

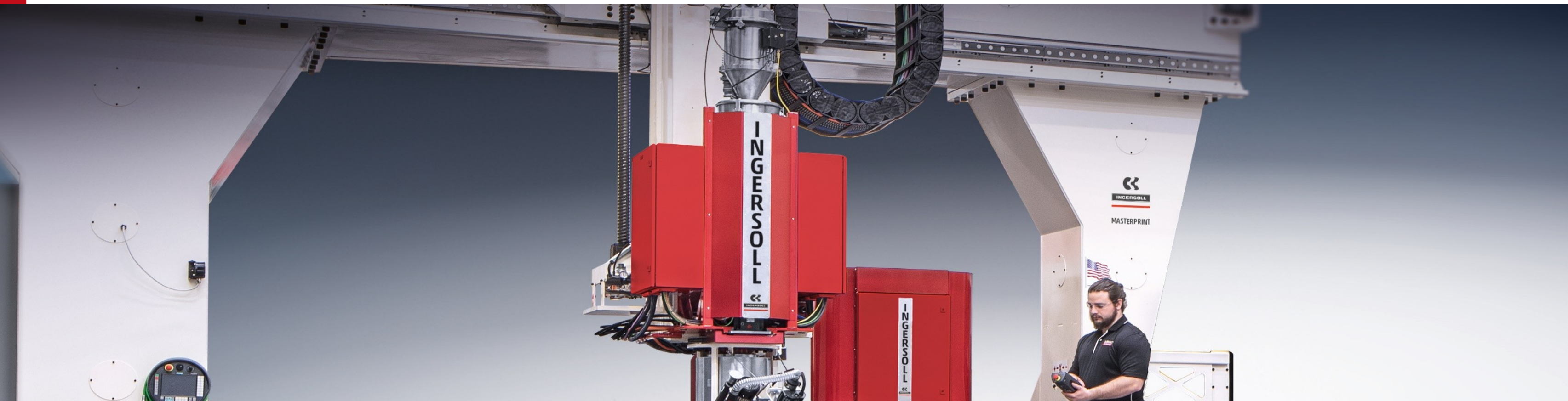
INGERSOLL AM 2021

May 2021 RENA SOLUTIONS
EVGENY MOLCHANOV
DANIELE MARTANI
DIRECTOR INTERNATIONAL SALES



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Machine Tools

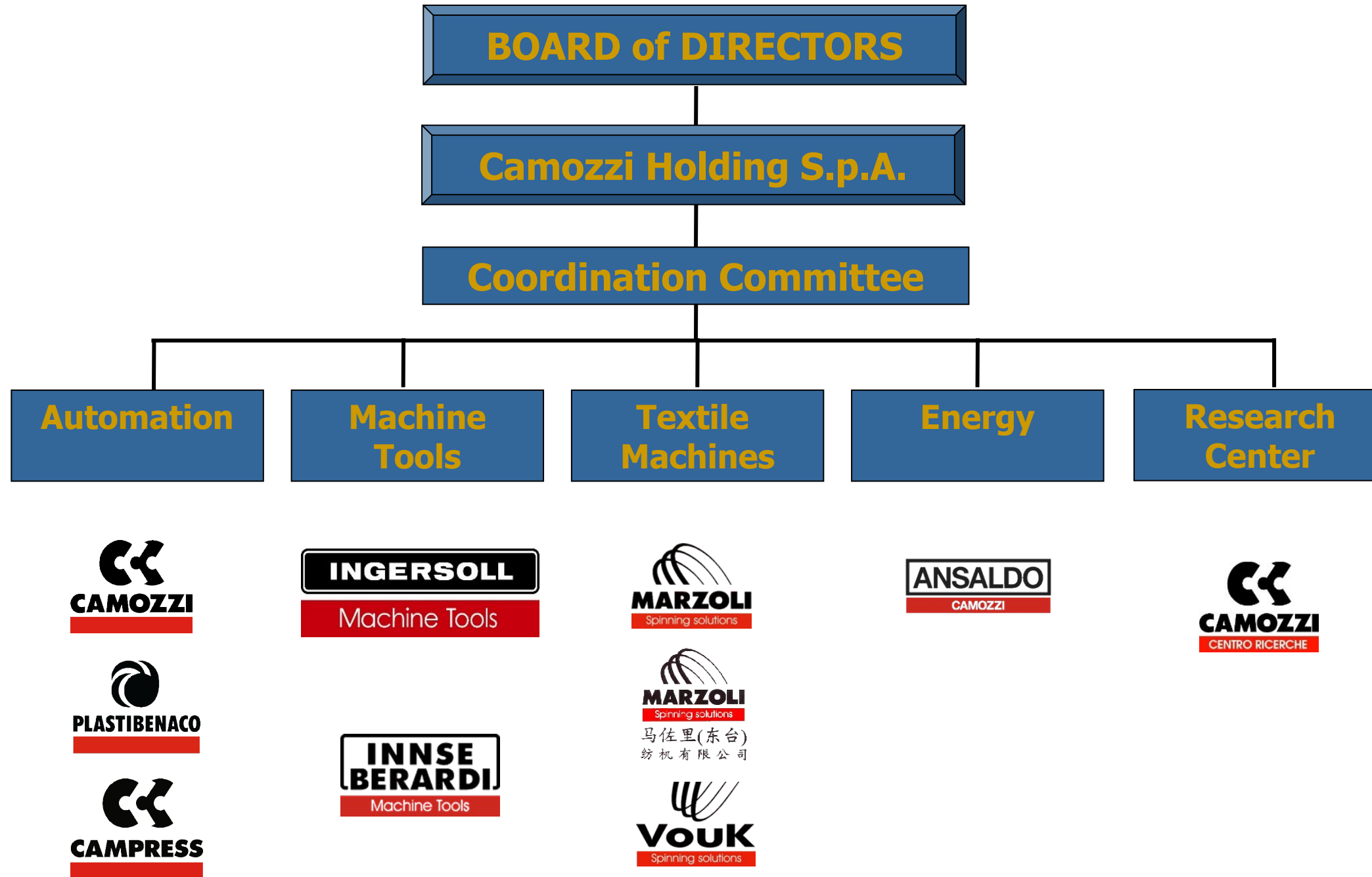


ROCKFORD ASSETS



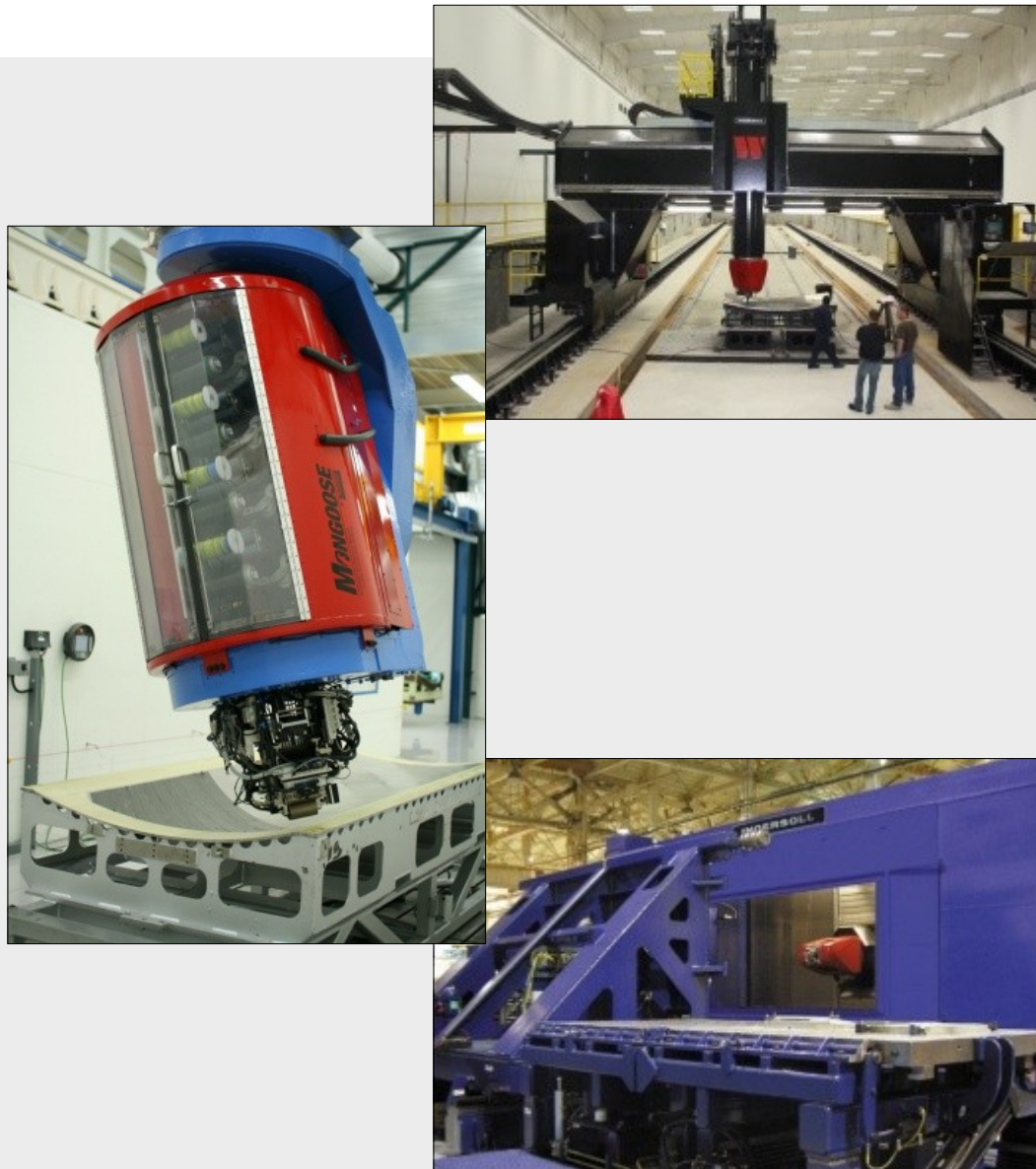
Rockford Illinois, Fulton Ave. facility - 500,000 sq.ft – 250 Employees

CAMOZZI GROUP



Ingersoll Background

Products and Services



Products and Services:

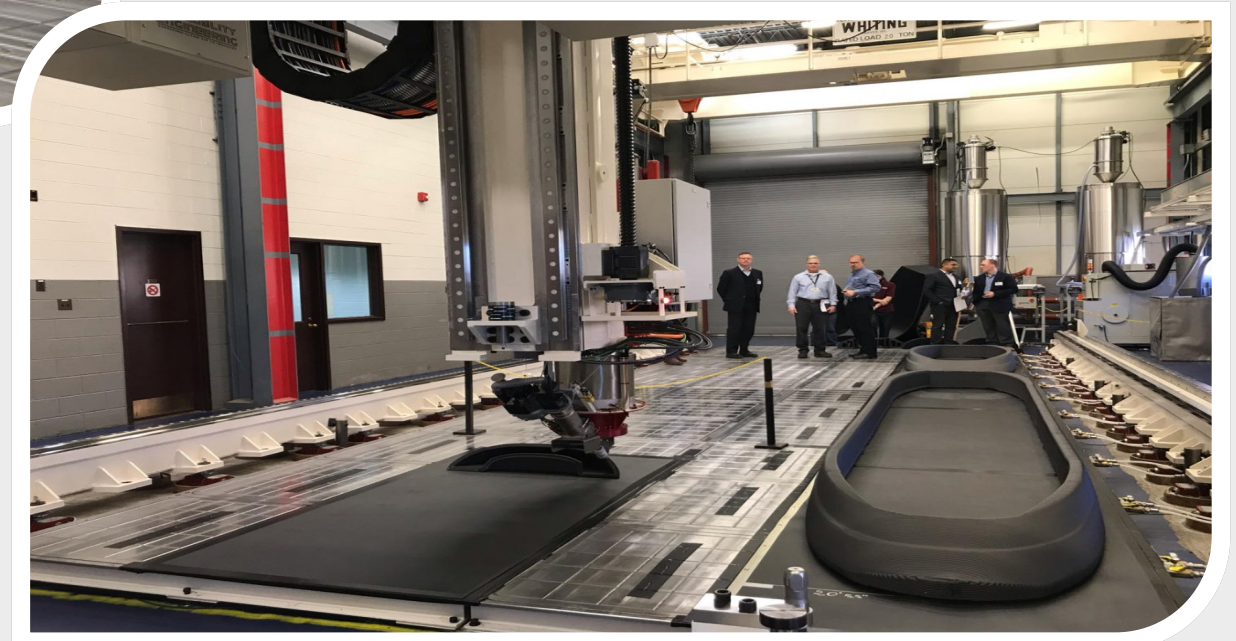
- 1890 Machine Tools for Metal Cutting
- 1994 Automated Fiber Placement Machines
- **2016 Additive Manufacturing Composite TP**
- Full Process Turnkey Solutions
- Software – Operations, Simulation, MES
- Machine Retrofitting
- Aftermarket Components and Support
- Contract Manufacturing
- Contract Engineering and Programming

