Automation for the Next Generation of Aerospace Thermoplastic Composites

David Leach

ATC Manufacturing

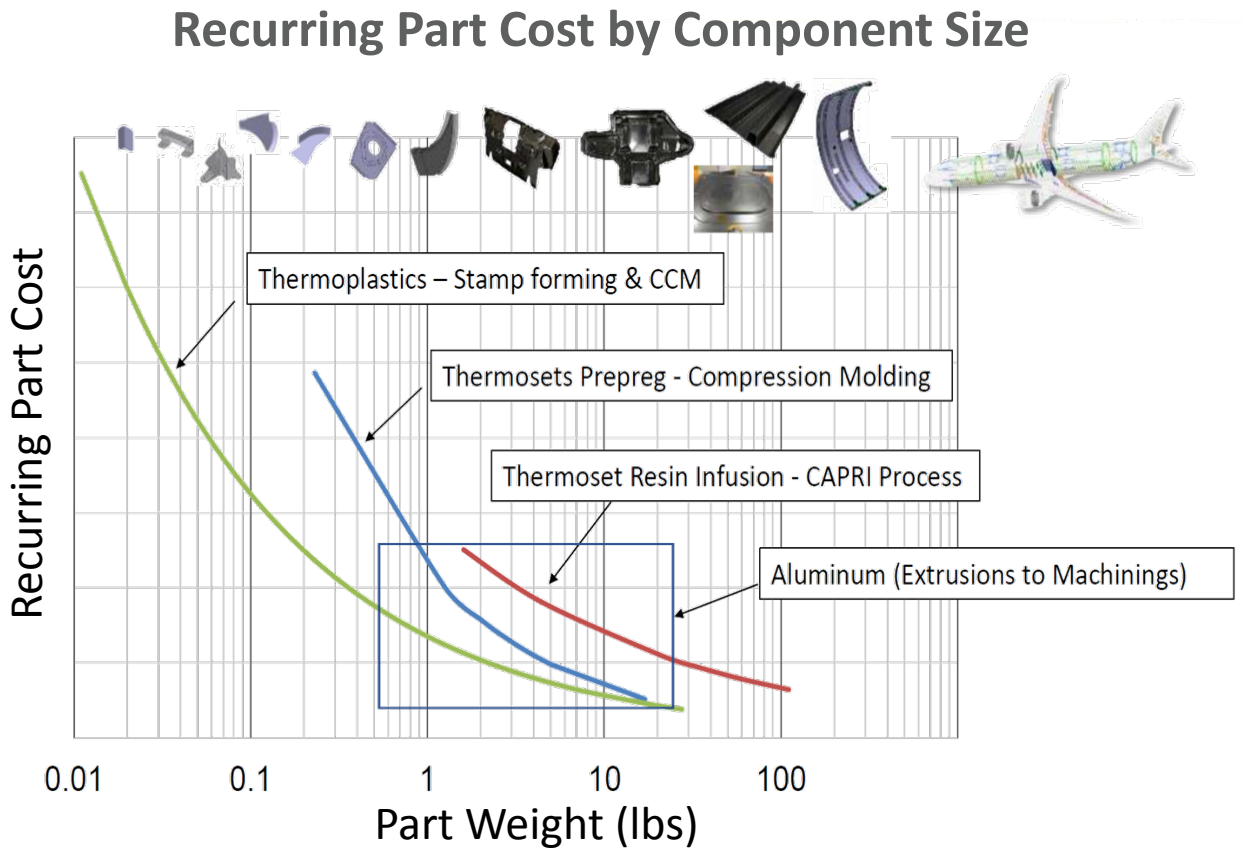
Outline

- Thermoplastic Composites for Aerospace
- ATC Manufacturing background
- Thermoplastic Fabrication Processes
  - Current Status
  - Future Opportunities
- Conclusions

