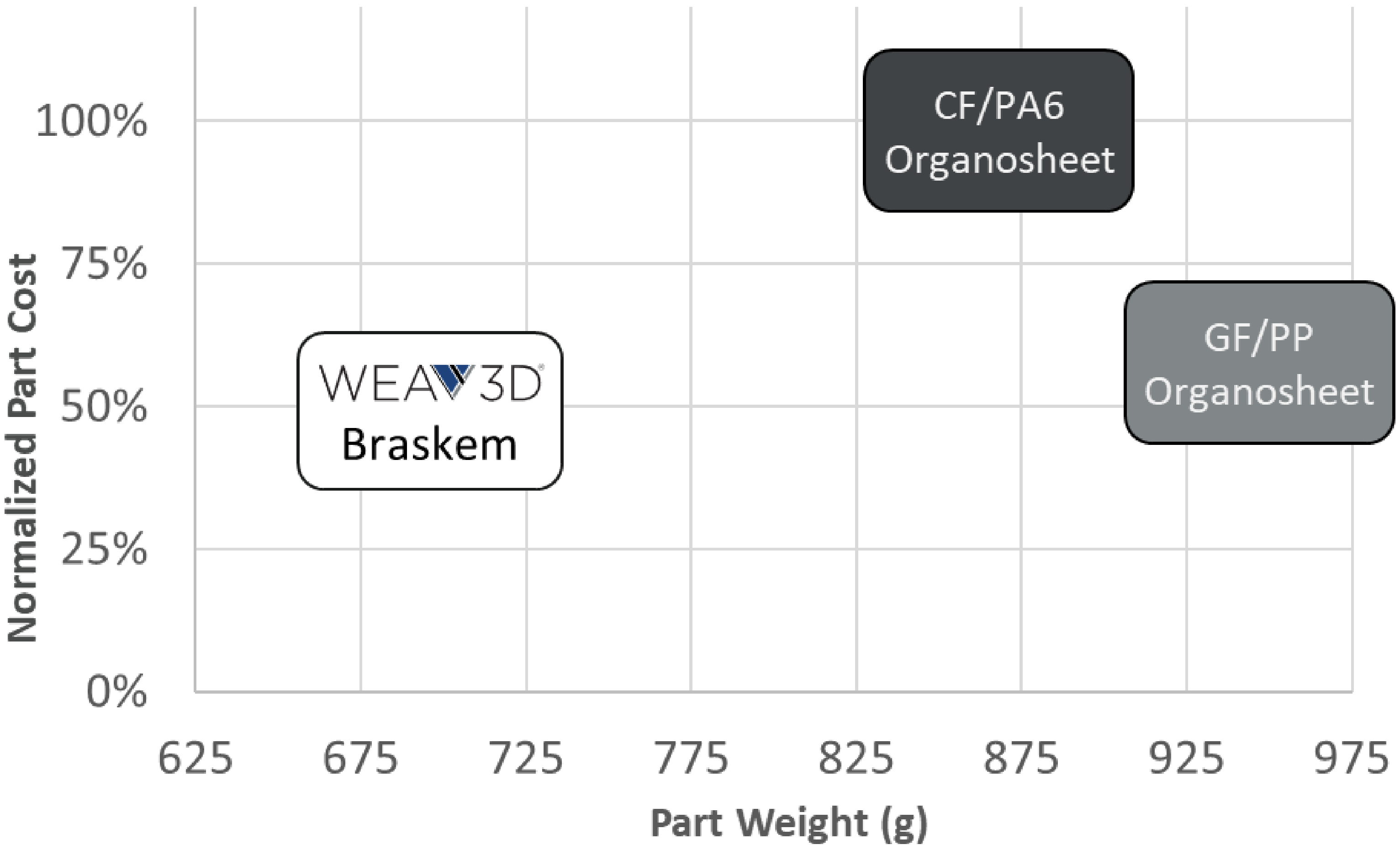
2-Layer 100% Dense Carbon Upper 2-Layer 100% Dense Glass Lower