Better than 3D-printed... MasterPrinted!
AM technologies for toolings and parts



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Machine Tools



GROUP

Printing COMPOSITE with THERMOPLASTIC

ADDITIVE MANUFACTURING APPLICATION FIELDS

- AM Tooling Process

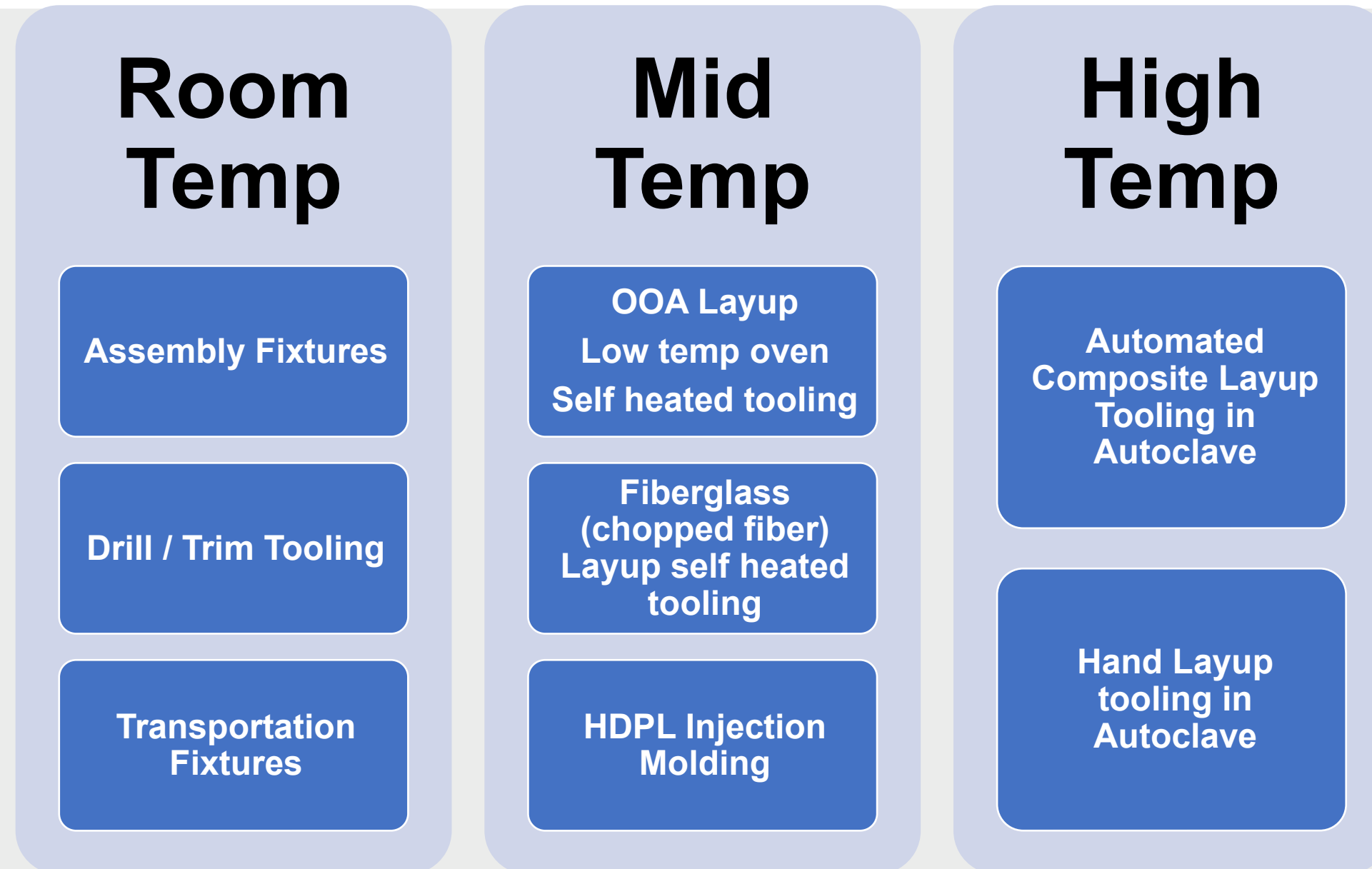
- R&D prototypes

- Short series Parts

production

ADDITIVE MANUFACTURING MOLD APPLICATIONS

TOOL TYPE AND TEMPERATURE REQUIREMENTS MATRIX



ADDITIVE MANUFACTURING MOLD APPLICATIONS

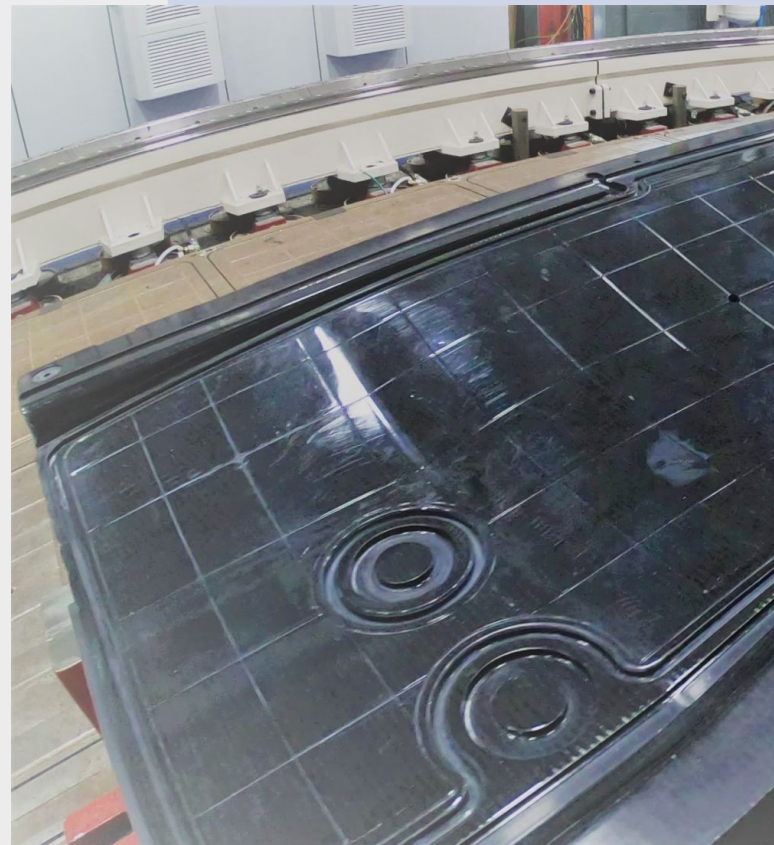


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Machine Tools

TOOL TYPE AND TEMPERATURE REQUIREMENTS SELECTION OF THERMOPLASTIC MATRIX AND CHARGE

**Room
Temp
PA620GF**



**Mid
Temp
ABS30CF**



**High
Temp
PEI20CF**



AM Layup Mold Advantages

The Ultimate Choice for Manufacturing Agility



- Overall **SHORT** lead time to fabricate the tool
 - Printing replaces fabrication
 - 90% reduction of subassembly cutting, welding, stress relieving and machining
 - Keep thermoplastic **feedstock on-hand**, eliminate short-life materials
- Reduced cost
 - Ideal for limited production environment
 - Great for programs requiring < 20 parts
 - Avoid expensive tooling for short programs-prototyping
 - **Minimum scrap** of material in manufacturing
- Flexibility
 - Immediate adapt to engineering design changes
 - Repair damaged tools
 - **Recycling** of material for future use

AM Tooling Molds have the greatest ROI of any Tool ...

INGERSOLL PROPRIETARY SOFTWARE
DESIGN, SLICER, PROGRAMMING fully developed
Two years license and training are scope
of the MasterPrinty supply

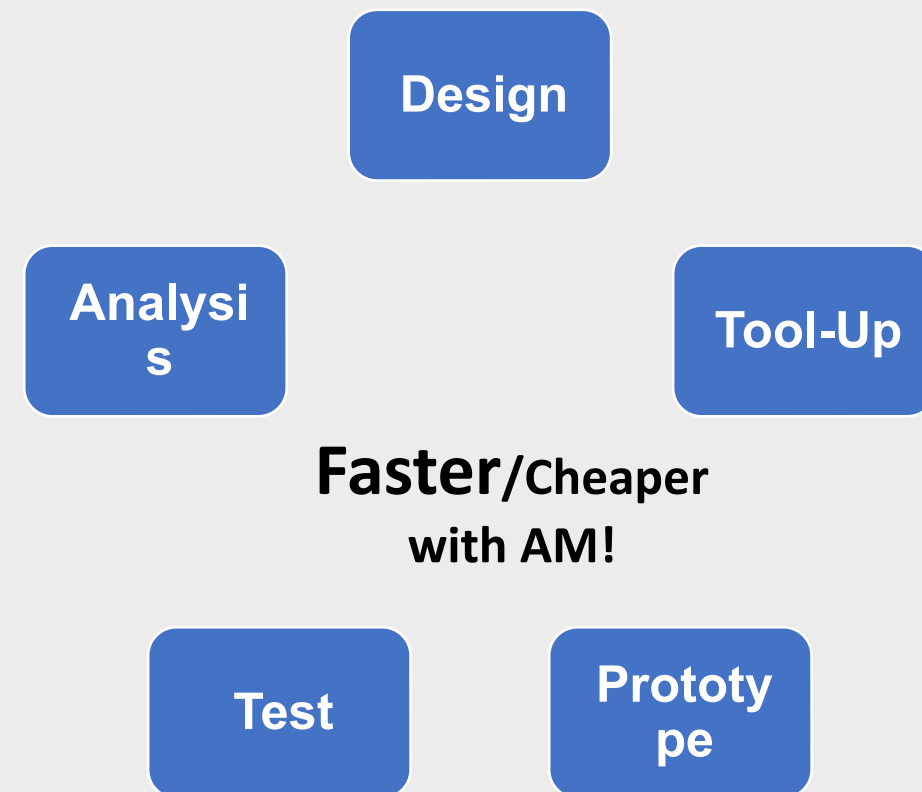
Rework and Retrofit

Accelerate the product development cycle!

Reduced risk via retrofit due to engineering design changes

Easily repaired compared to CF and Invar

AM tooling can be corrected by handmade “re-fill” , then 5 axis “re-mill”,



Materials Pellet-Fed Screw Extrusion

Open Material Platform

- Pellet feed stock
- Engineered thermoplastics, neat and charged
- **Open** to local material suppliers
- **GREEN** : Great recyclability of thermoplastic resins

SOME EXPERIENCES

Base Polymer (some of)	Key Advantage
ABS	Versatile, tough
ULTEM® PEI	Strength and durability
PPS / PEEK	Thermal/chemical resistant
PPSU	Dimensional stability, thermal resistant
Nylon	High fatigue resistance
Polycarbonate (PC)	Strong in tension and flexion
Polystyrene (HIPS)	High surface quality, shock resistance

