An Innovative Vision for Composite Materials:

A Platform Connecting Analysis, Design and Manufacturing

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Agenda

- Composite Design State of The Art
- Our Vision: A Connected Platform
- How Manufacturing Data drives Design

Composite Design: State of The Art

Today’s Composite Design Process Flow

Engineering Kickoff

Inputs: Loft,Initial Surface loads, Materials…..

Structural Analysis

Producibility (hand layup, ATL/AFP, Forming)

IML surfaces

Design Rule/Strategies Validation

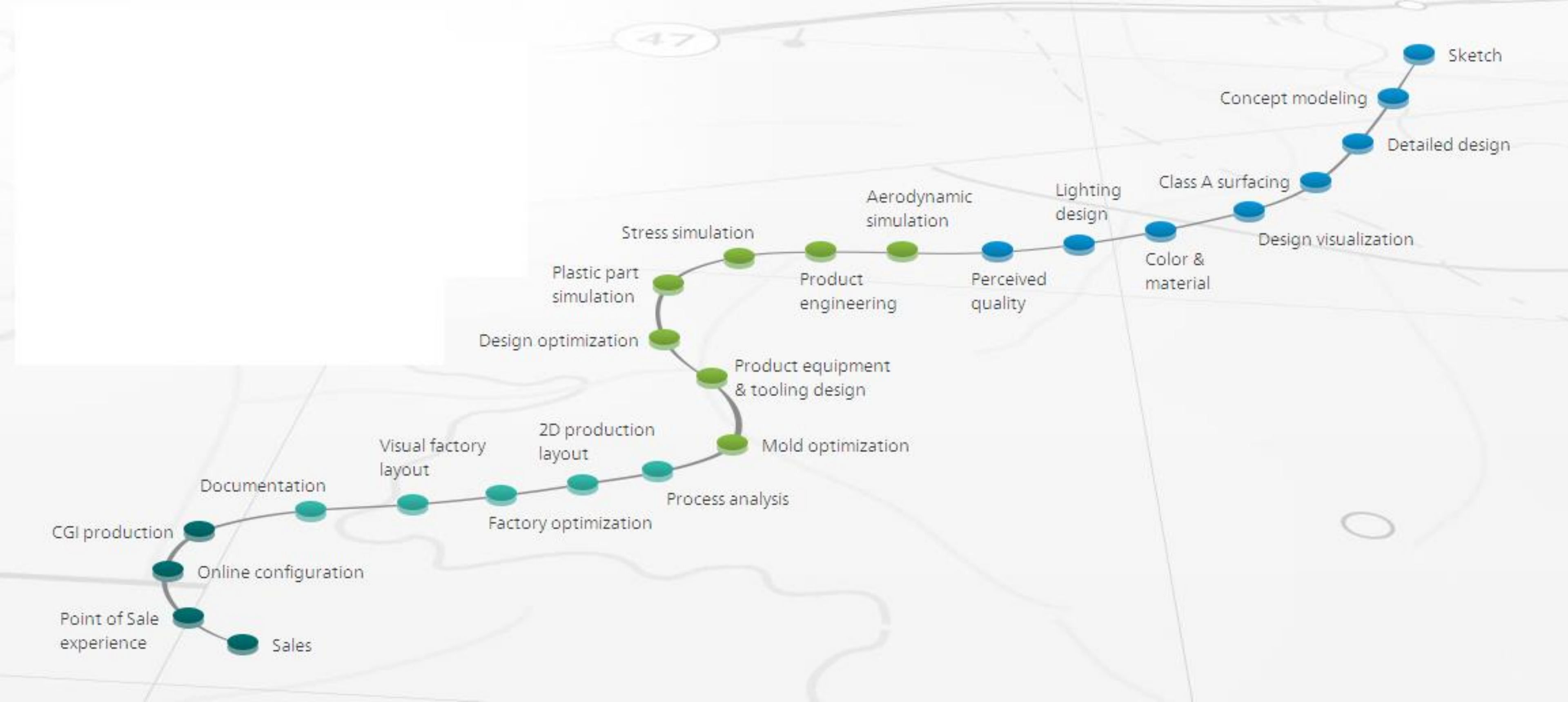
Substructure design (frames, ribs, spar…)

Release Documentation – ply books, MBD

Design Release

It is mainly a Cascade approach

Today’s Automotive Design Journey

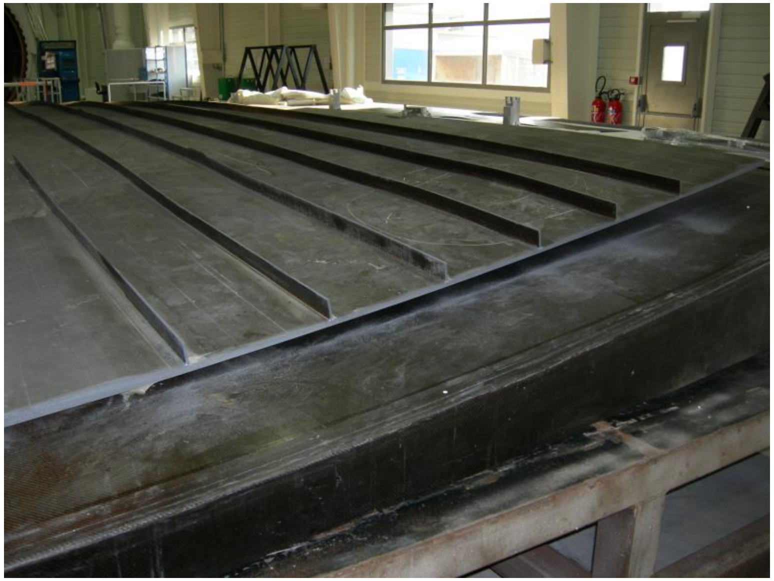


It is mainly a Cascade approach resulting…..

Composites: Black Metal?

- How do we exploit the benefits of composites when all Design Software are based on metallic methodology?
- Is Design in Assembly Context the future for composite?

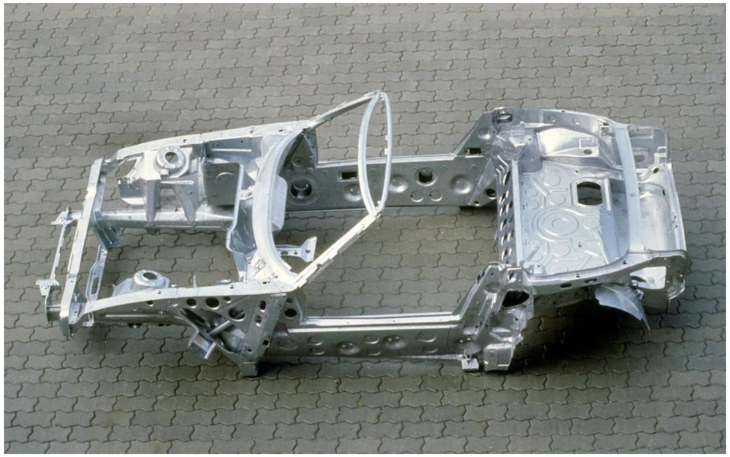
Example Bolted Aluminium Wing Skin



CFRP Wing Skin (Prior to bolting)

Composites: Black Metal?

- Is Today's Automotive Design flow adequate for composite materials?
- How Design/Simulation Software can help to improve composite design and manufacturing processes?