Thermoplastic Composites in Aerospace

Thermoplastic Composites for Aerospace

- Short fabrication cycle times
- Reduced recurring cost
- Reduced non-recurring costs
- Reduced handling costs
- Automation
- Improved performance:
  - Toughness
  - Flammability
- Recyclability



R Wilkerson Boeing R&T, ACMA Thermoplastic Composites Conference 2020

Aerospace Evolution TP Composites

Clips & Brackets

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Toray Advanced Composites

Assemblies

GKN Fokker

Stiffeners & Channels

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Structural Components

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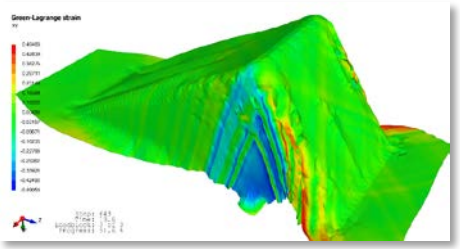
ATC Manufacturing Overview



- Founded 2004
- Manufacturing Technologies:
  - Stamp Forming
  - Continuous Compression Molding
- Approved to Aerospace Requirements
- Materials:
  - Polymers: PEEK, PEKK, LM-PAEK, PPS, PEI
  - Reinforcements: Carbon & Glass Fibers
  - Product Forms: UD Tapes and Fabrics
- Full Aerospace Inspection Capabilities
- Supply >1,100,000 parts per year
- R&D and Design Teams

