Why Projects at iacmi are Important to Airbus

IACMI Fall Member Meeting 2020

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30 Sept. 2020

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Agenda

- Zero Emission Commercial Aircraft
  - What it is
  - Rough timeline
- iacmi 5.4 Injection Overmolding of Continuous Carbon Fiber Preforms
- iacmi 5.5 Hybrid Additive Manufacturing (AM) Tooling for Large Composite Structures
- iacmi 5.7 Tailored Fiber Placement for Complex Preforms

Zero-emission Commercial Aircraft by 2035

Zero-emission Commercial Aircraft by 2035

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Zero-emission Commercial Aircraft by 2035

- Next 5 years identify technologies
- Then a couple of years to determine industrial, supply chain and manufacturing processes to support production
- 2027-2028
  - Begin detailed design of new H2 powered aircraft
- Goal: Mid 2030's
  - ZEROe aircraft entered into service

5.4 Injection Overmolding of Continuous Carbon Fiber Preforms

Objective

This project proposes utilizing continuous carbon fiber reinforcement to provide the structural strength and stiffness needed, but also combining it with the rapid manufacturing and lower costs/cycle times achieved by injection molding.

Partners

Airbus, UDRI, Zoltek, SABIC, JobsOhio

Technical Contribution to Industry

The project provides weight, energy, and cost savings as the TFP, combined with injection overmolding, allows the design to be optimized to suit the actual loading conditions.

Injection overmolding importance to Airbus

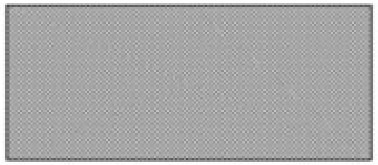
- ➢Weight reduction by metal replacement
- ➢Cost reduction
- ➢Galvanic corrosion protection by replacing metal with GFRP
- ➢Contribute to sustainability

5.4 Highlights

Flat Panel Results

- Tailored Fiber Placement (TFP) reinforced panels have a greater than 25% increase in tensile strength compared to short fiber reinforced thermoplastic specimens

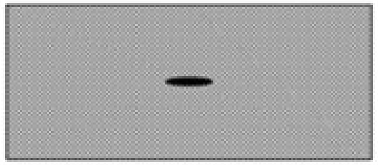
Flat Panel Tensile Strength



EC004APQ Carbon Fiber filled PEI

Finite Element Model Prediction: 111 MPa

Test Result: 84.5 MPa



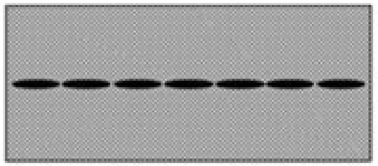
EC004APQ Carbon Fiber filled PEI

Single 12k Carbon Fiber Tow

Finite Element Model Prediction: 117.5 MPa

Test Result: 105 Mpa (24% over baseline)

11.0% Difference between modeled/tested



EC004APQ Carbon Fiber filled PEI

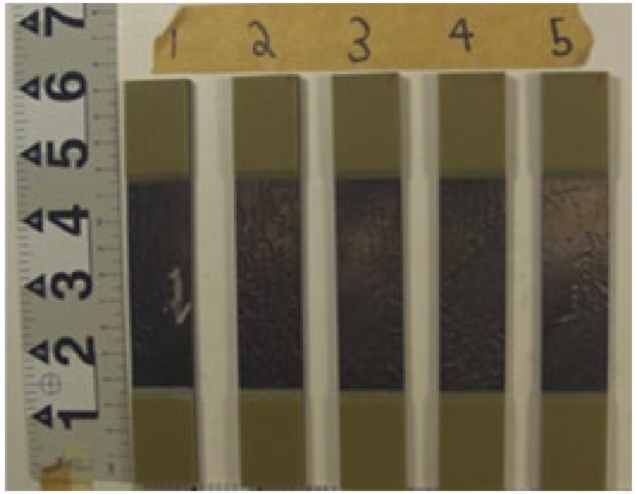
7 12k Carbon Fiber Tows (20% VF)

