Cost-Effective Weight Reduction with Multi-Material Composites

IACMI Fall Member Meeting 2021

WEAV3D®

Lightweighting for the Masses™

Agenda

- Intro to WEAV3D®
- Overview of WEAV3D process and Rebar for Plastics® design methodology
- Background on hybrid length-scale materials
- FEA Case Study
  - Effects of alignment of reinforcement fibers
  - FEA model validation
  - Effects of lattice positioning
- Summary

About WEAV3D

2014 — Technology invented

2017 — **WEAV3D founded** out of Georgia Tech

TODAY — Headquartered in metro-Atlanta, Georgia

$2.5M+ — In R&D and commercialization funding

Georgia Research Alliance

PLUG AND PLAY

TiECon 2017

MegaWatt VENTURES

CLEANTECH UNIVERSITY PRIZE — U.S. DEPARTMENT OF ENERGY

NSF

CREATIVE DESTRUCTION LAB

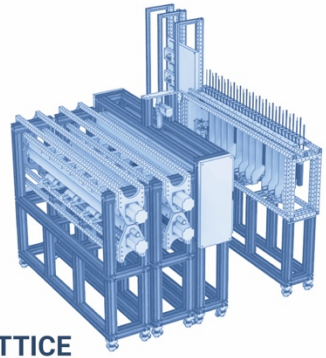
Rebar for Plastics®

Process Overview

THERMOPLASTIC PREPREG TAPE

Commercially Sourced

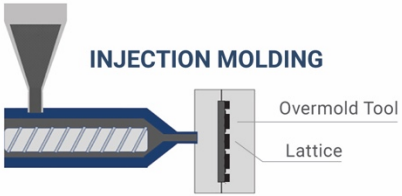
LIGHTWEIGHT STRUCTURAL COMPOSITE PART

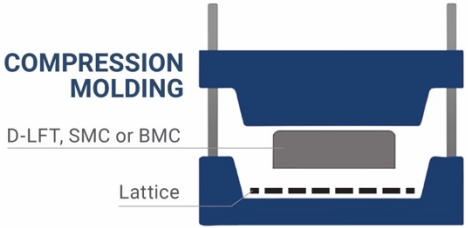


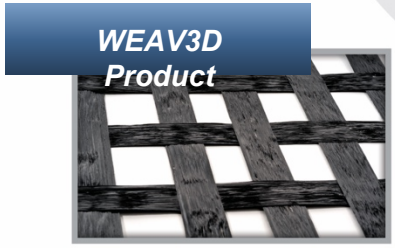
LATTICE WEAVING & CONSOLIDATION

WEAV3D Process

Standard Molding Processes







TRIMMED COMPOSITE LATTICE

Why Composite Lattice?

TUNABLE

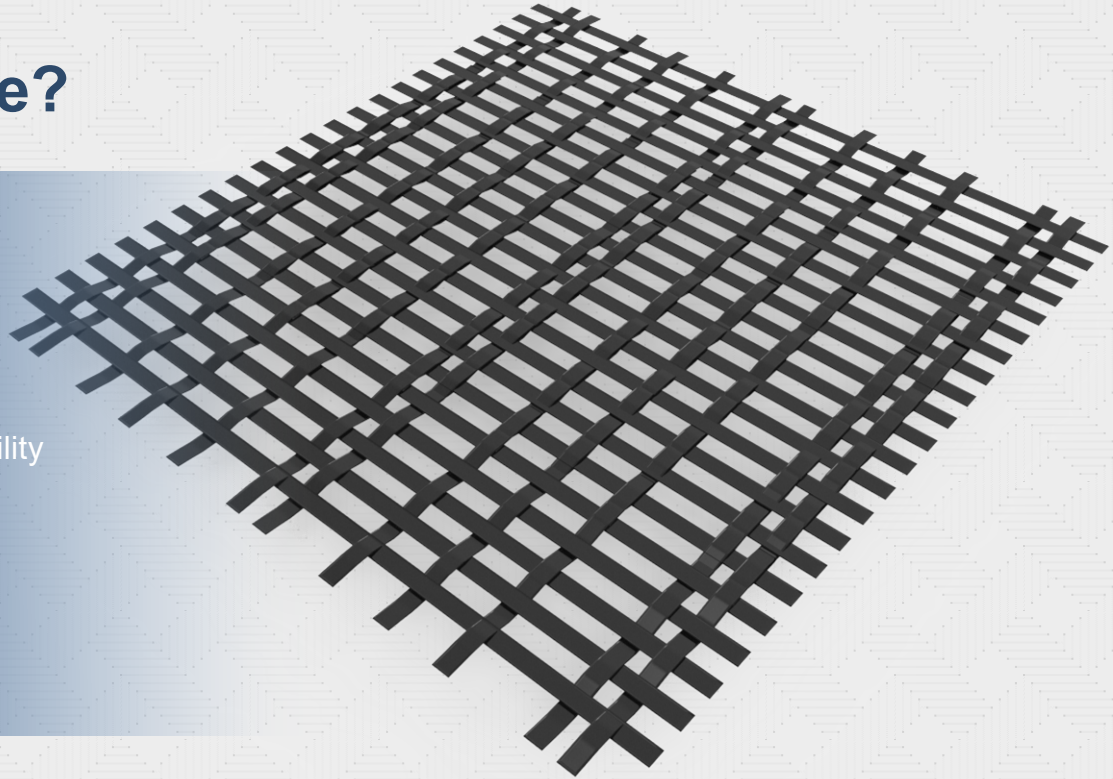
- Locally optimized:
  - Lattice density
  - Tape material