ISO 9001 CERTIFIED

AS 9100 CERTIFIED

NADCAP

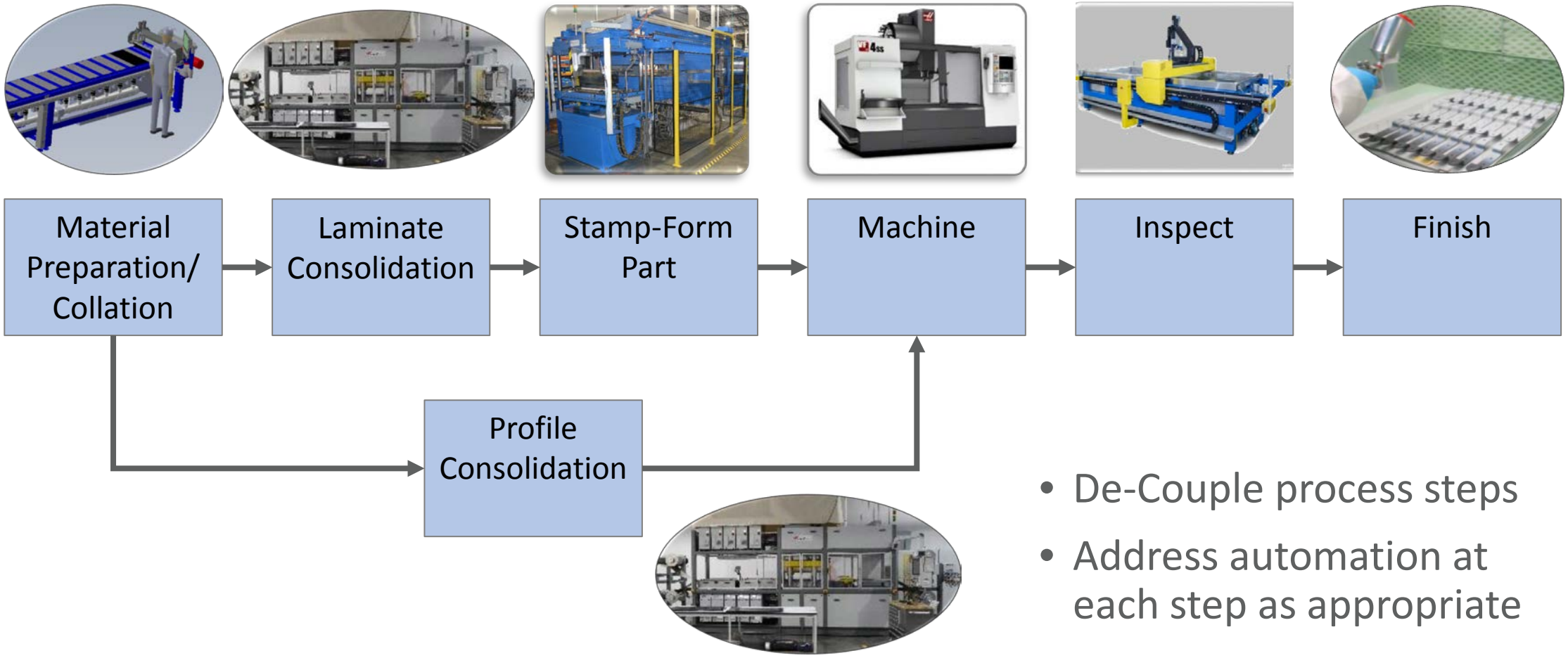
CW CompositesWorld TOP SHOPS

- Development of Fabrication Technologies
- Modeling of Part Forming
- Member of Thermoplastic Composites Research Center (TPRC)
- Collaborative R&D Programs:
  - DARPA / Boeing: Rapid high-Performance Molding (RAPM) Program
  - NASA / U Delaware / Spirit / Joby/ Southern University: ‘Composite Manufacturing Technologies for Aerospace Performance at Automotive Production Rates’

TPRC THERMOPLASTIC COMPOSITES RESEARCH CENTER

Thermoplastic Composite Part Fabrication

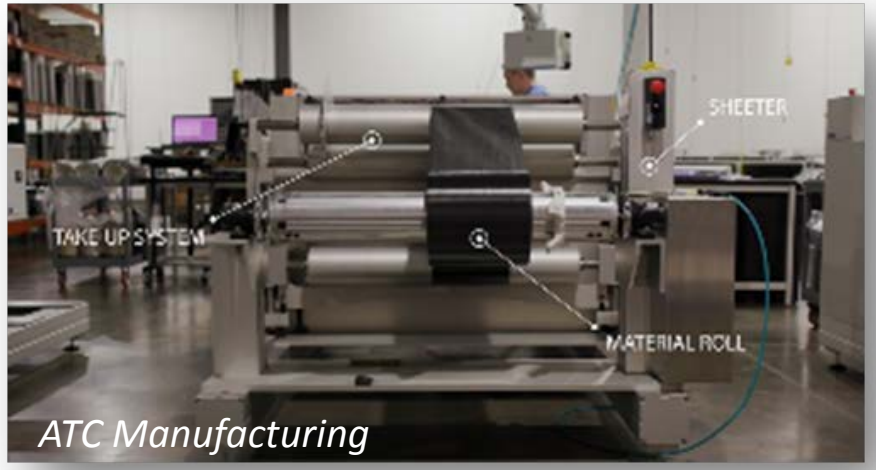
Thermoplastic Composite Process Flow



- De-Couple process steps
- Address automation at each step as appropriate

Material Preparation & Collation

- Prepare plies into standard orientations and widths eg 0°, +45°, -45°, 90°
- Edge Seam Welding or Tacking of Plies as needed
- Further Automation depends on:
  - Quality & consistency of materials
  - Allowance for overlaps/gaps
- Translate learning from non-aerospace materials handling