Finite Element Model Prediction: 205 MPa

Test Result: 194 Mpa (130% over baseline)

5.5% Difference between modeled/tested

Tensile specimens cut from panels



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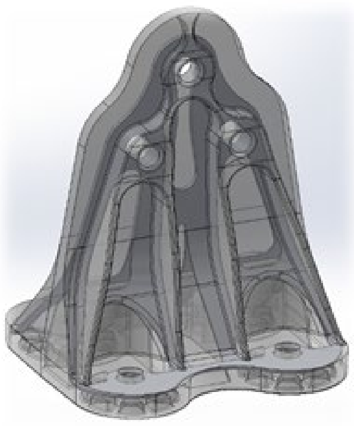
5.4 Ongoing Work

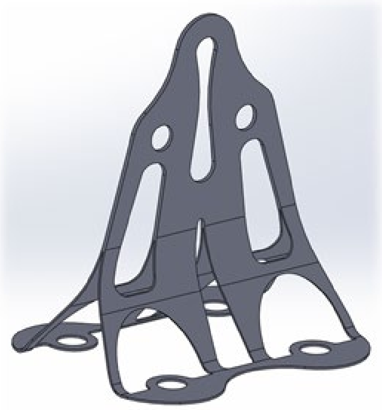
Molded Part Results

- TFP preform and injection molding tooling was designed based on Airbus part geometry.
- Results to be compared to with aluminum and chopped fiber reinforced technology

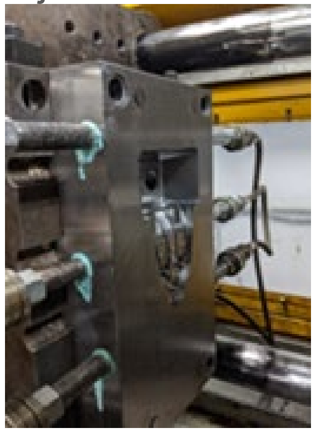
Design



TFP preform



Injection Mold



Structural Testing

Molding trials with different preform designs are being tested.

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5.5 Hybrid (Additive Manufacturing) AM Tooling for Large Composite Structures

Objective

Develop a hybrid AM tool capable of producing a 10 foot composite part. The tooling must be able to withstand multiple cycles in a 350F, 90psi autoclave and exhibit an isotropic thermal expansion matching that of Invar.

Partners

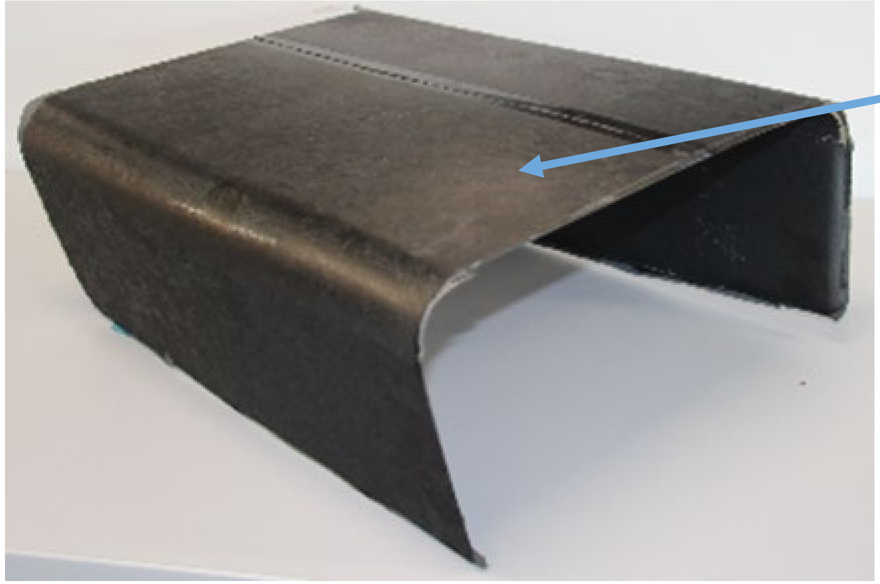
Airbus, Northrop Grumman, CI, AES, UDRI, JobsOhio, supported by SABIC and Hexcel

