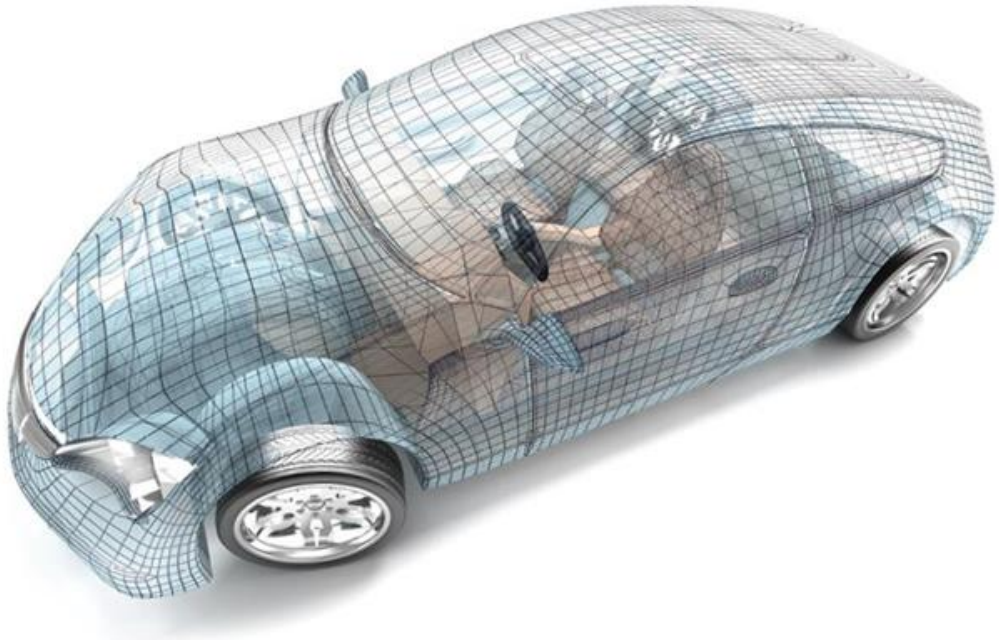
TCC 2020
THERMOPLASTIC COMPOSITES CONFERENCE

A VIRTUAL EVENT
APRIL 29 – MAY 1, 2020



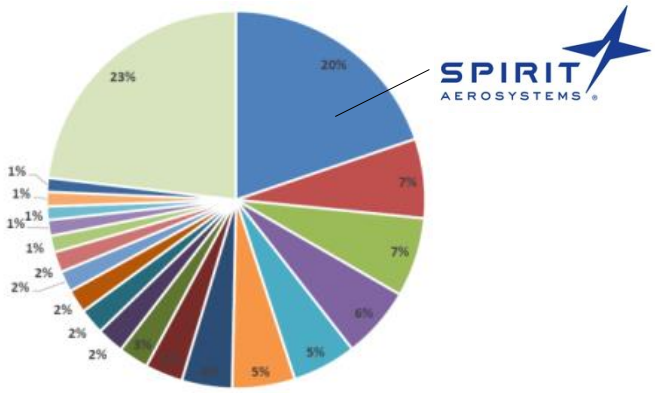
Thermoplastic Nose Wheel Well Bulkhead Demonstrator Build

Presented By: Kerrick Dando
Composite Research & Development Engineer
Spirit AeroSystems Inc.

Intro to Spirit AeroSystems

>15,000 employees

Global aerostructures leader



Source: Counterpoint

Balanced aerostructures portfolio

Fuselage
(52%)

Propulsion
(26%)

Wing
(22%)

