

A low-angle photograph of a white wind turbine against a clear blue sky. The turbine's blades and nacelle are visible, extending from the left side of the frame. The image is overlaid with a green and yellow geometric design consisting of overlapping triangles.

LEADERS IN LARGE FORMAT ADDITIVE MANUFACTURING

Tooling | End-Use Parts | Mockups



Akron, OH

CONFIDENTIAL

AES is an advanced manufacturing company and leader in Large Format Polymer Additive Manufacturing (LFAM) and traditional CNC machining solutions.

Tooling & Molds



Complete tool & mold making capabilities; LFAM Polymer, Metallic and Foam materials.

Full-Scale Mockups



Large scale, high fidelity prototyping and mockups.

End-use Products



End-use parts production; thermoplastic composites.

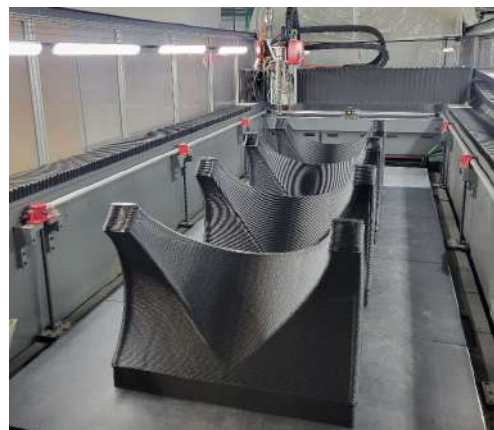
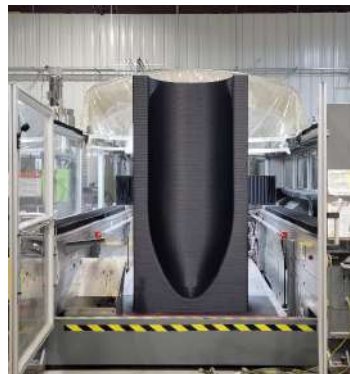
LARGE FORMAT ADDITIVE MANUFACTURING (LFAM)

Large Polymer 3D Printers

Model	Type	Dimensions	
BAAM 608	Gantry	12' x 5.5' x 100" Z	
BAAM 608	Gantry	12' x 5.5' x 100" Z	
BAAM 603	Gantry	12' x 5.5' x 36" Z	
BAAM 806	Gantry	20' x 7.5' x 72" Z	
CEAD AM Flexbot	Robotic/Pedestal	6' x 6' x 6' Z	
<i>Caracol AM Heron</i>	<i>Robotic/Rail</i>	<i>15' x 6' x 6' Z</i>	<i>Q4 25'</i>

HIGHLIGHTS

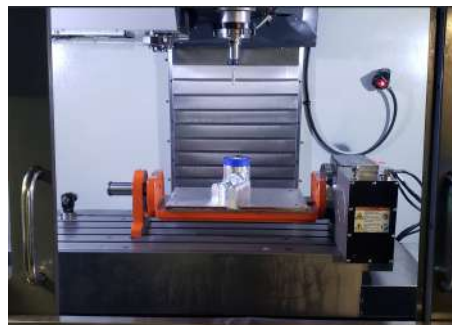
- The **FIRST** contract manufacturer to offer these services globally. Est 2016.
- The **LARGEST** *industrial* large format polymer printing **CAPACITY** in the world.



CNC MACHINING CAPABILITIES

- Temperature controlled CNC department
- Multi-material cutting capability
 - Foam/epoxy boards
 - Polymer composites (3D printed)
 - Metallics; aluminum & steel.

