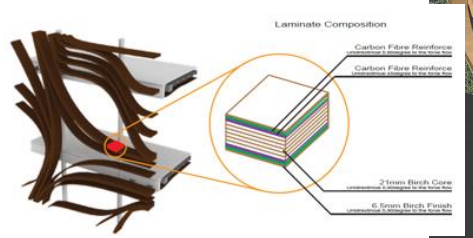
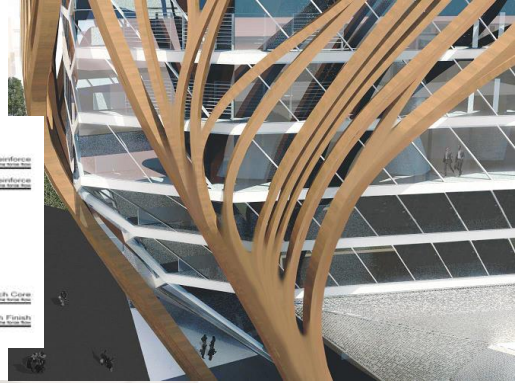
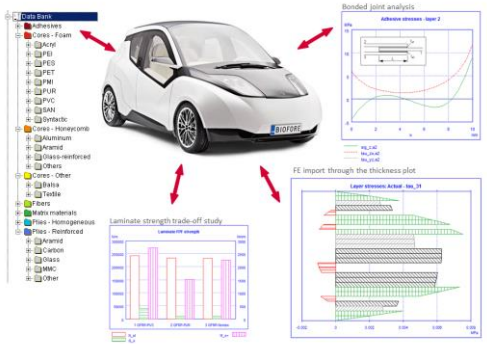
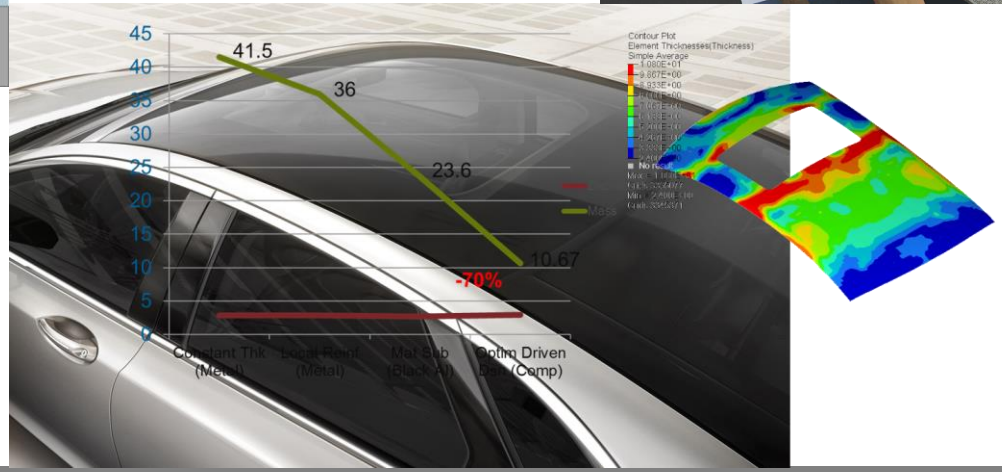
Buckling load cases by 10% & deflection improved by more than 35% without increase in overall weight