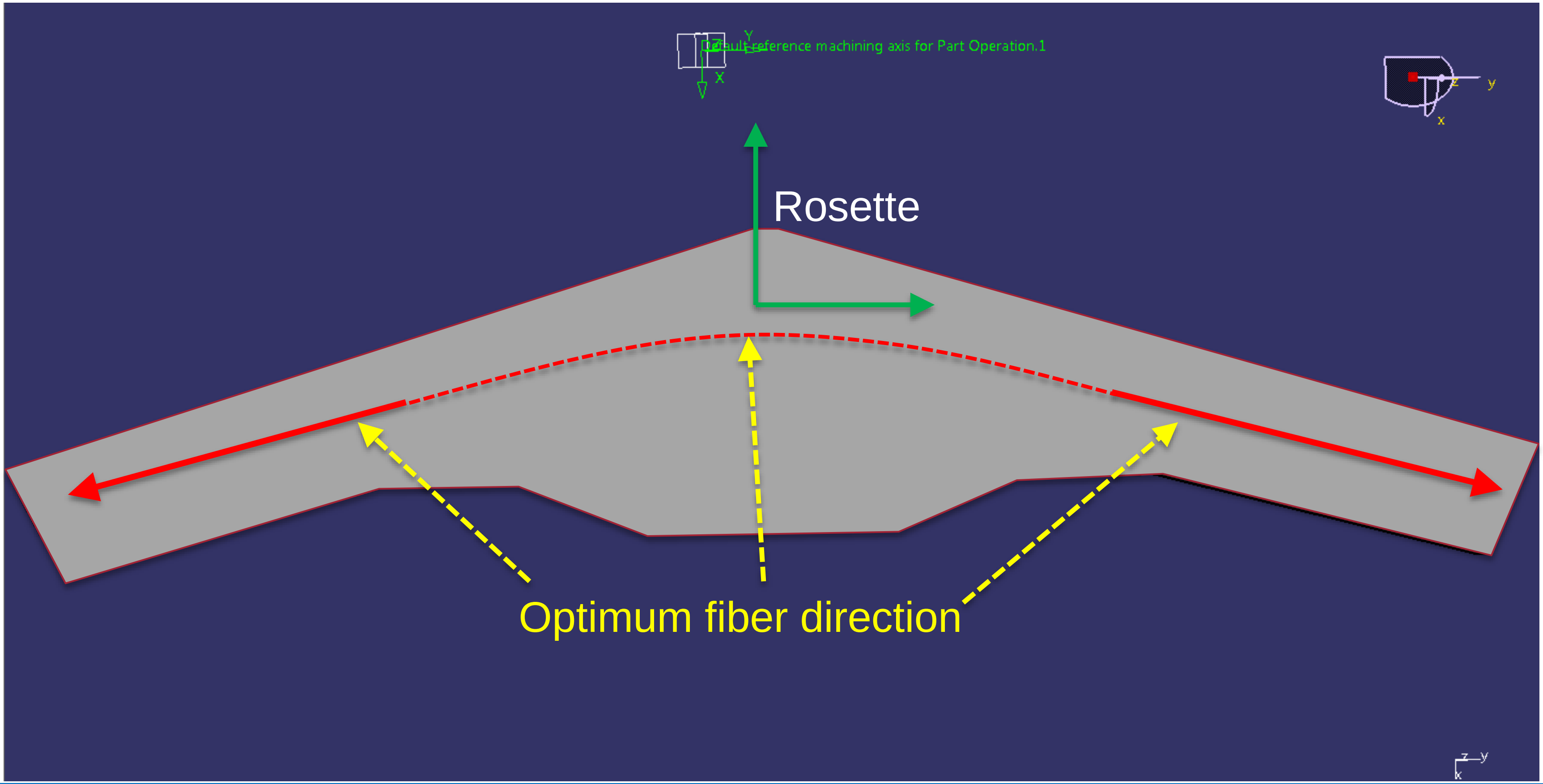


Example Bolted Aluminium monocoque

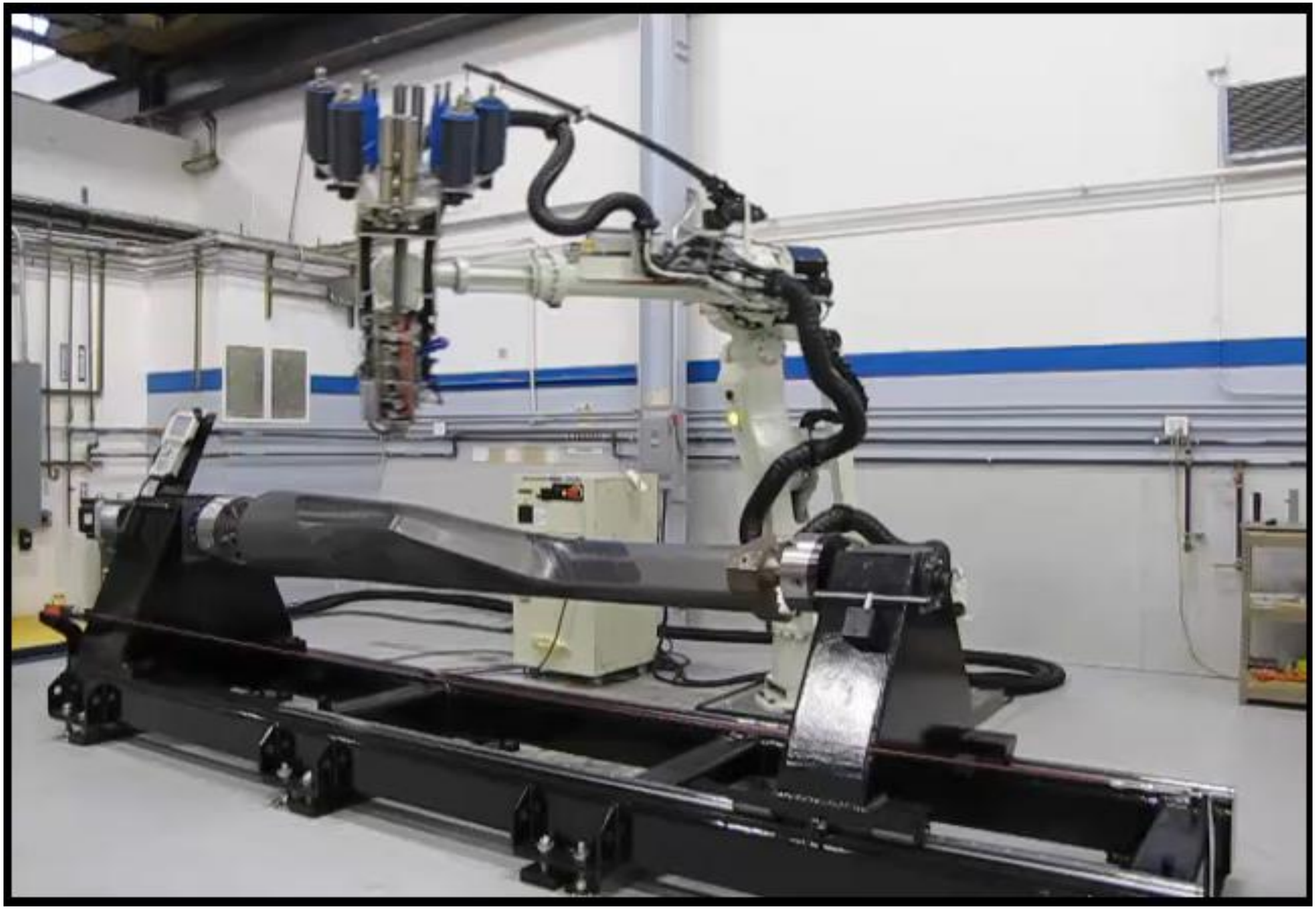
Composite Automotive monocoque

Composite design: state of the art

The best fiber direction is not always a straight line!!!
A Cartesian Design Rosette does not allow to unlock Composite Material benefits!!!



Manufacturing is Ahead of Design!!!

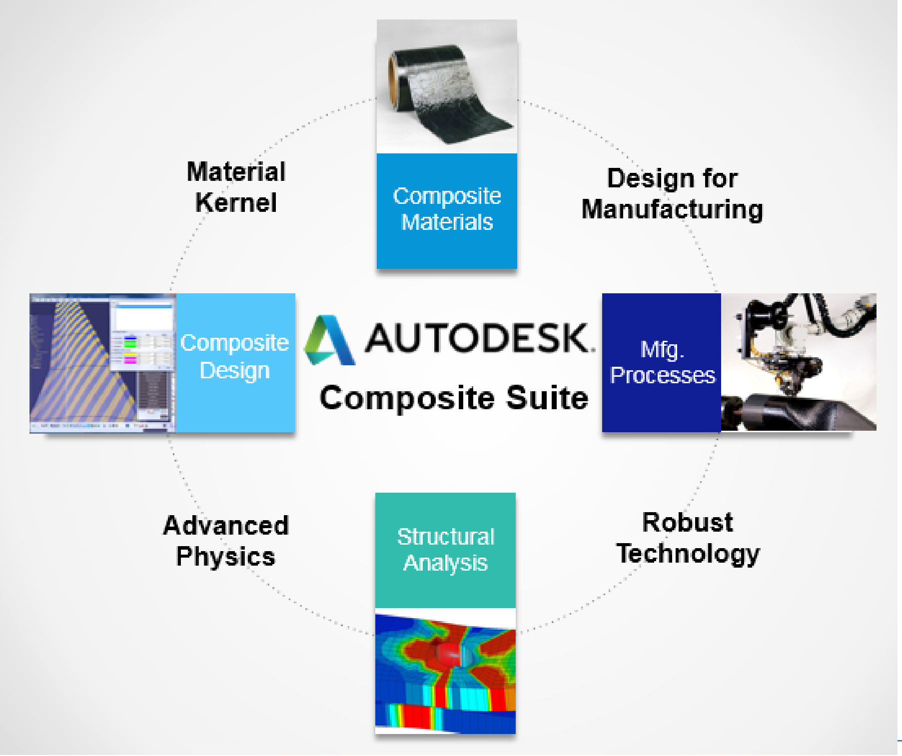


Source Automated Dynamics

Our Vision:
A Connected Platform

Autodesk: Composite Vision

- Innovative Platform based on Holistic Approach for and End-to End Solution
- Concurrent Engineering Platform
- Enables Design For Manufacturing
- Generative Composite Design…not black aluminum