Model	Type	Dimensions	
Zimmermann FZ32	5-axis Gantry	16' x 10' x 5' Z	
Quintax G5	5-axis Gantry	20' x 10' x 5' Z	
Thermwood 70	5-axis Gantry	15' x 10' x 4' Z	
Thermwood 70	5-axis Gantry	15' x 10' x 4' Z	
HAAS GM-2	3-axis Gantry	12' x 6' x 2' Z	
Sharp SVG-6335A	3-axis VMC	6' x 3' x 2' Z	
Sharp SVG-6335A	3-axis VMC	6' x 3' x 2' Z	
HAAS VF4SS	3-axis VMC	20" x 50" x 25" Z	
<i>Breton Eagle 1500</i>	<i>5-axis Gantry</i>	<i>9' x 13' x 4'Z</i>	<i>Q4 25'</i>



AES FACILITY, ENGINEERING & INSPECTION

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FACILITY

24,000 SQ FT Facility
+11,000 expansion Q4 25'
Temperature Controlled
Akron, OH



25 Full-Time Employees

- 5 Tool Design Engineers

Production Software



METROLOGY

Leica AT960 (qty 1)
Laser Tracker

Faro Arm (qty 2)
w/ Laser Scanning



Printing Resolutions

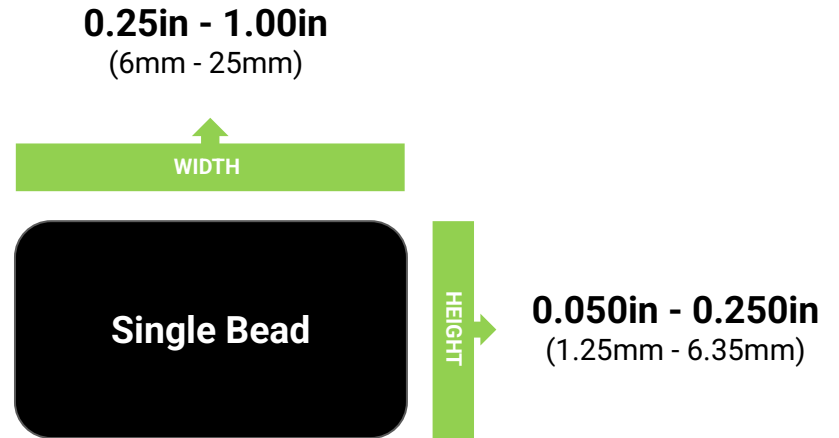


Low resolution example



High resolution example

Layer / Bead Dimensions



LARGE FORMAT ADDITIVE MANUFACTURING (LFAM)

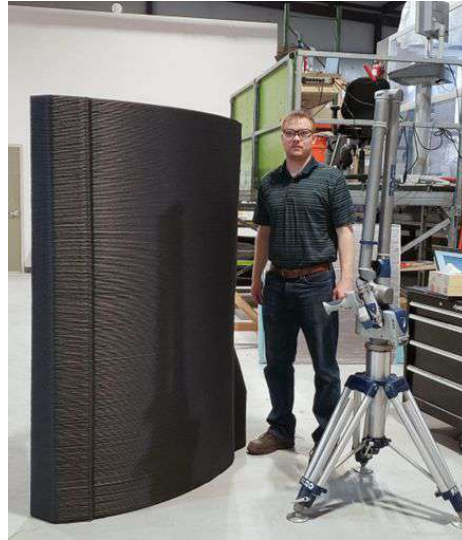
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We 3D print tools and parts in a variety of sizes.

Small: 5-15 sq ft



Medium: 15-40 sq ft



Large: 40-125+ sq ft



Thermoplastic materials - neat, glass fiber, or carbon fiber filled.

- **Room/Low Temperature** (150F Range)
 - ABS
 - PET-G
 - PLA
 - TPU/TPE
 - PP
- **Medium Temperature** (250F Range)
 - Polycarbonate
- **High Temperature** (400F Range)
 - ULTEM (PEI)



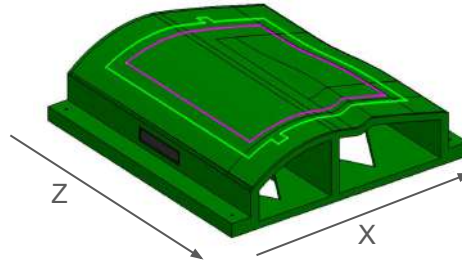
Foams and Metals (Traditional)

- **High Density Urethane Foam** (RenShape, Coastal, RAMPF, etc)
 - Tooling, masters, mockups/models, etc.
- **Metallics**
 - Aluminum and steel plate and billet for machining tooling, molds and fixtures.