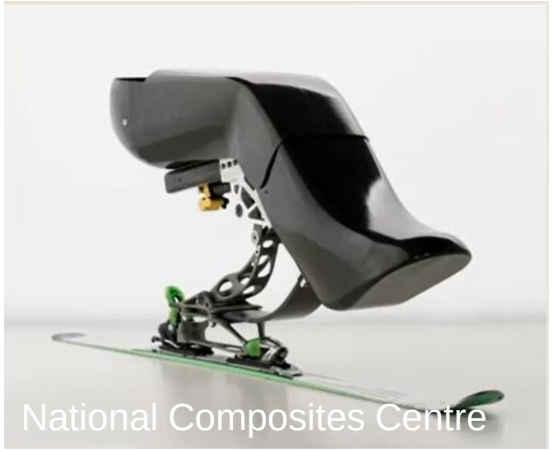




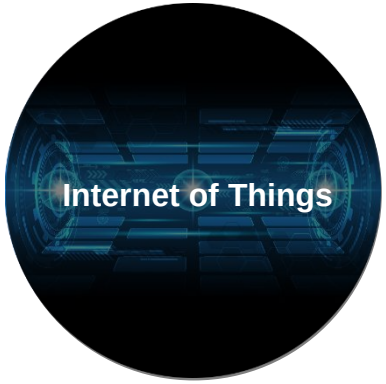
ALTAIR HYPERWORKS – EMPOWERING COMPOSITES INNOVATION THROUGH SIMULATION

Markku Palanterä • Director of Global Composites Business Development • JEC World 2019

Altair



TECHNOLOGY FOR ALL PRODUCT LIFECYCLE STAGES



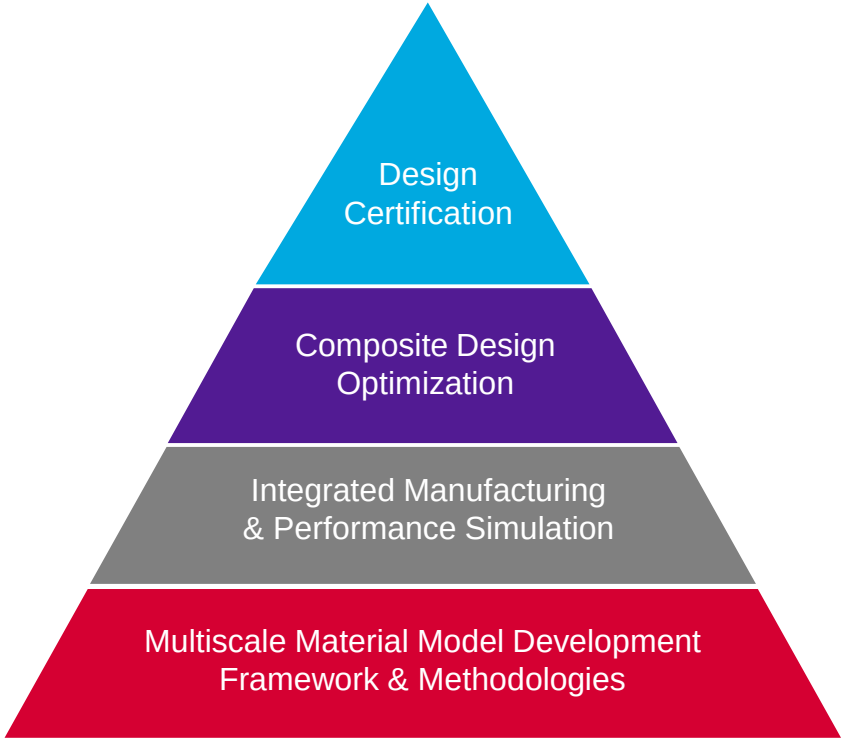
Altair solidThinking™ | Altair HyperWorks™ | Altair SmartWorks™ | Knowledge Works™

Altair Partner Alliance

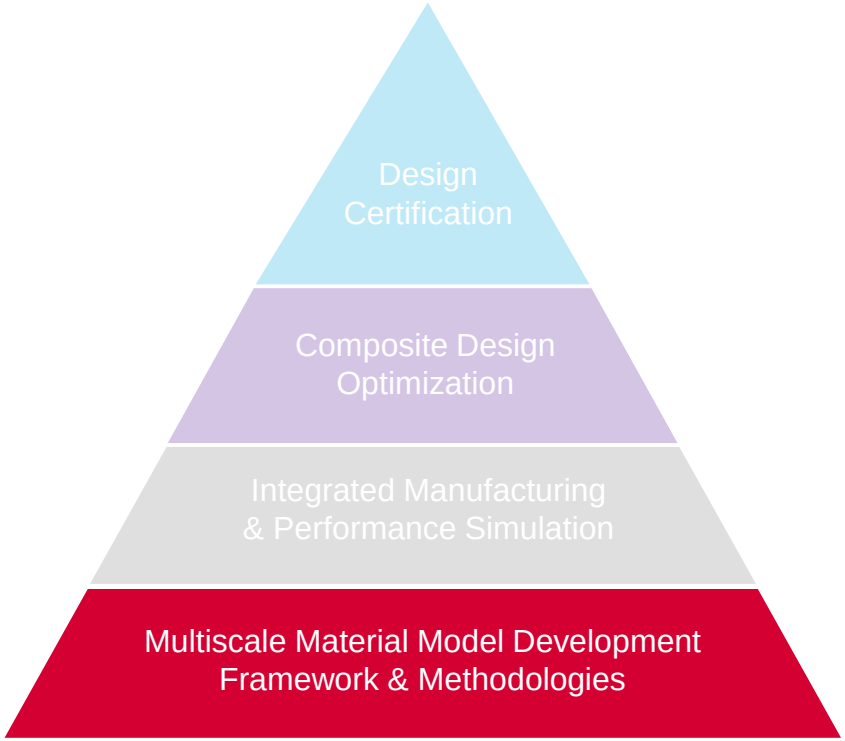
Enterprise-wide enablement
40+ Altair products and 150+ Partner apps
Leveling/Decay functions
Seamless cloud bursting