Benefits of collaborating with Autodesk:
…*more than a link between Design and Analysis*

- Highly Skilled Team of Engineers in Composite Applications
- Highly Reliable Modeling tools to guide and monitor all phases
- Strong Collaboration with Material Suppliers and Material labs
- Provide Pilot project to validate Process Flow

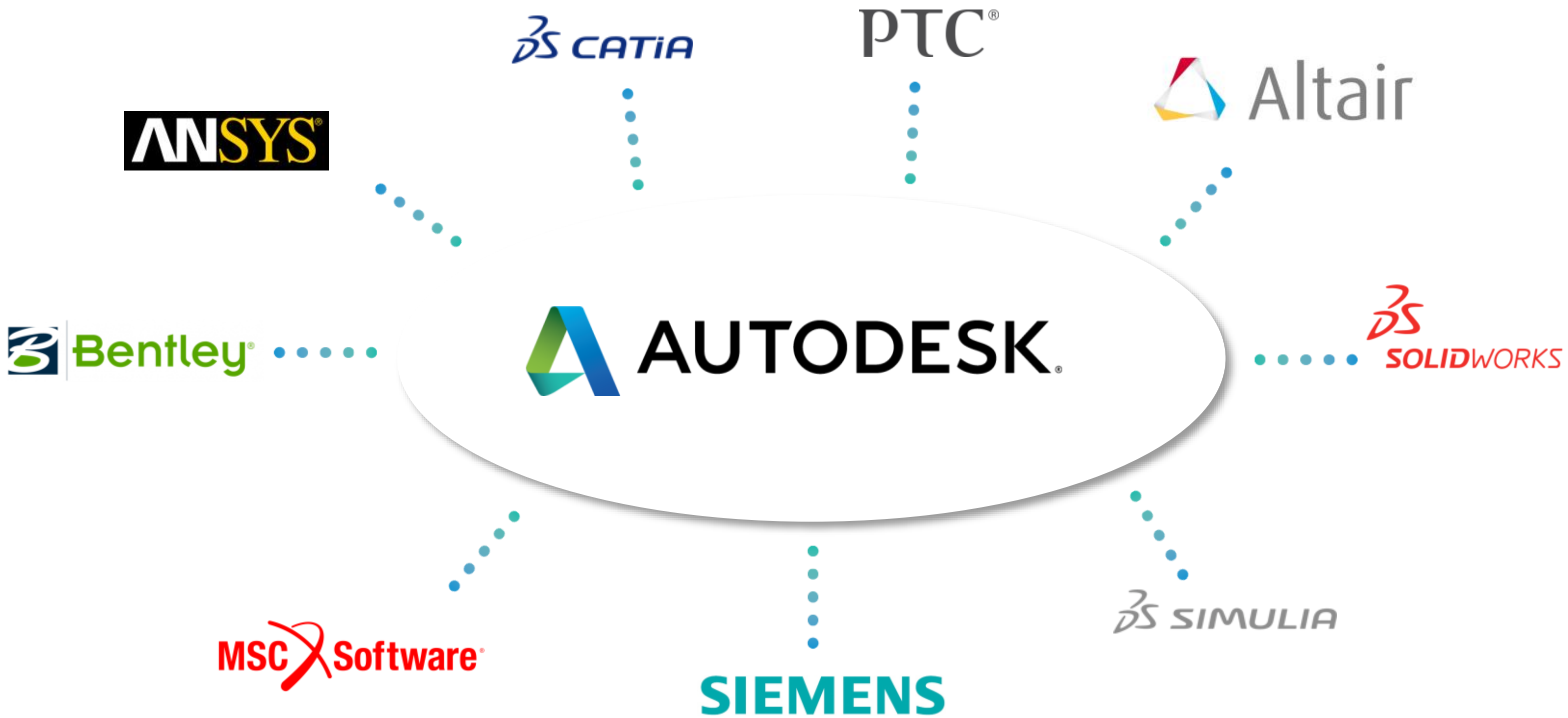
Material Catalogs

Combine Multiple Mfg. Processes

Design & Methods

Provide Pilot Project

Universal Platform

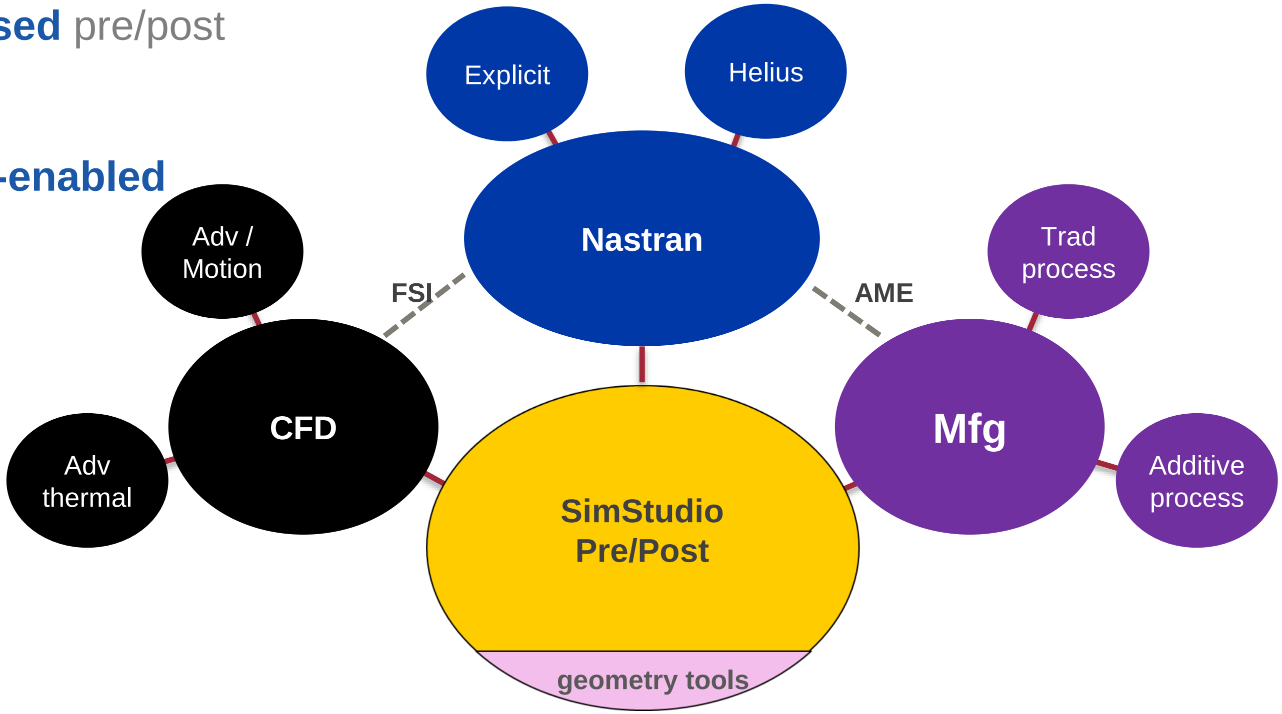


Example: SimStudio

Flexible, unified, geom-based pre/post for Nastran, CFD, +

CAD **connected *and* cloud-enabled** for solving and collaboration

Built for **optimization and goal driven design**



Advanced Materials at Autodesk

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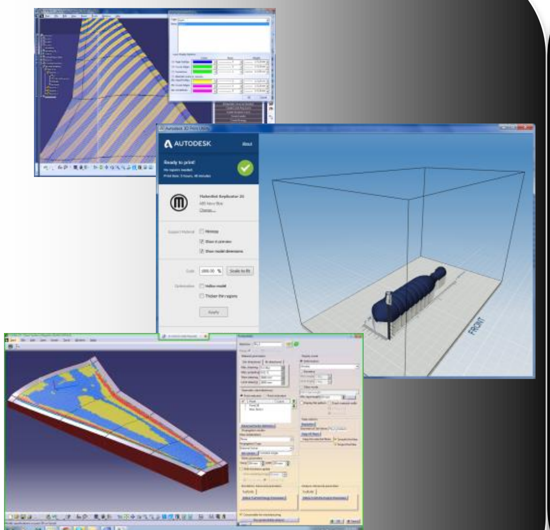
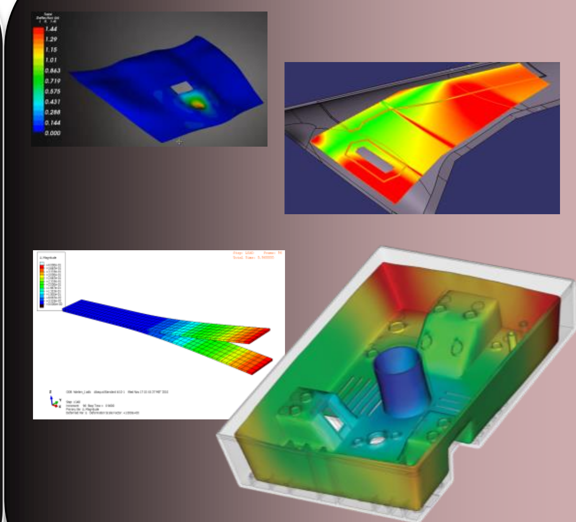
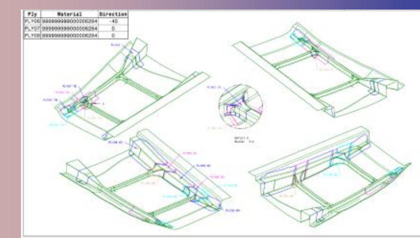