Temperature Rated Molds - CTE

Anisotropic properties

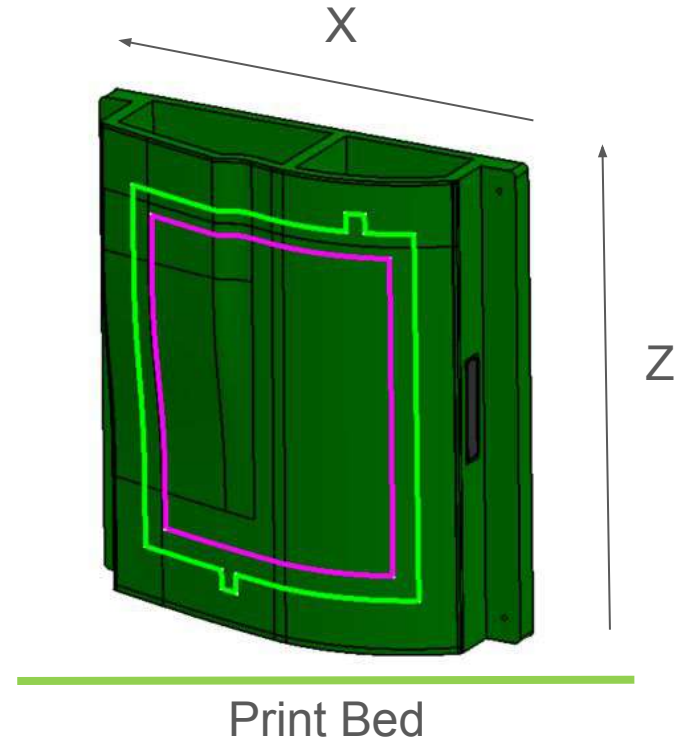
- Fiber content aligns with extruder toolpathing.
- 2D properties “stacked/bonded” on each other.



> CTE mismatch

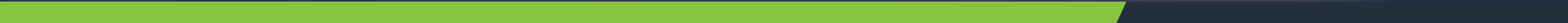
Compensate in XY&Z

PEI + 20% CF		
Direction	Value	Units
X&Y	$\sim 7 \times 10^{-6}$	in/in/degF
Z	$\sim 31 \times 10^{-6}$	



APPLICATIONS

Tooling, Molds and Fixtures



**FASTER
MANUFACTURING**

**COST
SAVINGS**

**BETTER
SOLUTION**

LFAM Benefits

- **24 hour near-net prints** - be within $\frac{3}{8}$ " of your final geometry within ~24 hours.
- **Monolithic designs** - tool facesheet and substructure printed as one piece.
- **Print only what you need** - use material only where necessary.
- **Reduced CNC Time** - minimal stock removal.

Versus Traditional Tool Manufacturing

- Billet & Block tooling
- Fabricated tooling
- Composite tooling

Bypassing a master and directly print your layup molds.