Altair PBS Works™

COMPOSITE SOLUTIONS IN ALTAIR HYPERWORKS



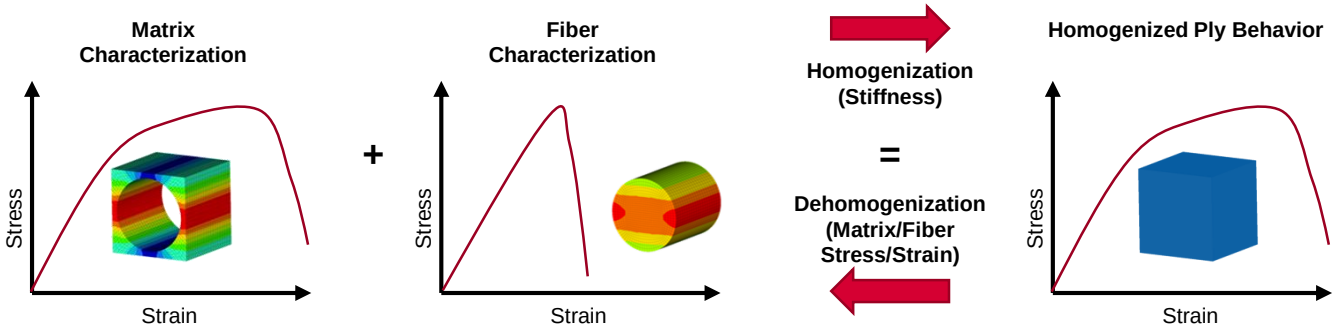
MULTISCALE MATERIAL MODEL DEVELOPMENT



MATERIAL MODEL DEVELOPMENT FOR COMPOSITES

Altair Multiscale Designer™

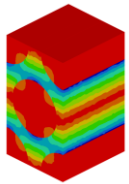
- Predictive Multiscale Material Models from the Linear Regime to Ultimate Failure requiring minimum experimental data

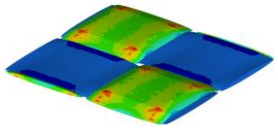


- For all Heterogeneous Materials
- Forward Homogenization vs. Inverse Characterization
- Stochastic Module – Virtual Allowables

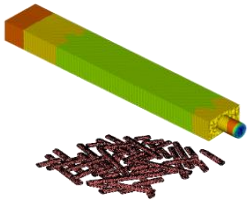
MULTISCALE SIMULATION OF STRUCTURES

Continuous Reinforcements (Unidirectional and Weaves)





Short/Long Reinforcements (Injection Molding)

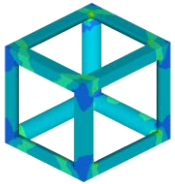


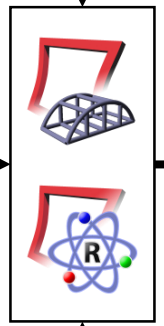
Fiber Orientation Generation and Mapping