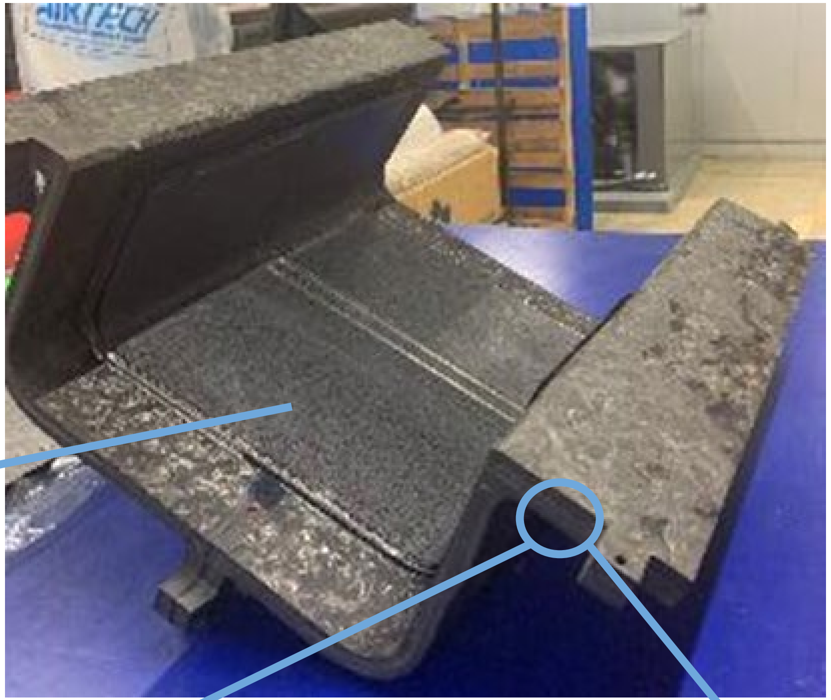
Technical Contribution to Industry

Use AM to provide a low to mid rate production tool at 50% cost while matching thermal performance of Invar.

5.5 Highlights

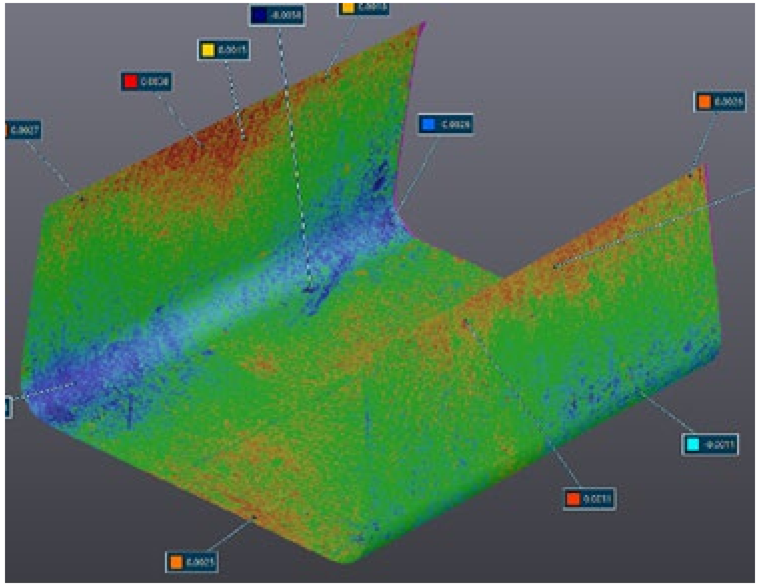
- BAAM-printed core to near net shape dimension (Airbus C-spar)
- Overlaid HextoolTM tooling prepreg on as-printed surface
- Final machining of prepreg surface