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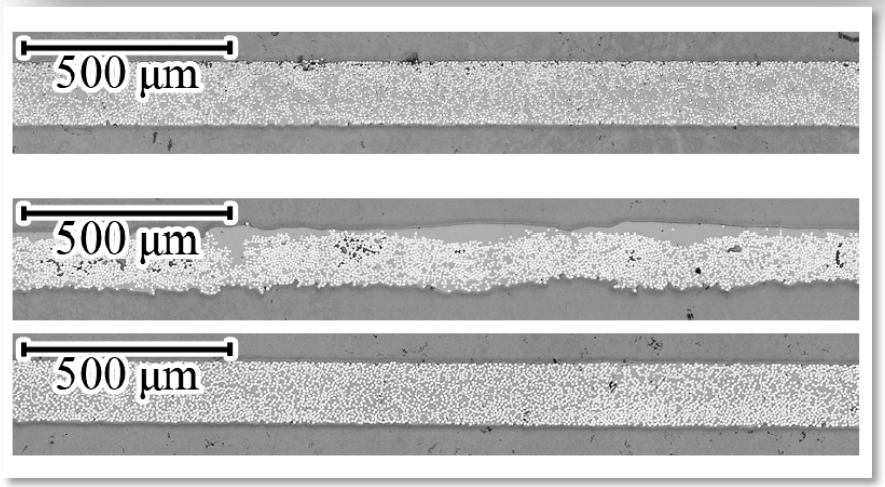
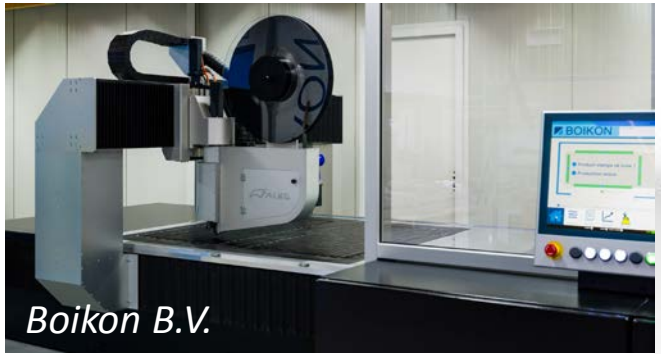


Slange et al, 20th ESAFORM Conference 2017

Material Preparation & Collation – Future State

- Greater use of UD Tapes
- Goals:
  - Reduced cost
  - Greater consistency
- Approaches:
  - Automated Tape Placement
  - Automated Collation: ‘Pick & Place’
- Acceptance of small Overlaps / Gaps:
  - Similar to thermoset prepreg lay-up
  - Dependent on material quality



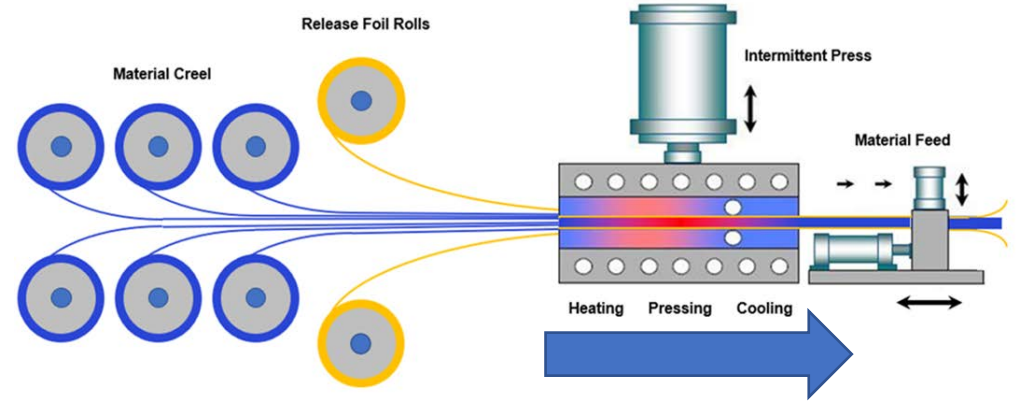
Boikon B.V.


Dieffenbacher


Airborne

Laminate Consolidation

- Intermediate laminate form required for rapid forming
- Can be highly automated today
- Approaches:
  - Press Molding
  - Continuous Molding – Laminates
  - Continuous Molding – Profiles



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Laminate Consolidation – Future State

