Additive Manufacturing for Tooling and Composite Parts

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4th June 2018 Arcachon, France

- **AGENDA**

- Stratasys Solutions
- First composite material: Nylon 12CF
- Composite tooling applications
  - Lay up tools
  - Sacrificial tools

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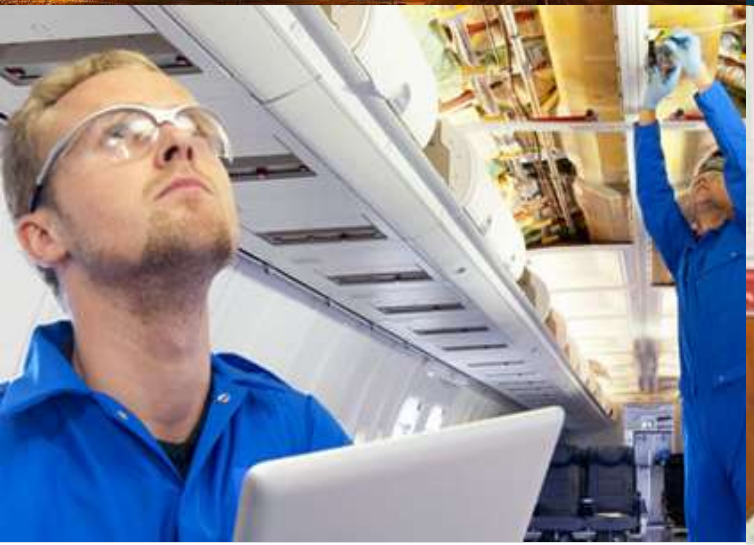
Stratasys, the 3D Printing Solutions Company



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The Stratasys Ecosystem

01

3D printers and production 3D printers

02

Stratasys Direct Manufacturing

03

Industry expertise and specialized applications

04

Stratasys Strategic Consulting

05

Professional Services and Customer Support

06

Extensive range of materials

07

Design and engineering communities

08

Strategic partnerships

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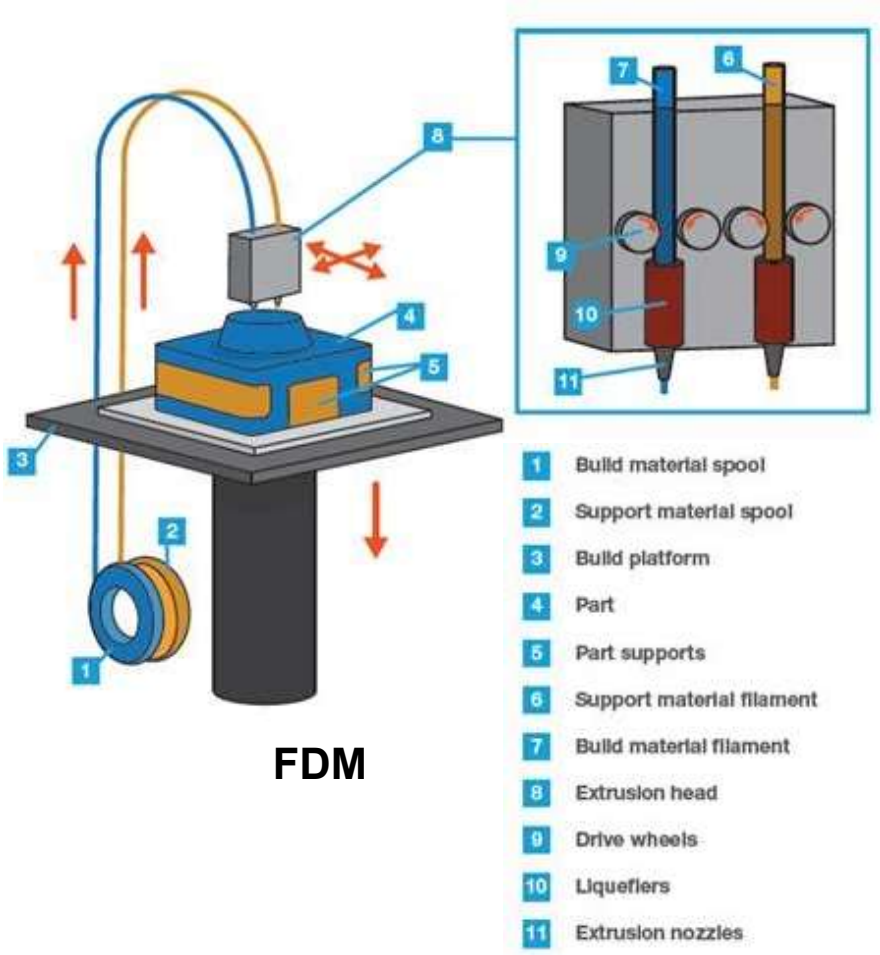
Stratasys Core Additive Manufacturing Technologies