Parametric Cost Modelling



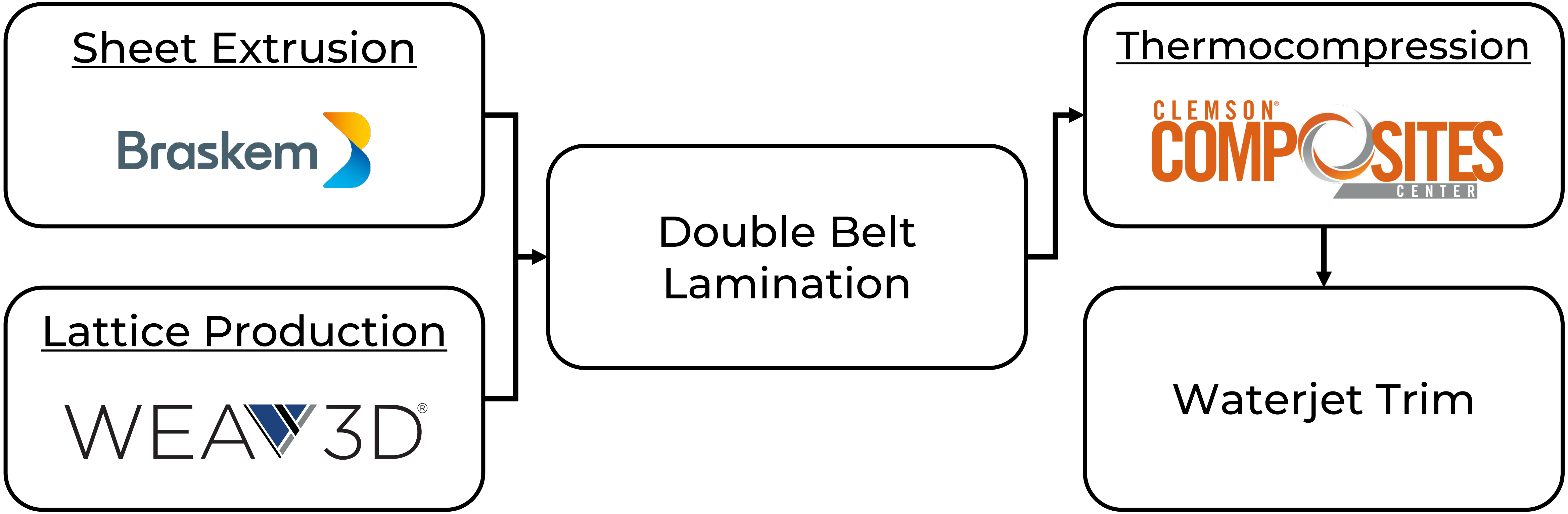
Cost Advantages over Organosheet



Relative to CF/PA6 baseline,
WEAV3D lattice optimization:

- Reduced part weight (-23%)
- Reduced cost (-50%)
- Increased trim yield from 27% to 44% by weight
- Reduced trim waste (-62%)