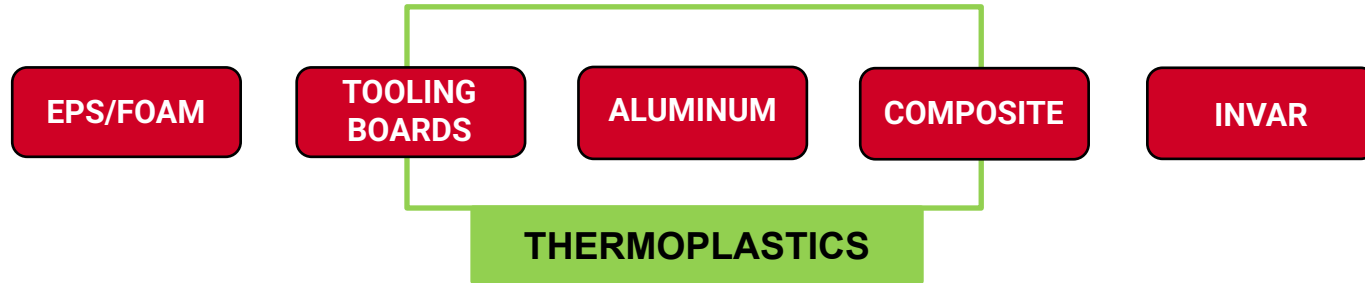
Image from General Plastics' Website

VS



3D Printed Layup Mold - No master needed.

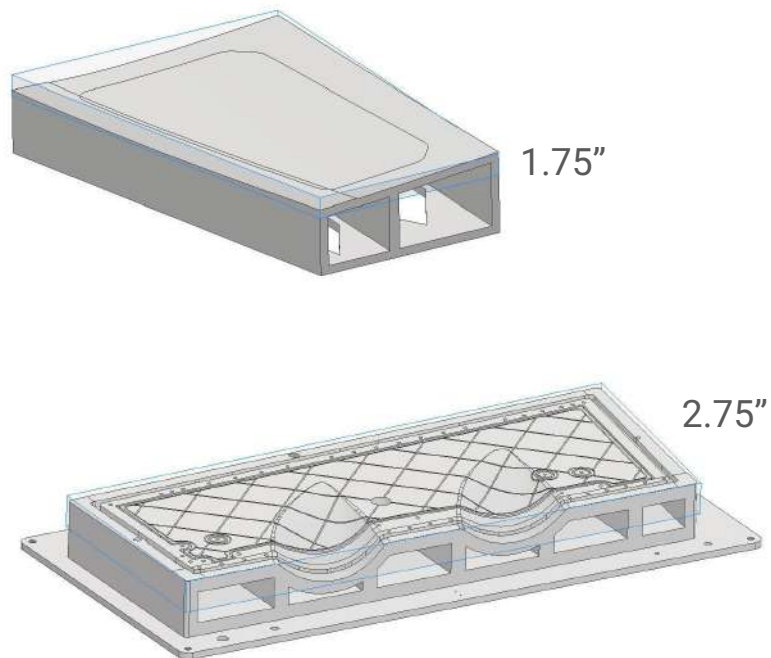
Match your need with our solution.



By introducing a new tooling material, companies are now able to match their needs more closely with a material solution that makes sense for their project's requirements and budget.

*The amount of **MONEY** and **TIME** that can be saved using LFAM is highly dependent on the *geometry* of the finished mold or part.*

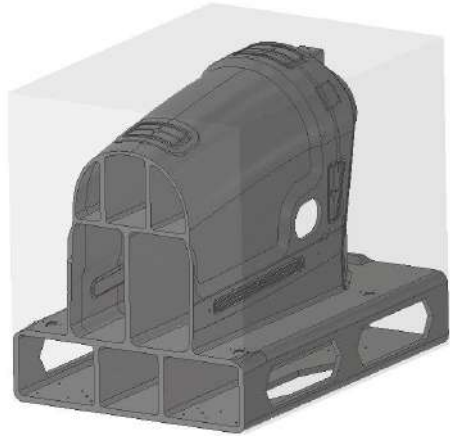
Examples of short part Z-height or small bounding box thickness



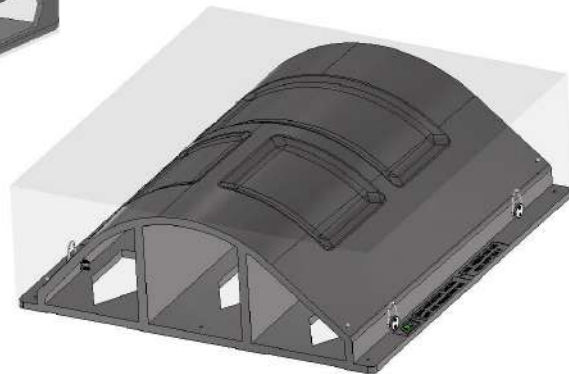
These types of geometries result in a **lower** value return for LFAM; neutral cost & time savings.