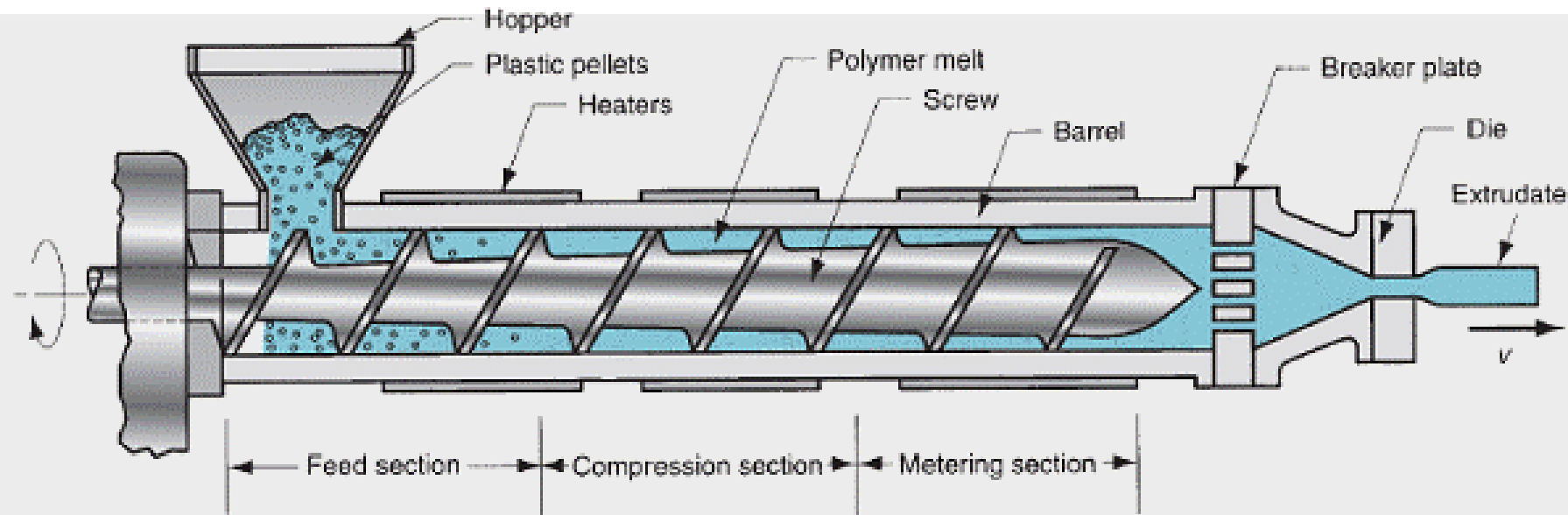
Materials

Changing the Print Material, full control of the extruder



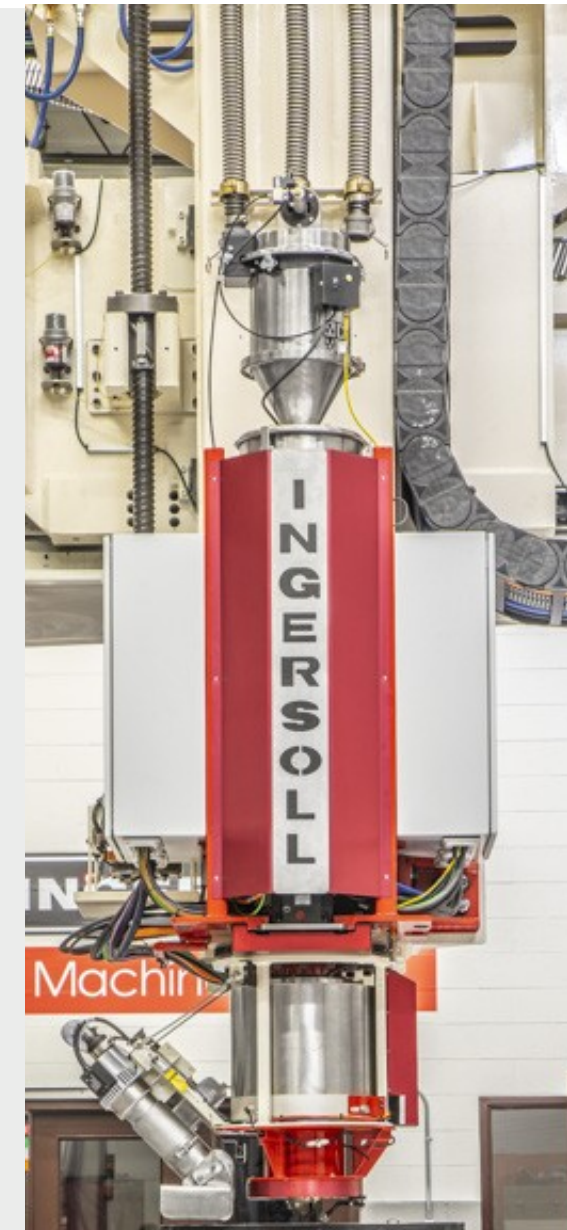
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Full CNC settings for Optimal Production

- Screw speed
- Barrel Heat Zones
- Nozzle Geometry (optional 5X)
- CNC Industrial control from Siemens 840DSL



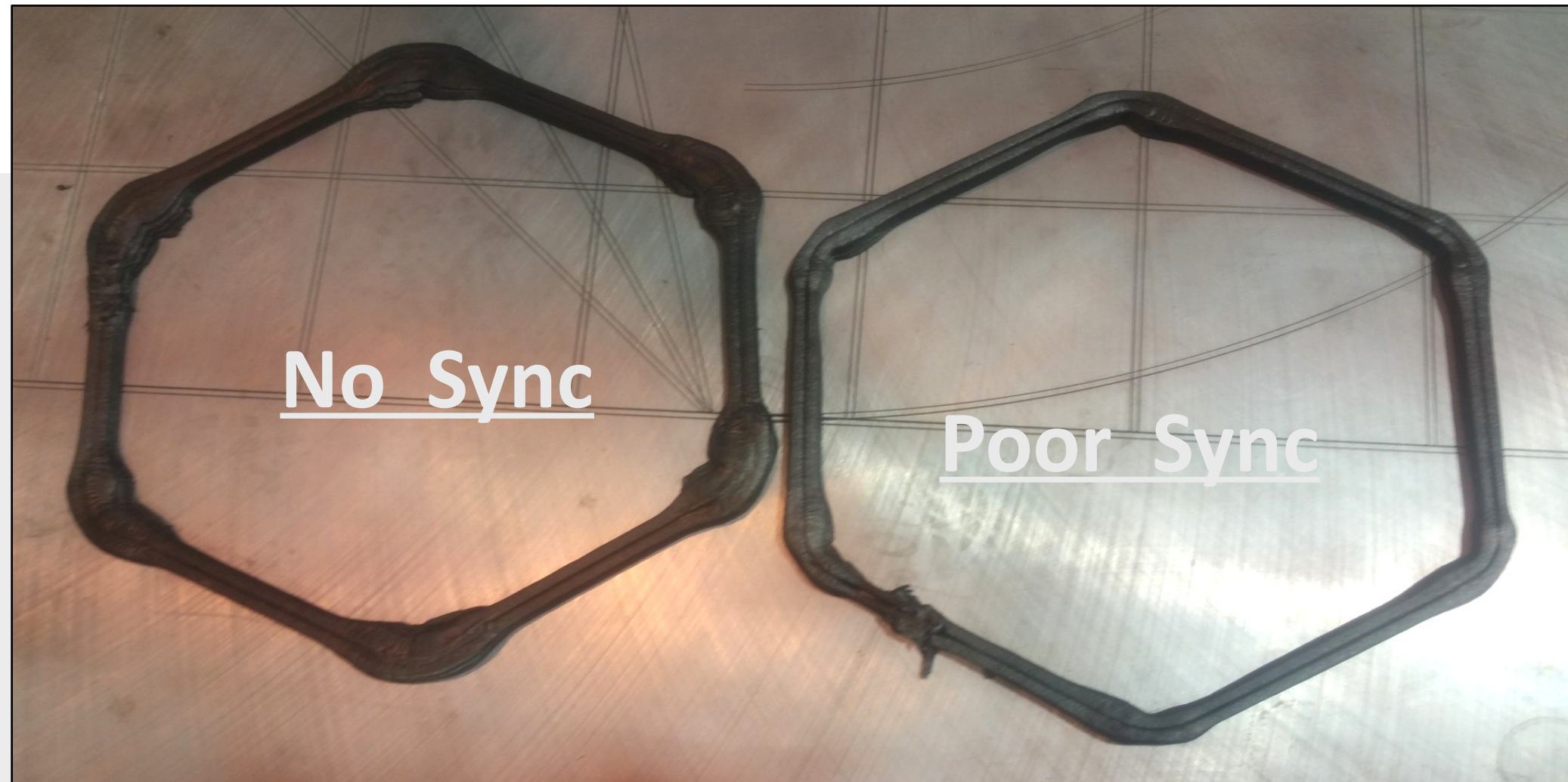
Process Parameters

Path Planning and Extruder Servo Example



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Machine Tools

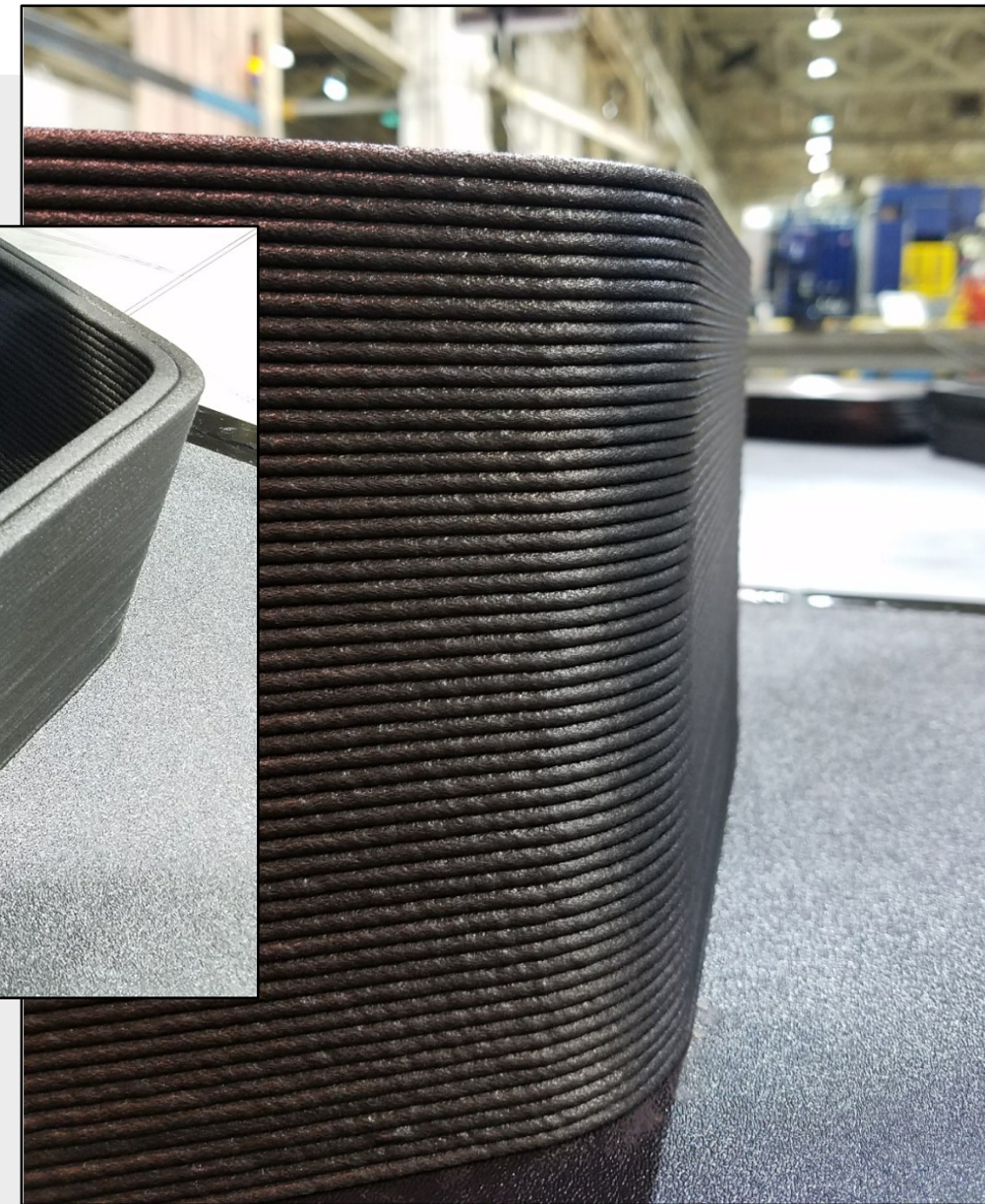


An example of a Process Parameter is Path Planning and its interaction with the Extruder Servo. In early programming there was no synchronization between the Path Planning and Extruder control to adjust flow based on path programming. In this case the Ingersoll Team used a feature in the Siemens 840D and material flow control to provide a path to synchronization and ensure a quality print.