Prototype Manufacturing



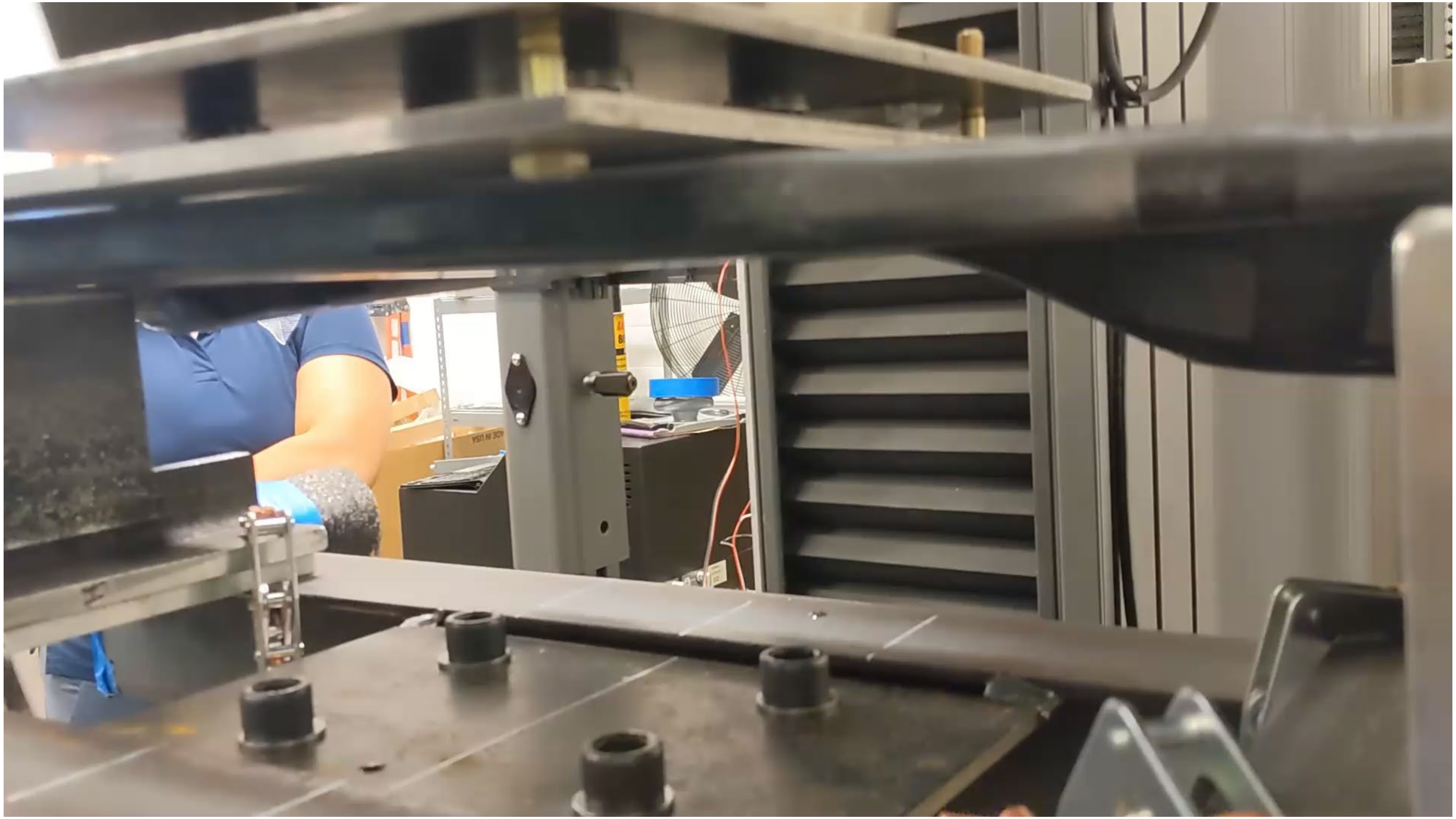
Prototype Manufacturing

Experimental Results - Setup

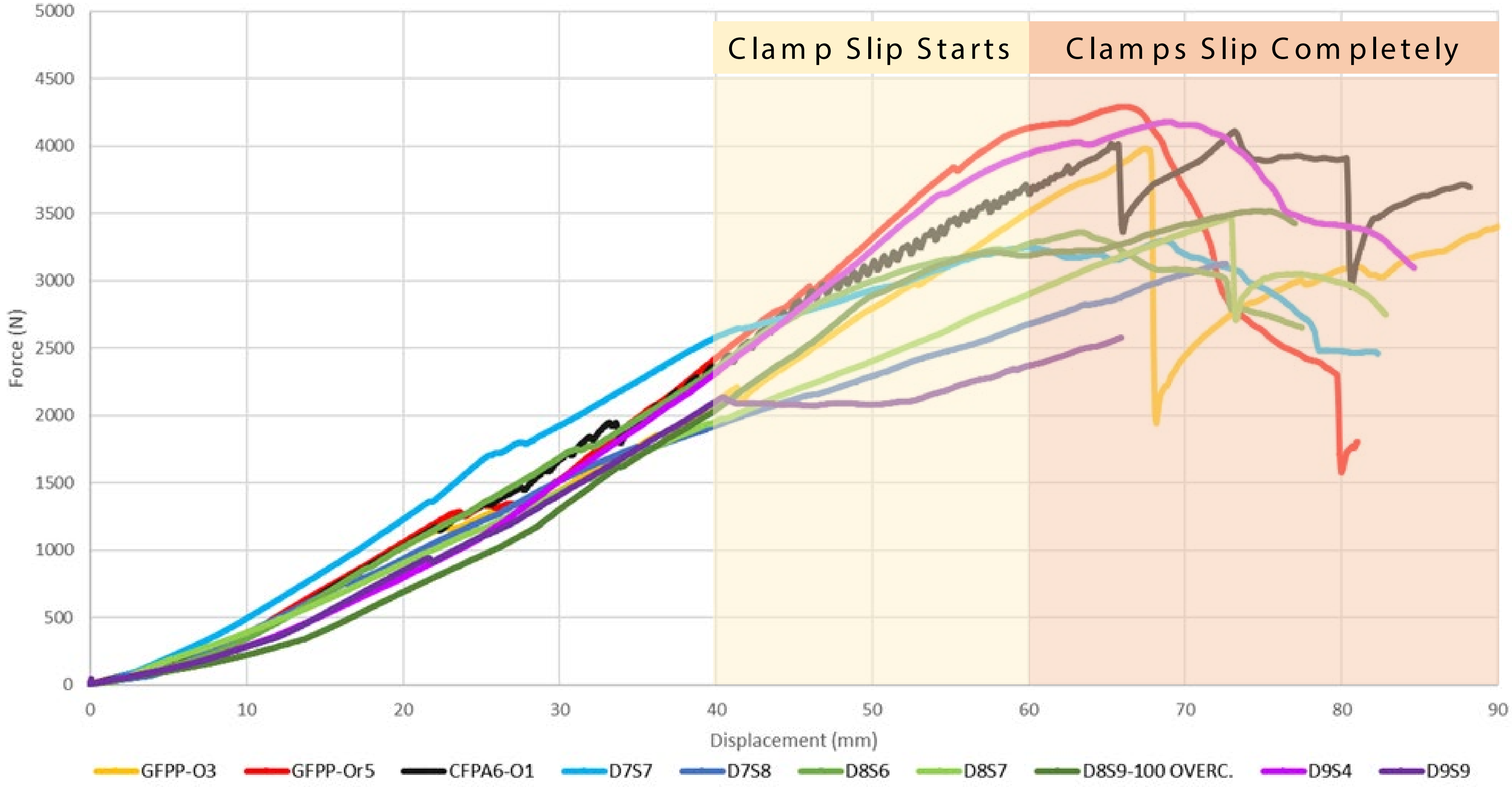
B-Pillar Clamping

A-Pillar Clamping

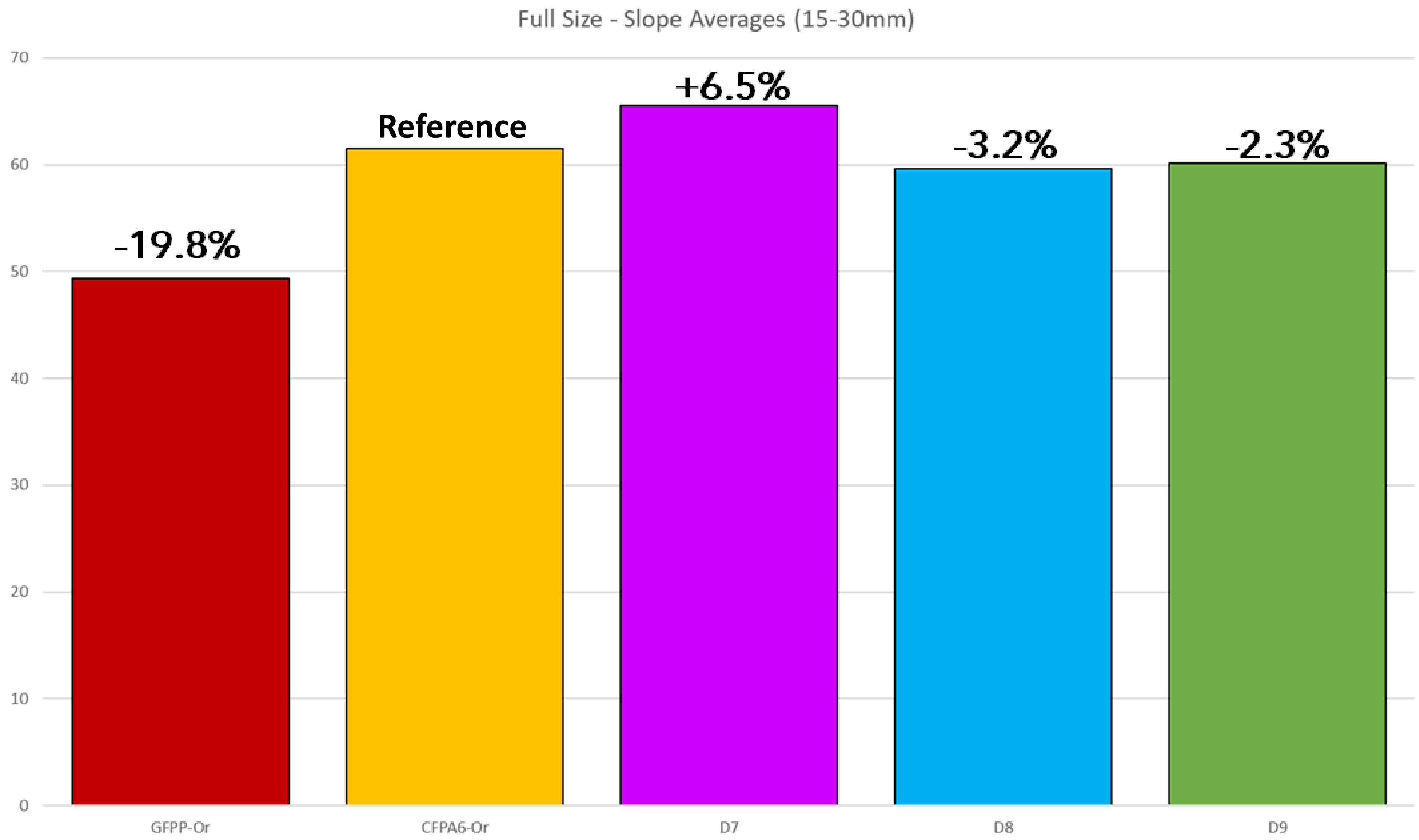