Fused Deposition Modeling

Thermoplastic filament is heated to a semi-liquid state and extruded across computer-controlled tool paths to build parts layer-upon-layer

Material Jetting

Deposits droplets of UV-cured resins in multiple colors and textures for fine-detailed prototypes



FDM

FDM NYLON 12CF™

FDM NYLON 12CF (Carbon fiber-filled)
CHARACTERISTICS

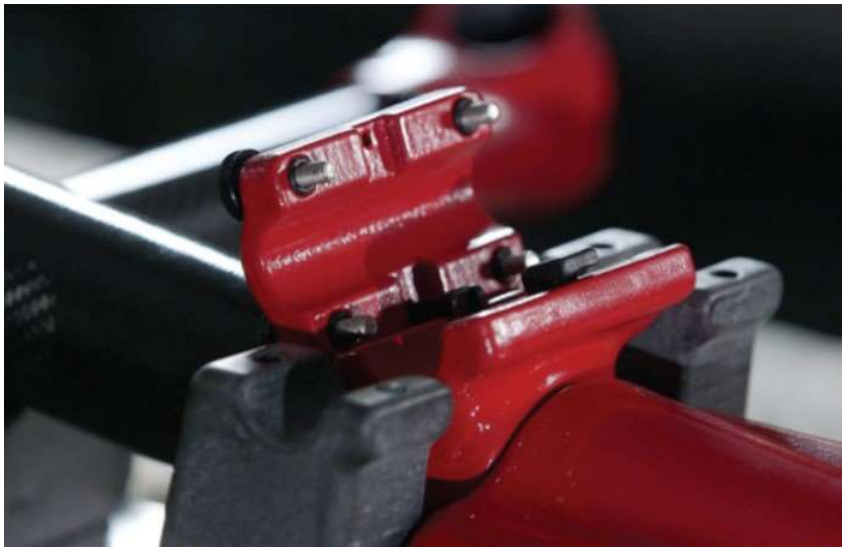
STIFFNESS & STRENGTH
HIGHEST STRENGTH-TO-WEIGHT RATIO

FDM Nylon 12CF, a **carbon fiber-filled thermoplastic** delivering the **highest strength and stiffness to weight ratio** of any Stratasys FDM material.

Layer resolution: 0.010 inch (0.254 mm)

Unique stiffness and strength allows it to:

- Build prototypes that withstand functional testing
- Replace metal components in
  - Prototyping
  - Jigs & fixtures
  - Select end-use parts