Emerging presence in Defense

Sikorsky CH-53K

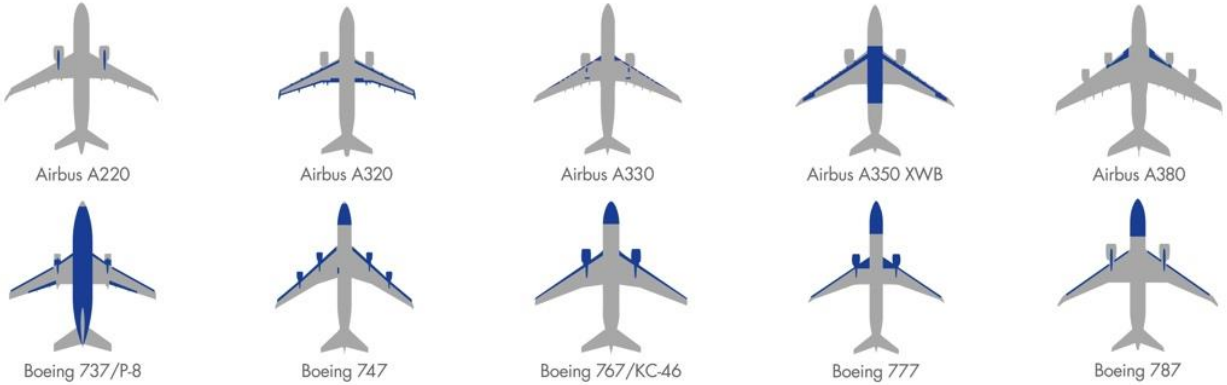
Bell V-280

P-8A, P-8I

KC-46A Tanker

Northrop Grumman B-21

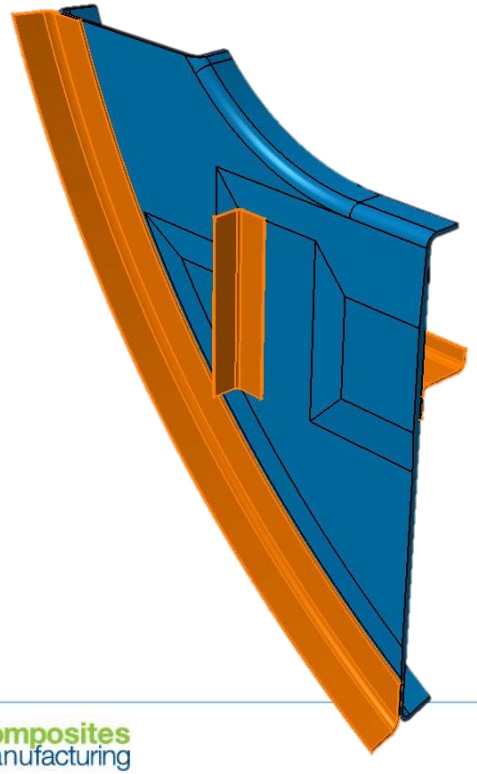
On all of 12,600 Boeing/Airbus backlog

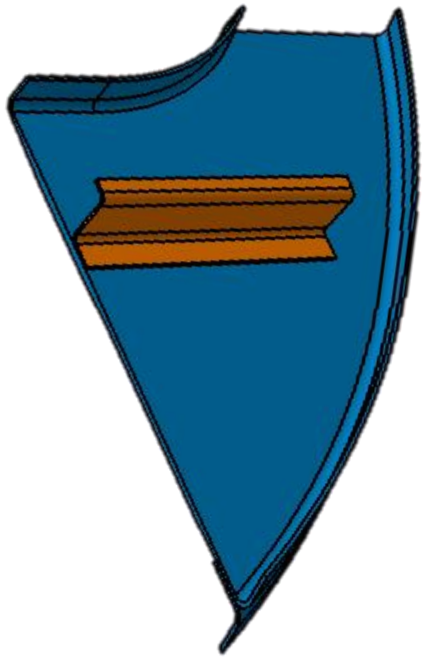


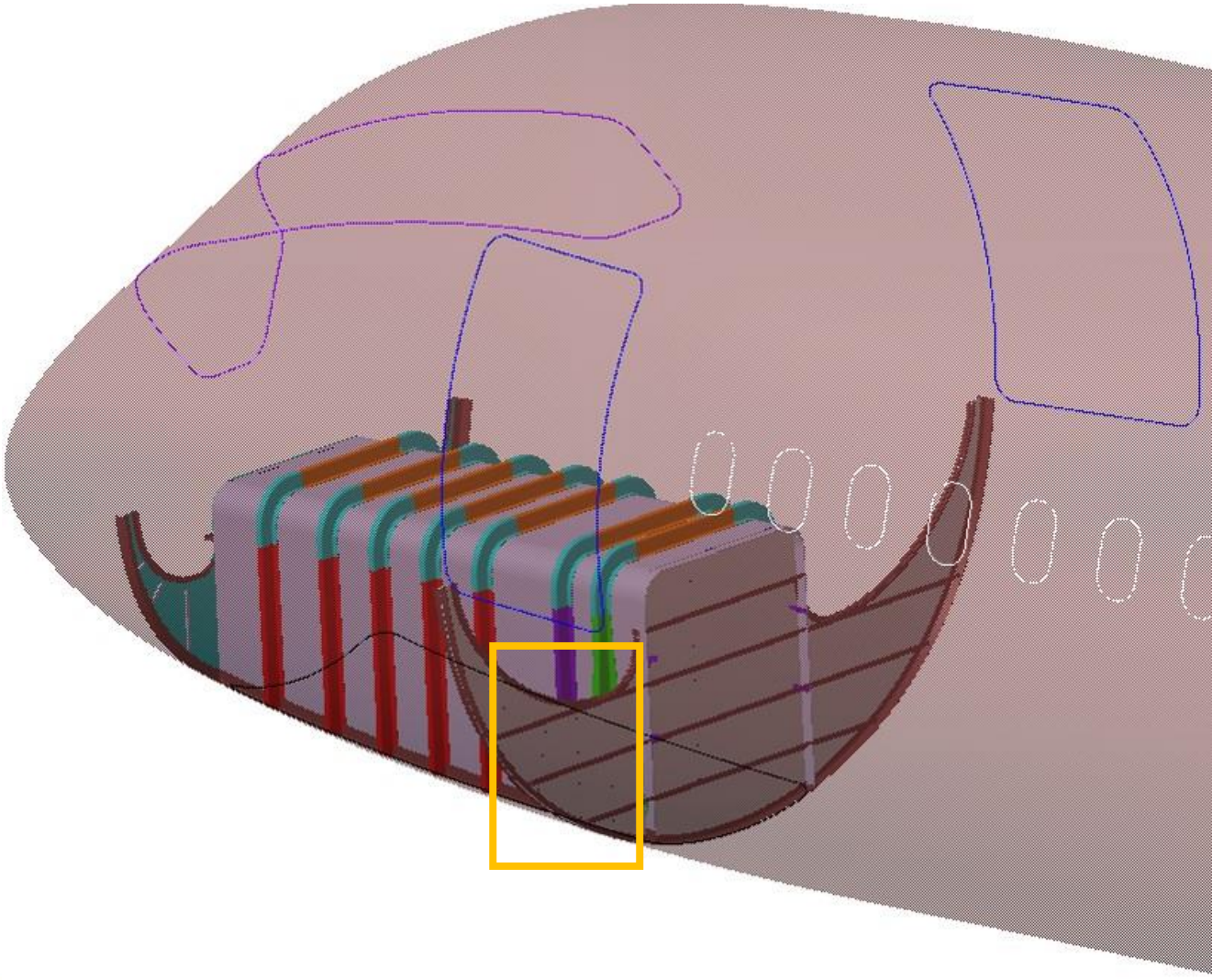
Spirit is the Leading Global Tier 1 Aerostructures Supplier