HANDLEABLE

- Woven and welded at interlace for stability
- Sheet or roll format

FORMABLE

- Reheat/reform
- Form in mold
- Colamination

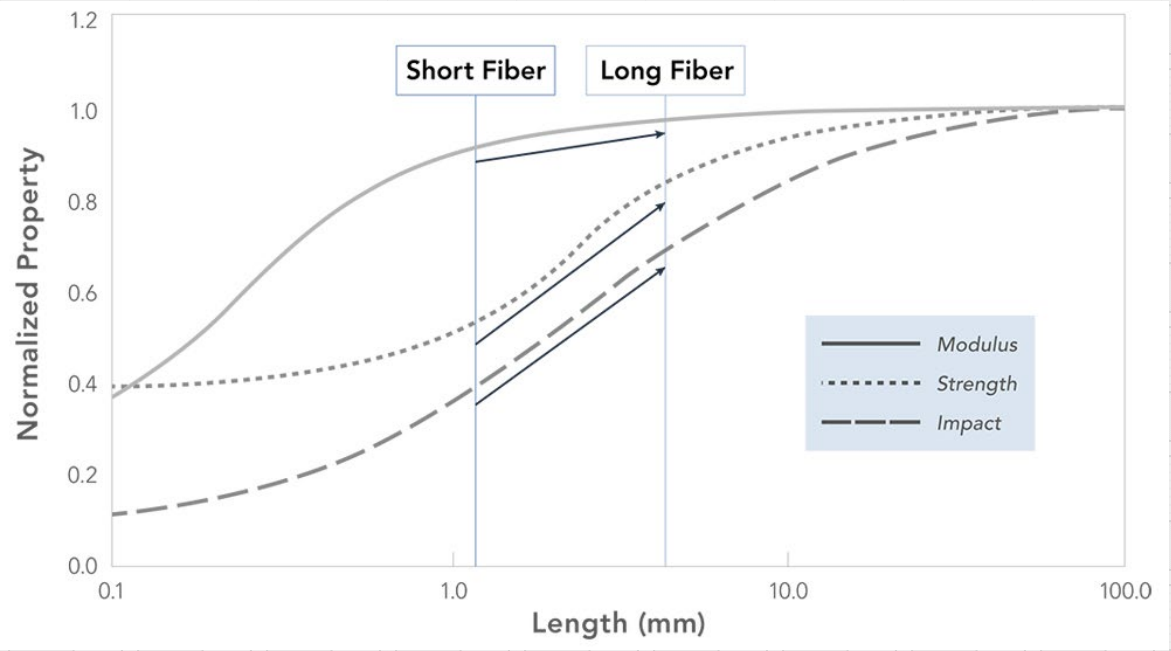


Strategic use of UD tapes in lattice provides a cost-effective and adaptable solution

WEAV3D Applications & Value Proposition

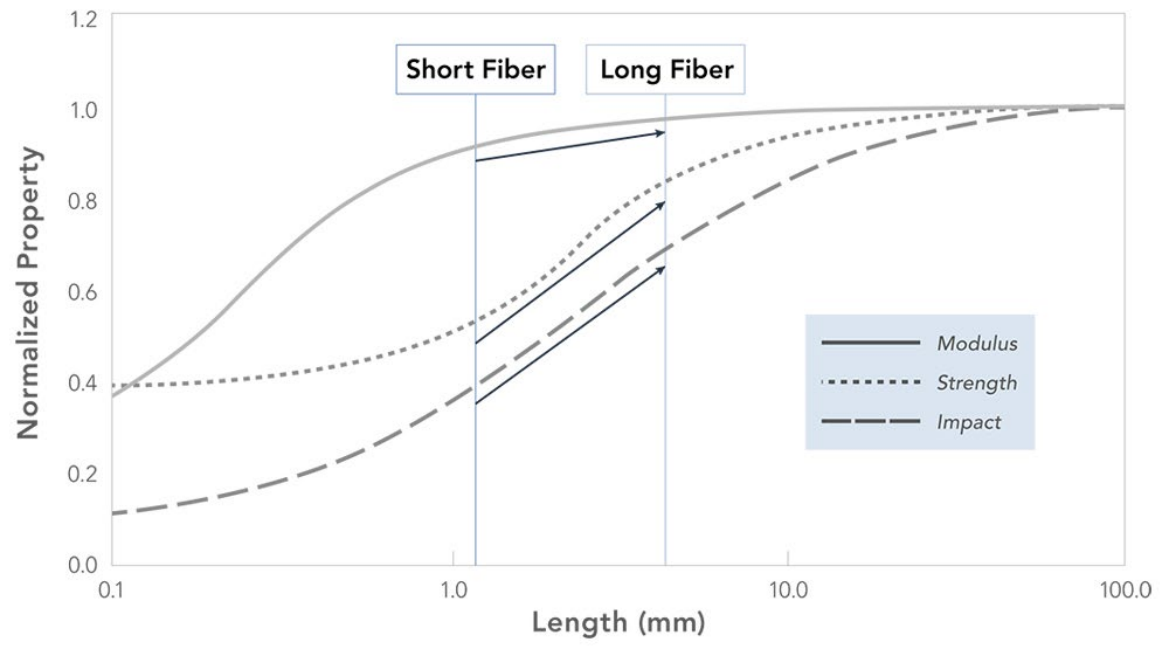
	Structural Metal Substitution	Structuralizing Molded Plastics	Composite Optimization
Example Application	Body in White	Interior Panels	SMC Covers
Weight Reduction	+++	++	++
Part Count Reduction	++	+++	+
Upcycling of Recycled Reinforcements	++	++	+
Expanded Use of Natural Fillers	+	+++	+

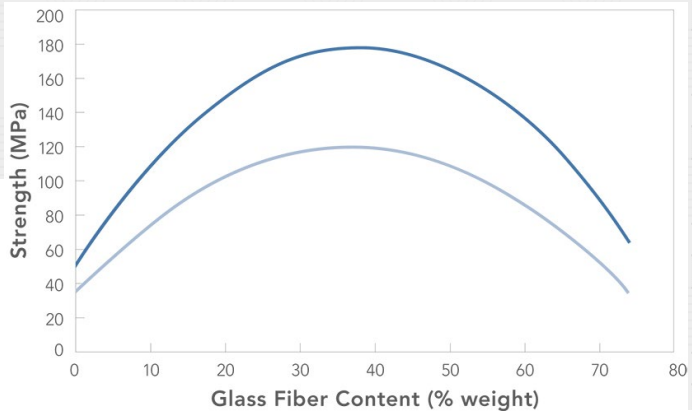
Why Hybrid Materials?