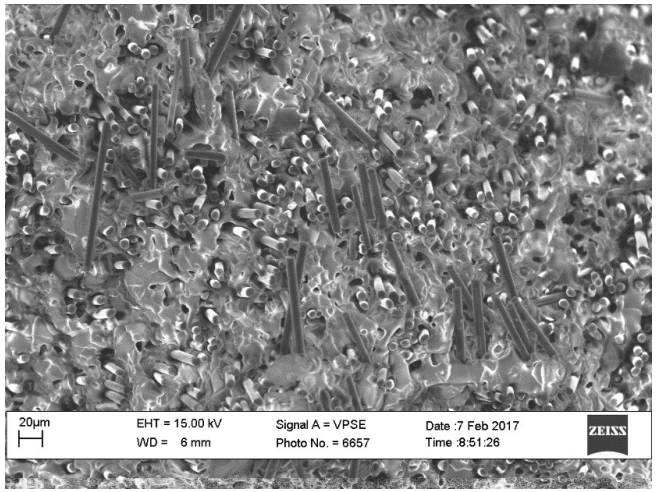


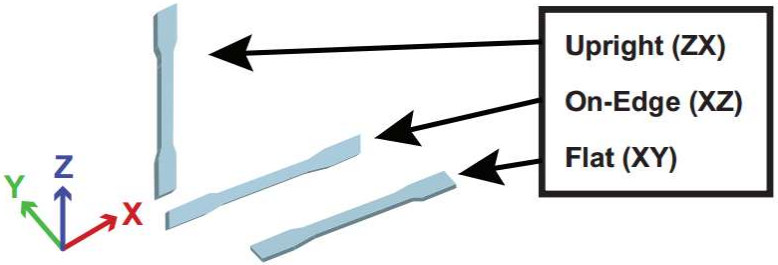
Highest strength and stiffness to weight ratio

For use on: 450mc

STRATASYS FDM NYLON 12CF
Mechanical Properties (Metric Units)

Product Features	Nylon 12CF XZ	Nylon 12CF ZX
Yield Strength	63 MPa	32 MPa
Ultimate Tensile Strength	76 MPa	34 MPa
Tensile Modulus	7,529 MPa	2,299 MPa
Elongation at break	1.9%	1.23%
Flexural Strength	142 MPa	58 MPa
Izod Impact (unnotched)	310 J/m	85 J/m





All Specimens Conditioned = 20°C and 50% RH for 72 hours
ASTM Test Method – reference available on specification sheet

FDM NYLON 12CF
TOP USE CASES & INDUSTRIES

USE CASES

- Functional prototyping, simulates final product
- Manufacturing tooling
- Production parts
- ESD components
- Structural components

INDUSTRIES:

- Automotive
- Sporting goods
- Aerospace

NYLON 12CF LIGHTENS THE LOAD IN WEIGHT AND COSTS

Converting metal to plastic

Nylon 12CF is strong enough to replace metal parts, in order to lighten the weight and reduce part costs.

Metal parts produced in Nylon 12CF

- Brake levers
- Caliper cover
- Chain guard
- Engine cover
- Stand
- Foot pegs

Benefits:

- Reduce part costs
- Lighten motorcycle, increase performance

MANUFACTURING GRADE MATERIALS THAT CAN MEET THE STRICTEST REQUIREMENTS

Orbital ATK

Orbital ATK Webinar
Manufacturing Applications for FDM Composite Materials

Orbital-ATK leverages the versatility of the first FDM composite material for tooling and flight hardware

http://www.stratasys.com/campaign/webinar/orbital-atk


Composite Tooling
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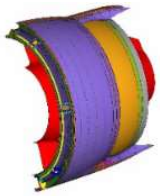
Composite Tooling Today

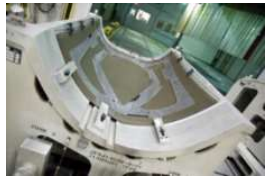
Metal Tooling - ~75% of market

Model



Mold
$300-600K
6-12 months

Machining Fixture
$100-200K
3-4 months



Part Fabrication

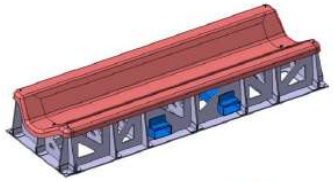
FRP Tooling - ~25% of market

Model

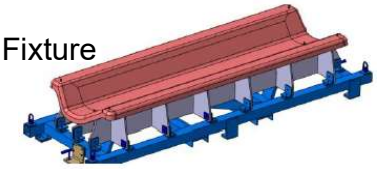
Master
$40-60K
7-8 weeks

Hand Lay-Up + Machining

Mold
$40-60K
9-11 weeks



Machining Fixture
$40-60K
9-11 weeks



Current Pain Points

- High costs and long lead times
- High levels of touch labor.
- Costly design changes
- Large, heavy tools – difficult to move and store