Process Parameters

Path Planning and Extruder Servo Example

Perfect Sync



Continuing to feed these developments to Siemens for native CNC support
Std nozzle 10 mm dia depose 12,5 mm bead, 5 mm high

Design Parameters

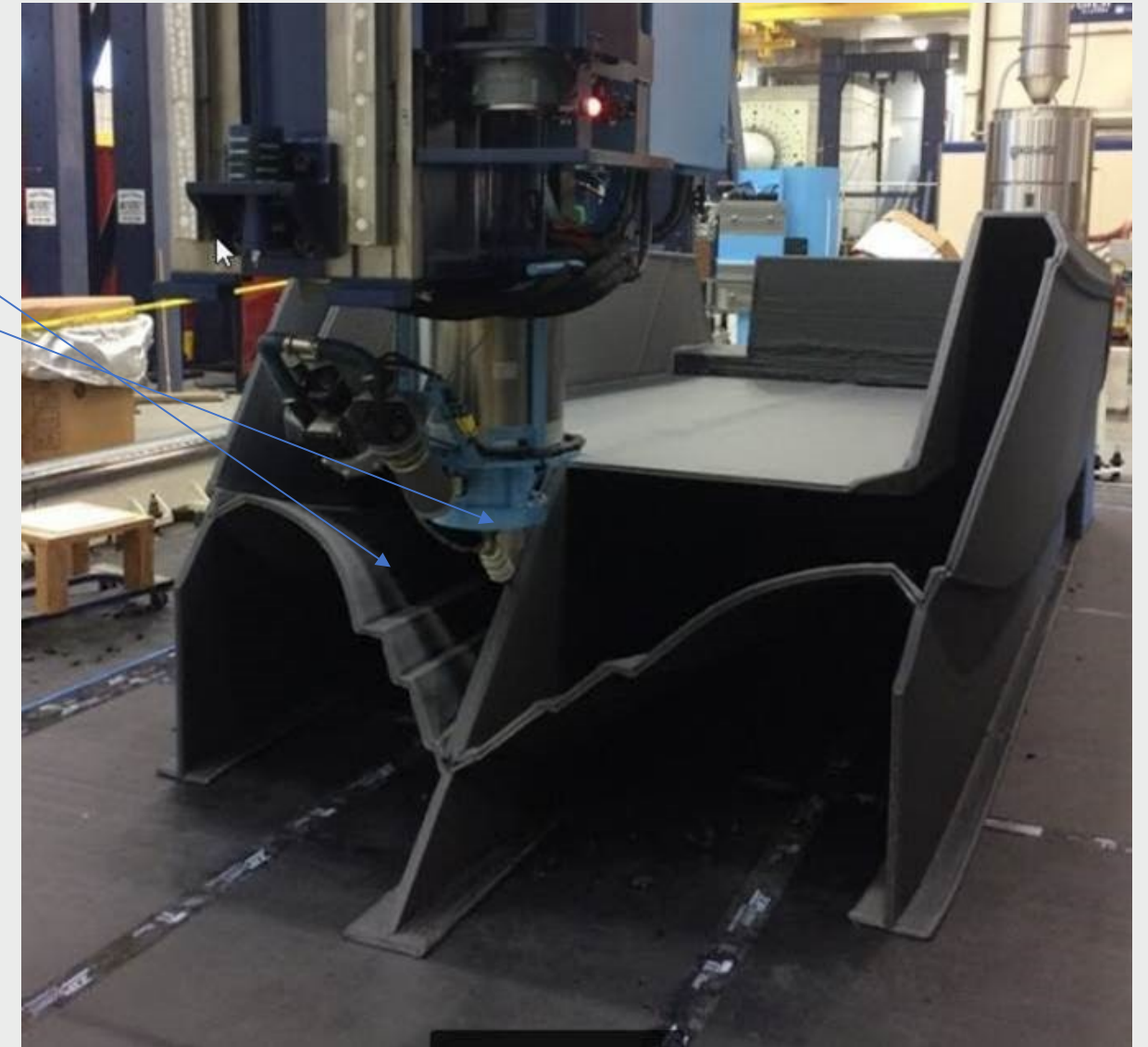
Path Planning and Extruder Synchronization



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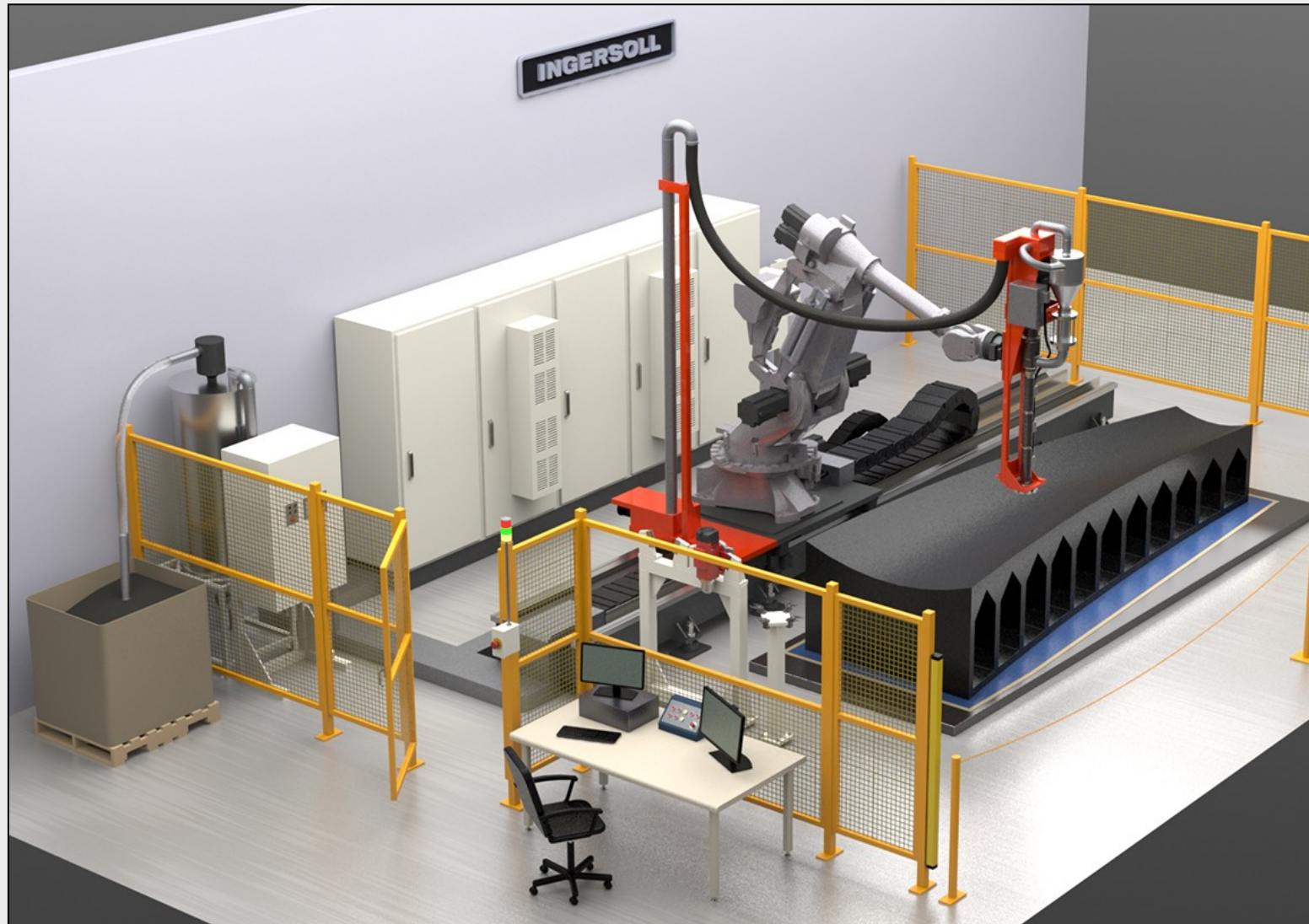
- ❑ Limited Support Structures (even **nothing**)
- ❑ Free design infill patterns (even hollow)
- ❑ Any slicing angle (typical 45 deg, not limited)
- ❑ Unattended printing : safe warnings
- ❑ Stop/Start efficient technique
- ❑ Easy welding/connection for modular printed parts



ROBOTIC MASTERPRINT



Machine Tools



	X	Y	Z
Travel	Multiple of 6 M	2.3 M	1.5 M

AM Extruder Head	
Throughput	150 lbs/hr Nominal, approx. 120rpm
Heat Zones	4 + 1 heated nozzle, 6kW
Nozzles	7 mm and 10 mm Diameter Available

OPTIONAL 5 AXIS MILLING SPINDLE

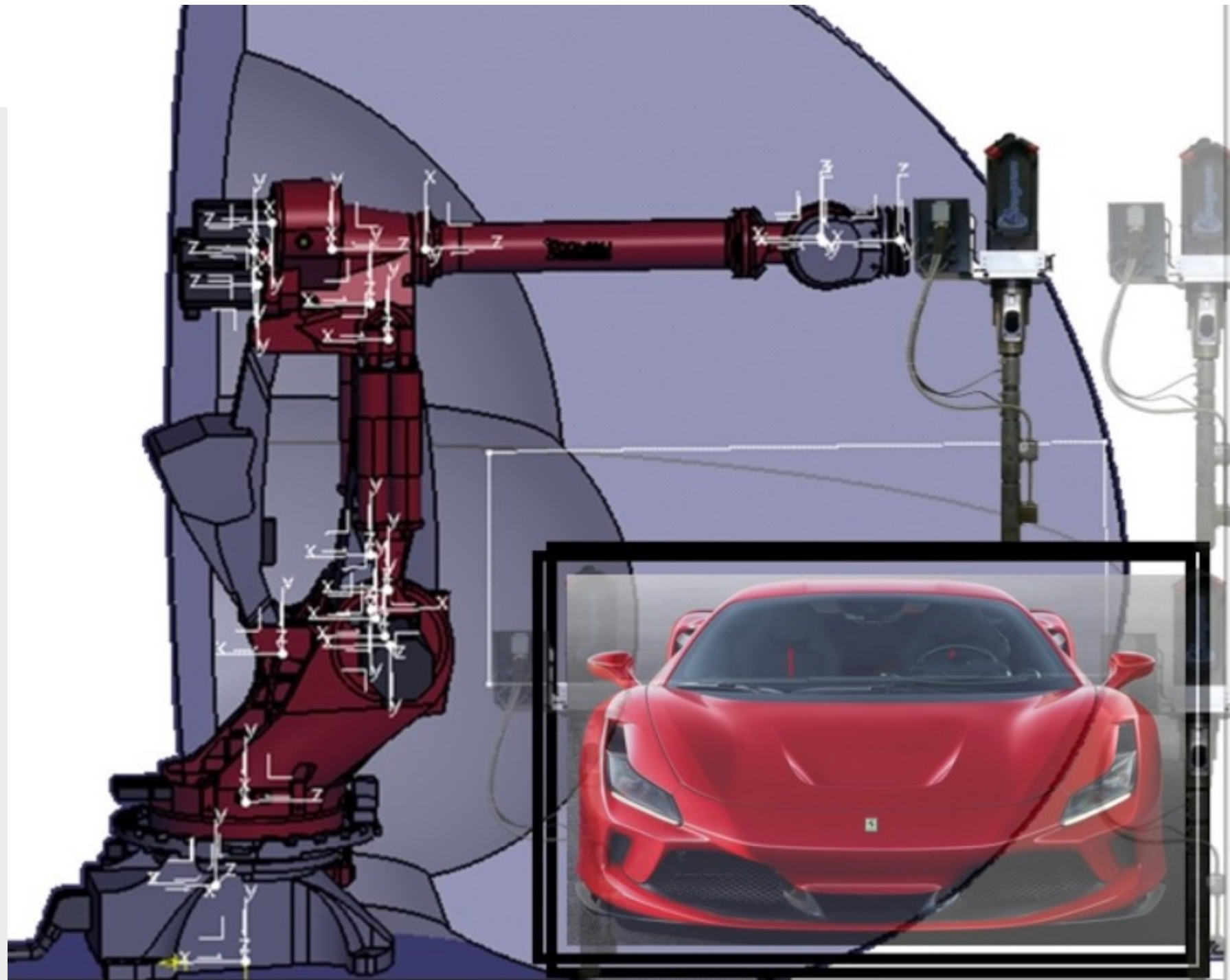
CNC INDUSTRIAL CONTROL BY SIEMENS 840DSL

ROBOTIC MASTERPRINT



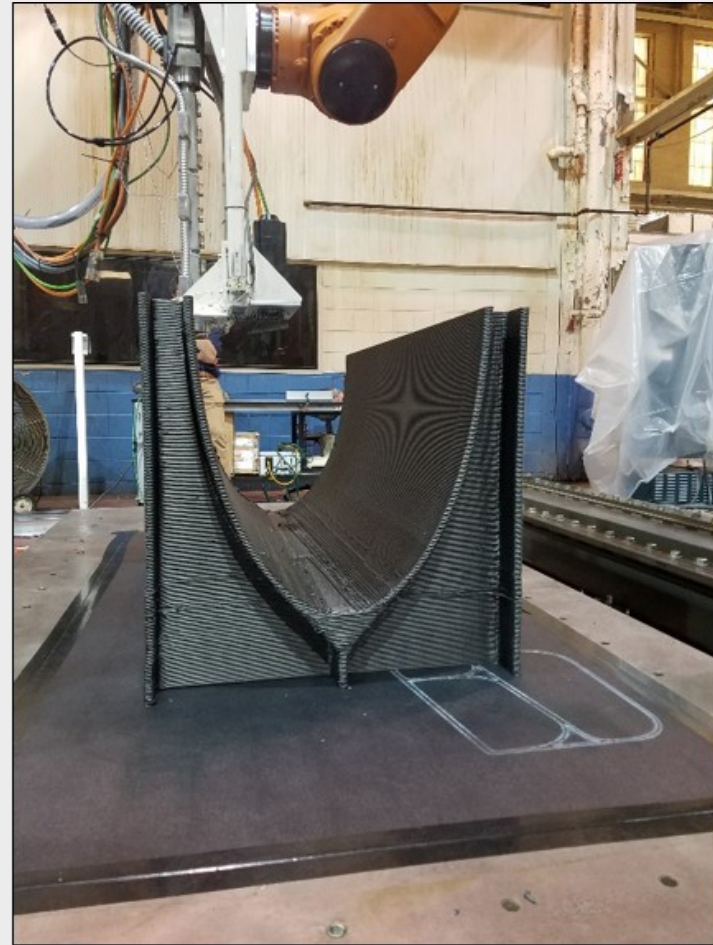
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Machine Tools



- The part can be about 2300 mm wide → the robot must slide along the rail during each layer in order to be able to reach the area near the rail
- The robot used in this example is a Comau NJ-420-3.0 . Robot brand can be selected nevertheless Siemens CNC control must be implemented.