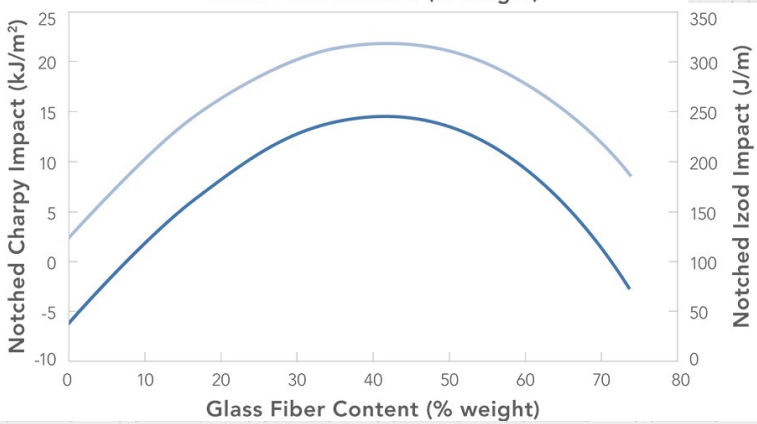


Ref: Thomason (2002, 2005)

Why Hybrid Materials?



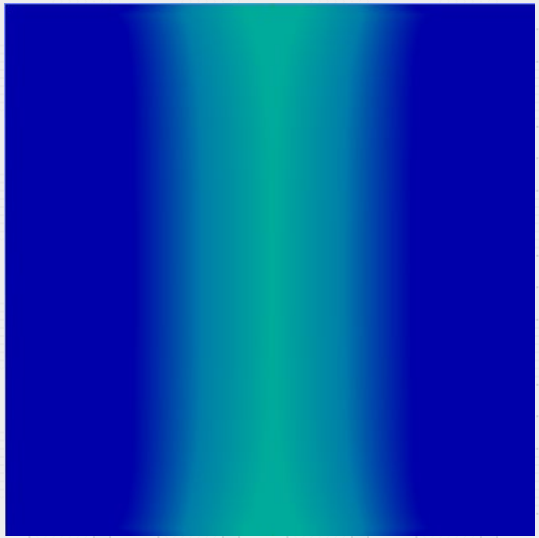


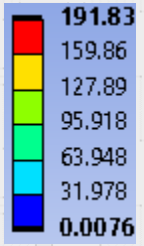


Independently tunable modulus, strength, and impact

Ref: Thomason (2002, 2005) – Studies on Long Glass Fiber PP and PA6

Stress Concentration of Lattice Reinforcement





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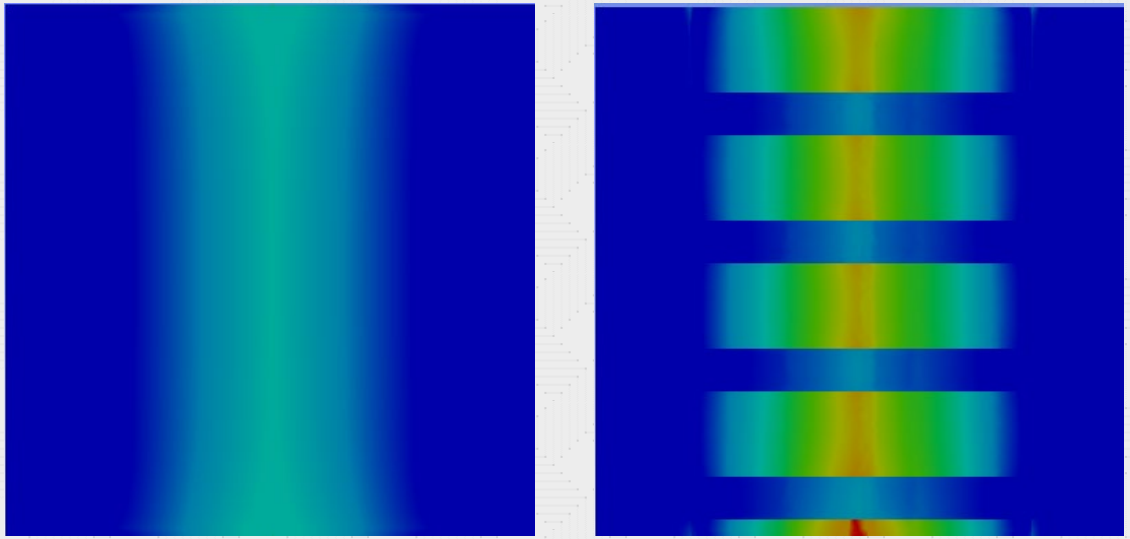
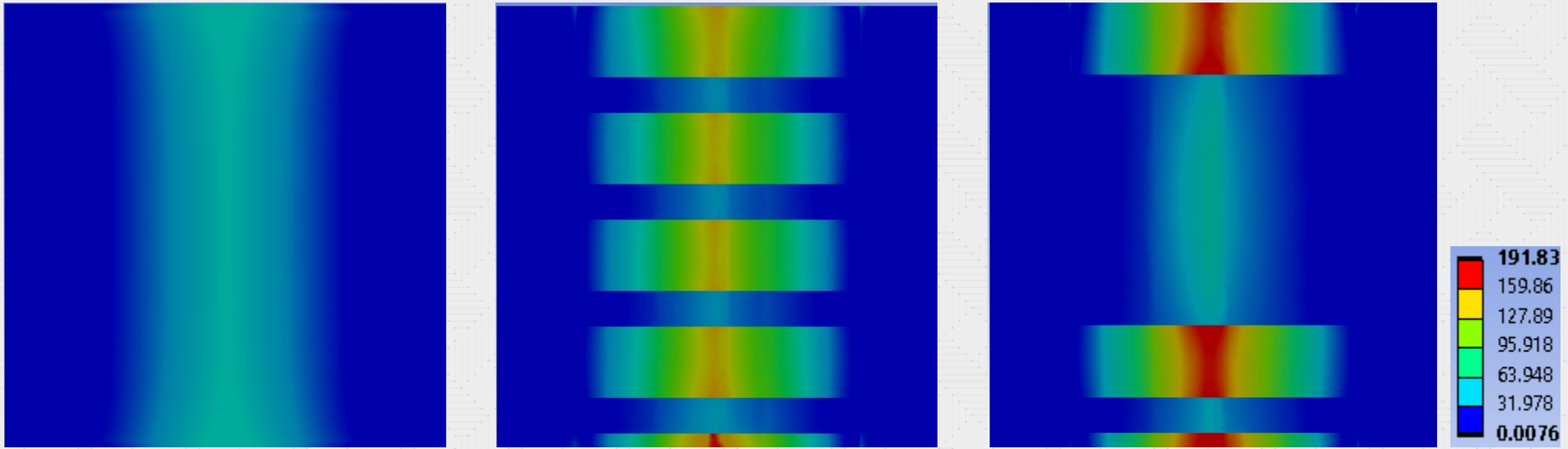