Experimental Results - Testing



Experimental Results

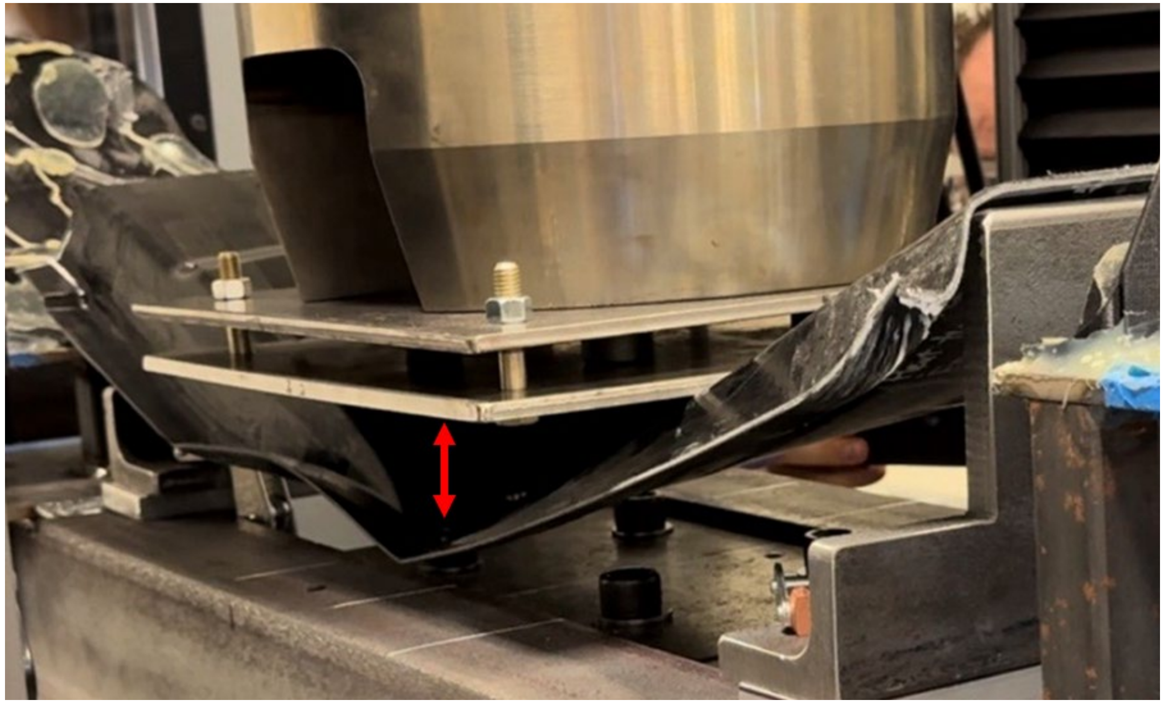


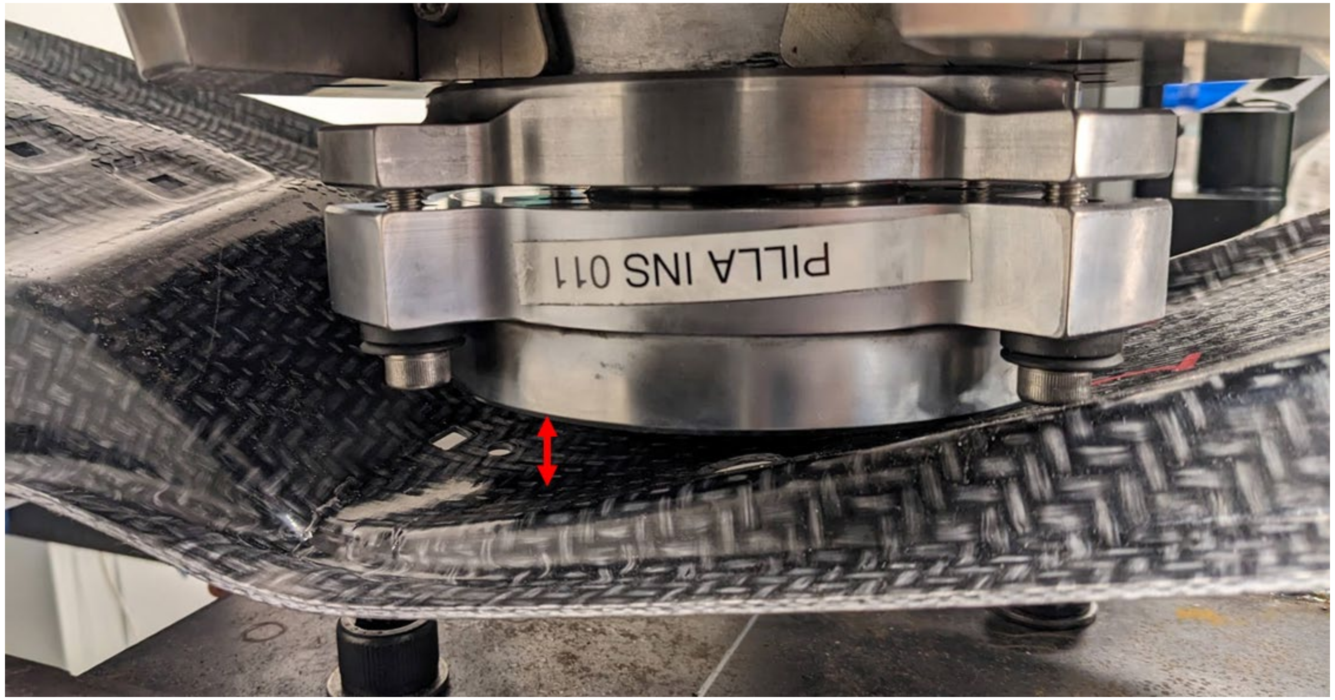
Experimental Results



FEA Validation - Setup

Boundary Conditions Simplified to Reduce Error



