Thermoplastic Composites Conference

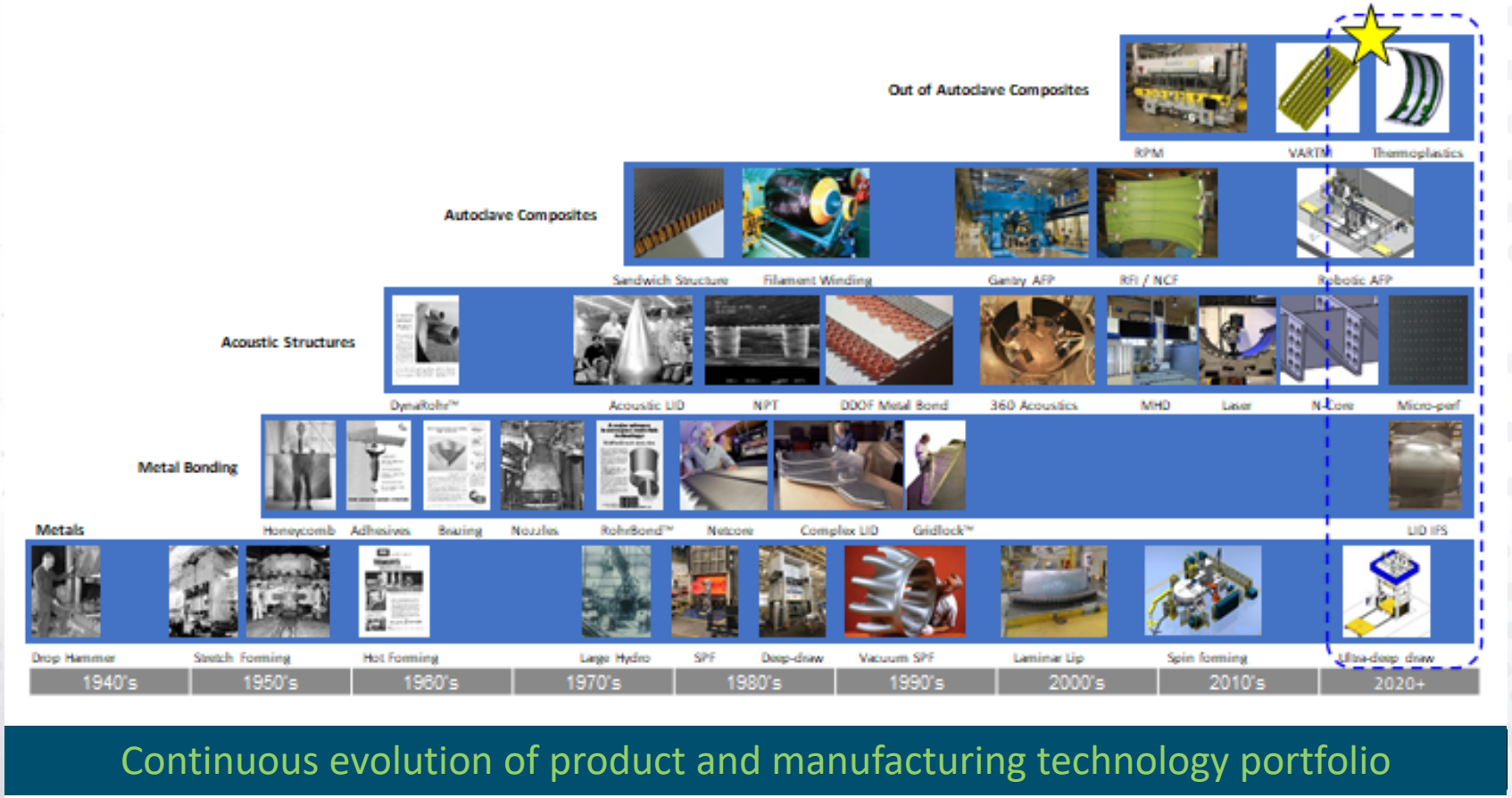
An integrated approach to large, complex stiffened thermoplastic composite structures