Lattice concentrates stress away from molded plastic

Stress Concentration of Lattice Reinforcement



Lattice concentrates stress away from molded plastic

FEA Case Study

Application Area

- Automotive interior panel, replacing long glass reinforced PP and metallic stiffeners

Problem Statement

- Develop a 2mm thick lattice reinforced plastic panel that can achieve an equivalent flexural stiffness of between 10 and 45 GPa with superior economics to magnesium

Design Approach

- Design – mold panels – validate – optimize

In Partnership with:

covestro

DSM
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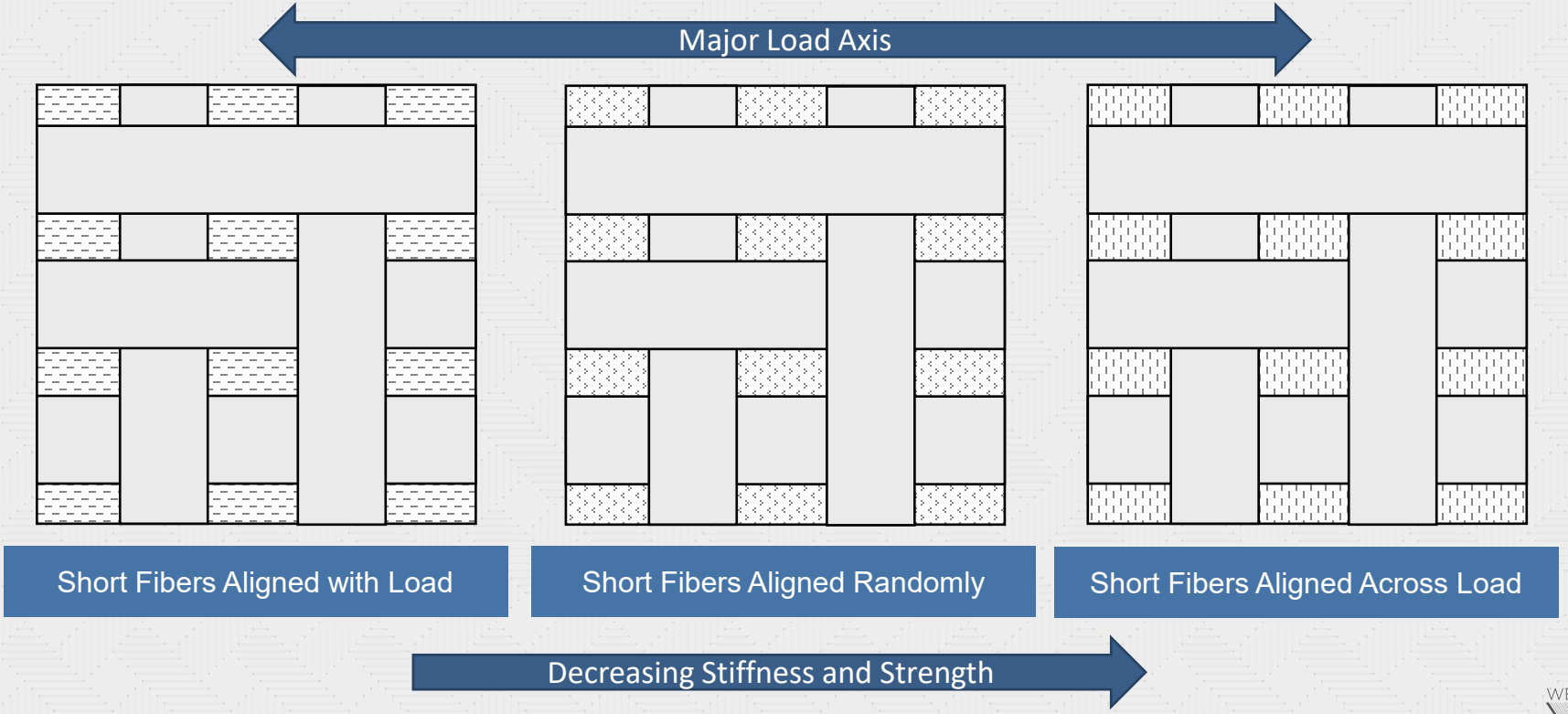
CLEMSON COMPOSITES CENTER

Materials

	UD Tape for Lattice	Overmolded Plastic
Design 1	Maezio® Composite Carbon Fiber (PC CF)	Bayblend® T85 XF (PC+ABS)
Design 2		
Design 3		Bayblend® T88 GF-10 (PC+SAN GF10)
Design 1	Udea™ Akulon® K20HG60 (PA6 GF60)	Akulon® K224-HG6 (PA6 GF30)
Design 2	Udea™ Akulon® K20HC50 (PA6 CF60)	
Design 3		

Experimental vs. FEA



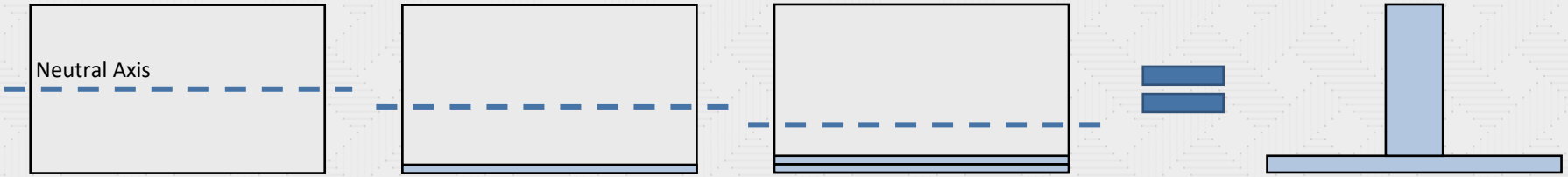
FEA Validation

- Samples simulated for short fibers aligned with load axis and aligned across load axis
- Flexural and tensile sample produced for each design
- Plaque samples were all fabricated with short fibers aligned across the load axis (worst-case)