Nose Wheel Well (NWW) Bulkhead

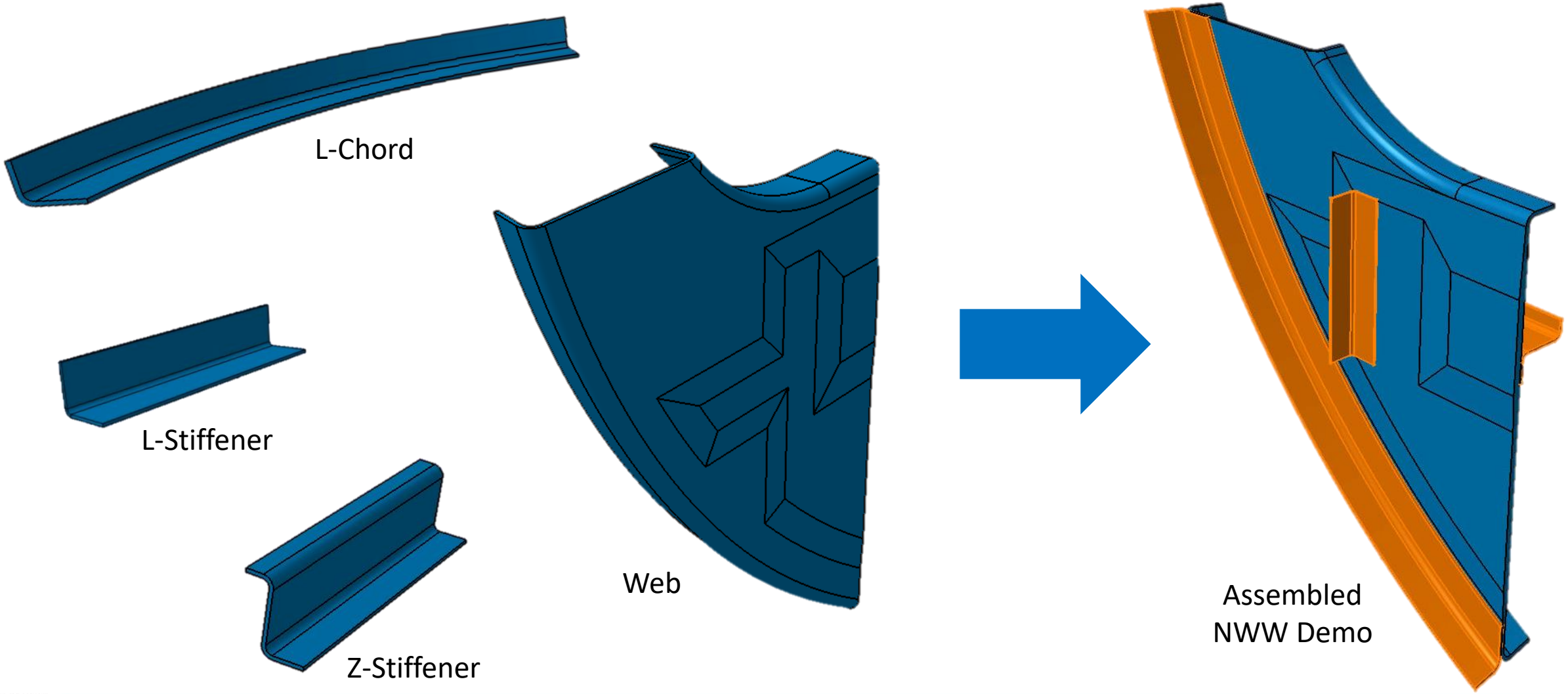
- Technology Demonstration:
  - Automated Fiber Placement (AFP)
  - Stamp Forming
  - Welding