Dan Ursenbach & Michel van Tooren

Collins Aerospace

Thermoplastic Composites at Collins

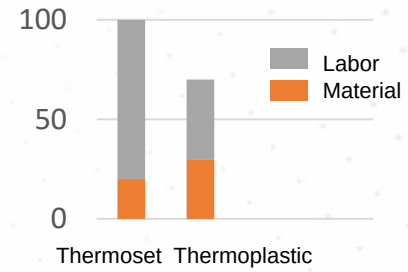
Continuing the legacy



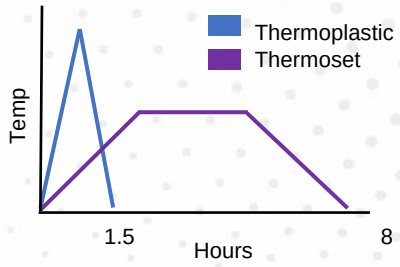
Continuous evolution of product and manufacturing technology portfolio

Why thermoplastics

Lower Cost



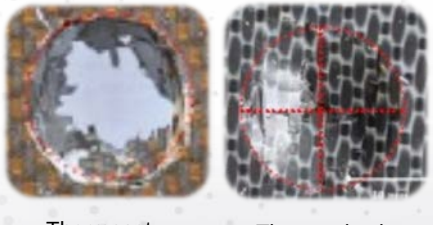
Shorter Cure Time



More Fireproof

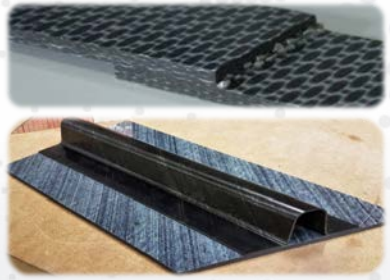
More sustainable

Tougher Matrix



More Integrated

Weldable

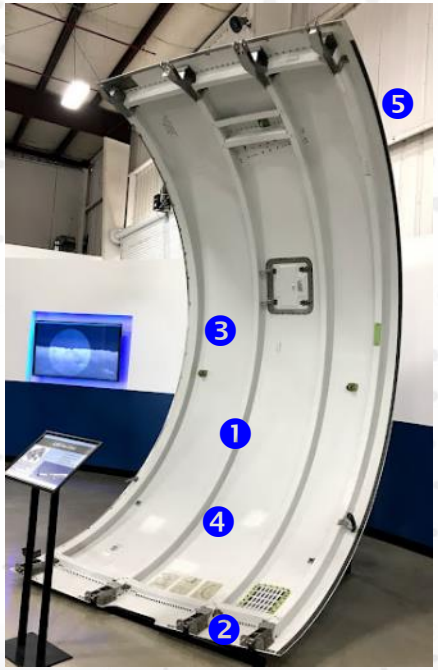


Superior cost and performance with automation

TPC Fan Cowl Pathfinder