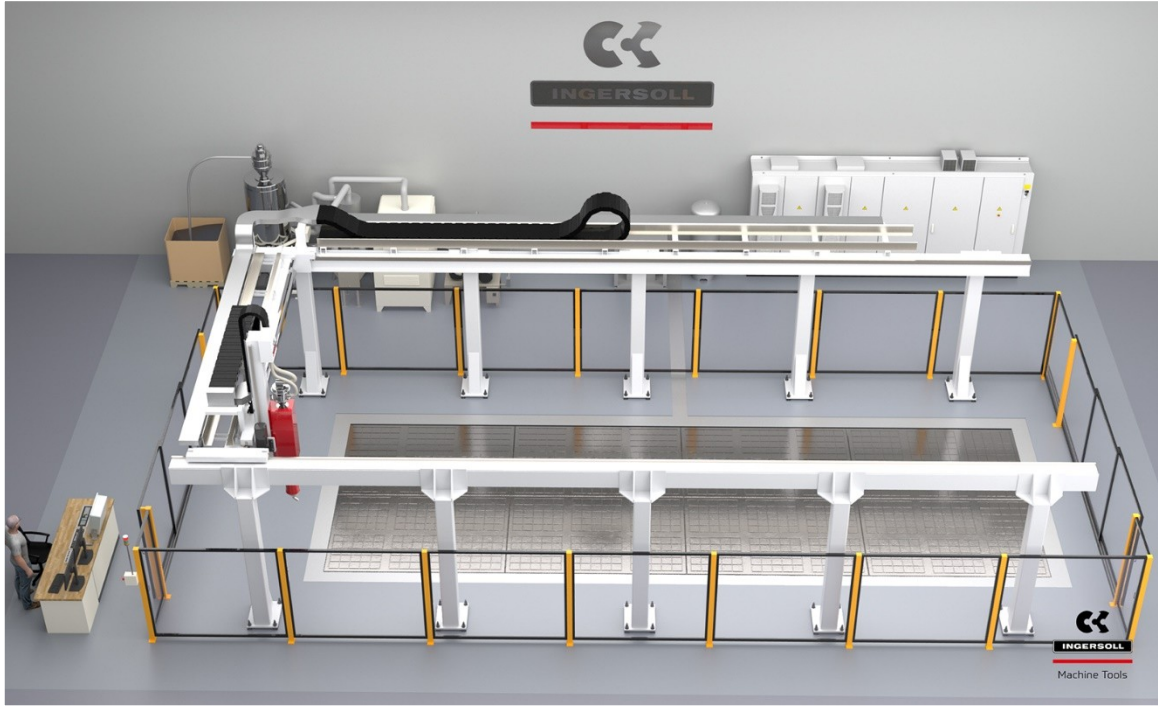
SOME PRINTINGS FROM ROBOTIC MASTERPRINT



MASTERPRINT LINEAR

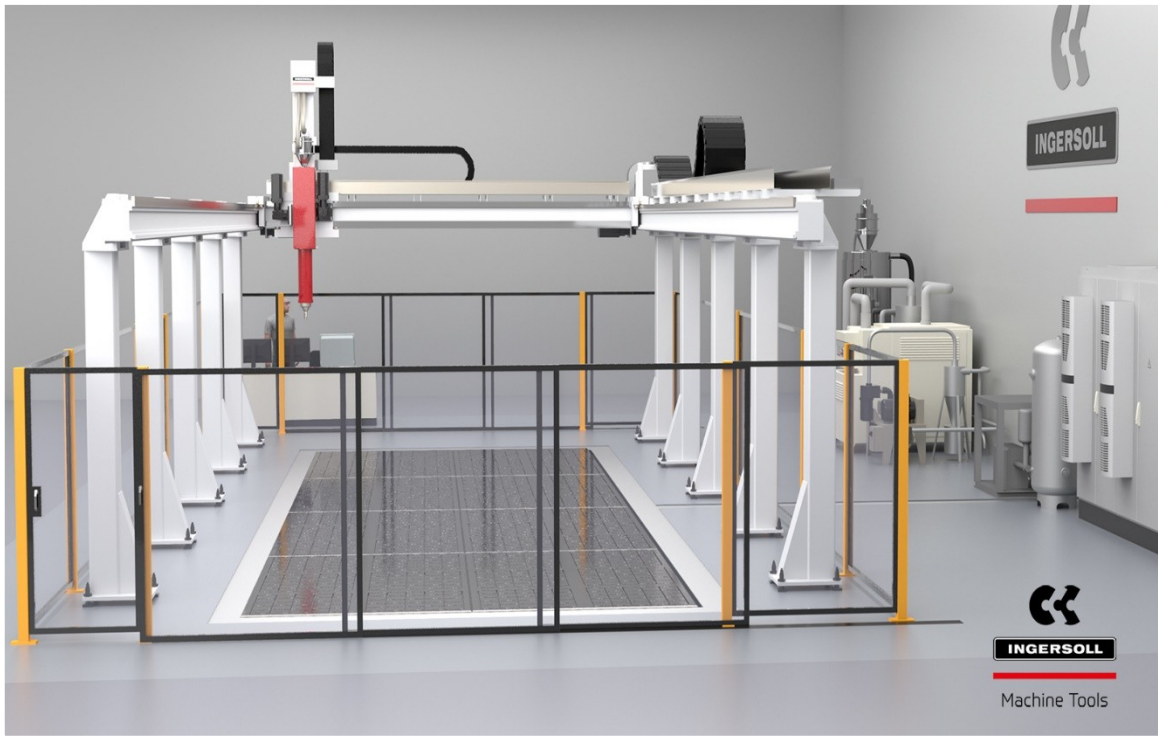
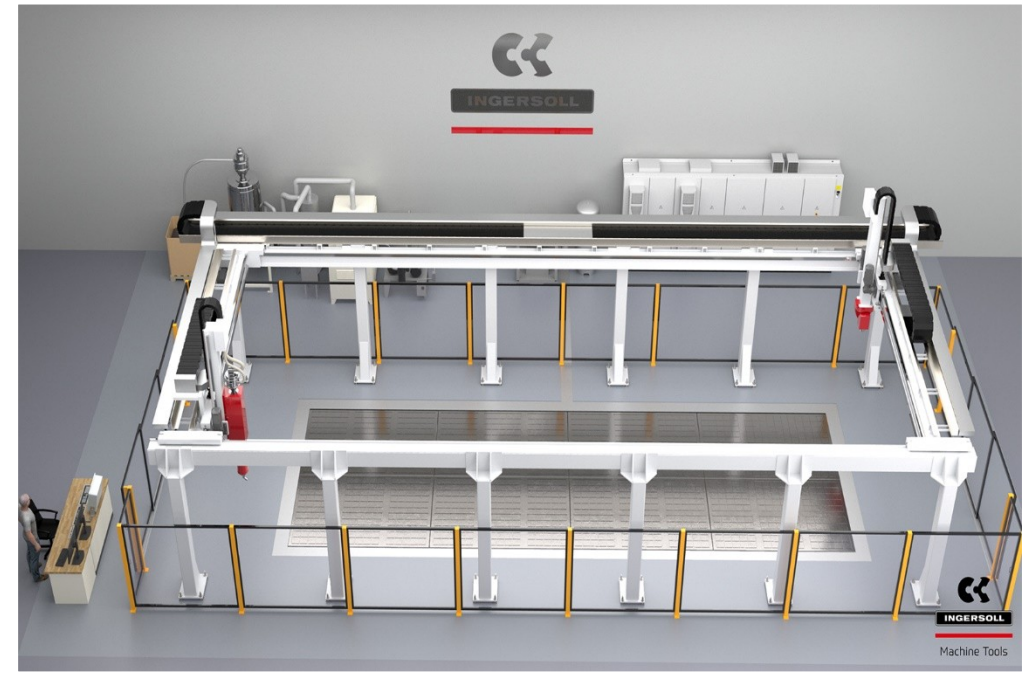


Machine Tools



	X	Y	Z
Travel	> 12 m	> 3 m	2 m

AM Extruder Head	
Throughput	150 lbs/hr Nominal, approx. 120 rpm
Heat Zones	4 + 1 heated nozzle, 6kW
Nozzles	7 mm and 10 mm Diameter Available



OPTIONAL ADDITIONAL CROSSRAIL WITH 5 AXIS MILLING SPINDLE
 CNC INDUSTRIAL CONTROL BY SIEMENS 840DSL

SOME PRINTINGS FROM ROBOTIC MASTERPRINT



MASTER PRINT 3X MASTER PRINT 5X with optional attachment milling head 5 axis



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Machine Tools



5-Axis Milling Spindle	
Max Power	25 kW
Max Speed	18,000 RPM
Tool Holder	HSK 63 A

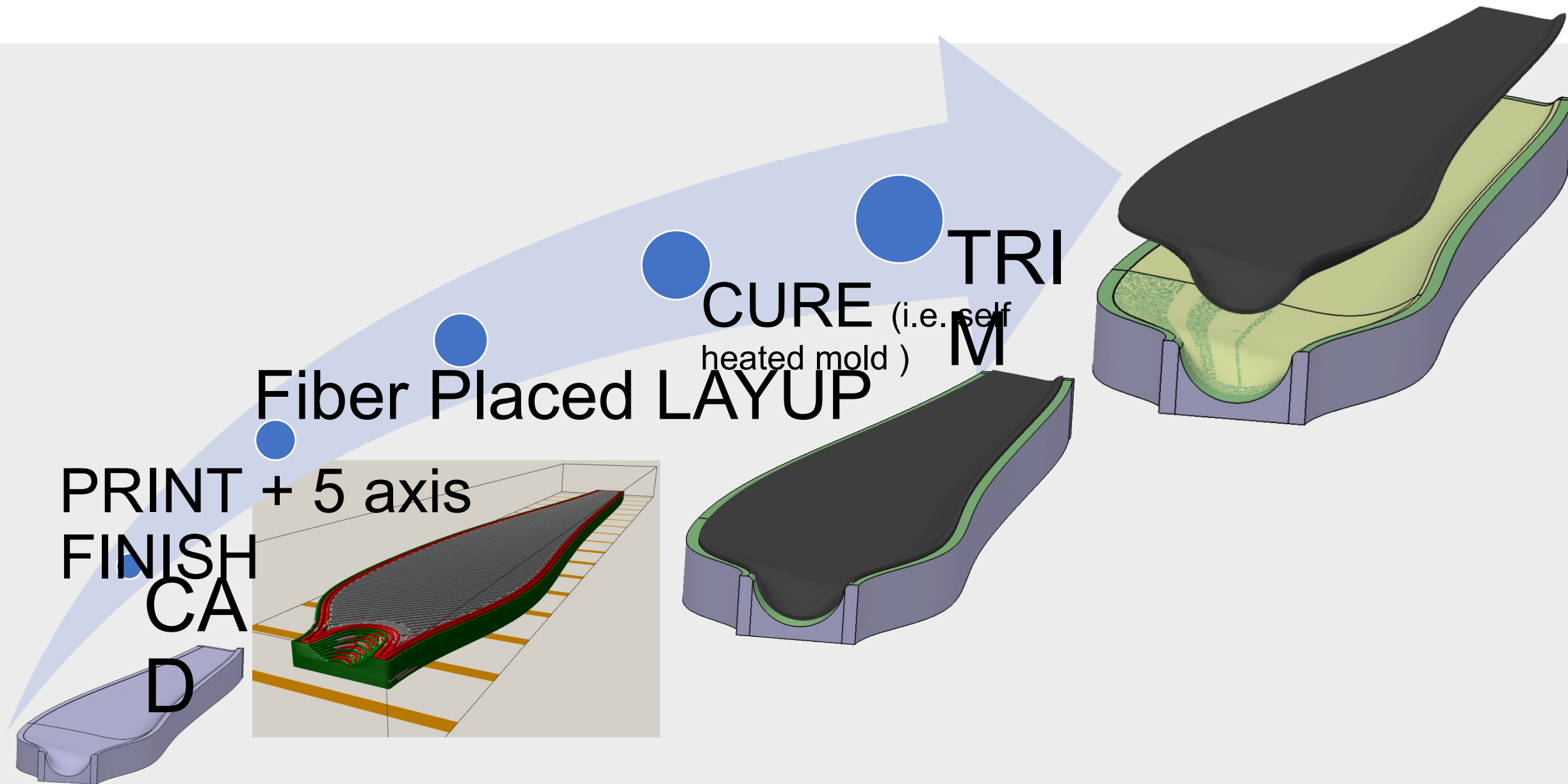
	X	Y	Z
Travel starts from	12 M	4 M	2 M
Extruder Size to select among 150,300,500 lbs / hr			