Design



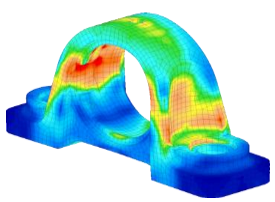
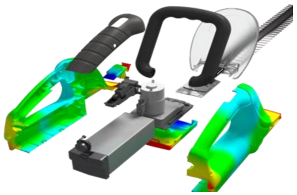
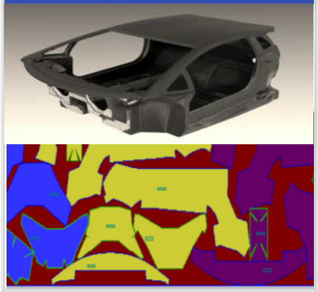
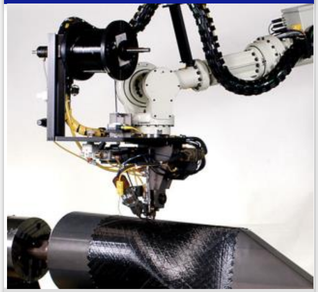
Simulate



Make

Materials Database

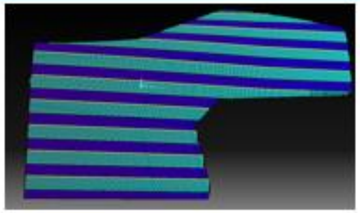
Portfolio of Solutions

Structural Mechanics	CFD & Thermal Analysis	Molding Processes	Composite Design	Composite Manufacturing
				
Autodesk® Nastran®	**Autodesk® Simulation CFD**	Autodesk® Simulation Moldflow®	Autodesk® TruPLAN	Autodesk® TruNEST TruFIBER

Autodesk® Composite Suite: ***From Design…to…Manufacturing***

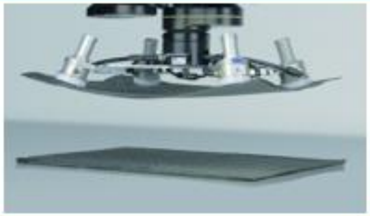
How Manufacturing Drives Design

Autodesk: Deep Investment in Manufacturing Technologies



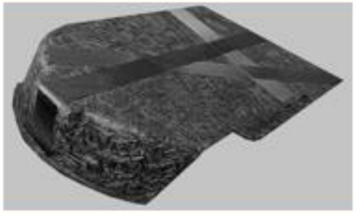

truPLAN

Advanced "Design For Manufacturing" application for composite structures



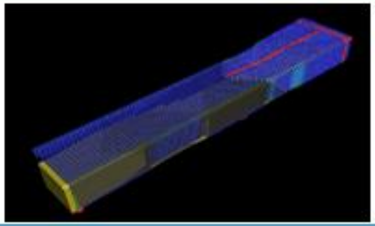
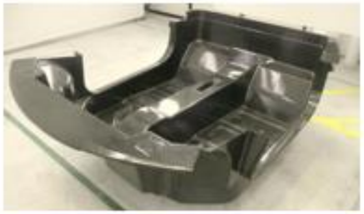

truNEST

Nesting Solution for Automated Preforming line

truFIBER

Programming Suite for Tailored Fiber Placement

FORMING

Design and Predictive Analysis for dry textiles or prepregs forming processes.

TruPLAN: Generative Composite Design

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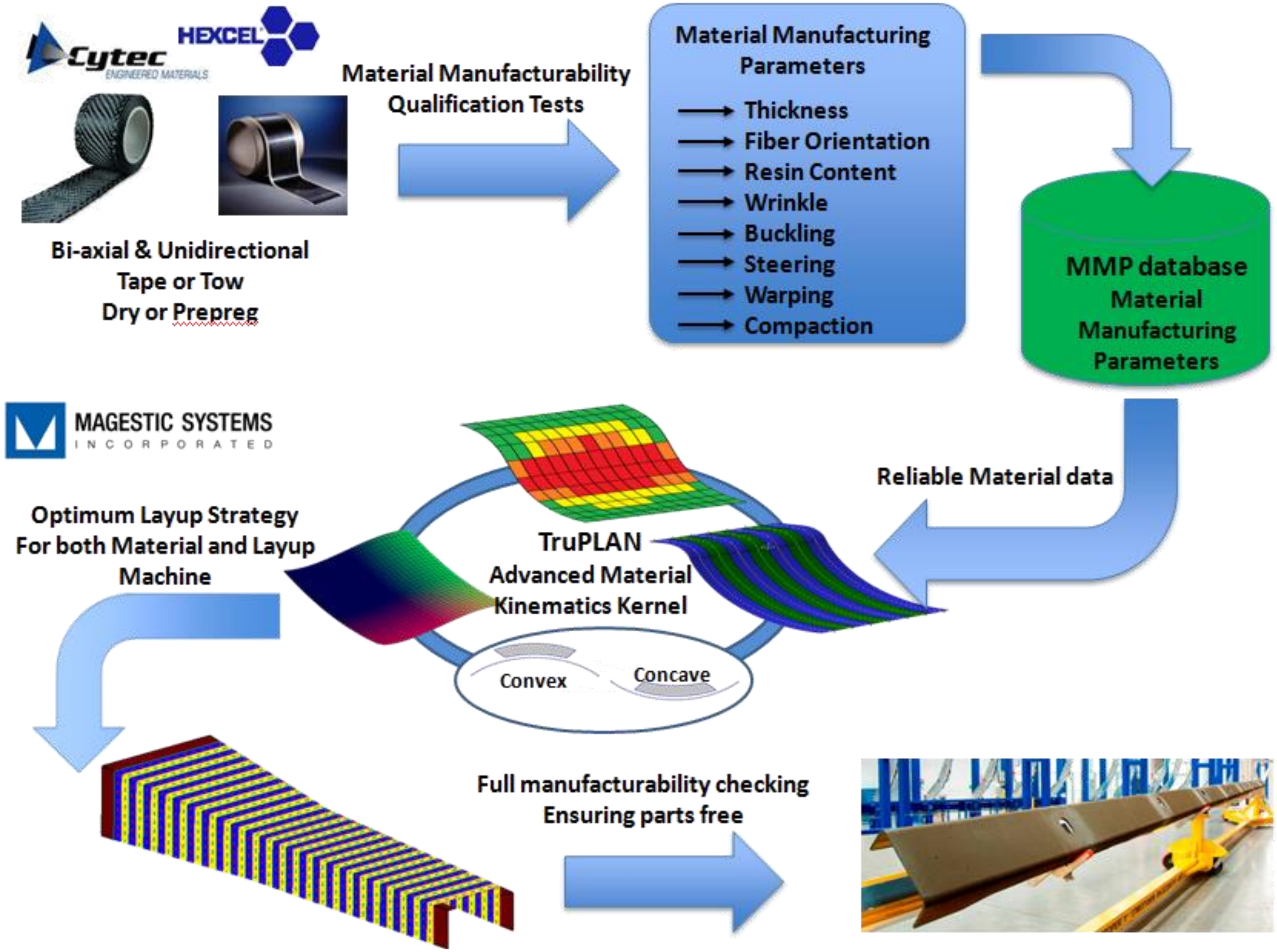
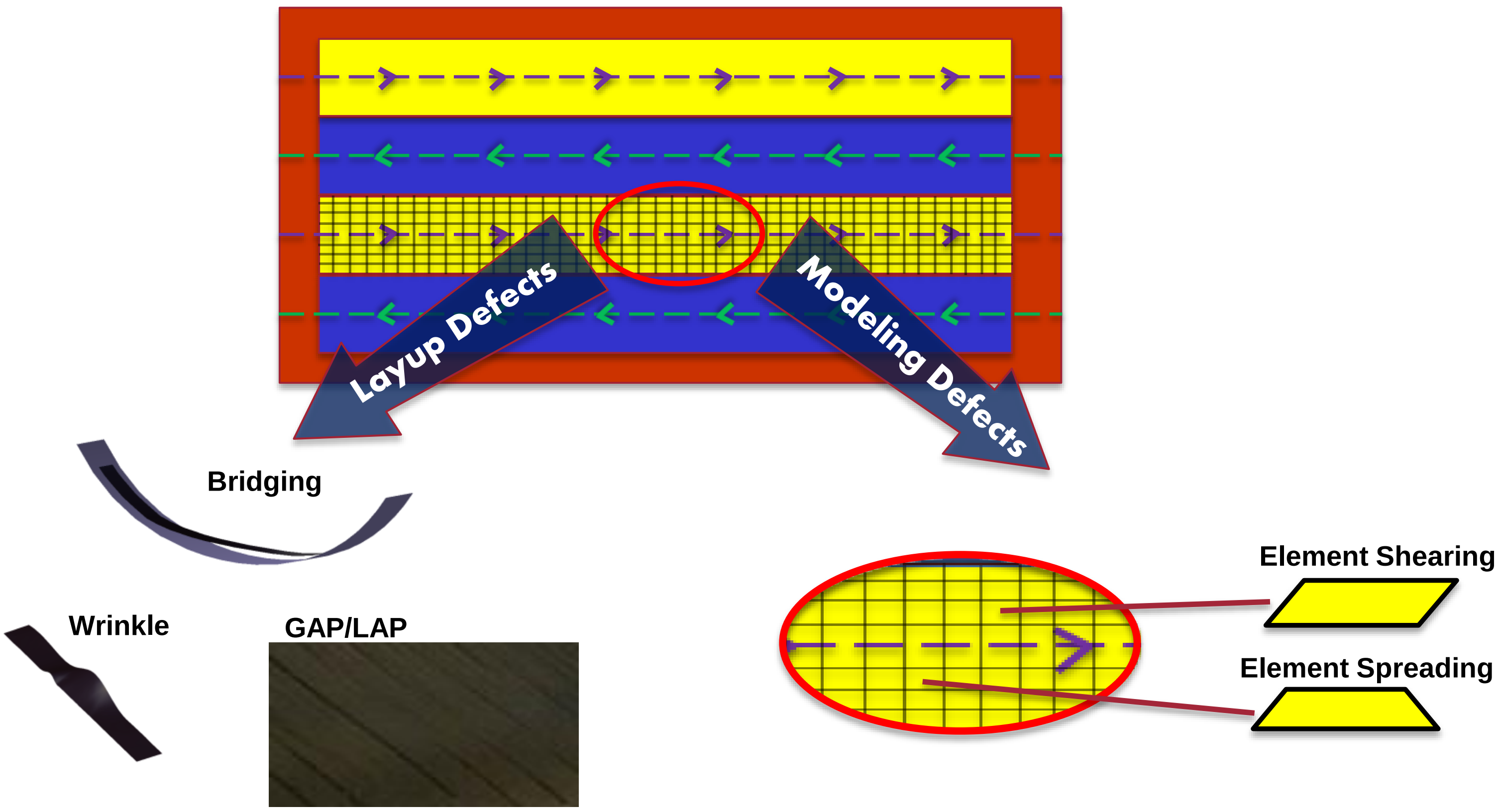