Benefits of FDM

- Disruptive time & cost savings
- Reduced lead times enable iteration, change, optimization
- Respond quickly to demand fluctuation
- Tailor the tool to the application vs. one-size-fits-all
- High temperature-capable materials
- Handle tools with people, not cranes and forklifts

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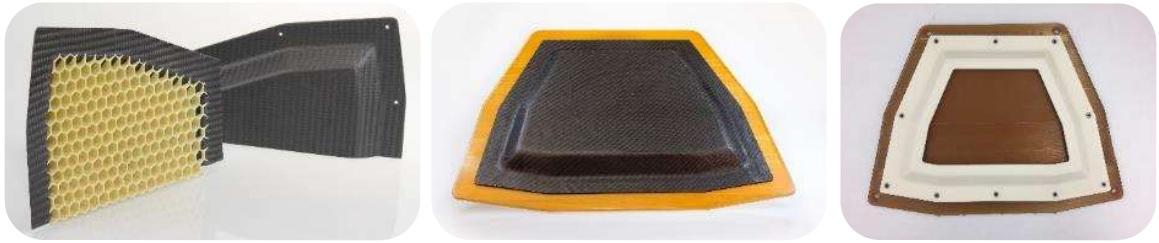
FDM Applications in Composite Tooling

Lay-Up Tooling

Sacrificial (Wash-Out) Tooling

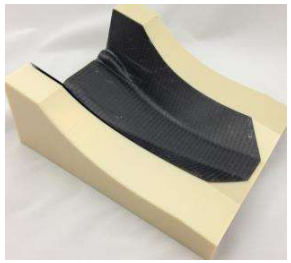
Large Lay-Up Tooling

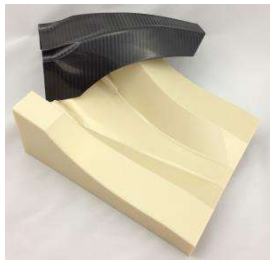
Coordinated Tool Family

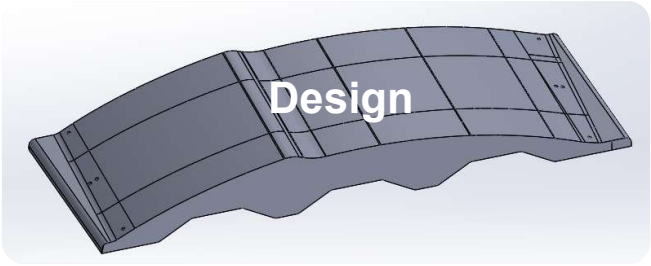


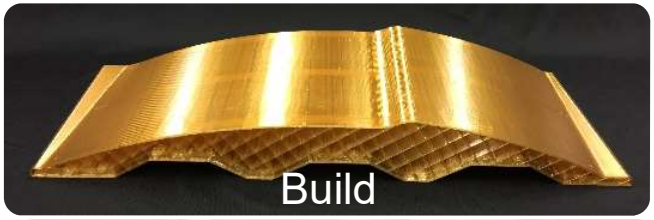
Lay-Up Tooling

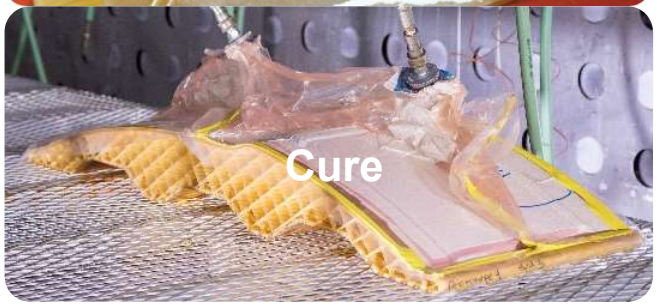
- Capable, cost effective lay-up tooling
- Lay-Up Tools, High temp, Autoclave compatible
  - >177°C (350°F), 7 Bar (100 psig)
- Eliminates the need for masters, machining, and assembly
- Iterate, change and modify designs with relative ease