Oversized system for;

- Medium /Large molds
- Nautical Hulls
- Multiple parts
-

Additive Manufactured Composite Tooling

From CAD to Composite prepreg UD Part (virtually no move needed)



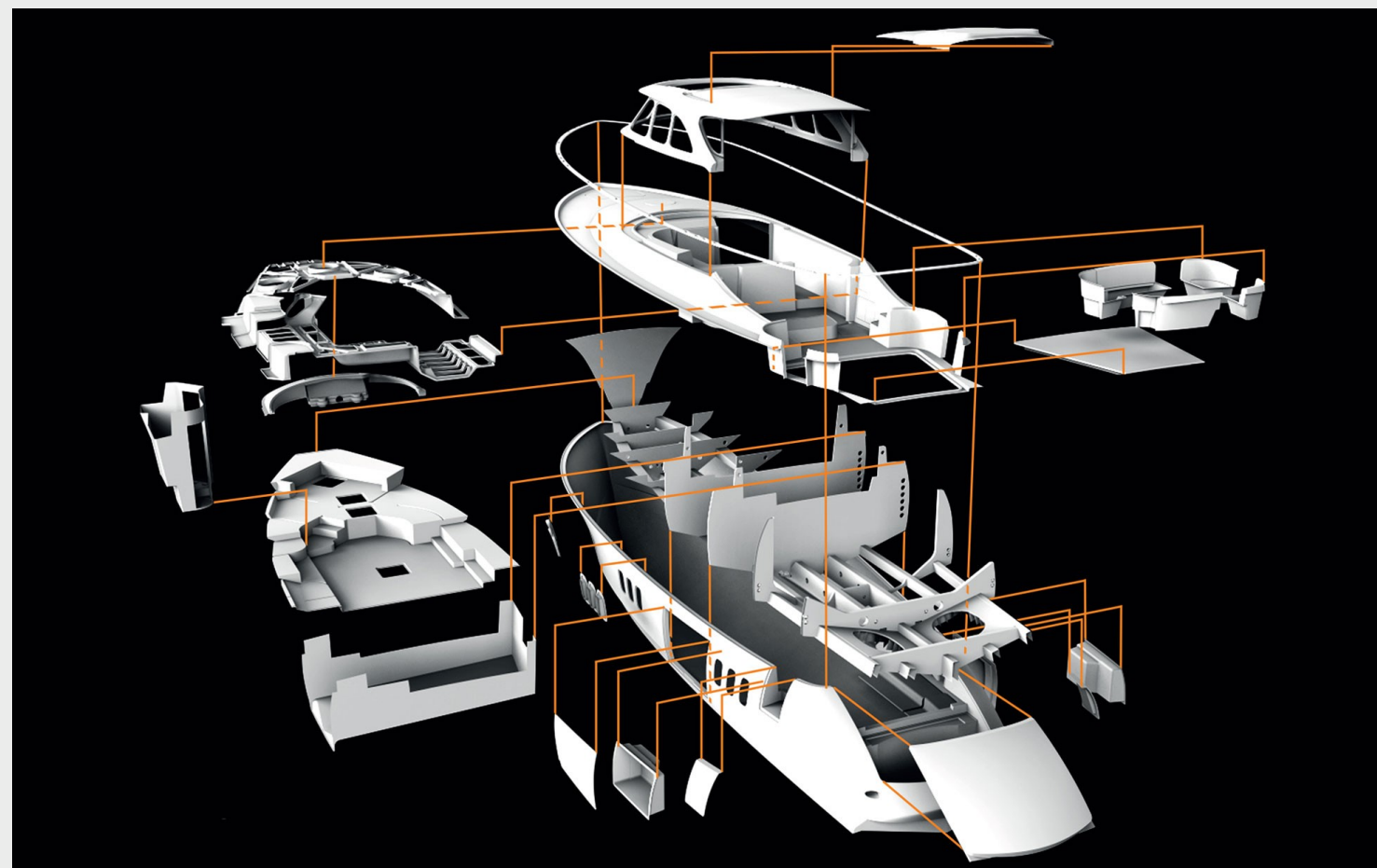
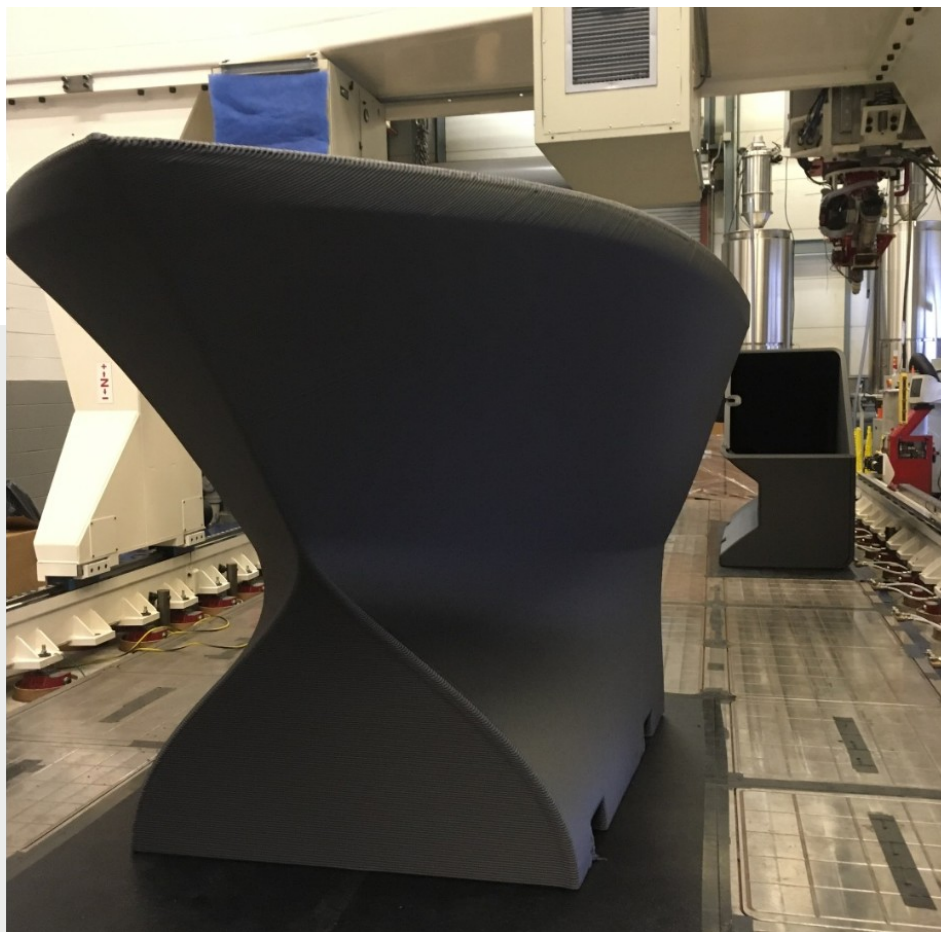