1. Frame stamping
Labor and machine time reduction

2. Integrated design
Material and labor savings



3. LAFP Skins
Large double curvature & OOA consolidation

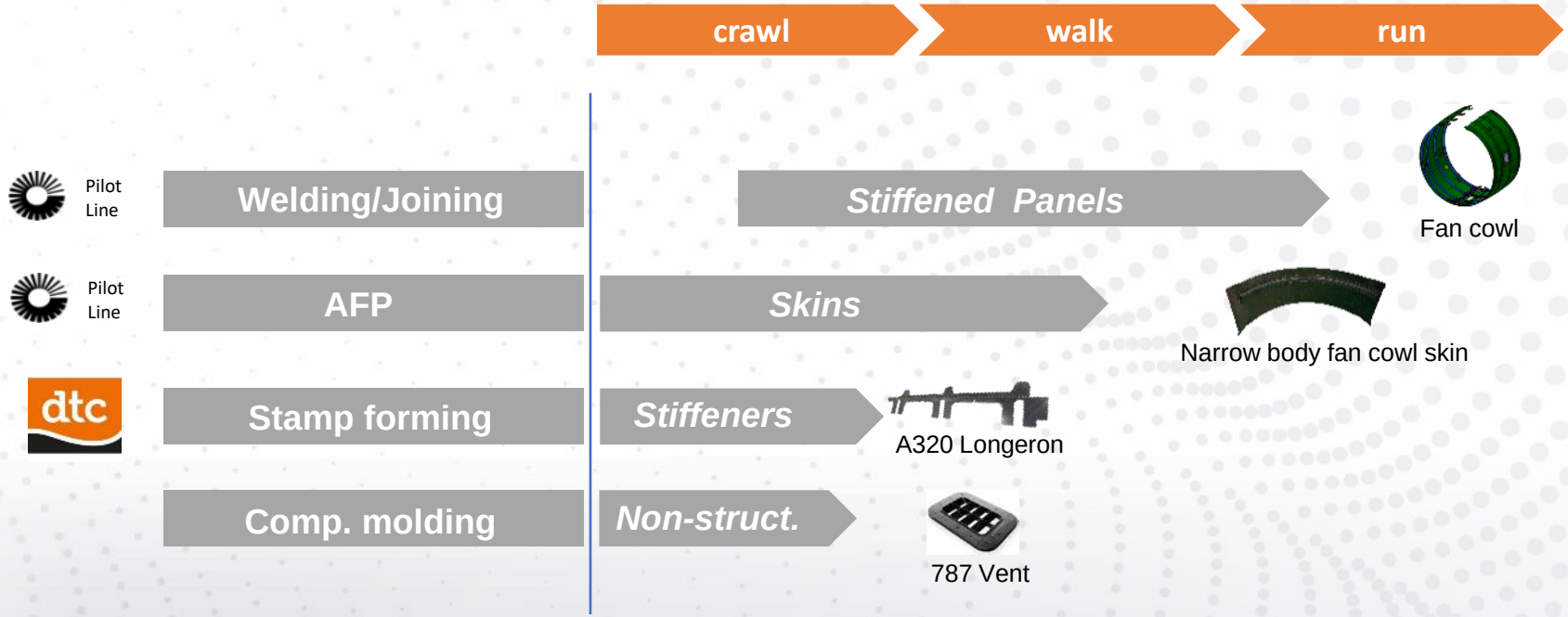
4. Welded joints
Eliminate labor and weight

5. Surface
Lightning strike protection, paint & repair

Processing proof and certification path

Climbing the complexity stairs

The Collins Journey



Moving from current excellence to future disruption

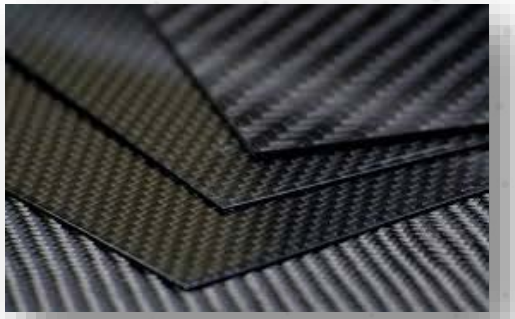
Key processes

1. Material selection and lay-up
2. Shape forming
3. Welding and joining

How do we get there?