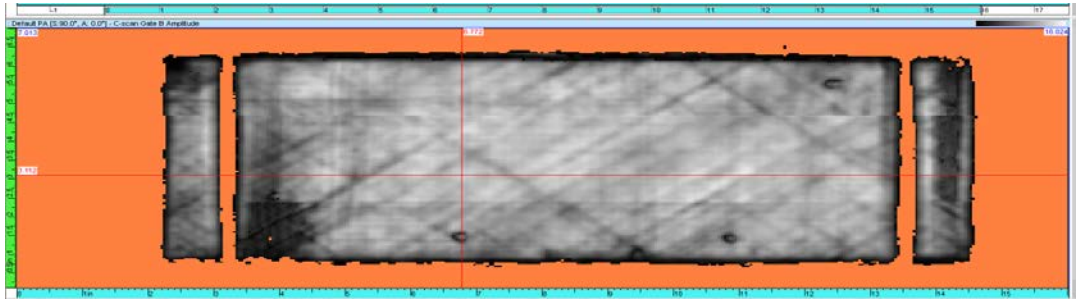
- Greater Customization:
  - Lay-up orientations
  - Non-rectangular blanks – material optimization
  - Variable thickness – in two dimensions
- Partially consolidated laminates for secondary forming
  - ATL, Pick & Place or AFP lay-up
  - Enable ply drops / build-ups
  - Low pressure blank consolidation

Laser Heated AFP of Thermoplastic UD Tape

Electroimpact

Partially Consolidated Blank: Double joggle formed part

NDI of stamp formed part



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Stamp Forming

- Rapid heating and forming of blank
- Very efficient for high volume parts
- Robotic cells developed
- Effective use of capital equipment & tooling

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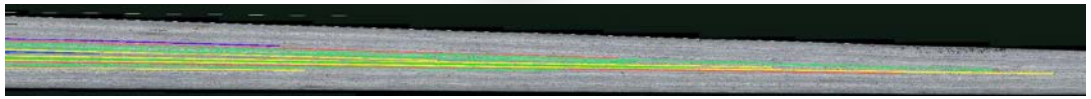
Premium Aerotec

Stamp Forming – Future State

- Larger and more complex parts
  - Single part per ship set
  - Modular tooling
  - Non-rectangular blanks – material optimization
  - Variable thickness: placement accuracy
- Integrated cells using Cobots:
  - Stamp form
  - Machine
  - Dimensional Inspect



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Machining, Inspection & Finishing

- Processes not unique to TP composites
- Processes:
  - Machining
  - Dimensional & Visual Inspection
  - Non-destructive Inspection
  - Surface Preparation
  - Prime, Paint & Edge Seal
- Usually performed discretely with some in-process automation

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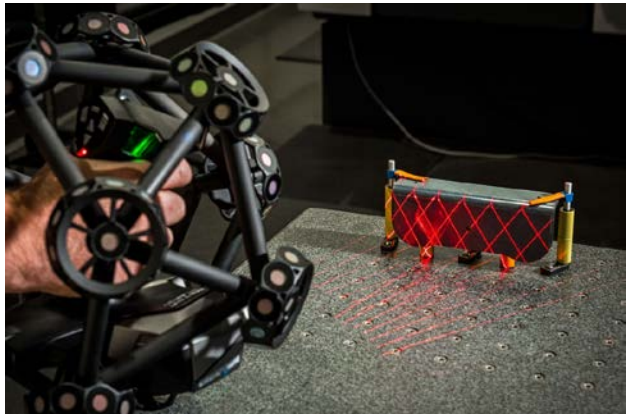
Inspection & Finishing – Future State

- Increased automation
- Surface preparation techniques more appropriate for Thermoplastics
- Flexible, automated & integrated cells eg machine and inspect
- Cobot solutions