	Error Range (negative indicates underprediction)	**Average Error**
Flexural Modulus	-14% to +6%	-4.4%
Tensile Modulus	-26% to +10%	-6.1%

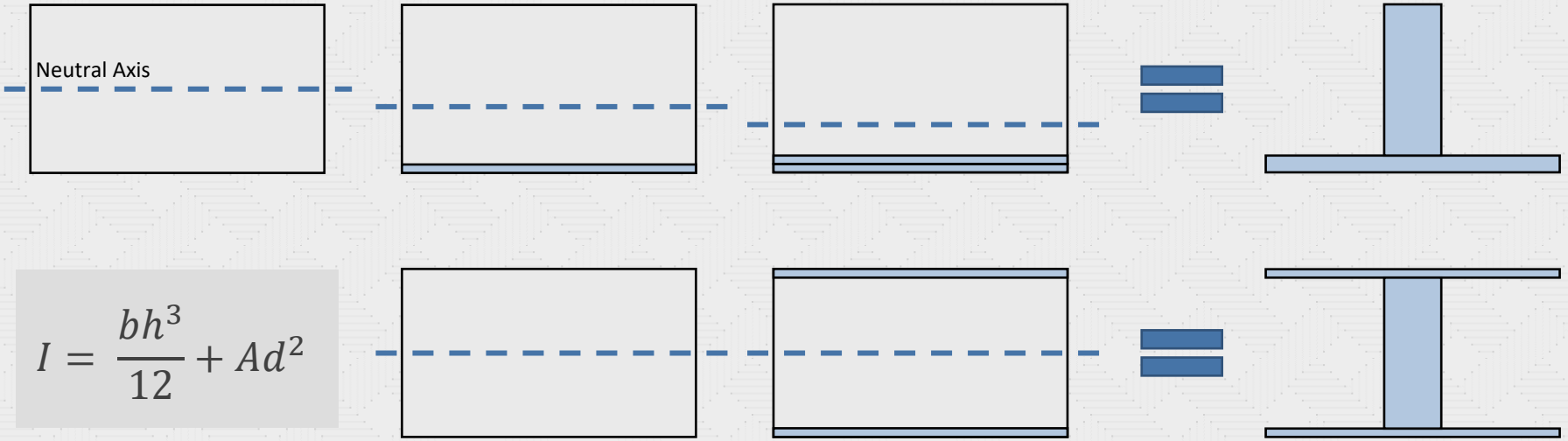
High degree of correlation between WEAV3D FEA models and experimental results

Single vs. Double Sided Panels



$$I = \frac{bh^3}{12} + Ad^2$$

Single vs. Double Sided Panels



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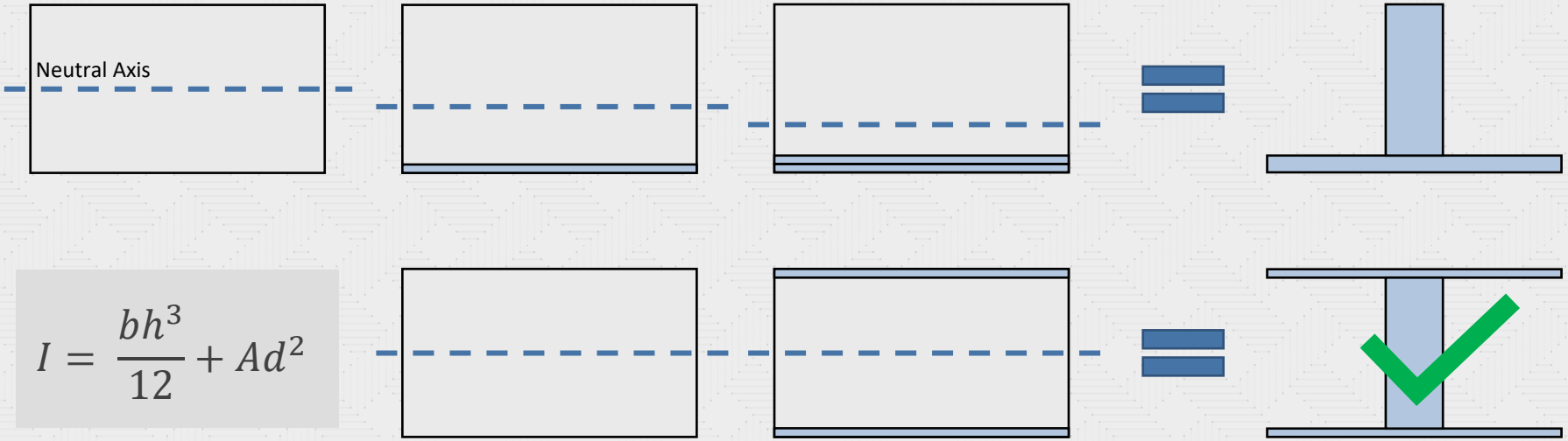
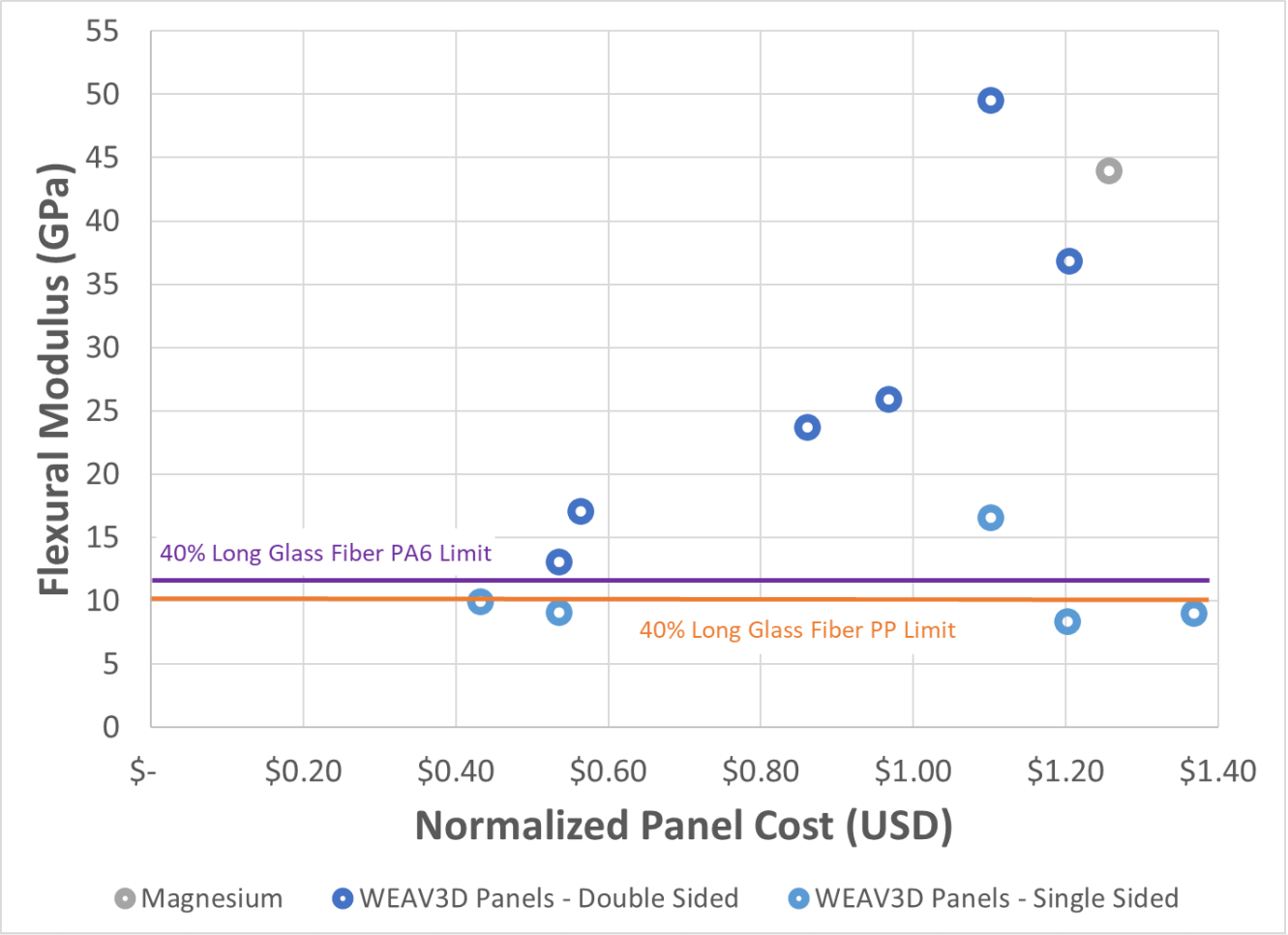