Base Material Forms

Standard blank



- Uniform thickness
- Defined lay-up
- *Purchase as commodity*

Pre-ordered blanks

Clips, brackets, longerons

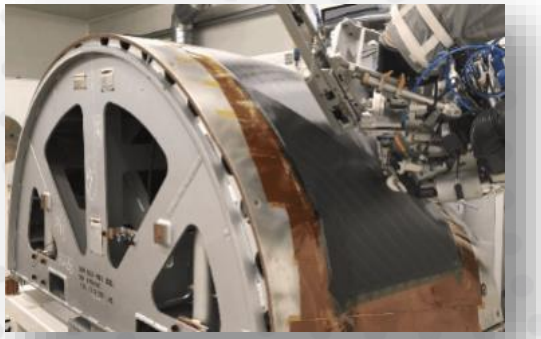
Custom blank

- Tailored thickness and lay-up
- Automated tape laying
- Pick and place
- *Make in-house… supplied mat'l*

Tailored in-house blanks

Frames, stiffeners, patches & reinforcements

Contoured shape



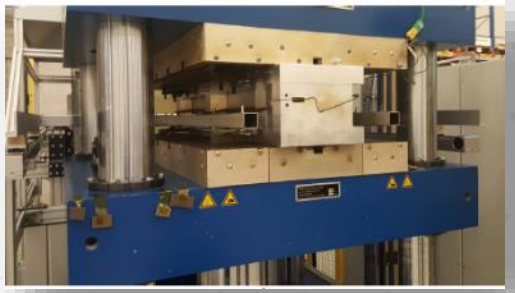
- Tailored thickness, lay-up, shape
- Automated fiber placement
- Lightning strike integration
- *Make in-house… supplied mat'l*

Large, high contour part

Skin

Shape Forming

Stamp forming

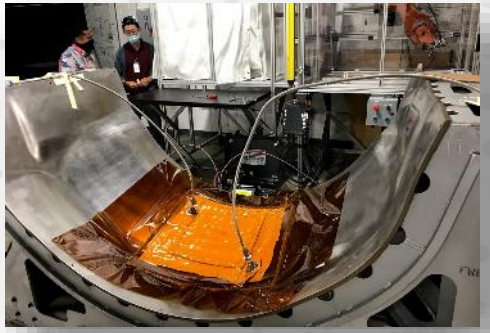


- Fast, best consolidation
- Press-limited
- *Industry proven*

Small to medium surface shapes

Clips, brackets, longerons

Vacuum



- Adequate with new LM materials
- Manage heat cycle, consumables
- *Interim solution*

Large skins

Large skin

In-Situ

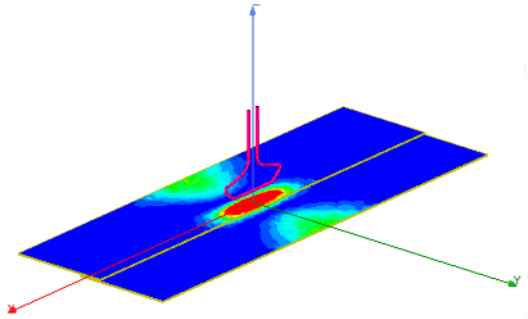
- >30% strength knockdown
- Slow
- *Not economical*

Continue to develop

Not used for fan cowl

Welding / joining

Non-contact

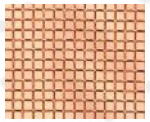


- Induction fields & parent material
- Complex physics, CF only
- *Long continuous welds*

Least intrusive

Frame and stiffener to skin

Susceptors & Resistors

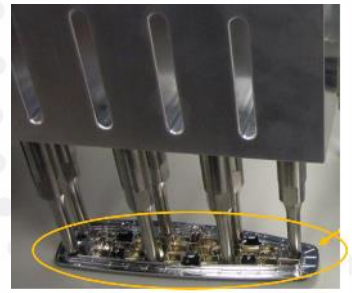


- Focuses energy where needed
- Second material required
- *Short to medium lengths*

Complicates certification

Not used for fan cowl

Thermo-Mechanical



https://www.dukane.com/blog/2019/08/30/composite-horn-ultrasonic-welding/

- IR, Ultra sonic, Conduction, Slip, Partial co-consolidation
- Intrusive tooling required
- *Discrete, short lengths*