Traditional mold making would require metal plates or tooling board that could be ordered and machined with ease. **We also offer metallic tooling capabilities in-house.**

Examples of tall part Z-height or large bounding box thickness



44"



20"

These types of geometries result in a **HIGH** value return for LFAM; great cost and time savings.

Traditional mold making would be both very time consuming and labor intensive to create these geometries.

Durability

- Density 85lbs/ft³
- HDT ~420F

Longevity

- Airtech Study
 - 500 cycles (lab)
- AES Customer-base
 - 1-100 cycles, typical
- **Max potential is untested**
 - 1,000+?

Failure Modes - CF Molds

- Delamination
- Fiber Breakage
- Matrix cracking
- Resin-rich wear areas

Failure Modes - AM Molds

- Cracking (stress management, mishandling)
- Porosity (process anomaly)

Radome Vacuum Mill Fixture



3D PRINTED TOOLING EXAMPLES

Aerospace Robot Drilling Fixture - *hundreds of 5-axis holes*



Aerospace Mill Holding Fixtures



3D PRINTED TOOLING EXAMPLES

32FT Long Vacuum Mill Holding Fixture; upper/lower & left/right.



Aerospace Metal Stretch Forming Die - Polycarbonate



Size: 12' x 4' x 4"

Form metal with plastic!

Large radius shapes are excellent geometries for 3D printing, extremely low material waste.

3D PRINTED TOOLING EXAMPLES

Aerospace Metal Stretch Forming Die - Polycarbonate



3D PRINTED TOOLING EXAMPLES

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Aerospace 350F Autoclave Molds



3D PRINTED TOOLING EXAMPLES

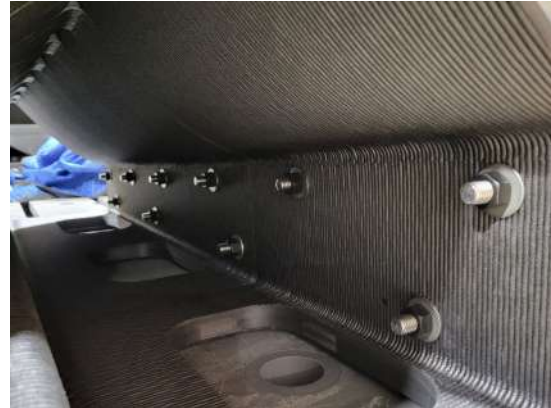
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Aerospace Layup Mold and Mill Fixture Combo (PSU 300F & ABS)



3D PRINTED TOOLING EXAMPLES

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3D PRINTED TOOLING EXAMPLES

Large and unique shapes can be much easier to manufacturer via 3D printing.
This speciality check and testing fixture is 18ft in length!



3D PRINTED TOOLING EXAMPLES

10ft long autoclave mold 350F, 90PSI (PEI Material)



METALLIC TOOLING CAPABILITY

In addition to LFAM tooling, we also offer **in-house metallic tooling** so you do not need to split tooling packages up between LFAM and metallic suppliers, we do it both.