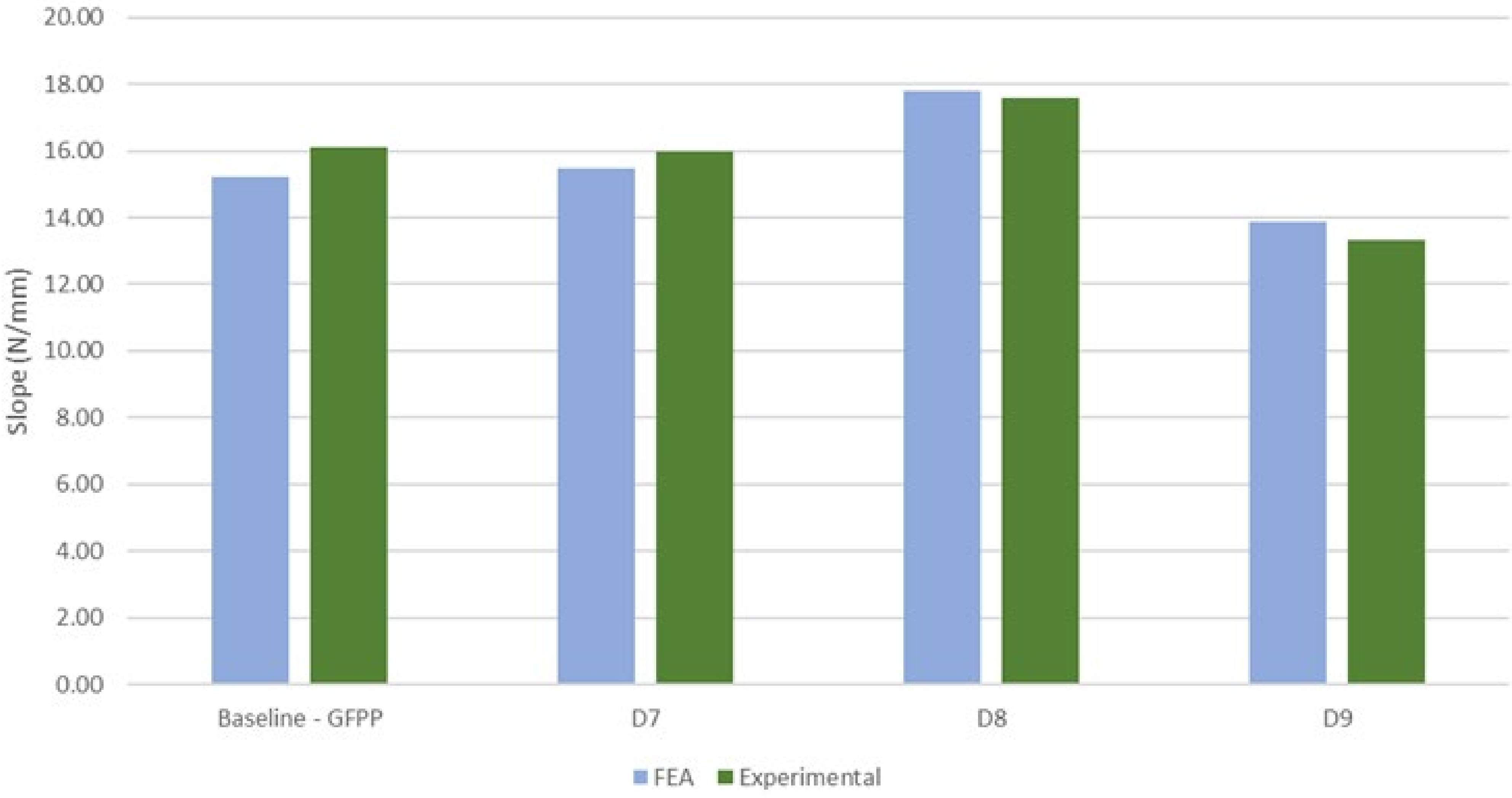


Simply Supported Load Case - Original Load Applicator

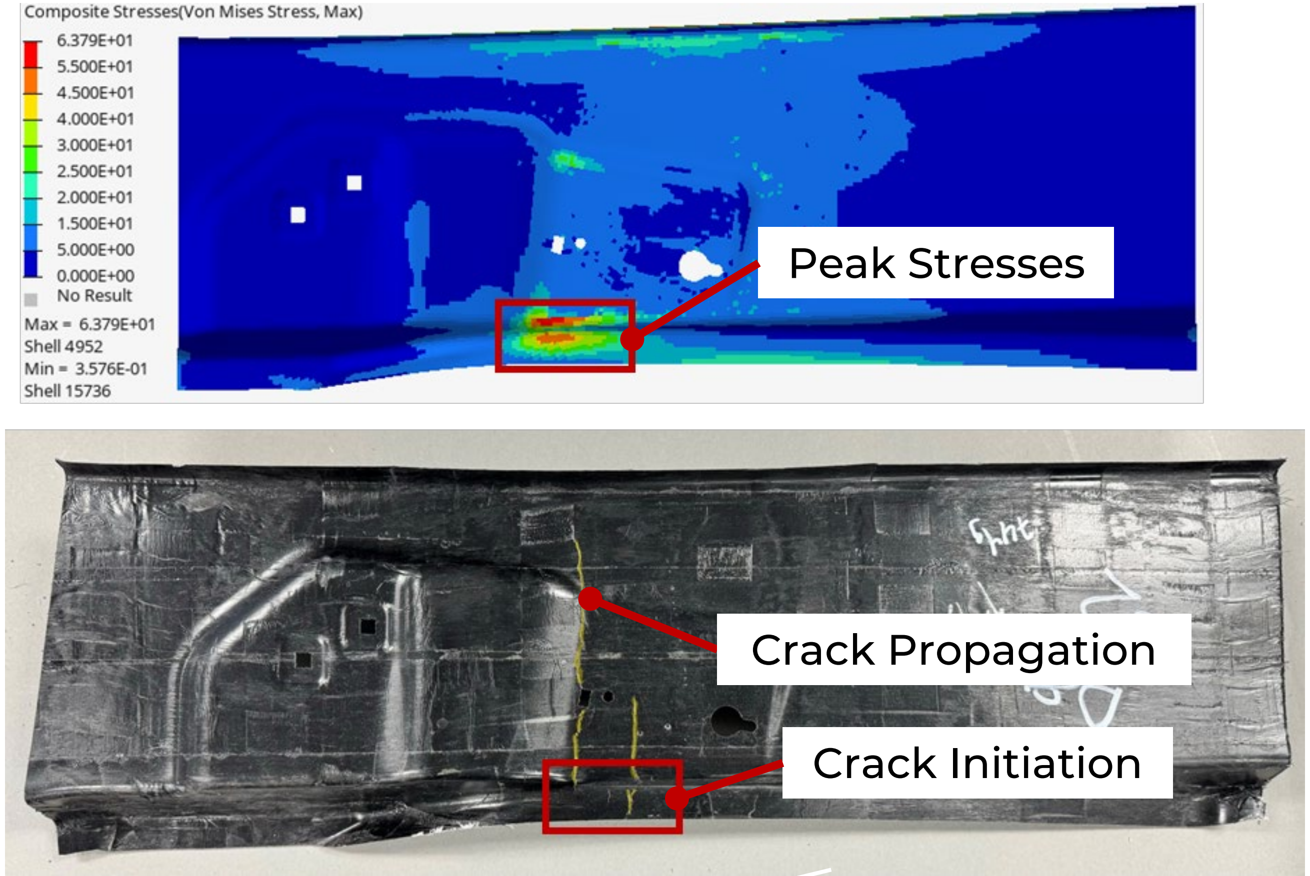
Reduce Part-Load Gap →

Simply Supported Load Case - Round Load Applicator

FEA Validation - Comparison