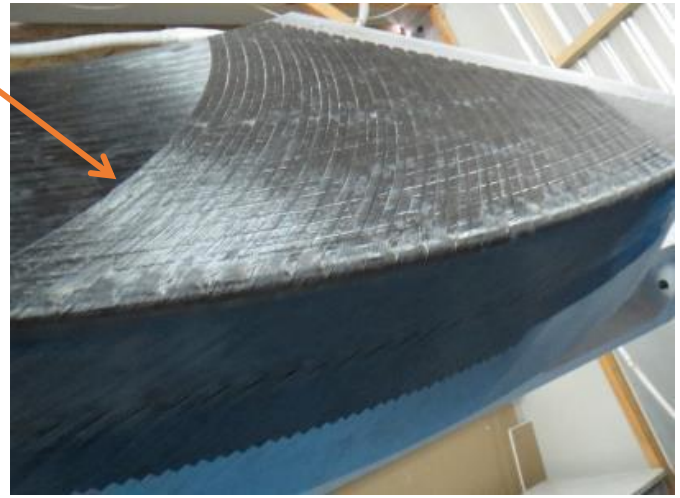


Nose Wheel Well Bulkhead – Components

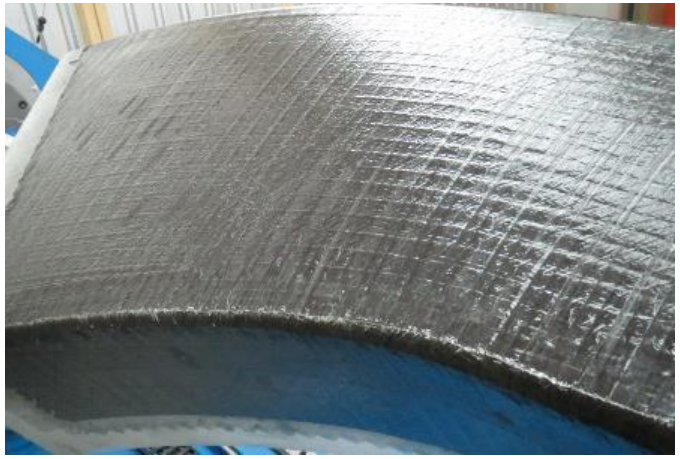


Web Manufacturing

Tow Steering

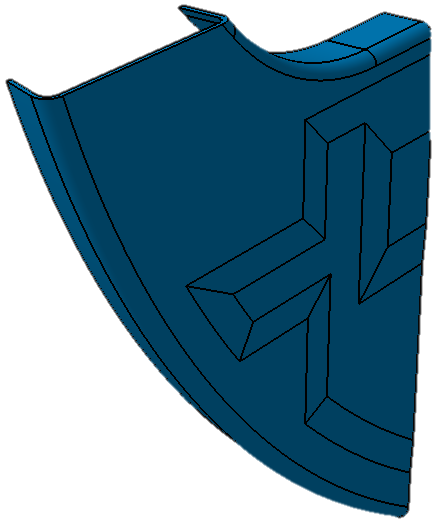


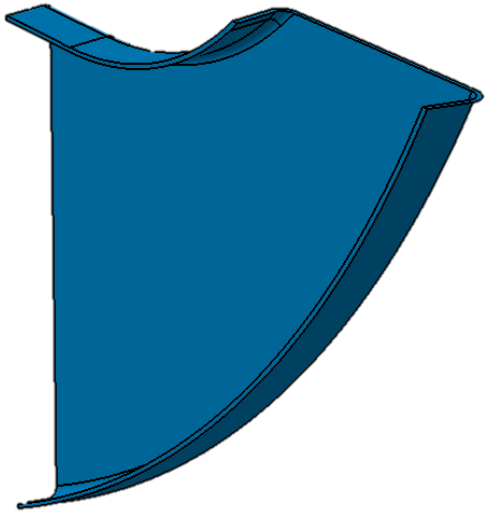
Web AFP



Variable Pad-Ups

Completed Web





L-Chord Manufacturing

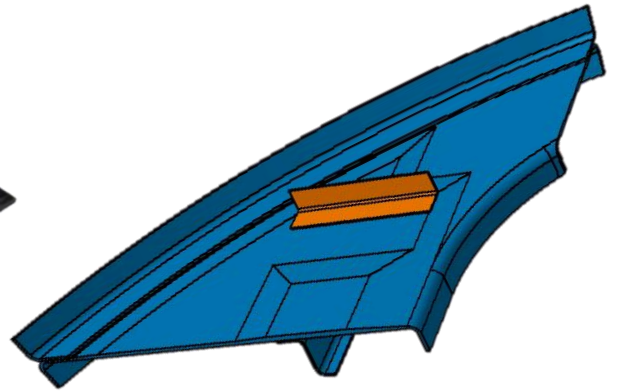
AFP Preform

L-Chord

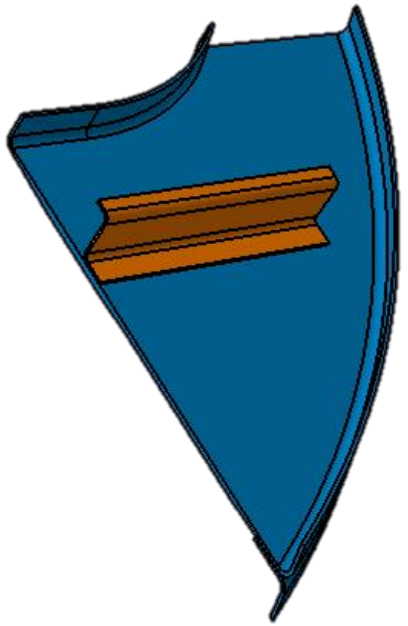
Stamp Forming

L-Stiffener/Z-Stiffener Manufacturing

Spirit Stamp Forming Cell



L-Stiffener



Z-Stiffener

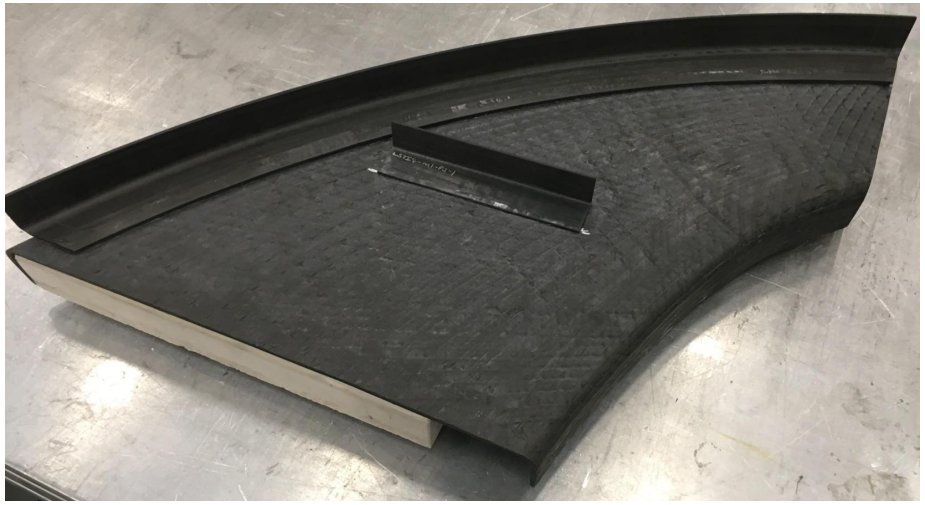
Demonstrator Assembly

L-Chord

L-Stiffener

Z-Stiffener

Web

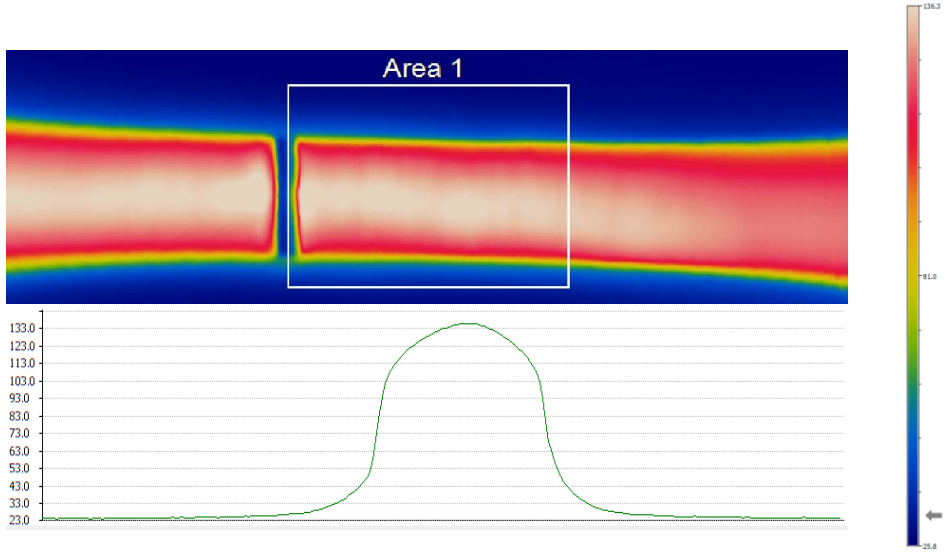


NWW Demo

Resistance Welding

Overview:

- Resistive element placed between component faying surfaces
- Current applied across resistive element
- Resultant heat generation across element
- Welds created when combined with adequate pressure and controlled cooling
- Electrically insulative material placed between susceptor and material when welding carbon composites to prevent current leakage



Resistance Welding – Considerations

Assembly objective is to weld L-Chord and L-Stiffener using recipes optimized for strength and crystallinity