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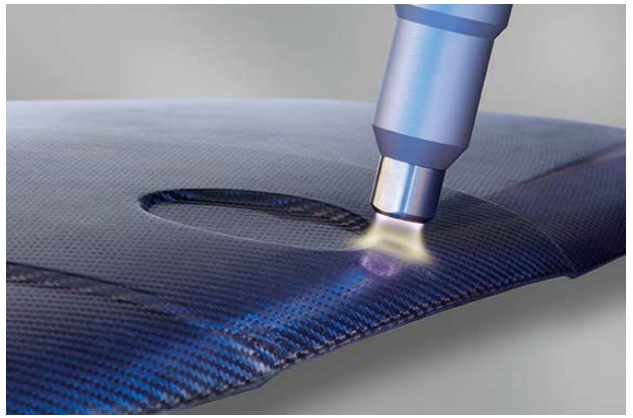
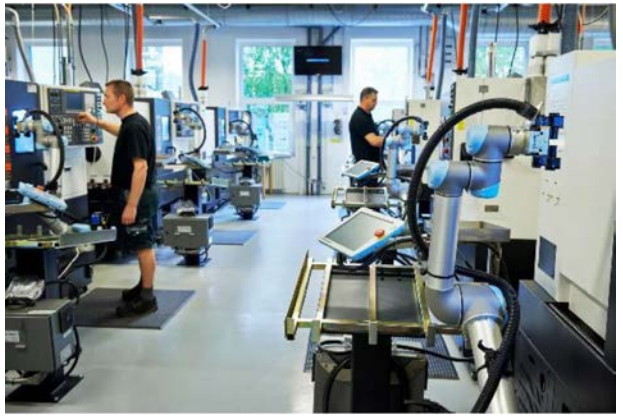
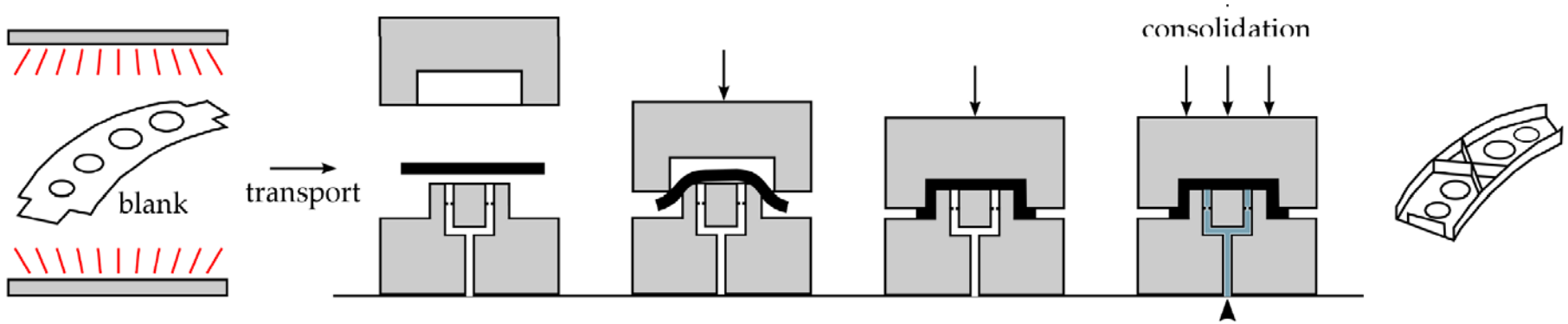


Plasmatreat



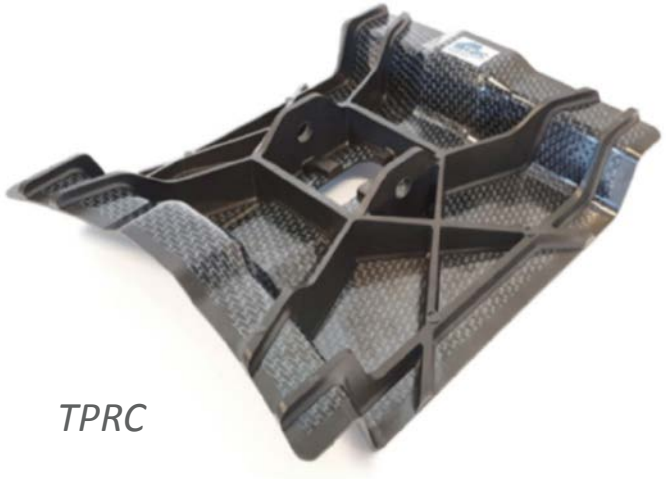
Universal Robotics

Complex Parts – Injection Over Molding



ThermoPlastic composites Research Center (TPRC)