MOLDFLOW

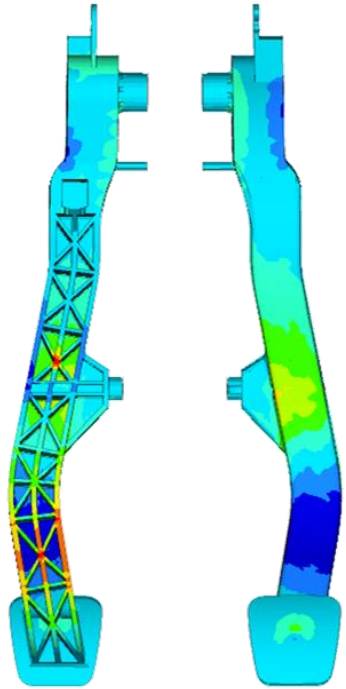
Moldex3D MOLDING INNOVATION

Lattice Structures



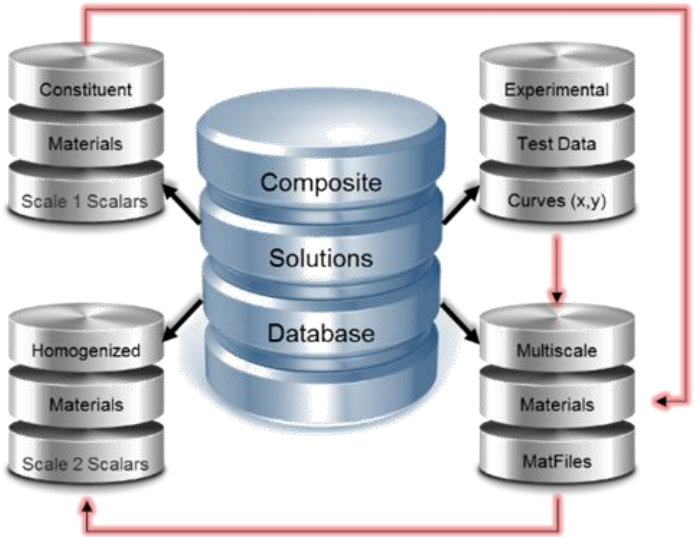


Multiscale Simulation of a Component

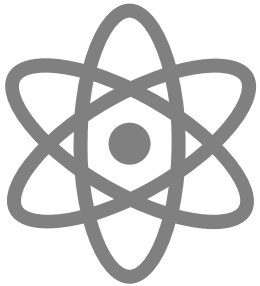


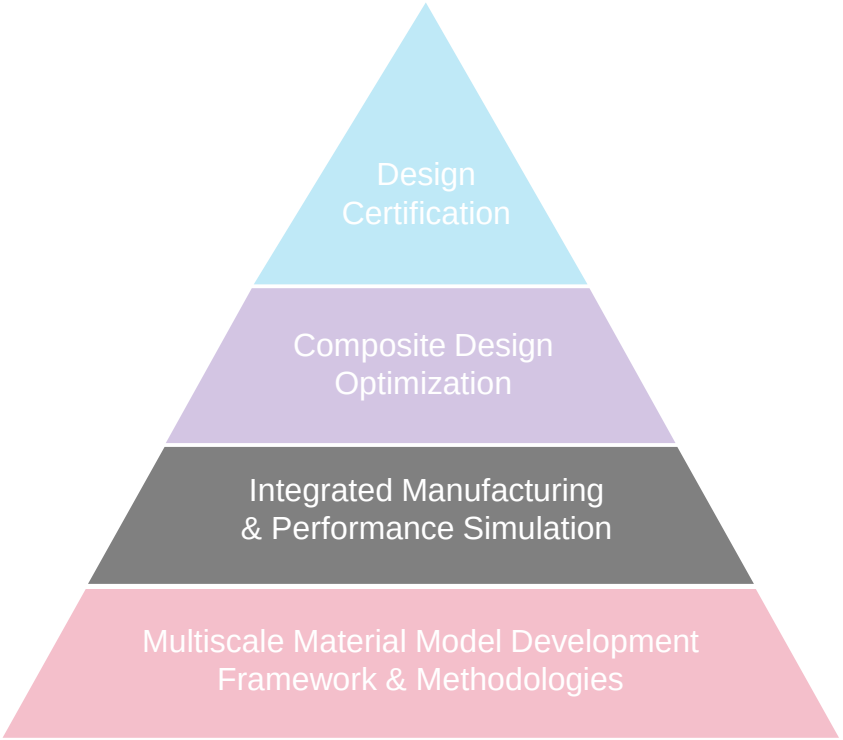
COMPOSITE SOLUTIONS MATERIAL DATABASE

- Experimental test data
- Constituent materials
  - Fibers, polymers, adhesives,…
- Multiscale material models
  - Developed from experimental test data and constituent material data using Altair Multiscale Designer™
- Homogenized materials
  - “Legacy” experimental data