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PARTS AND/OR MOLDS READY FOR LEASURE BOAT INDUSTRY

- HULL MOLDS FROM CAD FILE, RECYCLABLE
- DECK PARTS
- FULLY CUSTOMIZED FURNITURE

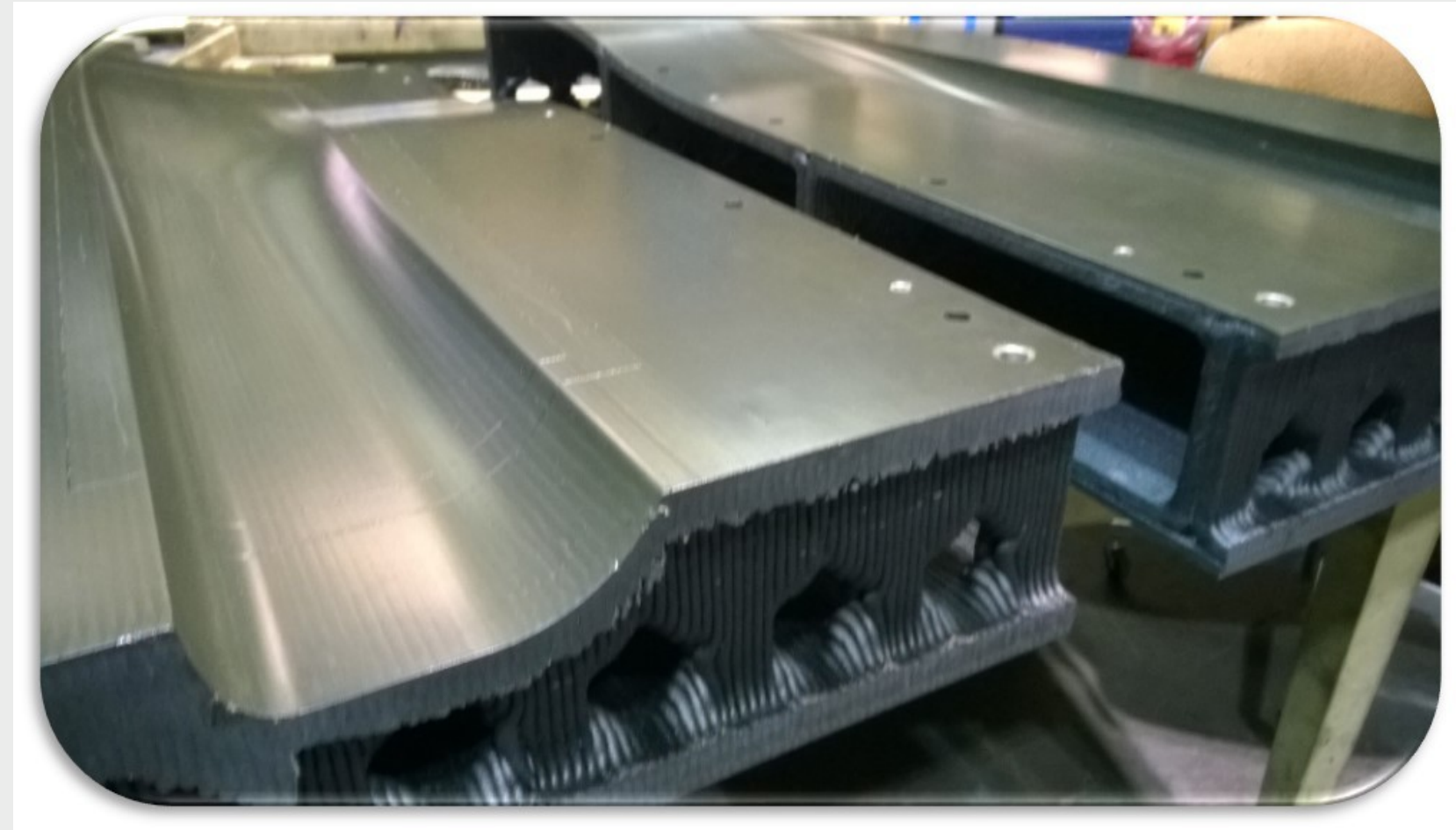


Process Validation

Internal R&D



Machine Tools

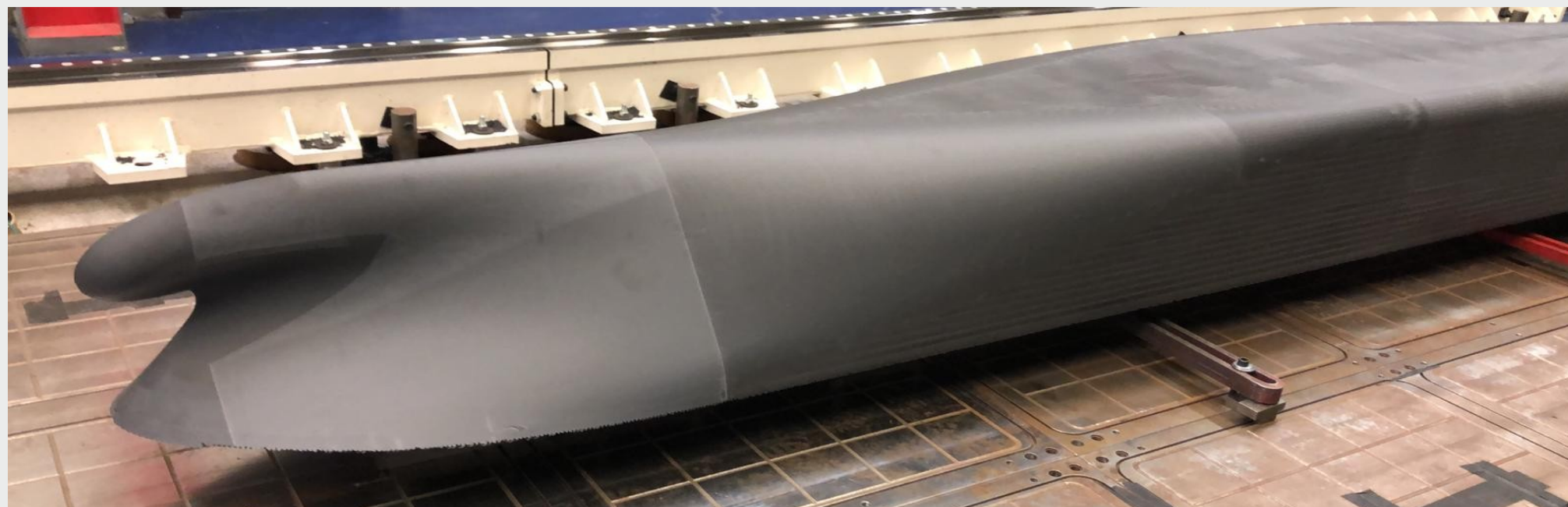
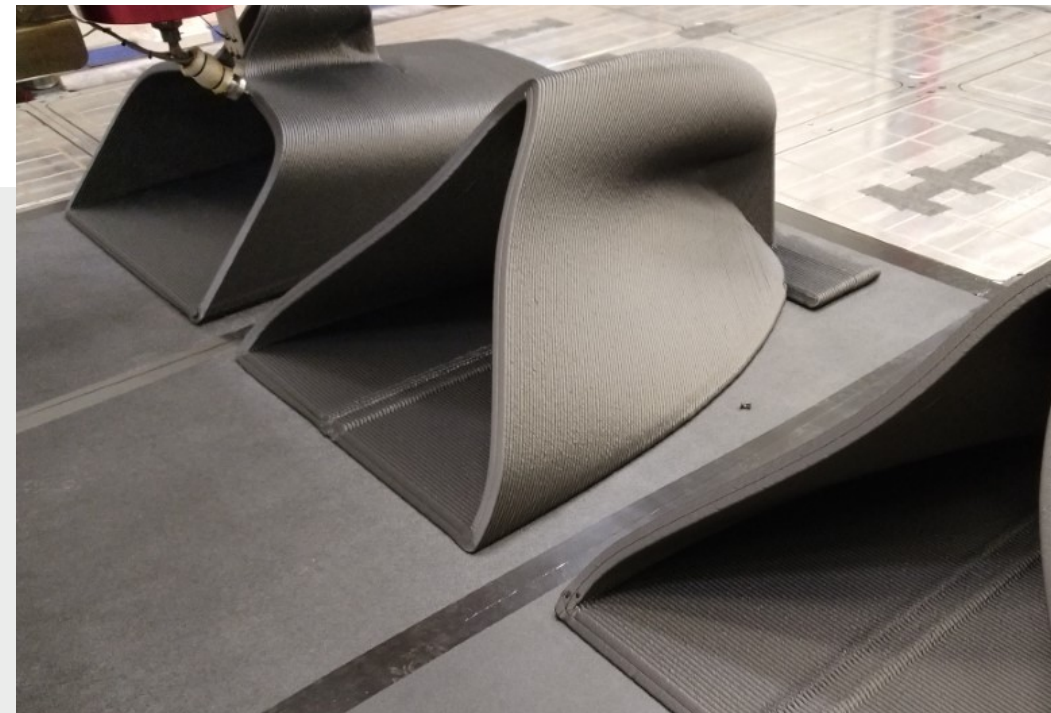


Manufacturing Revolution



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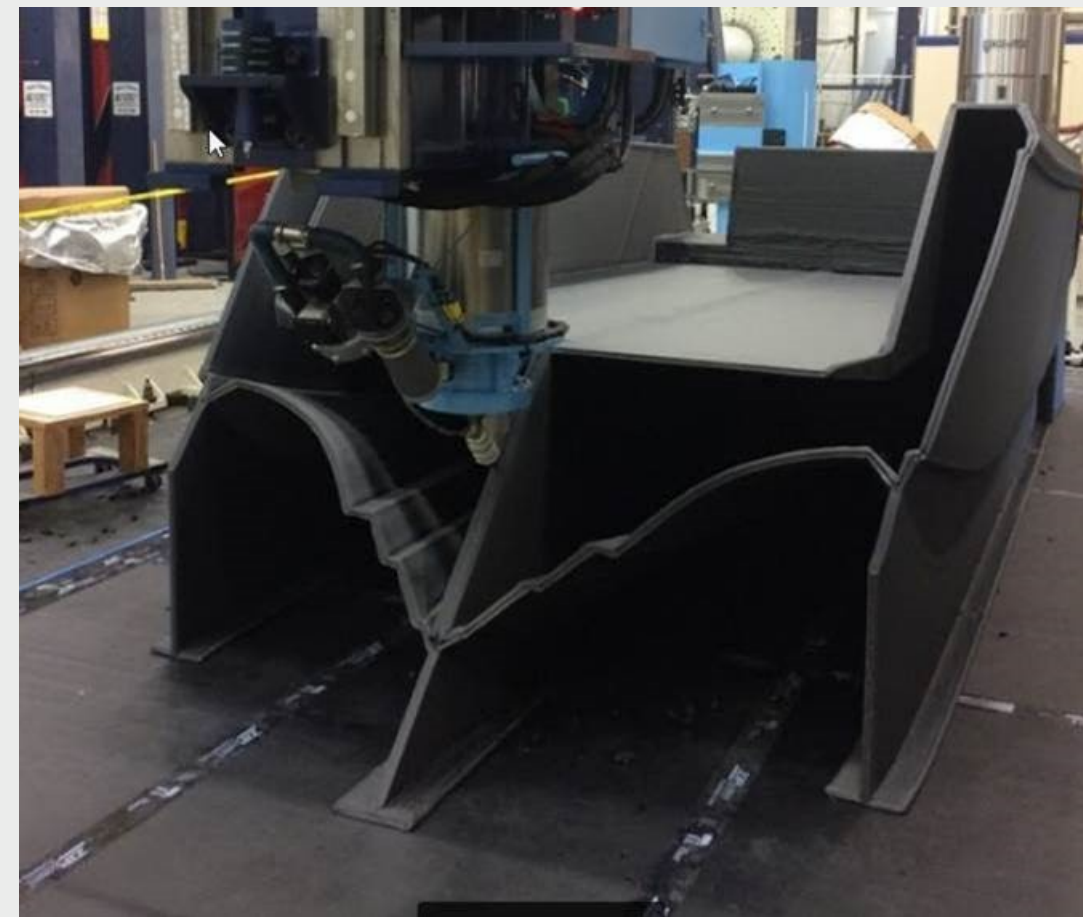
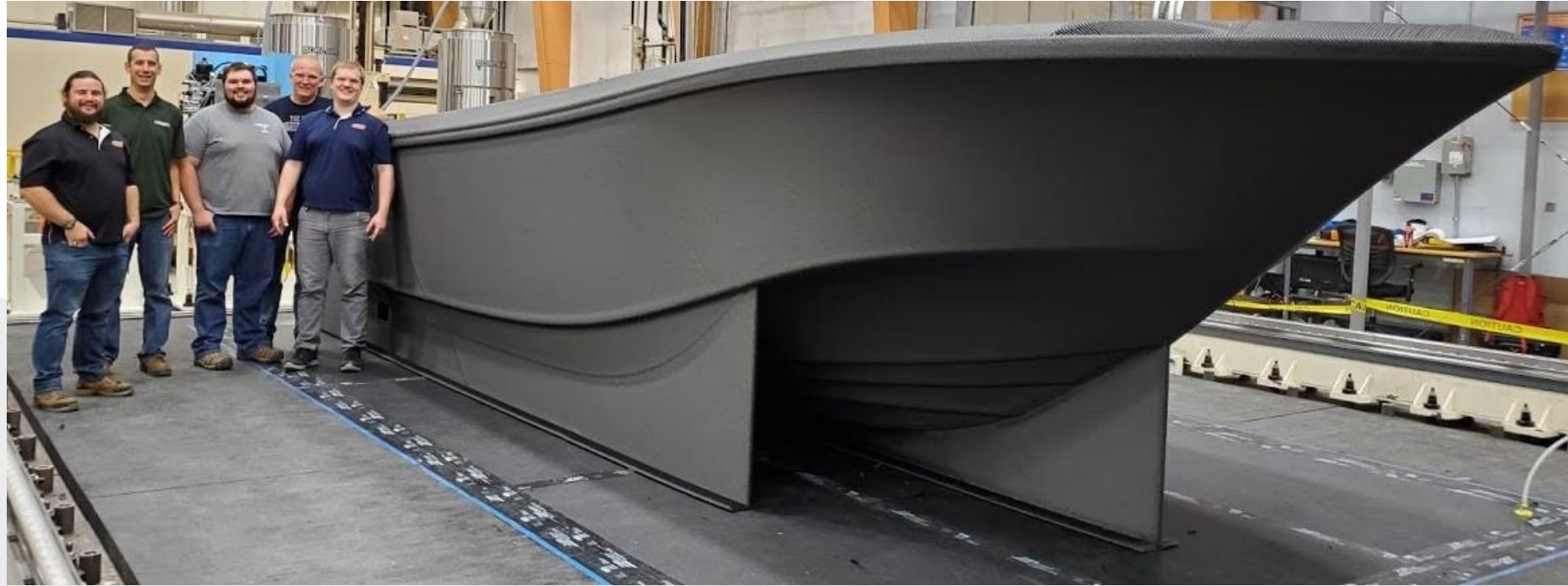