- One-step or two-step over-molding
- Integrate:
  - Complex structure
  - Stiffening elements
  - Attachment points



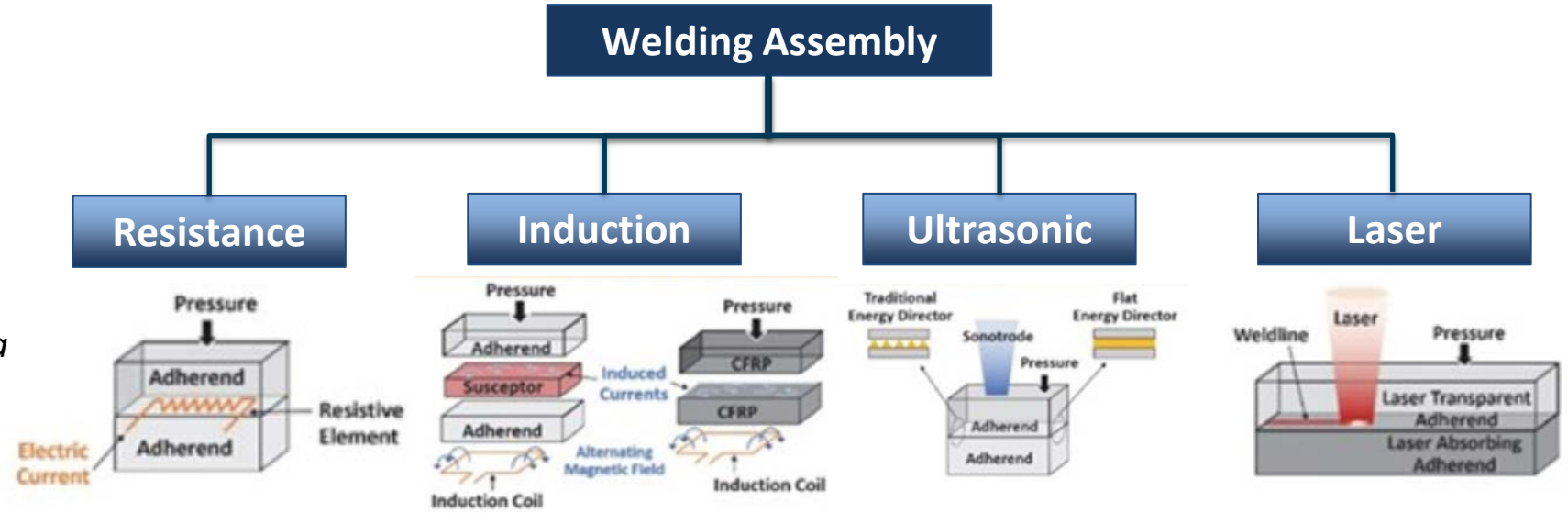
TPRC

TxV Aero Composites

Assembly – Utilize Benefits of Thermoplastics

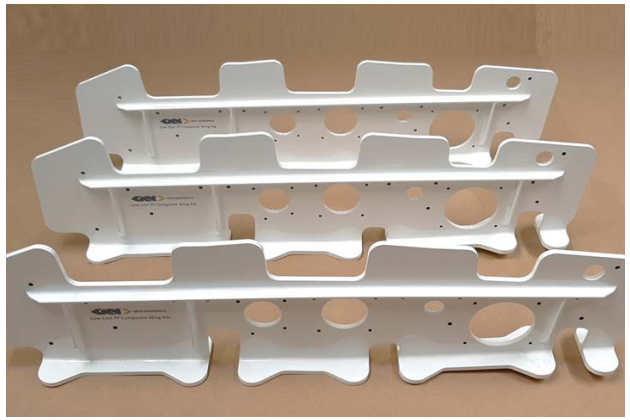
- Welding

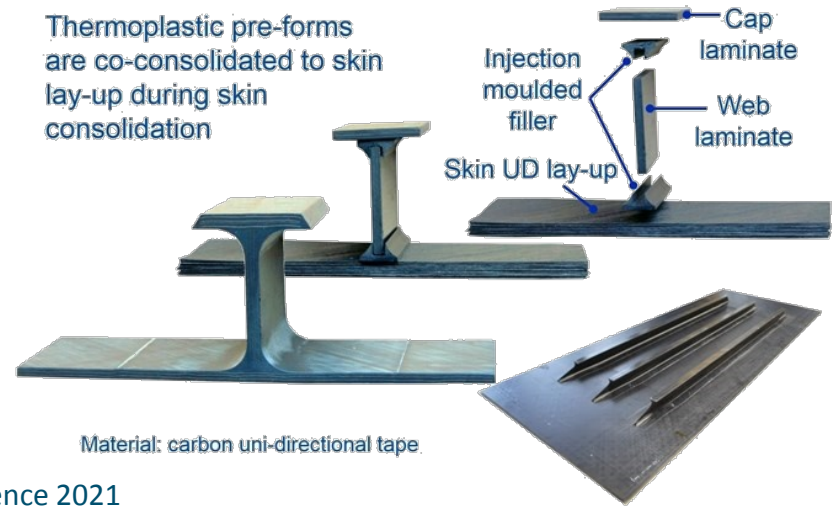
A Yousefpour: National Research Council Canada - CompositesWorld



- Complex Assembly

GKN Fokker