Lay-Up Tooling Considerations

Key Considerations

- Cure temperature (and pressure)
- Coefficient of thermal expansion
- Accuracy / tolerances, design features
- Build orientation / design for additive manufacturing (AM)
- Vacuum bagging, structural integrity
- Surface preparation (tool sealing)

Design Guide

Design → Build

FDM Sacrificial Tooling Overview

Easy-to-produce, cost-effective wash-out tooling for complex, trapped geometries

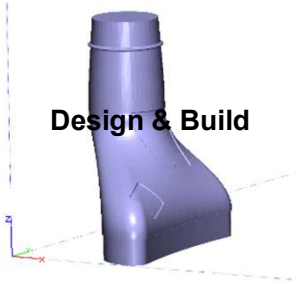
- Wash-out solutions capable up to 121 °C
- Break-away solutions capable of >177 °C

Eliminates complexity of traditional trapped tooling methods

- No casting, molding, machining…no mess
- No material phase changes (e.g., eutectic salts)
- No complex, multi-piece, collapsible tools or inflatable bladders
- No steep learning curves or extensive prior expertise required

Tools available in hours, not weeks or months

Iterate, change and modify designs with relative ease

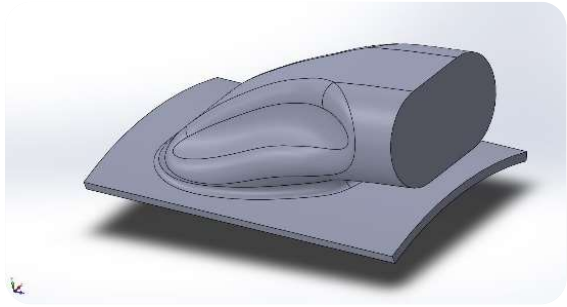


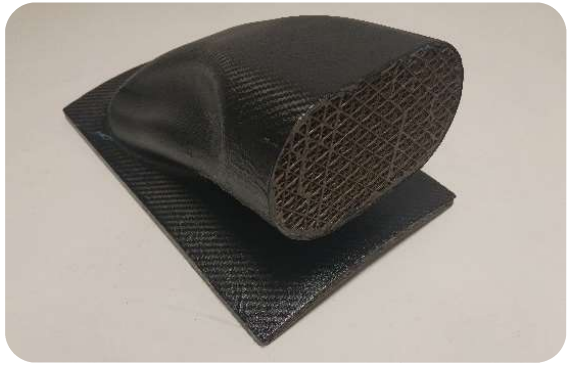
Customer Success Story – Sacrificial Tooling

Enabling an advanced product development team through complex part fabrication

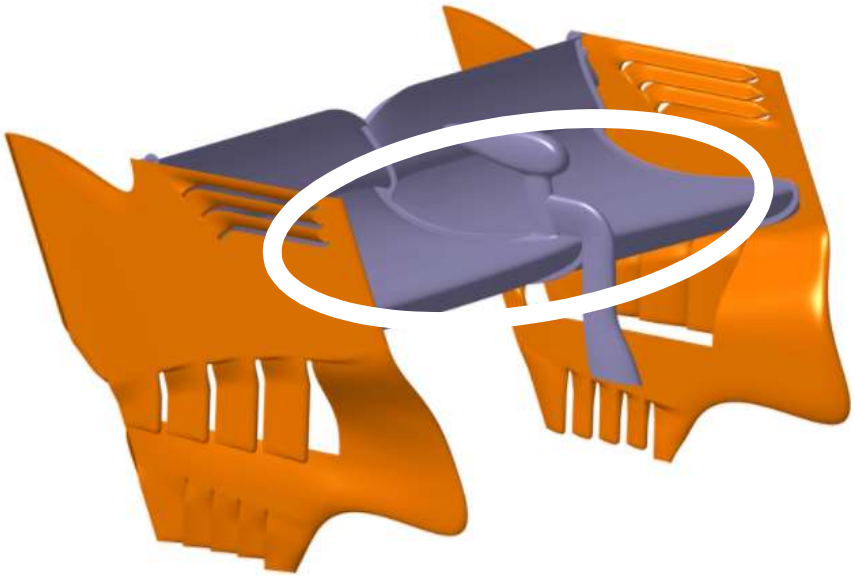
Swift Engineering Inc.