World record



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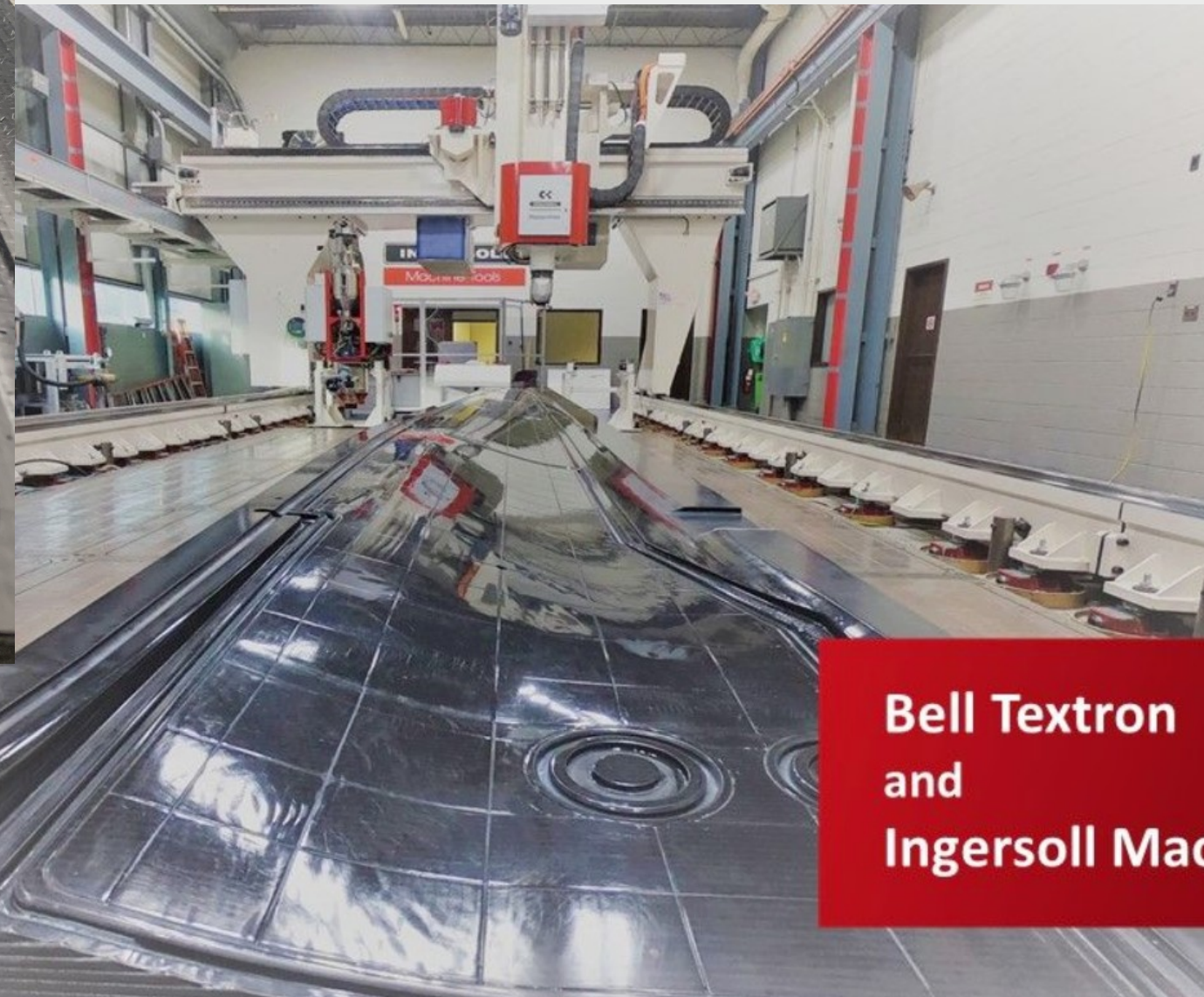
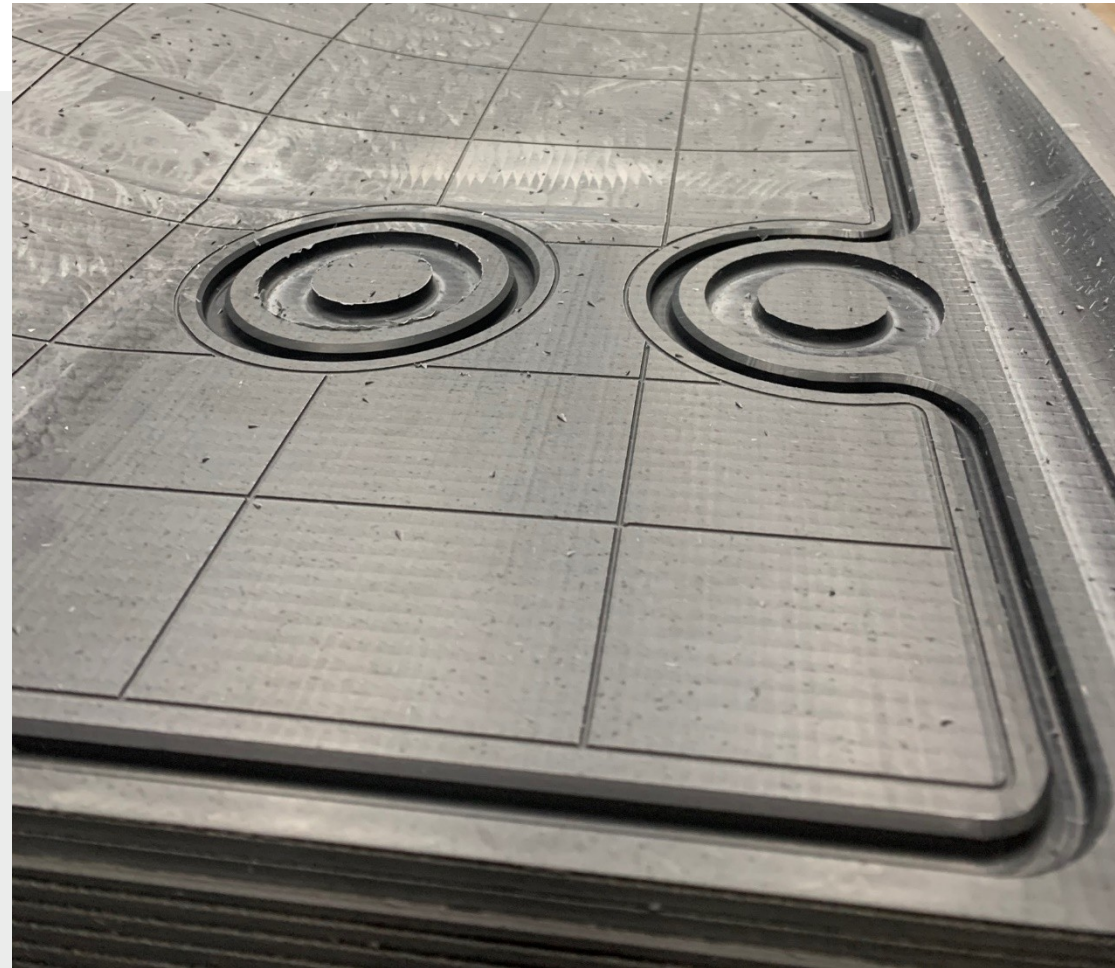


Trim and drill aerospace molds



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Machine Tools



MASTERPRINT

Continuous Filament

BY **INGERSOLL**
Machine Tools



Applications – Thin-Wall Parts



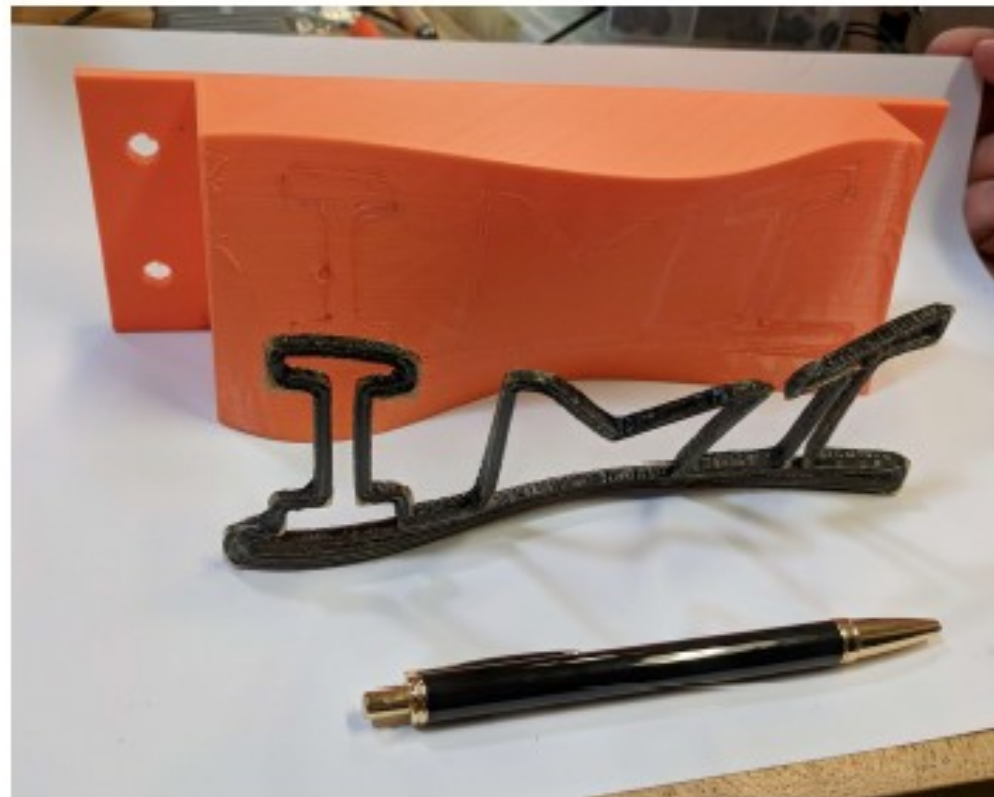
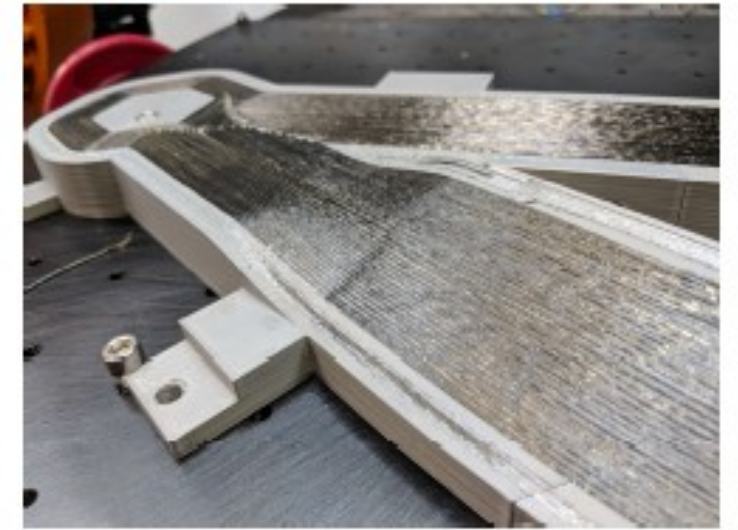
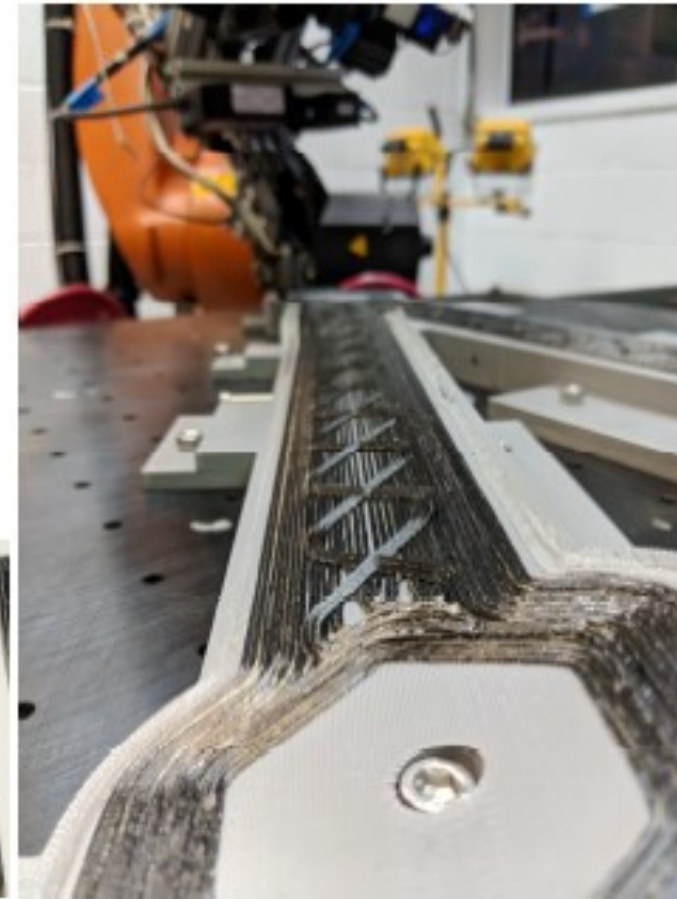
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Machine Tools

- Printing parts entirely with continuous fiber



- Overprinting on composite parts
 - Selective localized reinforcement
 - Addition of features



Best Regards
Daniele Martani
Director, International Sales

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JEC COMPOSITES
CONNECT Online event
June 01-02, 2021
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