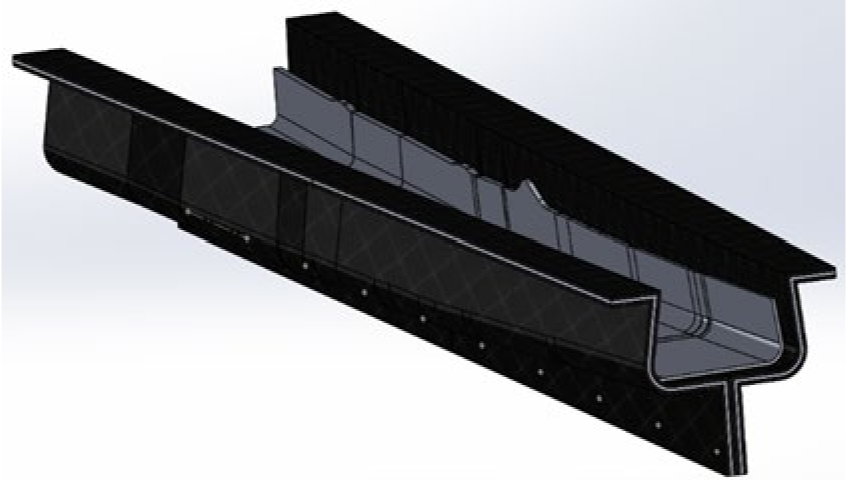


5.5 Results

- Nearly isotropic CTE within a few ppm/deg C from Invar
- Ten autoclave cycles with no tool damage
- Less than +/-0.005” tool deflection between Part 1 (Cycle 1) and Part 2 (Cycle 11)
- Tool cost $24,200 versus $46,800 for identical Invar tool (confirmed with external commercial quotes)



		PEI Tool (as-printed)	PEI Tool (with 5 plies HexTool)
$CLTE_{177C}$ ppm/C	flow	5.8	2.6
	x-flow	57.1	6.3



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5.7 Tailored Fiber Placement for Complex Preforms

Objective

Develop the confidence of computational tools to design and build TFP primary structures, that have an optimized fiber architecture integrating metallic features to improve performance while reducing costs/weight.

Partners

Airbus, Lockheed Martin, MSU, ZSK, UDRI, JobsOhio

Technical Contribution to Industry

Develop and demonstrate analytical tools are capable of predicting TFP component performance in order to optimize a part design to improve performance against traditionally fabricated components.

TFP importance to Airbus

- Allow integration of reinforcements for highly loaded structure

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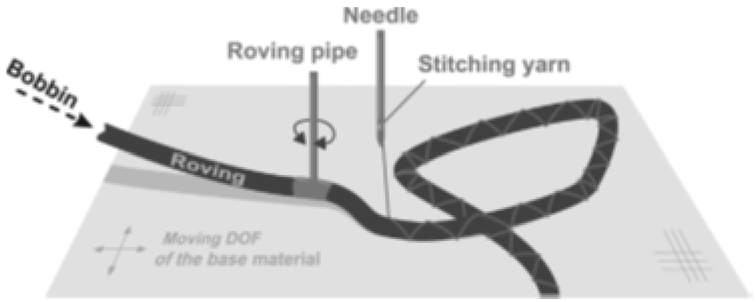
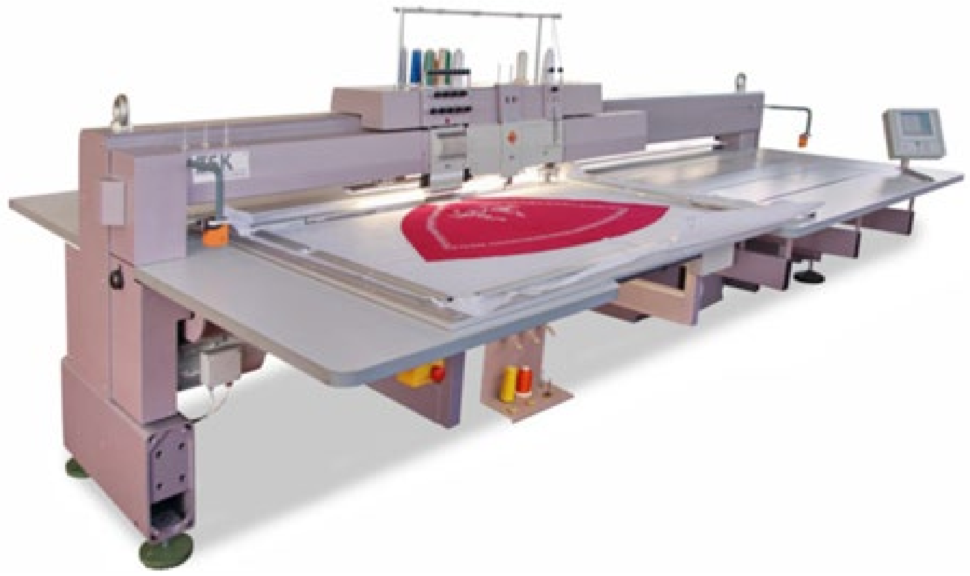
5.7 Tailored Fiber Placement