- Aero inlet duct with a complex, trapped-tool geometry
- Wash-out tooling material (ST-130) used in place of multi-piece bonded assembly and traditional wash-out tooling materials
- From concept design to composite part in < 1 week
  - FDM build time is < 24 hours
  - Default porous triangle fill pattern – optimized for autoclave curing and tool dissolution
  - Low temperature (<93°C), 90 psi cure cycle

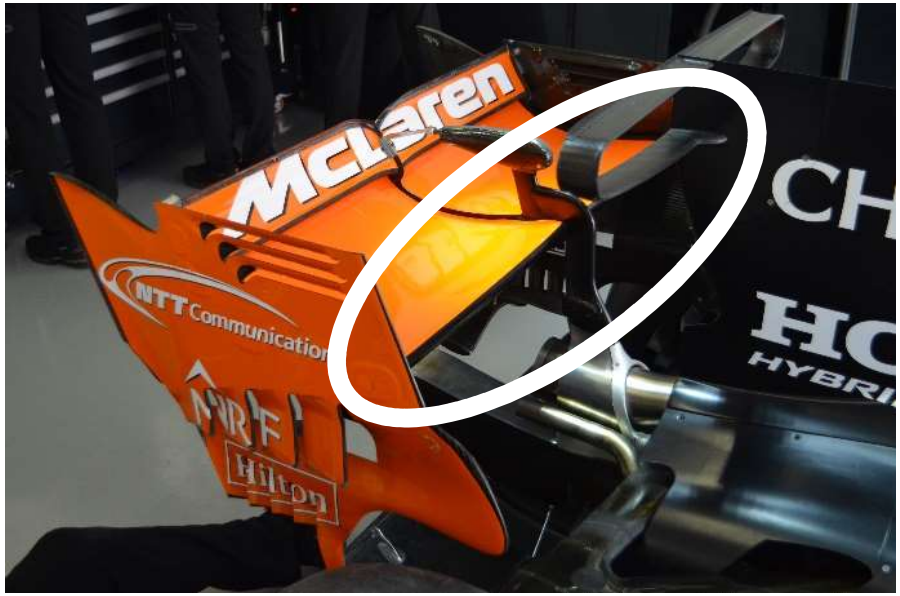




McLaren Racing - Rear Wing Main plane



7 DAYS



WOKING, UK

DESIGN STUDIO

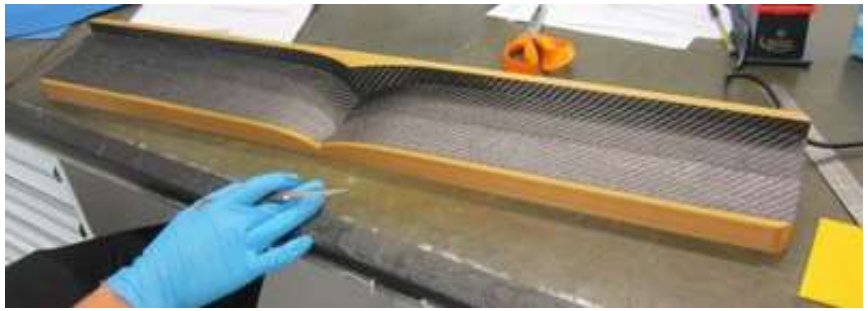
TUESDAY 29th MARCH

SHANGHAI INTERNATIONAL CIRCUIT, CHINA

TRACKSIDE FOR PRACTICE SESSION 1

WEDNESDAY 5th APRIL

McLaren Racing – DRS Wing Flap



3 DAYS

TEAM PENSKE – INDYCAR | GETTING AN EDGE IN RACING

Composite Tooling

“ Racing engineers are always trying to get another tenth of a second. With 3D printing, it improves the cycle of part development ”