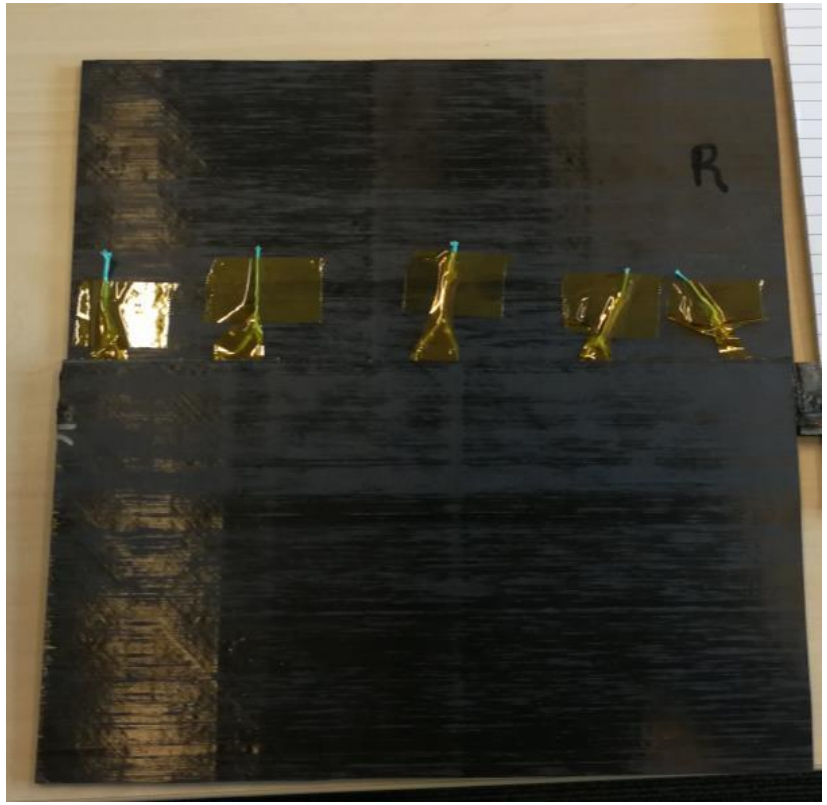
L-Chord

Components represent separate process recipes and challenges

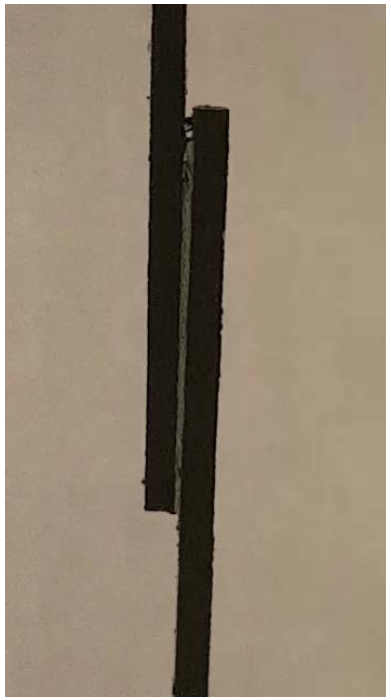
- Contoured shapes
- Part thickness variations

L-Stiffener

Resistance Welding of L-Stiffener

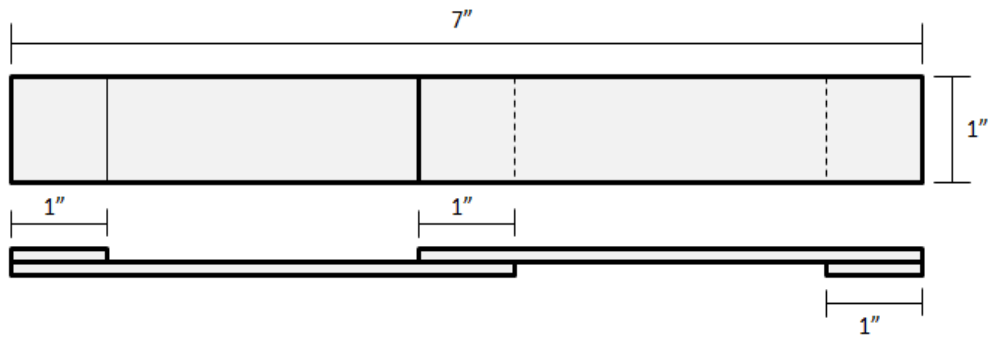


Recipe Development Coupon

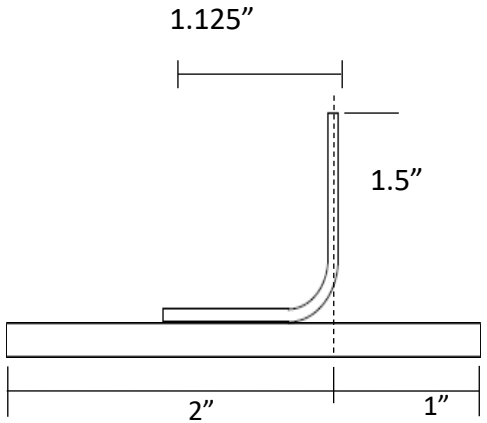


Lap Shear Coupon

Fracture Surfaces



Resistance Welding of L-Stiffener



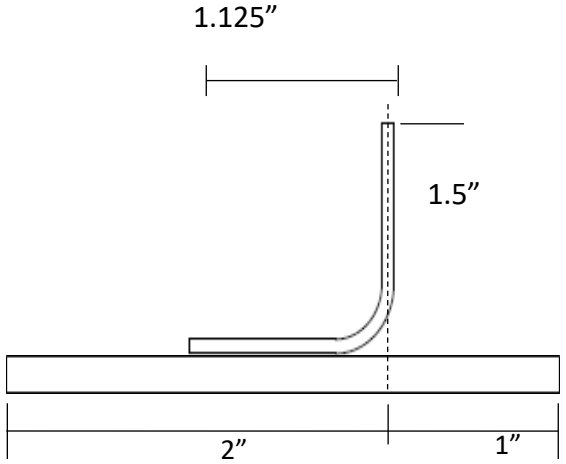
Recipe optimization for strength, crystallinity through mechanical characterization

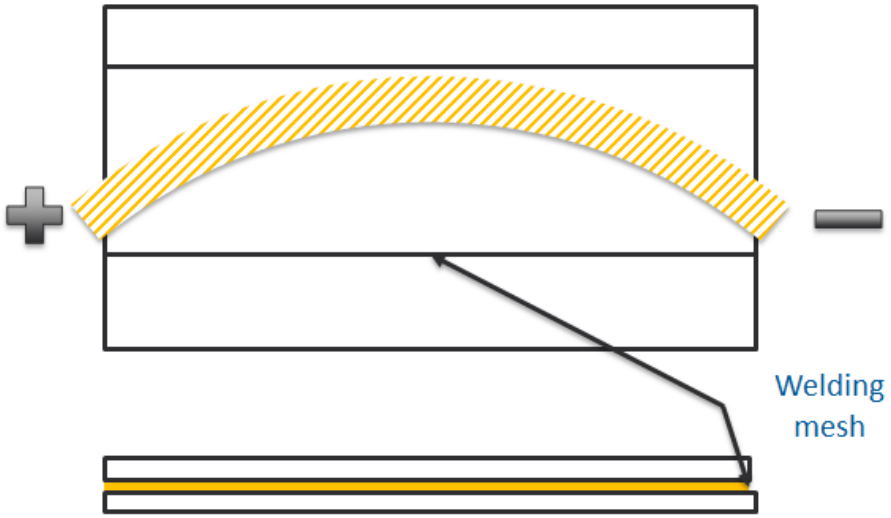
- Single lap shear
- Pull-off testing
- DSC
- Photomicrographs