TRUPLAN: MATERIAL MODELING



Software Testing

<u>Tow Steering Trials</u>

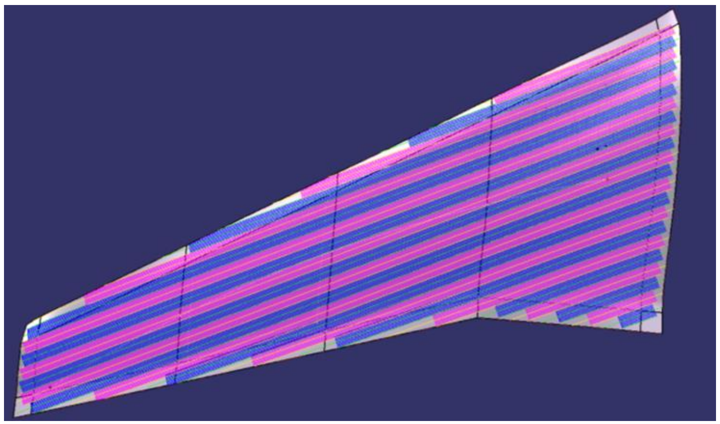
- **Tow steering using different:**
  - **Tow widths (1/4” vs 1/8”)**
  - **Resin systems (different level of tackiness)**
  - **Substrate (bare tool surface or woven ply)**
- **Steering radii varied until minimal defects were obtained**
- **Results used to define “Warn” and “Limit” steering values**

Gaps

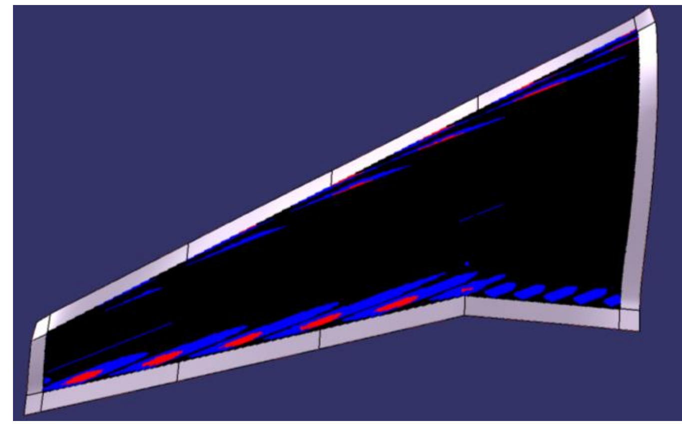
Minimal or no tow defects

TRUPLAN: MATERIAL ANALYSIS KERNEL

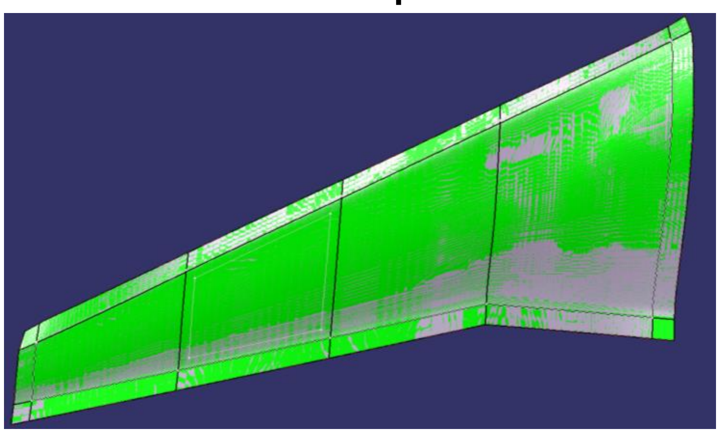
Fiber Path



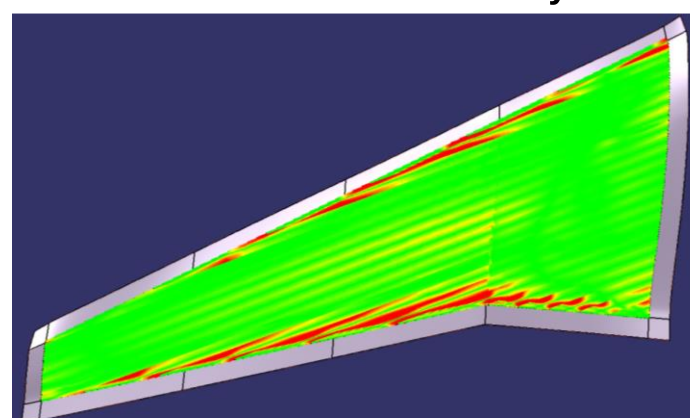
Material Compaction Analysis



Surface Update

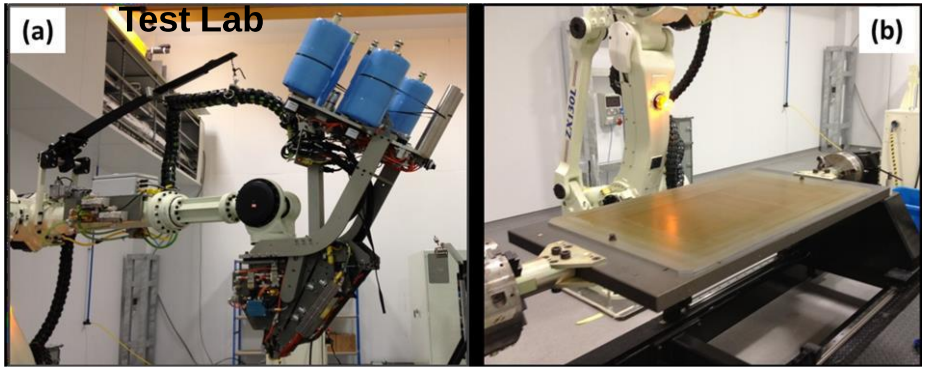


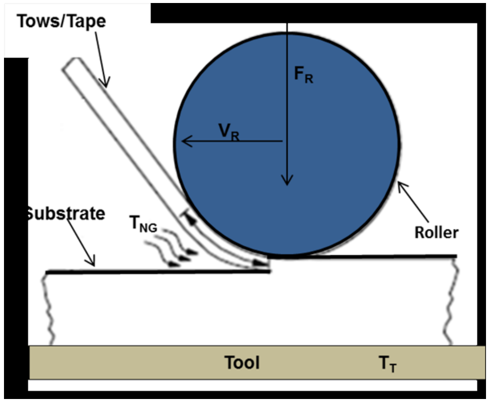
Material Orientation Analysis



Capturing Material & Manufacturing Constraints

Large Scale Additive Continuous Fiber Test Lab





Composite Materials Tested

Material (Thermoset matrix/carbon fibre)	Tow/tape width (inch)
MTM44-1/IM7	1/4
MTM44-1/HTS	1/4
977-3/IM7	1/4
MTM44-1/HTS	1/8