Simple physics

Clips and brackets, sub-assemblies

Changing paradigms

Process

Thermoset

- Long cure cycles
  - Avoid exotherm
  - Cross-linking
- Drapable material, consumables
- Frozen raw material storage
- Irreversible process

Thermoplastic

- Multiple quick steps
  - Cooling uniformity
  - Confirm deg of cryst, reptation
- Machine handling, no sticky mess
- Room temp raw material storage
- Virgin state possible for multiple processes

The physics of lowering cost

Changing paradigms

Joining

Thermoset adhesive

- Sanded surface
- Two separate materials, cures
- Possibility of kissing bonds after correct P, T & t

Thermoplastic welding

- Surface condition insensitive
- Parent materials only
- No kissing bonds possible after correct P, T & t

Unique from thermoset joining

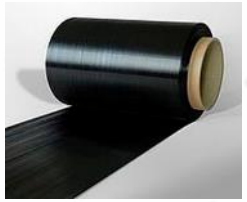
Changing paradigms

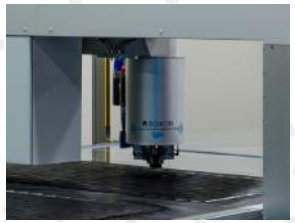
Physical vs. Chemical state change

Thermoplastics (physical)


Formulation


Pellatizing


Prepregging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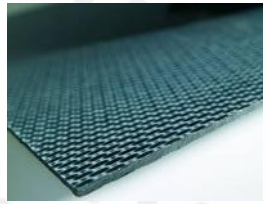
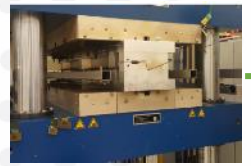
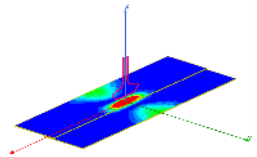

Consolidation


Stamp forming


Welding

Thermosets (chemical)