Recipe Development Coupon

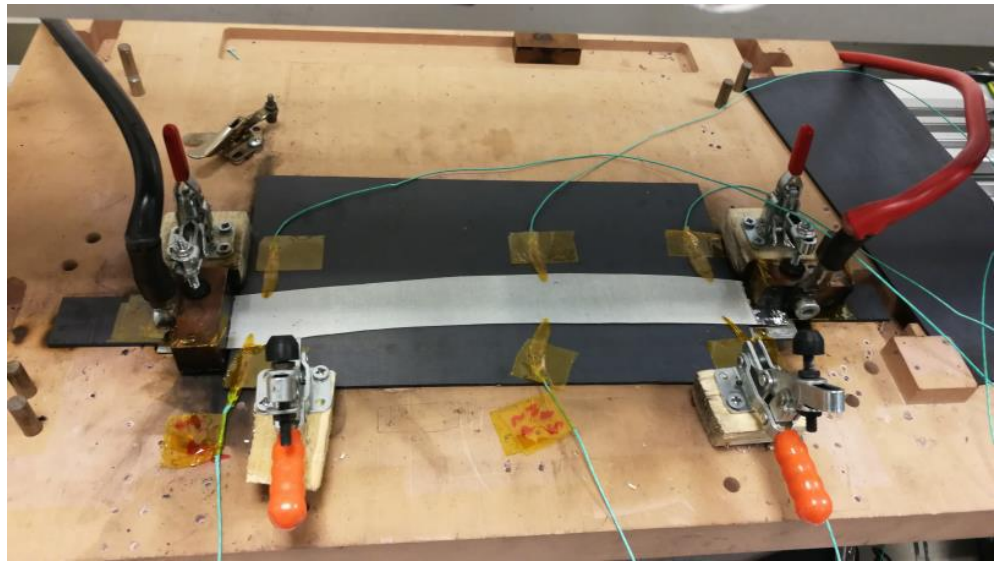
Pull-off Test Coupons

Resistance Welding – L-Chord



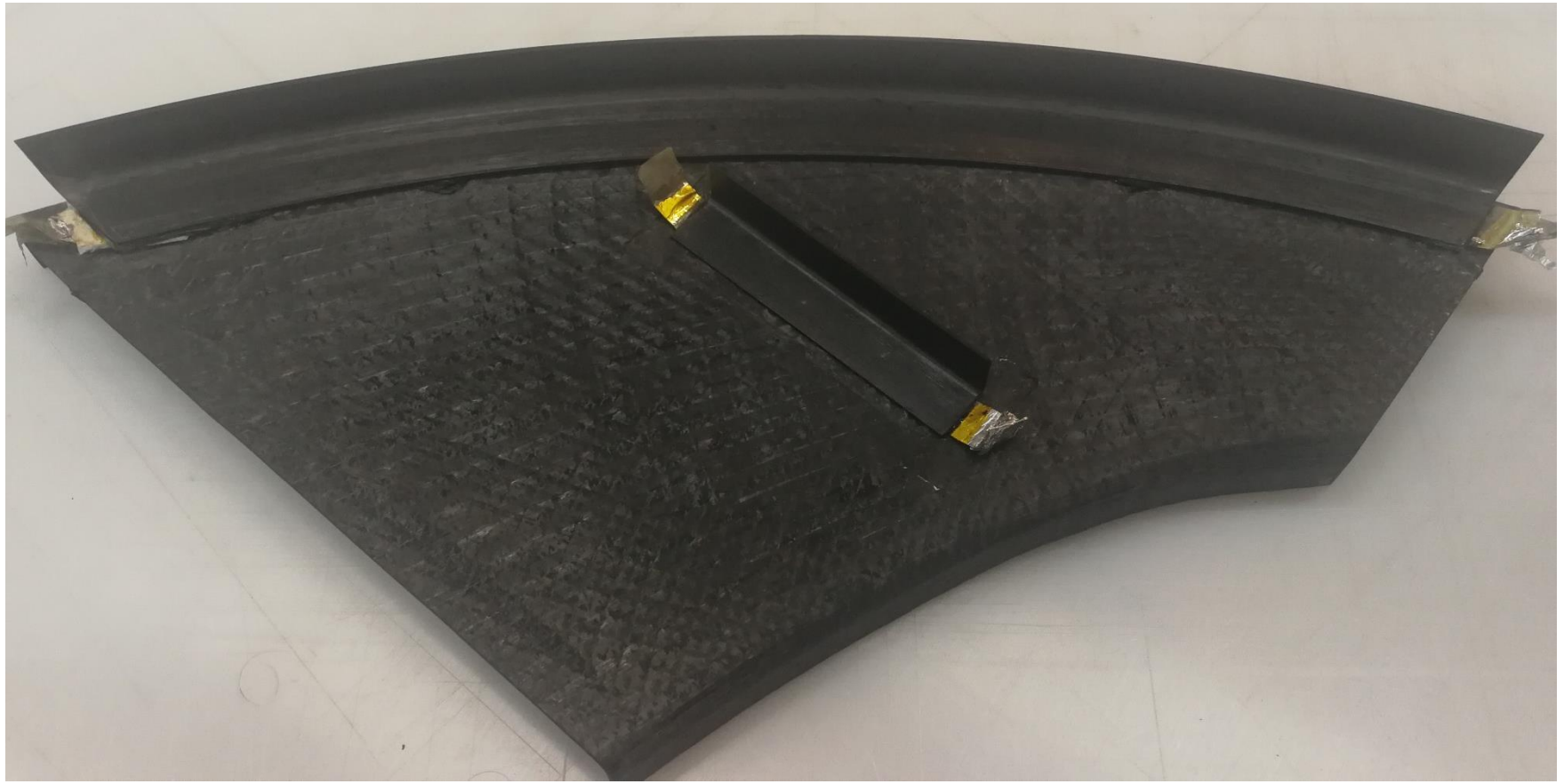


- Contoured part presents manufacturing challenges
  - Mesh is not steered to contour
  - Unique optimized welding recipe