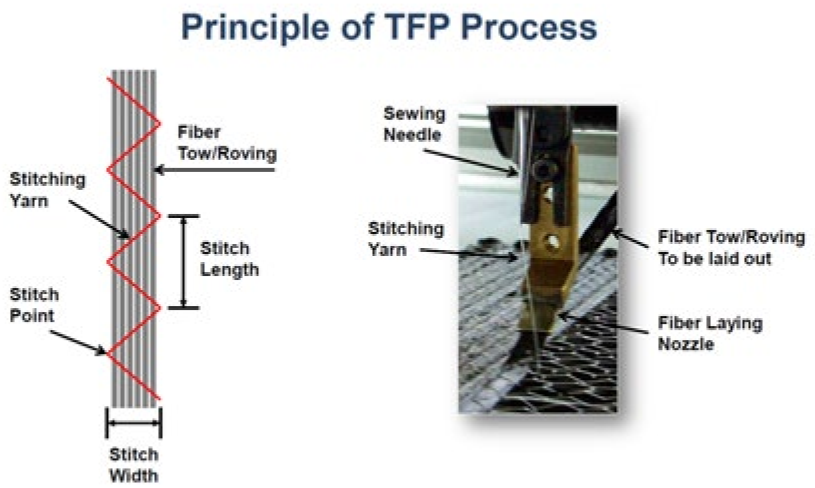
Tailored Fiber Placement

•Embroidery-based technology

•Automated tow steering process known as Tailored Fiber Placement (TFP)





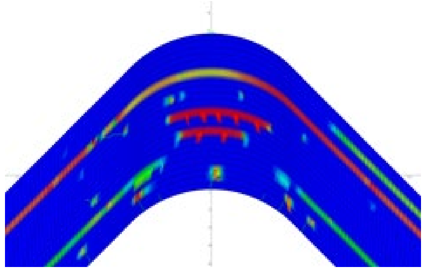


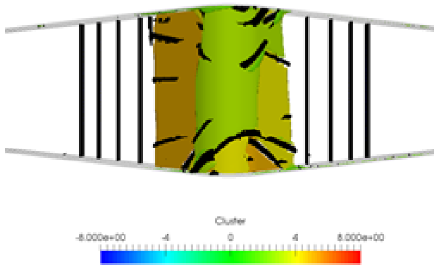
5.7 Highlights

- Characterized mechanical performance and distortions as function of stitch density
- Showed z-stitching can greatly increase strength and toughness
- Developed computational methods of simulating various fiber and stitch architectures