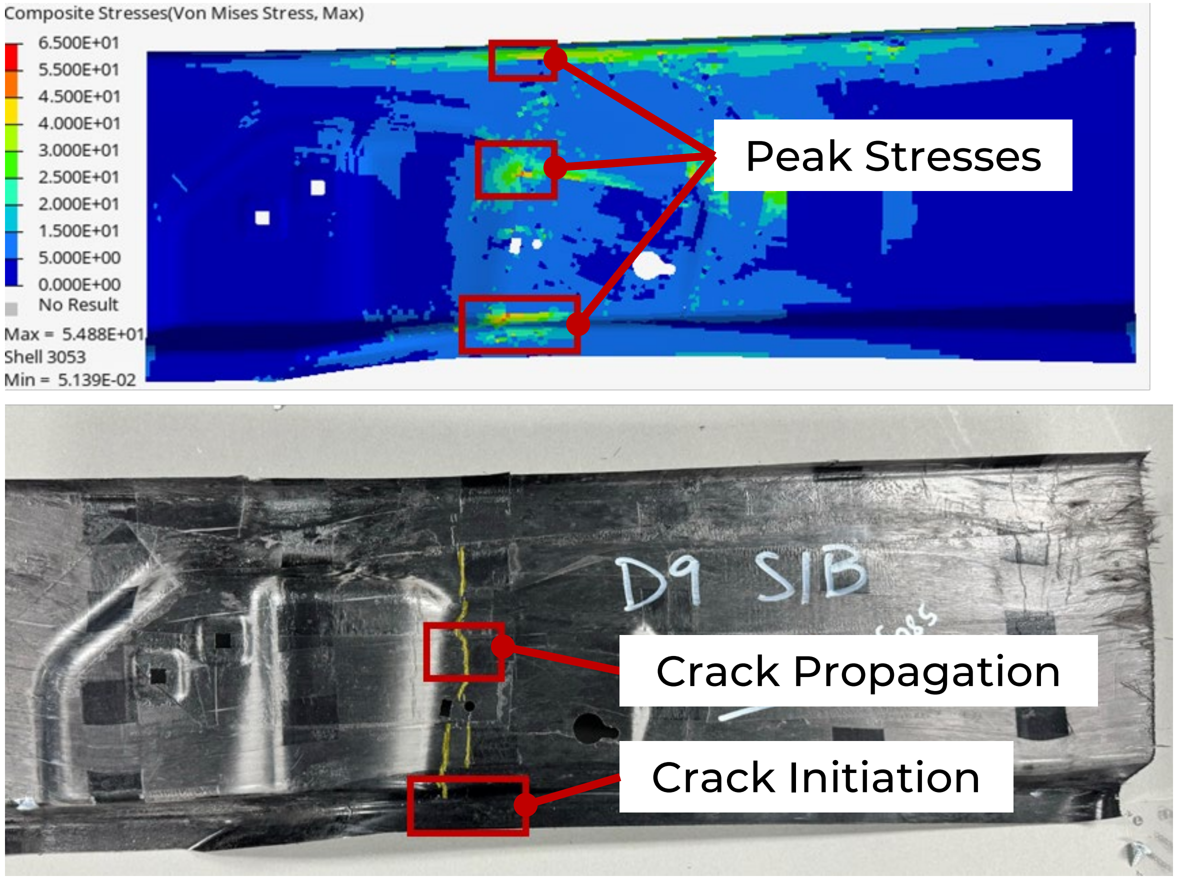


FEA Validation – Failure Locations



Design 8

2-Layer 100% Dense
Carbon Inner, Glass Outer



Design 9

2-Layer 100% Dense Carbon Upper
2-Layer 100% Dense Glass Lower

Summary

Beltline Stiffener Demonstrator

1. 50% cost reduction from baseline (CF/PA6 organosheet)
2. Comparable performance in high-rate full-scale bending load case
3. 23% weight reduction from baseline
4. Good correlation between FEA and experiment in simplified load case

Future Work

Partner with OEM to conduct crash test of full door assembly, with WEAV3D reinforced beltline stiffener

In Partnership with:

WEAV3D®, Braskem, Clemson Composites Center, Altair spe

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