Recipe Development Coupon

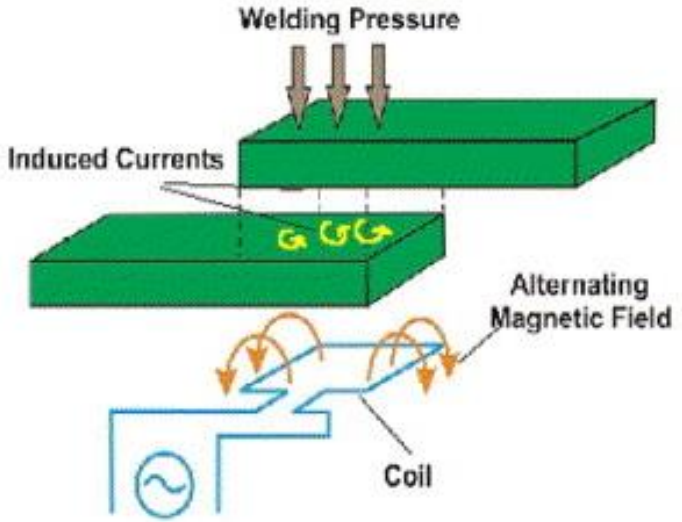
Resistance Welded Bulkhead



Induction Welding

Overview:

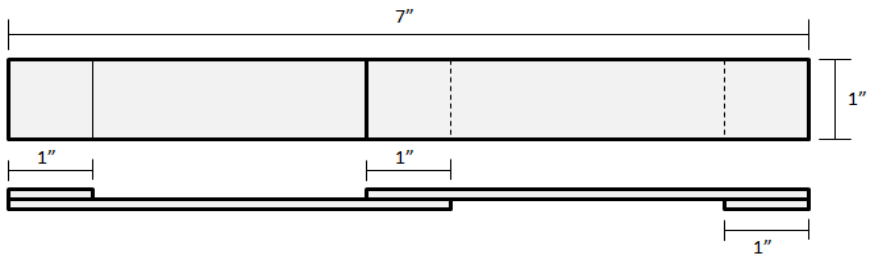
- Non-contact welding process
- Alternating voltage placed across coil, creating an Alternating Current (AC)
- AC produces a magnetic field
- Magnetic field produces eddy currents in material
- Conductive network must be present for eddy currents to be induced (cross-ply)
- Requires low fiber contact resistance
- Eddy currents met with material resistance, energy loss given in the form of heat



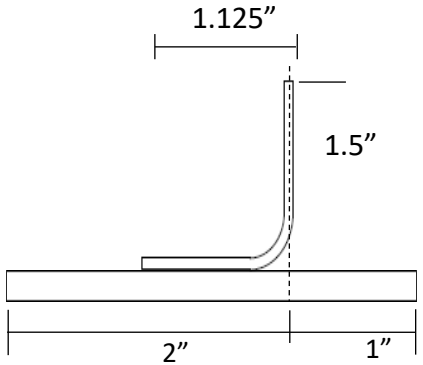
Ahmed, T. J., Stavrov, D., Bersee, H. E. N., & Beukers, A. (2006). Induction welding of thermoplastic composites—an overview. *Composites Part A: Applied Science and Manufacturing*, *37*(10), 1638-1651.

Induction Welded Bulkhead

- Proprietary induction welding head
  - Optimized recipes for each component
- Parts present unique welding challenges
  - Unique geometries
  - Contoured vs. straight sections
  - Varied part thicknesses
- Optimization through designed experiments
  - Single lap shear testing
  - Pull-off testing