Mfg. Process Parameters

Variable	Setting
AFP Head(s)	¼" and 1/8" where indicated
Tool	Release Aluminium flat plate tool
Speed, V_R (mm/s)	300
Roller Compaction Force, F_R (lbs)	80
Nitrogen Gas Temperature, T_{N2} (^oC)	150
Nitrogen Gas Flow Rate, $\dot{V}_{N2}$ (lpm)	100
Tool Temperature, T_T (^oC)	Room temperature (20°C)

Composite Materials Layup Tests

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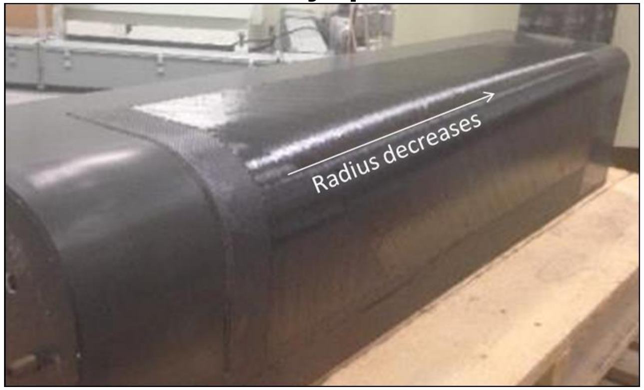
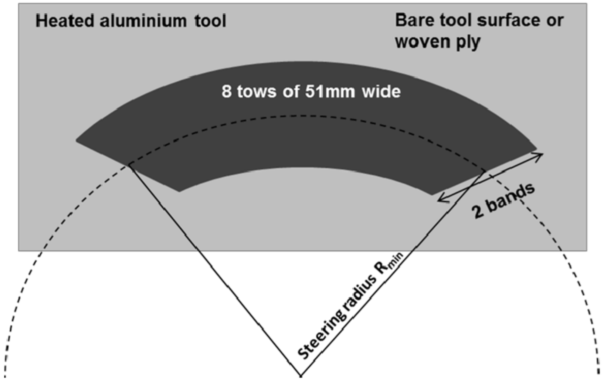
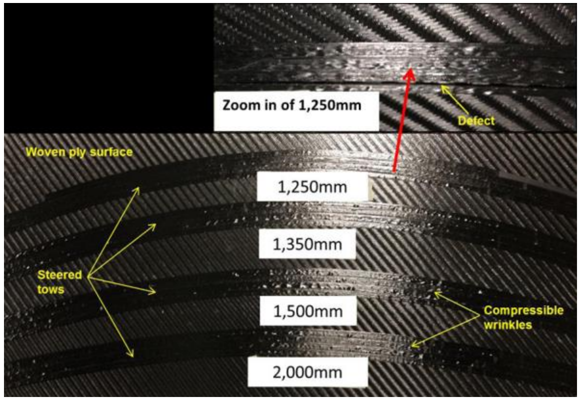
Test Layup Mould