$$I = \frac{bh^3}{12} + Ad^2$$

Double sided designs yield better performance for the same material cost



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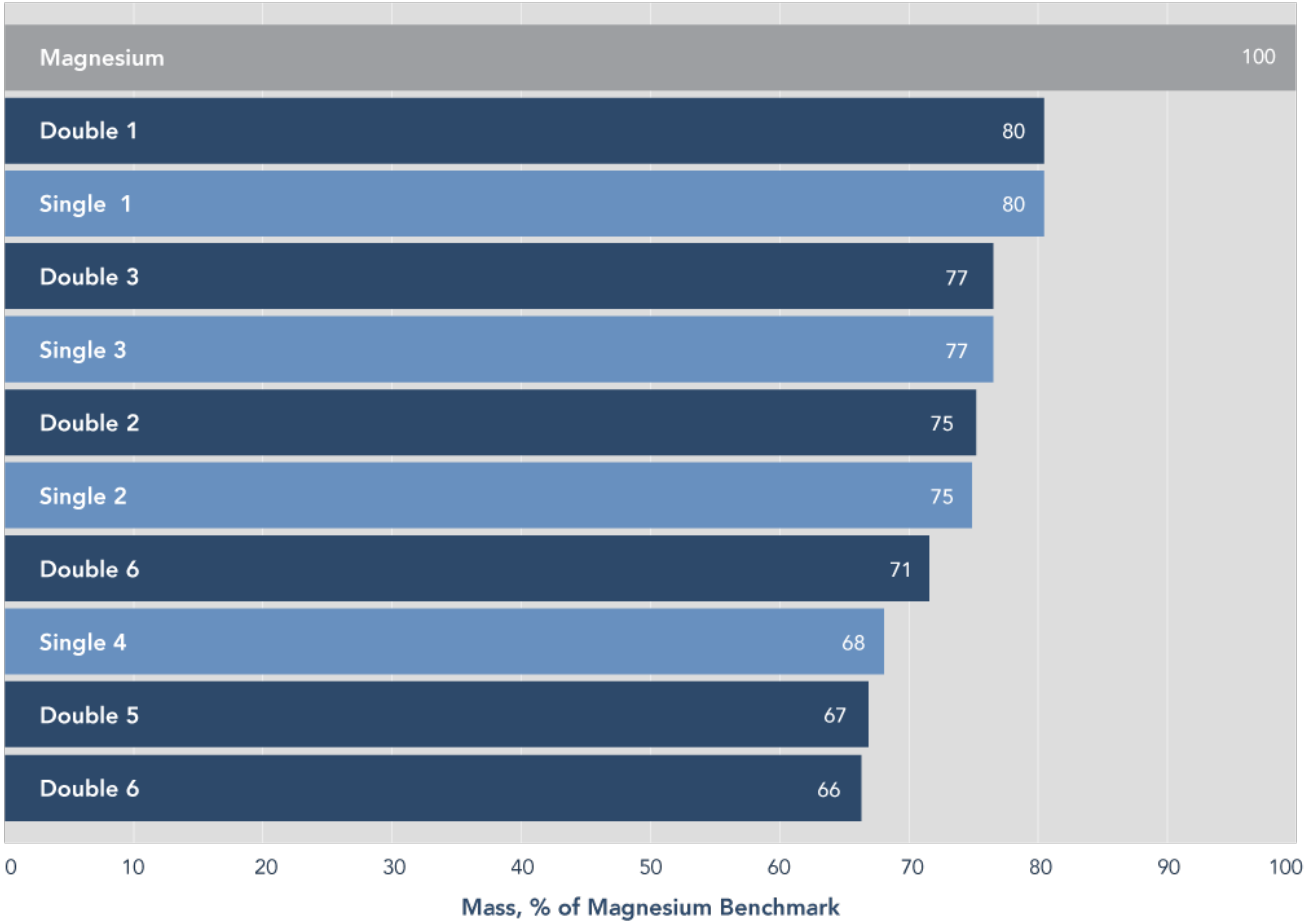