Conclusions

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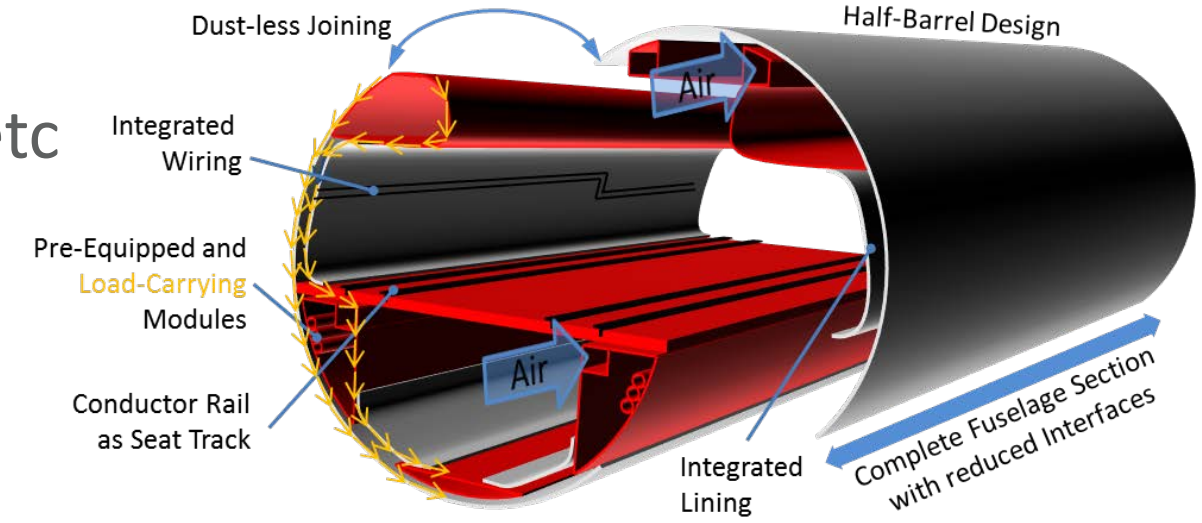
- Higher levels of automation enable further cost reduction, increased complexity and larger structures
- TP Composites most cost effective at high volumes
- Design for manufacturing:
  - Standardization: lay-ups, radii etc
- Use of flexible automation
- Cobots vs highly robotic cells
- Integrated Structures



Cleansky Program