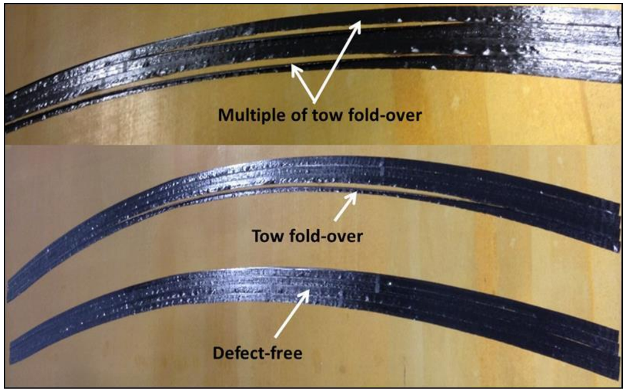
Curvilinear Fiber Path



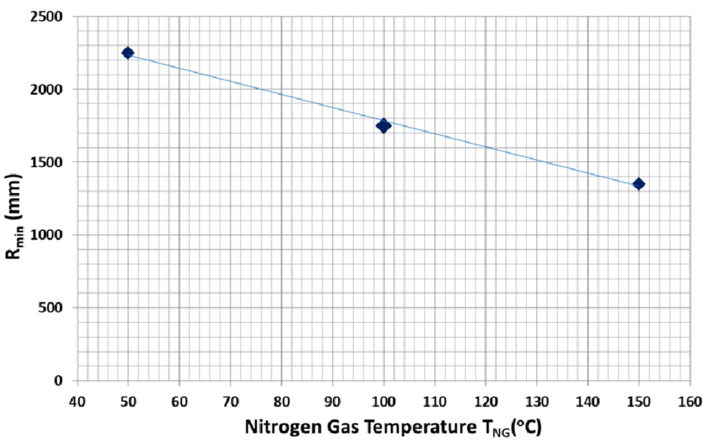
Carbon Fiber – Carbon Fiber

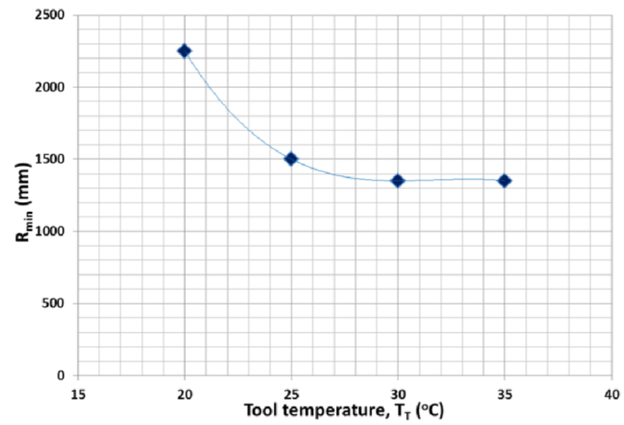


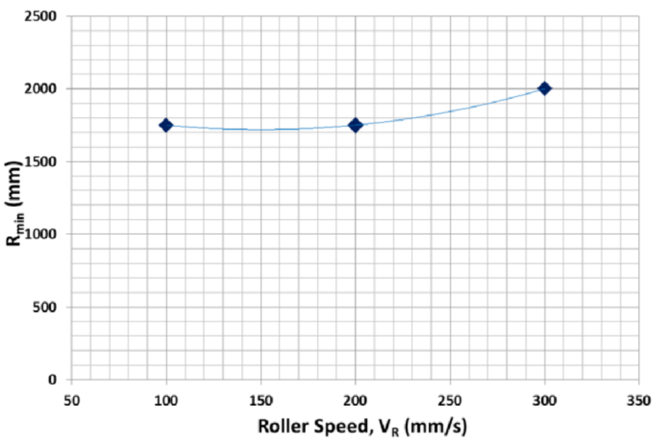
Carbon Fiber – Metal Interface

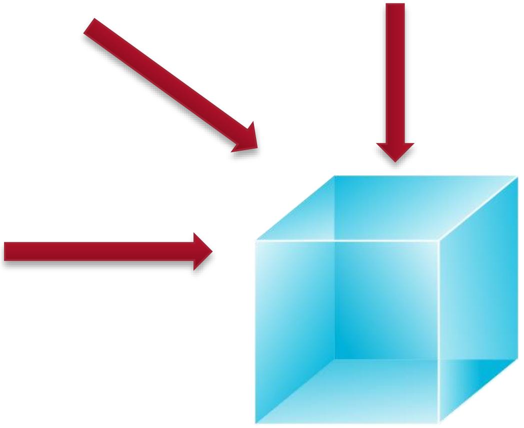


Mapping Topology-Material-Manufacturing Correlation Function



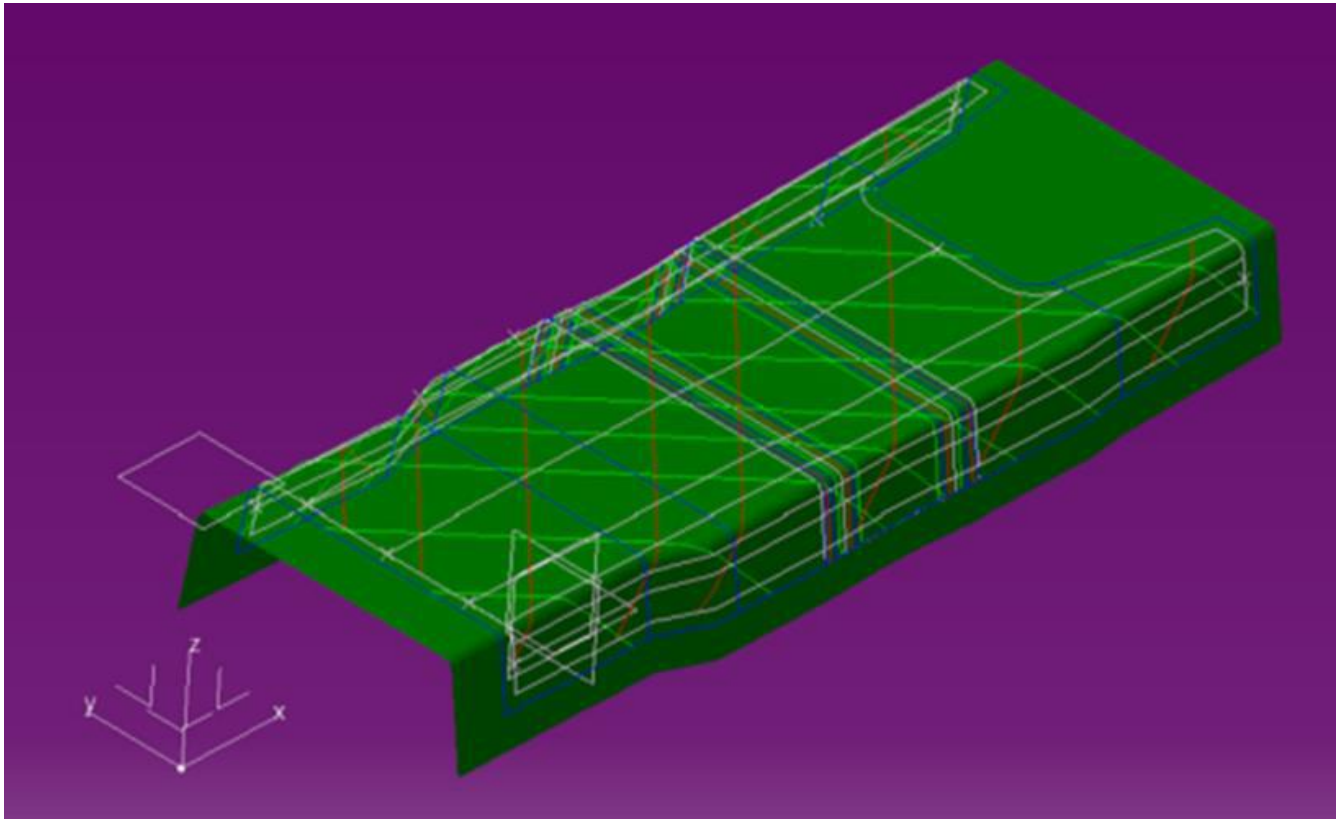




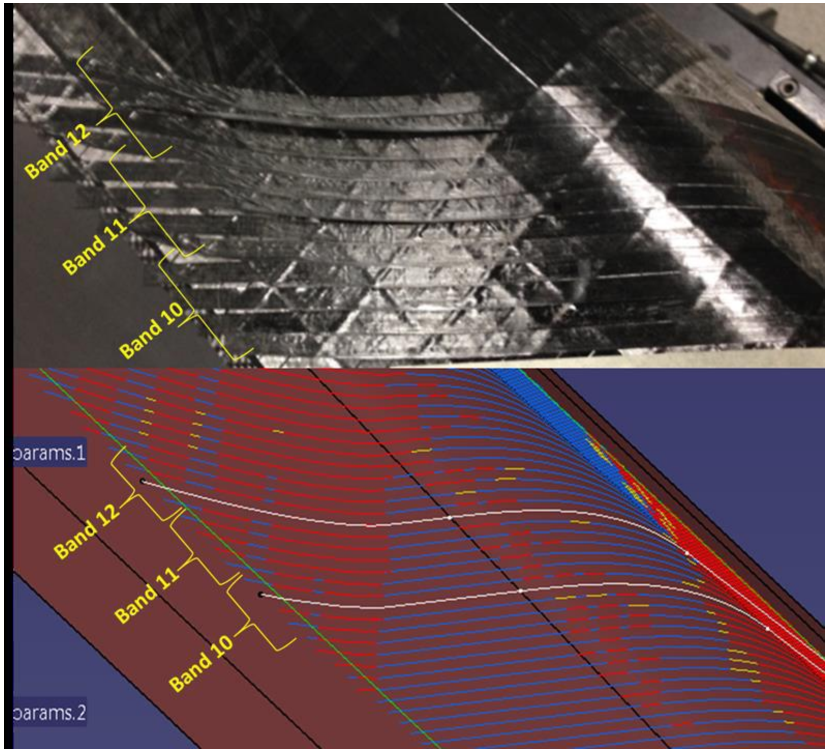


Material & Manufacturing Knowledge can be Mapped to Voxels describing a discrete Design Volume

TRUPLAN: EXPERIMENTAL VALIDATION
WING SPAR CASE STUDY



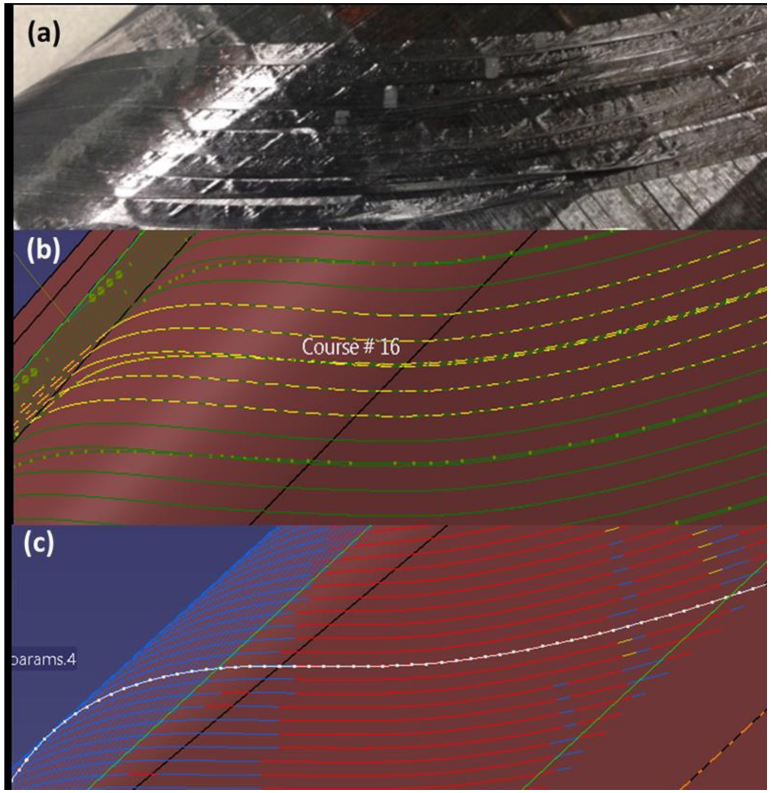
TRUPLAN: EXPERIMENTAL VALIDATION
WING SPAR CASE STUDY



Steering Results for +45$_o$ Ply, Bands 10-12

a) Fiber placed part exhibiting considerable steering defects (Courses 10-12)
b) Simulated part in TruPLAN steering analysis exhibiting considerable steering defects in the same region (courses 10-12)

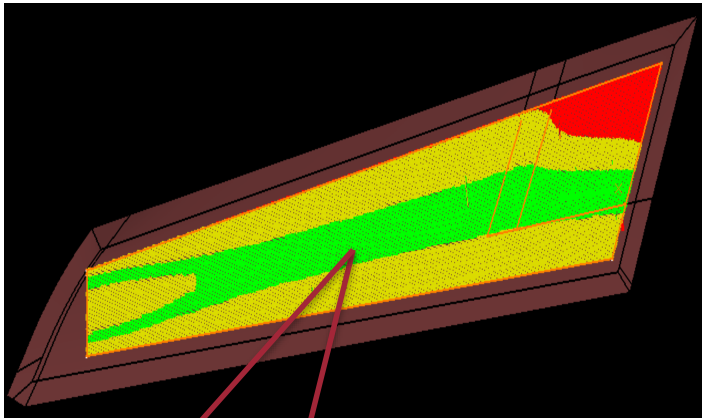
TRUPLAN: EXPERIMENTAL VALIDATION WING SPAR CASE STUDY



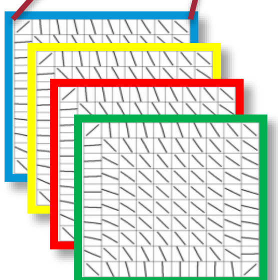
TruPLAN Steering Results

a) Fiber placed part with relevant courses/bands (16-17) in the case of -45o ply
b) Simulation from TruFIBER for layup (courses 16-17)
c) Simulation from TruPLAN for steering (white line represents center line for course 16).