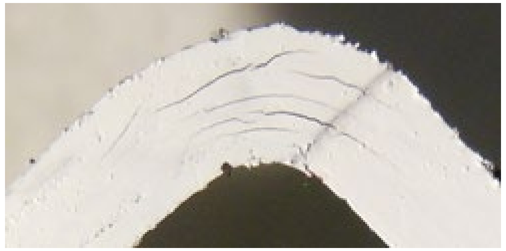
Mode I testing of Stitched TFP preform

Damage Modeling in Curved TFP Beams





Damage Observations in TFP Curved Beams



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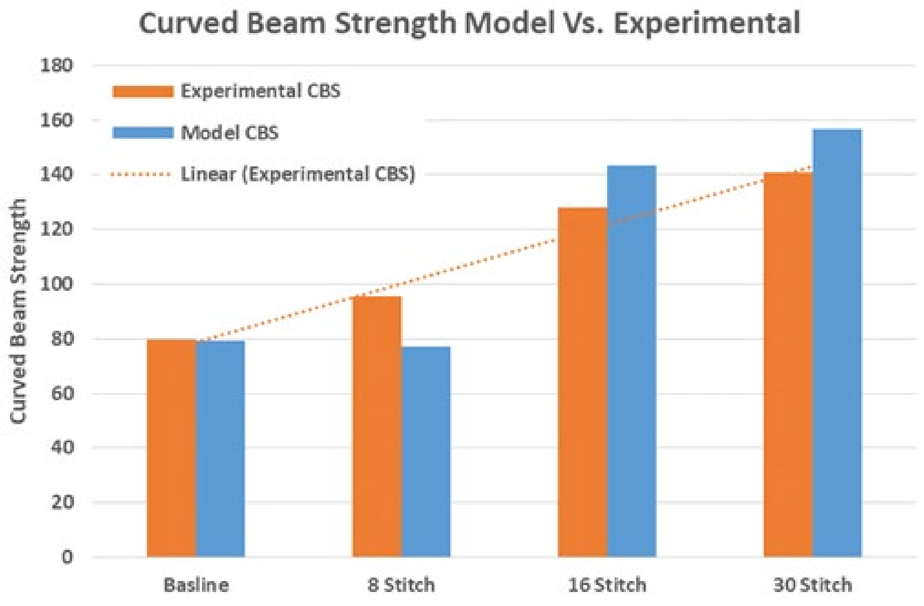
5.7 Results

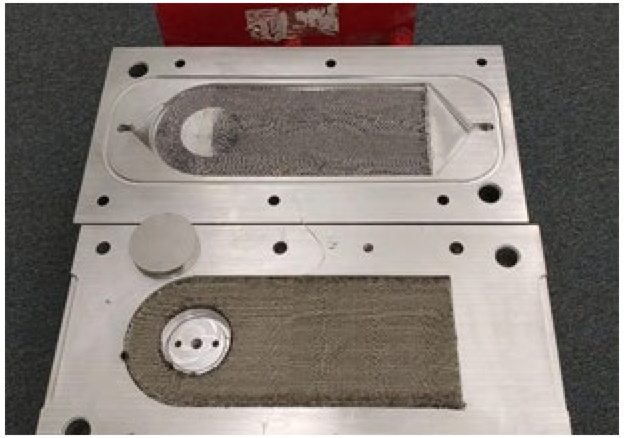
- Verified that stitching leads to large increase in Mode I toughness and ILT
- Model captures increase in Curved Beam Strength as a function of stitch density (model within 18%)
- Model can capture fiber distortions leading to changes in performance