Formulation


Prepregging

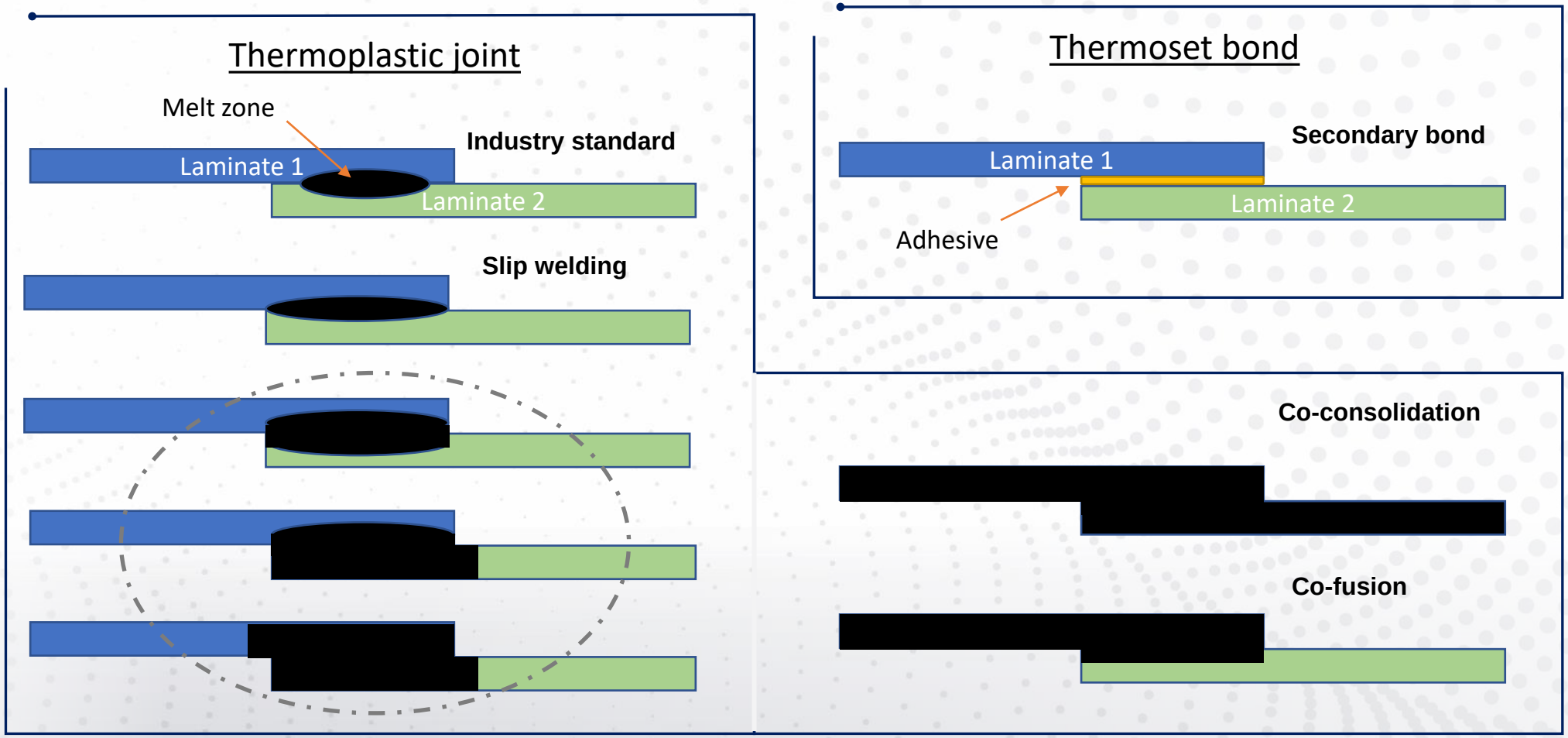

Autoclave cure


Secondary bonding


Autoclave cure

Multiple reversible processes vs. singular irreversible processes

When does a joint become a laminate?



Thermoplastic and thermoset joints are very different

Changing paradigms

Design for manufacture and material

Thermoset

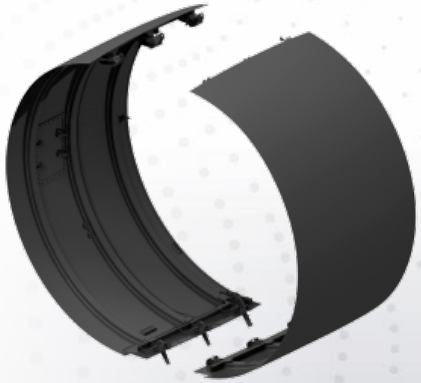
- Maximize assembly in cure
- Limited out-time window
- Sticky first ply
- “Chicken” fasteners required for secondary bonding
- Sizing for impact

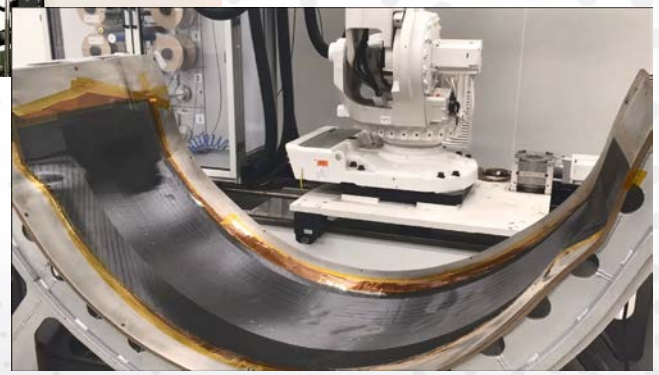
Thermoplastic

- Sequential short assembly steps
- Make-and-stack
- First ply challenge
- Homogenous joints always possible
- Sizing for impact – need to modify approach

Re-writing design handbooks

Conclusion





Shift in Paradigm

- Design
- Processing
- Joining
- Certification