  - “Virtual allowables” created using multiscale material models
  - Altair ESAComp™ database (1000+ material systems)



INTEGRATED MANUFACT. & PRODUCT PERFORMANCE SIMULATION

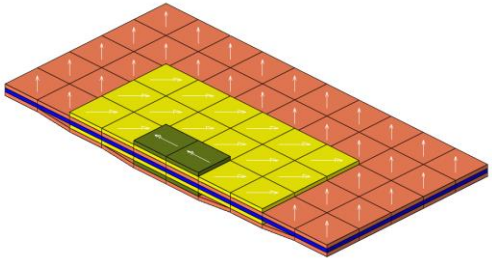


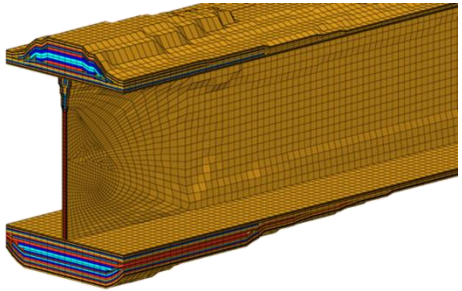


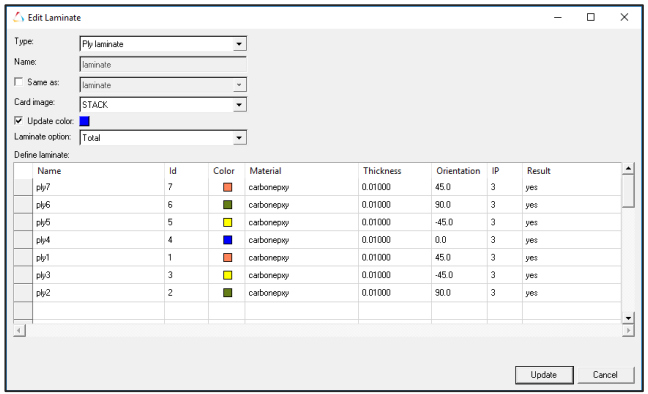
ADVANCED PRE FOR COMPOSITE DESIGN & ANALYSIS

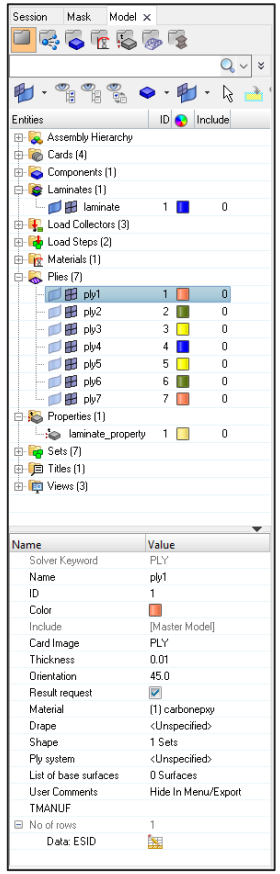
Altair HyperMesh™

- Ply-Based Modeling
  - Plies defined as physical objects with shape
  - Stack plies to make a Laminate
  - Direct relationship to the manufacturing process improves Modeling and Interoperability