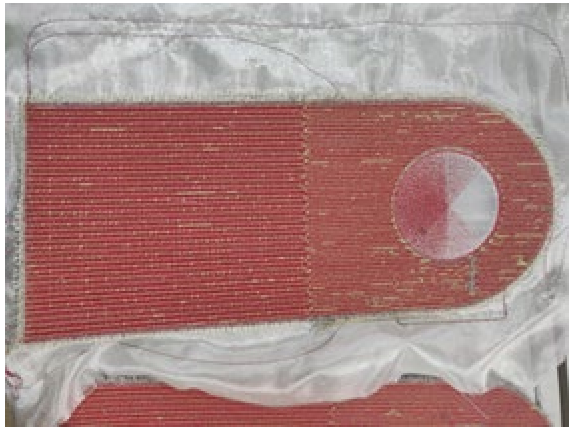
	Fracture Toughness (kJ/m^2)	% Improvement G_{IC}	ILT IMPa)	% Improvement ILT
Baseline	0.445		19.54	
8 Stitches/cm^2	1.93	333.71	22.99	17.66
16 Stitches/cm^2	4.22	848.31	26.3	34.60
30 Stitches/cm^2	7.45	1574.16	32.34	65.51

5.7 Ongoing Work

- Building Primary Lug Structure
  - Computational model running for blind predictions

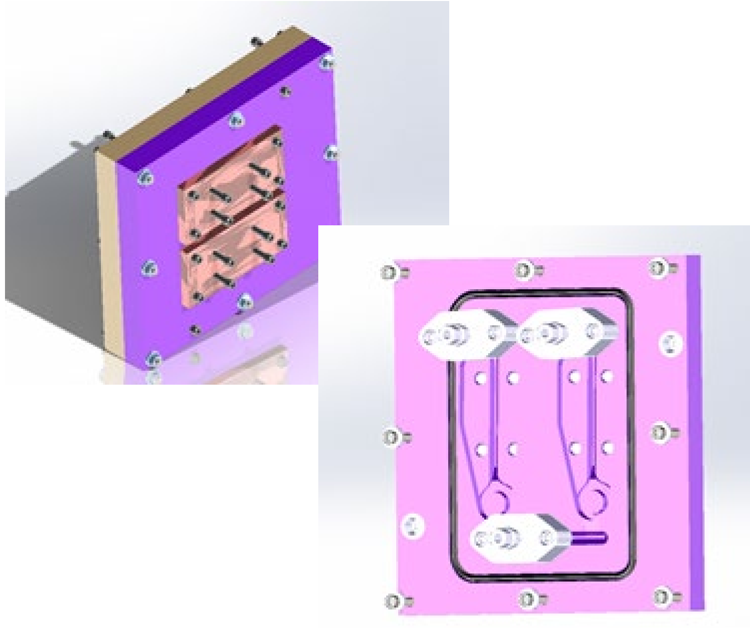


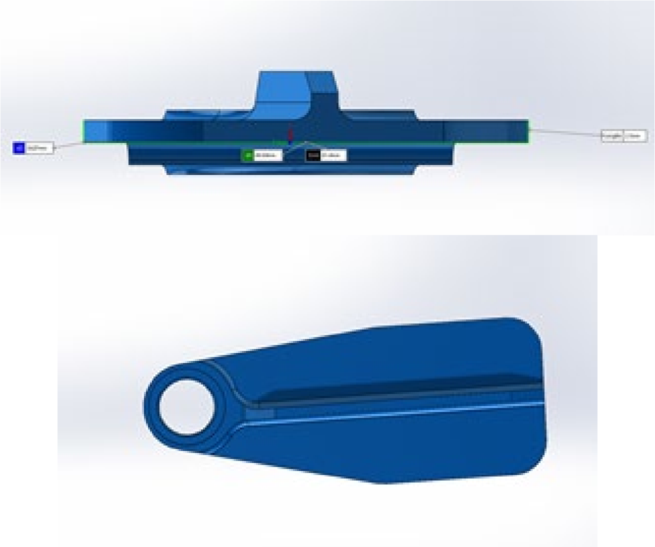
Lug Component in Tooling Mold



Lug Preform Showing Stitch Density Variations

- Building Complex Clip Bracket
  - Comparison to actual component cost and weight)





Summary / Q&A

- The IACMI projects are providing essential building blocks to enable lighter and more cost effective structure
- The teamwork and collaboration within IACMI enables adoption of overmolding technology into many applications in the future

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Thank you