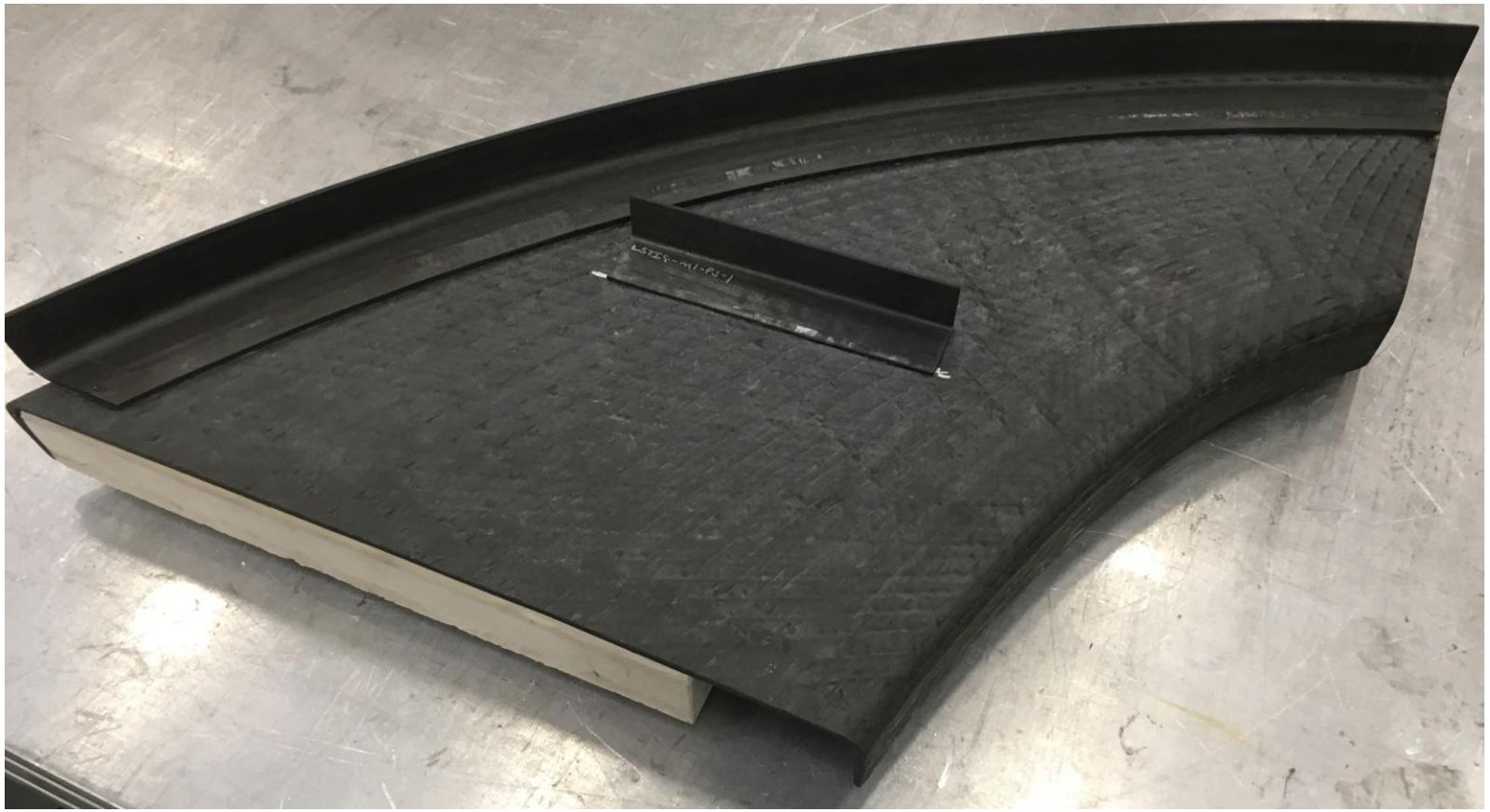


Lap Shear Coupon



Pull-Off Coupon

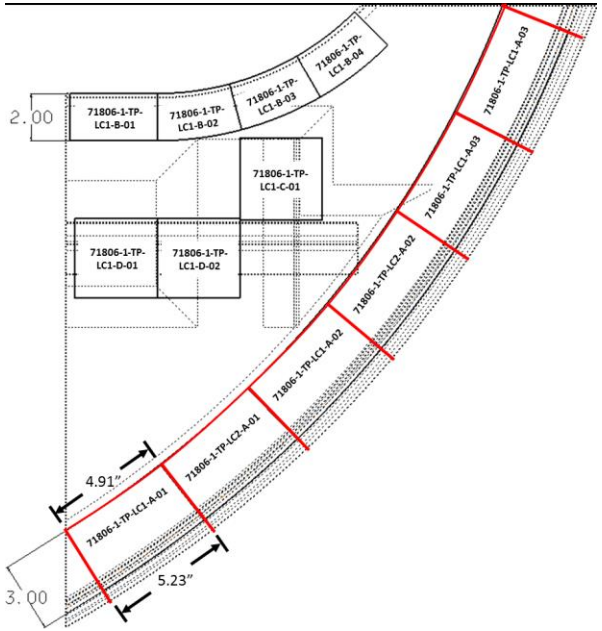
Induction Welded Bulkhead

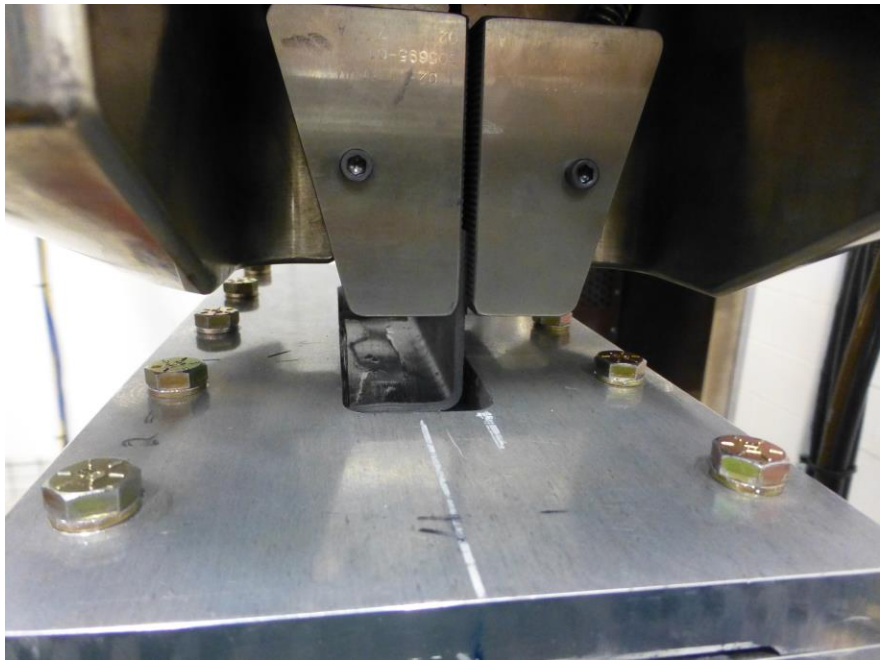


Assembly Evaluation

Mechanical testing of nose wheel well bulkhead demonstrators

- Comparison of test results to optimization recipes
- Comparison between joining methodologies

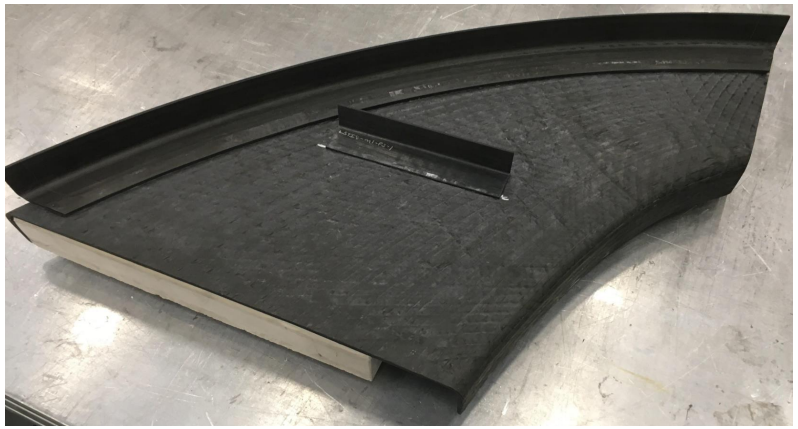


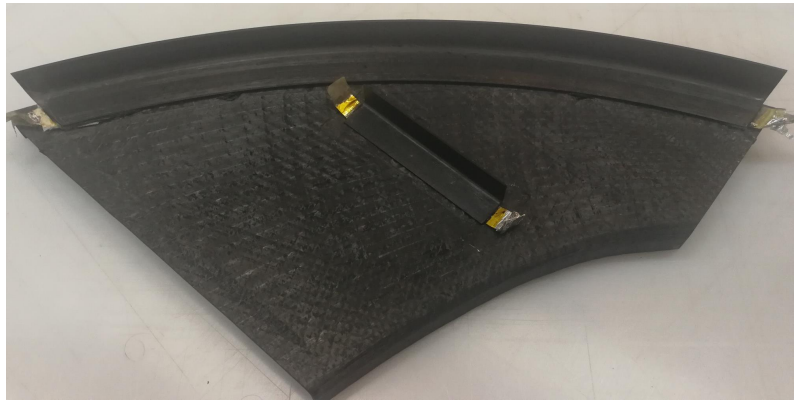


Summary

Spirit and partners fabricated NWW bulkhead demonstrators showcasing:

- Automated Fiber Placement
  - Complex geometry
  - Tow steering
  - Pad-ups
- Stamp Forming
  - Medium, contoured part forming
  - 3-D preform with fiber steering
- Welding
  - Resistance welding
  - Induction welding





Questions?

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