Lattice panels are 20-34% lighter than magnesium panels of same size

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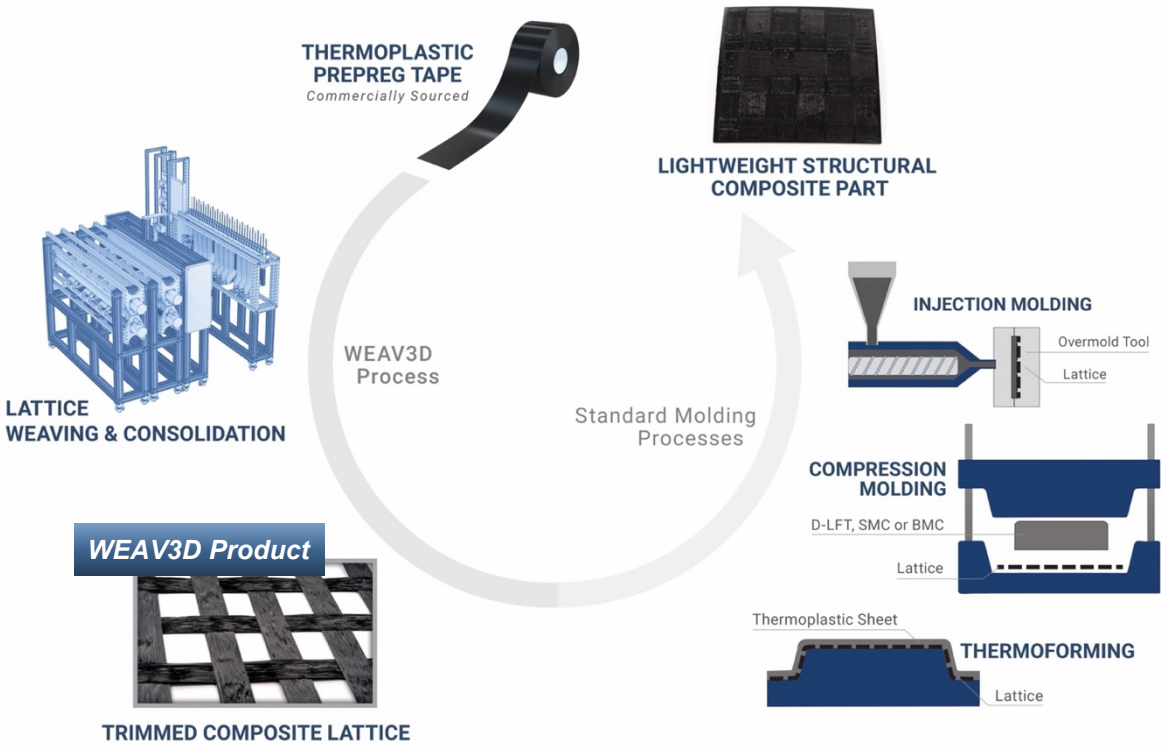
Summary

- WEAV3D's Rebar for Plastics® design approach combines a continuous fiber lattice with short fiber or unreinforced molded plastics to achieve cost-efficient structural performance
- FEA simulation must take into account molded plastic fiber alignment
- Stiffness improvements are most significant when lattice can be applied to opposite part surfaces
- Carbon reinforced lattices can provide superior performance at the same or lower cost than glass reinforced lattices in some application areas



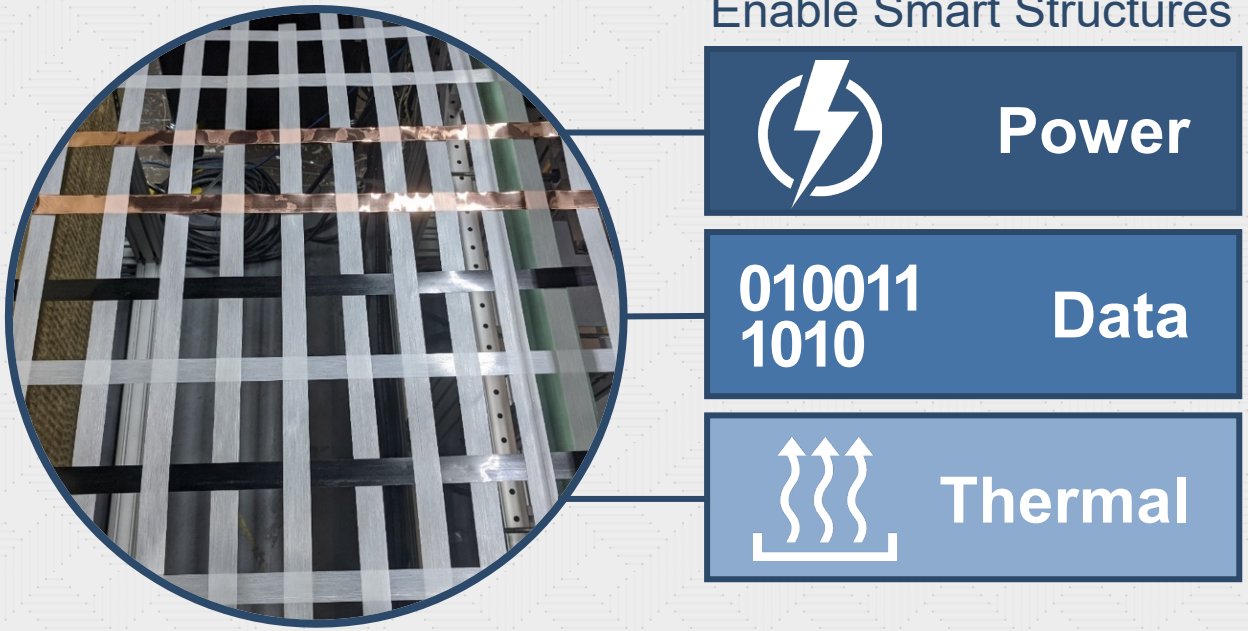
WEAV3D®

WEAV3D is partnering with OEM and Automotive Tier suppliers to support automotive product development.