A NEW WAY OF DOING THINGS

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BEYOND TOOLING

Mockups | End-Use Parts



Autonomous Underwater Vessel (AUV) 3D Printed Fairings



Benefits

- **Performance:** 3D printed fairings functionally work out great. Many materials to choose from; impact resistance, rigid or flexible, UV stabilization, etc. Power of thermoplastics!
- **Part consolidation:** Connection details are printed. Reduces labor required for assembly. Simplified BOM!
- **Customization:** Design changes can be made incredibly quick with a very low cost impact.
- **Speed:** An entire fairing set for a 19ft AUV can be printed in one week! **Minimal post-processing.**
- **Flexibility:** additional parts can be printed on demand instead of tying up cash in a bunch of inventory.

3D PRINTED PRODUCTION PARTS

Autonomous Underwater Vessel (AUV)



3D PRINTED END-USE PART EXAMPLES



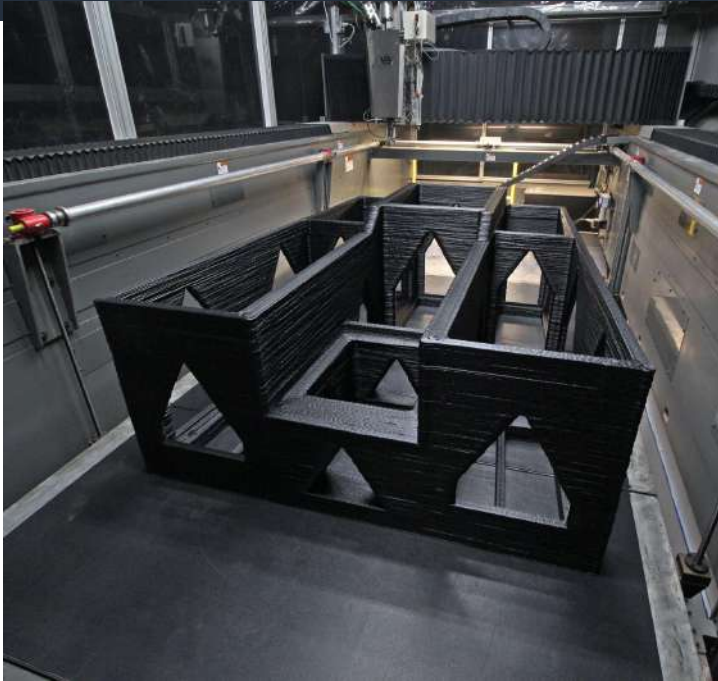
Problem:

Current frame was constructed from aluminum and fiberglass; welded and bolted together for a total part count of 3,000+ components. Lead time 4-6 months.

Solution:

Redesign for LPAM.

- **Parts:** 300 pc vs a 300 pc
- **Speed:** 4-6 months to 6-8 weeks



3D PRINTED END-USE PART EXAMPLES

F-16 Flight Simulator



3D printed simulator cockpit

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EMERGING GROWTH SEGMENT: Reusable Custom Dunnage / Material Handling



Durable, reusable dunnage from thermoplastic composites vs. one-time or low usage wood solutions.

3D Print complex geometries to match the shapes of the parts you're trying to hold, stow, and transport.

EMERGING GROWTH SEGMENT: Reusable Custom Dunnage / Material Handling SBIR with USAF

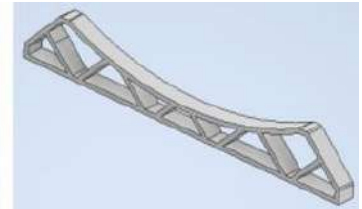


PROBLEM:

Carts are stored outdoors and existing wood required high maintenance and frequent replacement.

SOLUTION:

- LFAM net shape using low cost materials.
- AES reverse engineered from 60 year old drawings!



GhostEye™ LTAMDS Radar Mockup



Problem:

Needed a four month turnaround on design and manufacturing of full-scale mockup at roughly 50ft in length.

Solution:

- AES took current CAD data and transposed to a manufacturing mockup model.
- CNC machined foam panels attached to steel frame with 3D printed features.
- Manufactured, assembled and painted in two months.

THANK YOU

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