Team Penske, an American racing team, one of the most successful INDYCAR racing

CHALLENGE

Current fueling probe used during pit stops was heavy and not ergonomic, slowing down

SOLUTION

Stratasys FDM ULTEM 1010 resin composite tooling and ST130 sacrificial tooling

BENEFITS

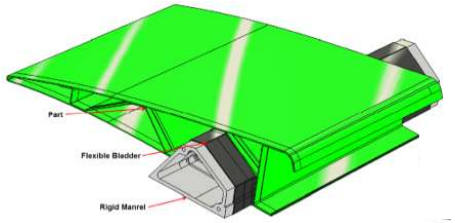
- Tooling **lead time reduction** from 4-6 weeks to less than 1 week compared to epoxy tooling board and soluble ceramic tooling
- **Reduced weight** of refueling probe housing
- Able to refuel cars with **greater speed and ease**

TEAM PENSKE

Customer Success Story – Lay-Up Mandrels

Enabling innovation for a leading business-jet OEM

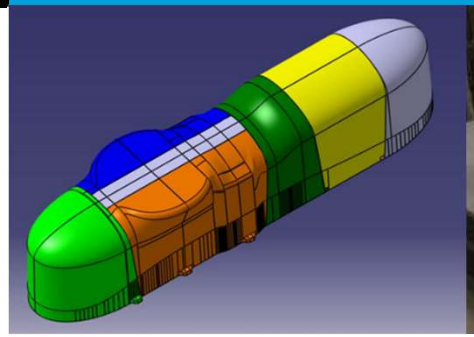
- High-temperature, cost-effective lay-up tooling for an innovative “single shot” composite aileron (patent pending)
- Guided material selection (ULTEM 1010 resin) and optimization of the design and build parameters
- Leveraged experience to use a typical drawback (high thermal expansion) as a significant advantage – improved compaction and hassle-free mandrel extraction
- Cut tooling lead time from months to under 10 days



Aurora FLIGHT SCIENCES

AFS addressed a critical customer need for a 3 meter composite “belly pod” fairing tool

Reduced lead time from 2-3 months to 2 weeks

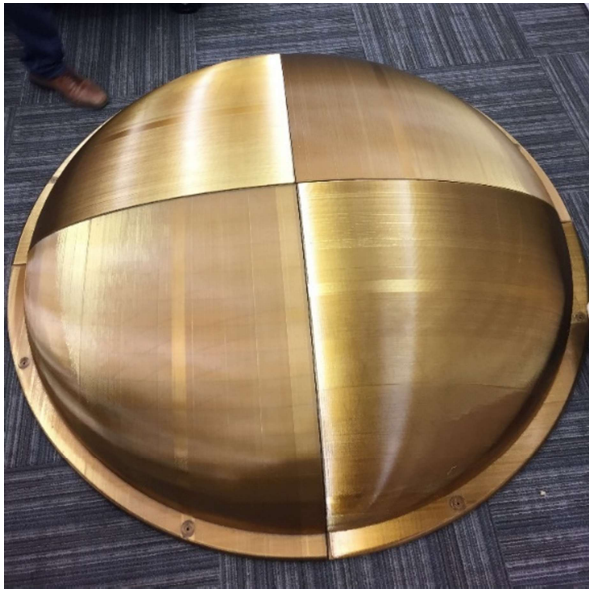


Featured in June 2015 *Composites World* article

LARGE TOOLING PROJECTS IN DEVELOPMENT

DASSAULT FALCON

Aurora FLIGHT SCIENCES



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WHAT COMES NEXT FOR COMPOSITES

Today

Tomorrow

THANK YOU

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