To learn more, get in touch with us at info@weav3d.com.

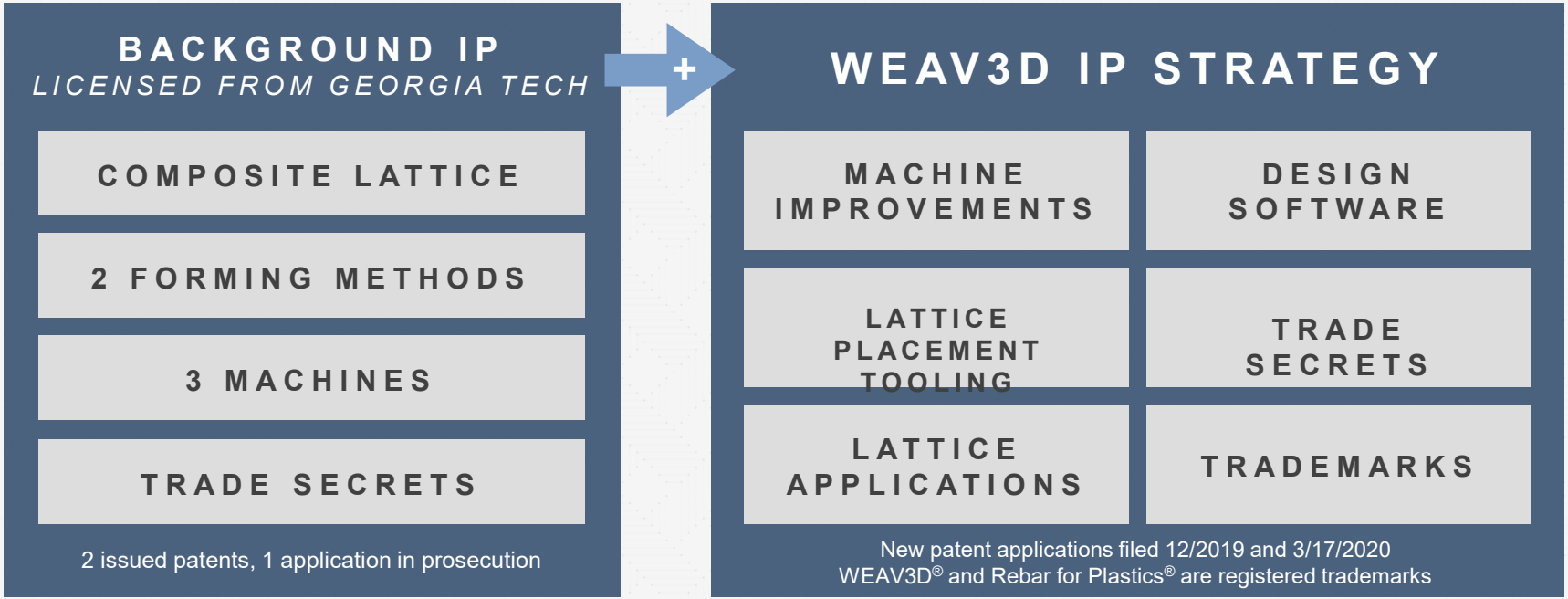
Appendix

Smarter than Steel™ Hybrid Material Lattices

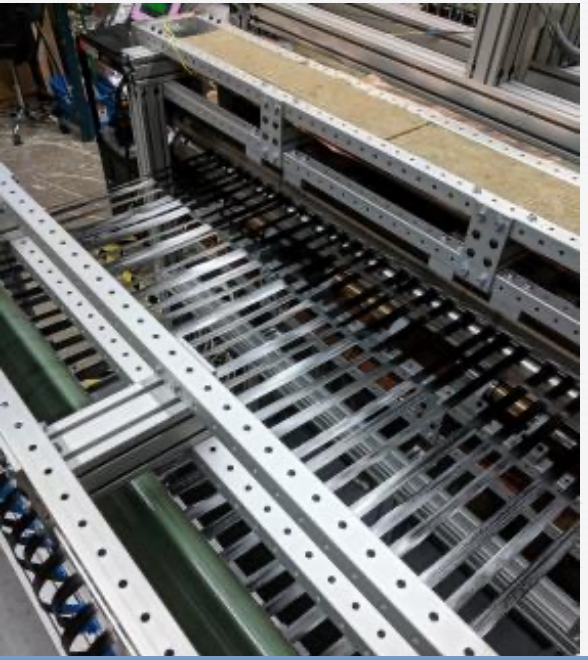


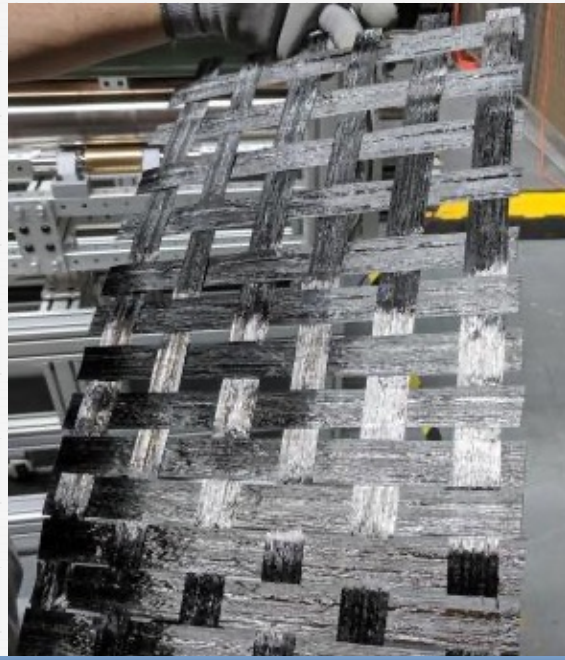
WEAV3D lattices can combine structural reinforcement with transmission materials

WEAV3D Intellectual Property Overview



WEAV3D Full-Scale Pilot Machine





Patent-pending customizable lattices and lattice forming process