Capturing Structural Constraints

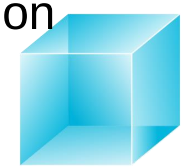


- **Analyze "As Built"**
- **From Black Metal to Optimal use of Composite!!!**

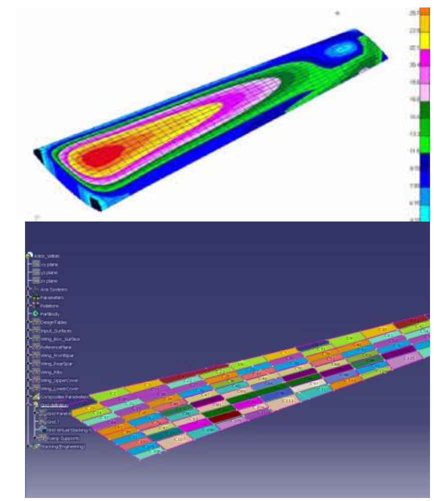


Laminate

Mapping TRUE Fiber Direction



Reference Element



Total Manufacturing Process Tracking

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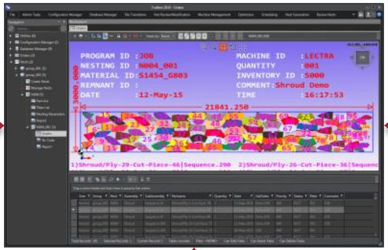
Freezer

Autoclave

RFID
Bar Code

RFID
Bar Code

- Expiration dates for all plies
- In/Out time for all plies
- Remaining shelf life for plies
- Which Roll Each Ply Came From



Cutting

Layup

RFID
Bar Code

RFID
Bar Code

What is Coming

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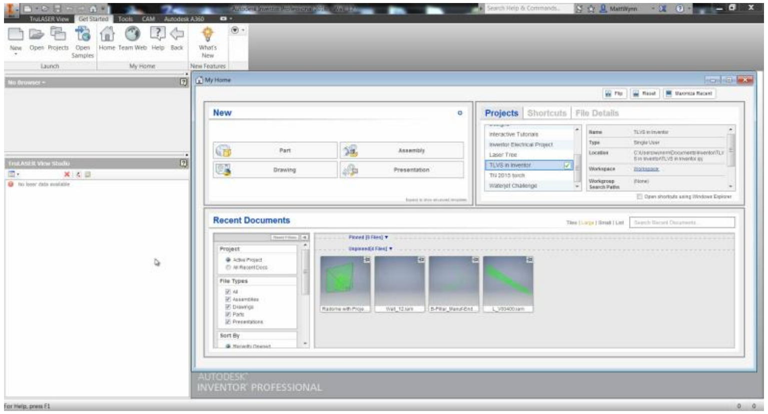
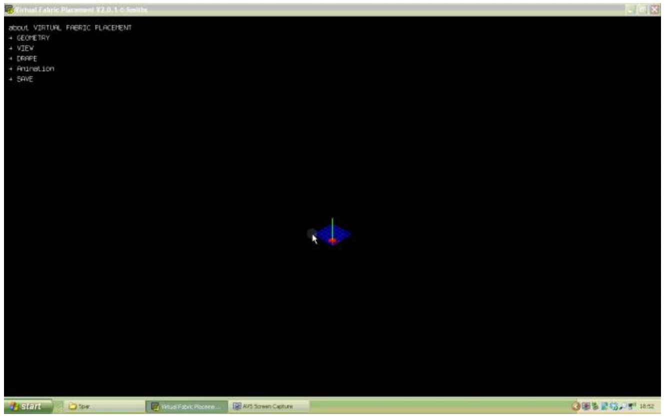
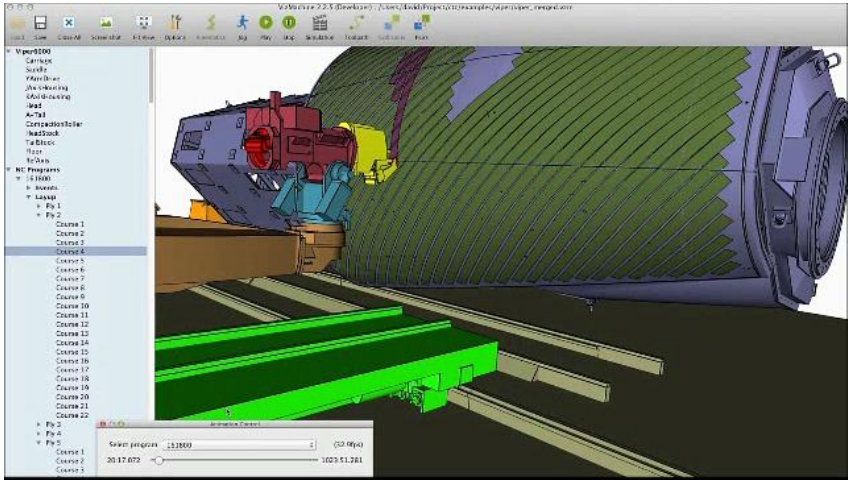
Hand-Layup



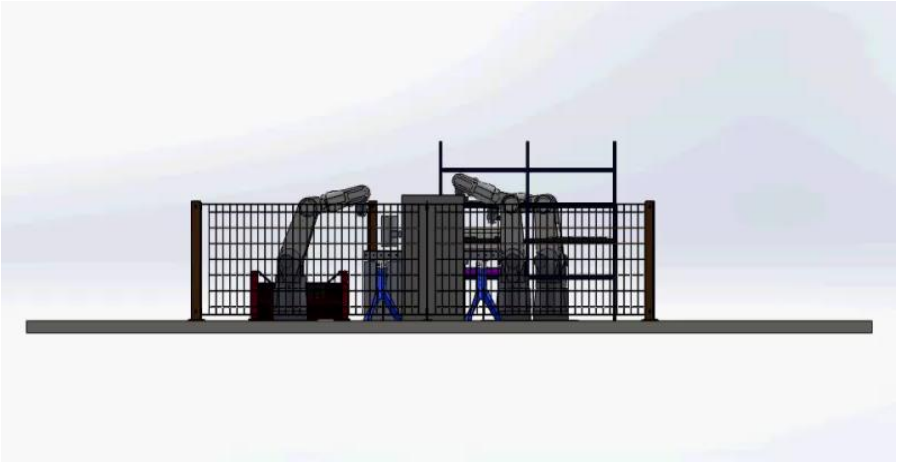
Advanced Forming



Additive Simulation



Automated Workcell



Advanced Materials at Autodesk

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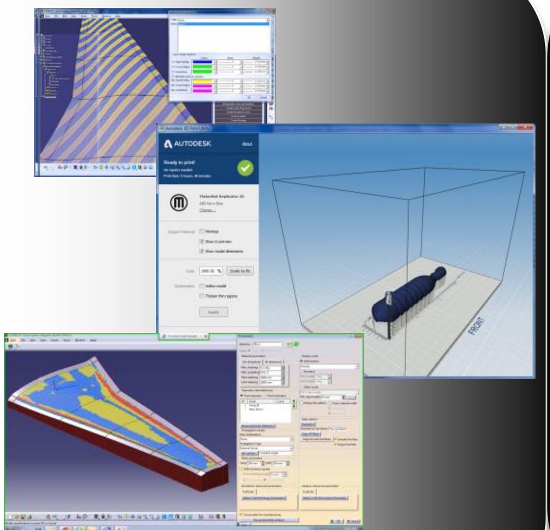
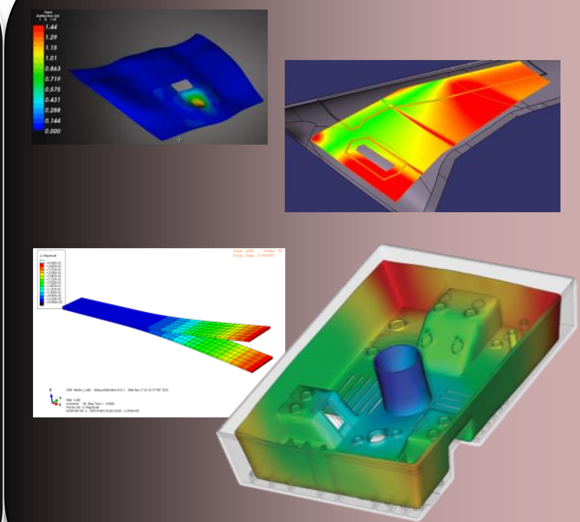
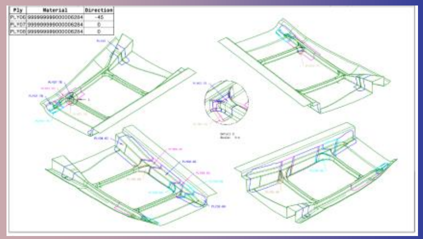


Design



Simulate



Make

Materials Database

Contact Info

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