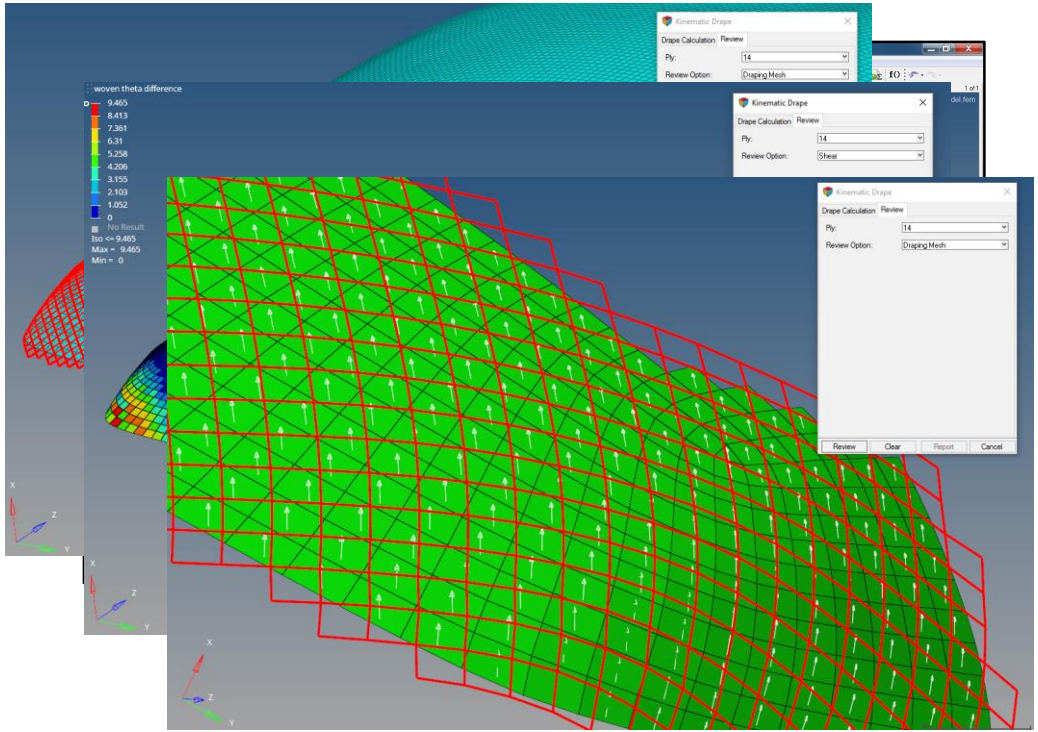




MANUFACTURING SIMULATION – DRAPING

Altair HyperMesh™

- Drape Estimator
- Kinematic Drape



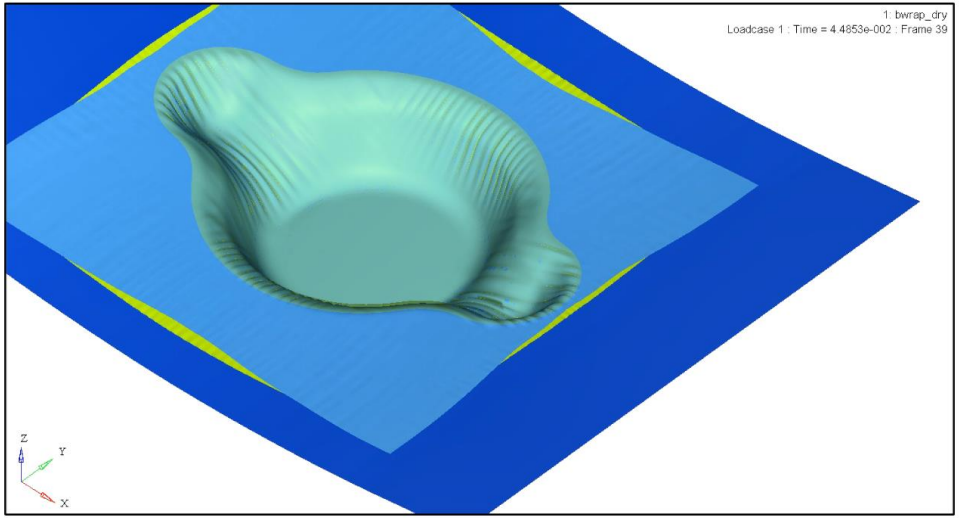
MANUFACTURING SIMULATION – DRAPING

Altair HyperMesh™

- Drape Estimator
- Kinematic Drape

Altair Radioss™

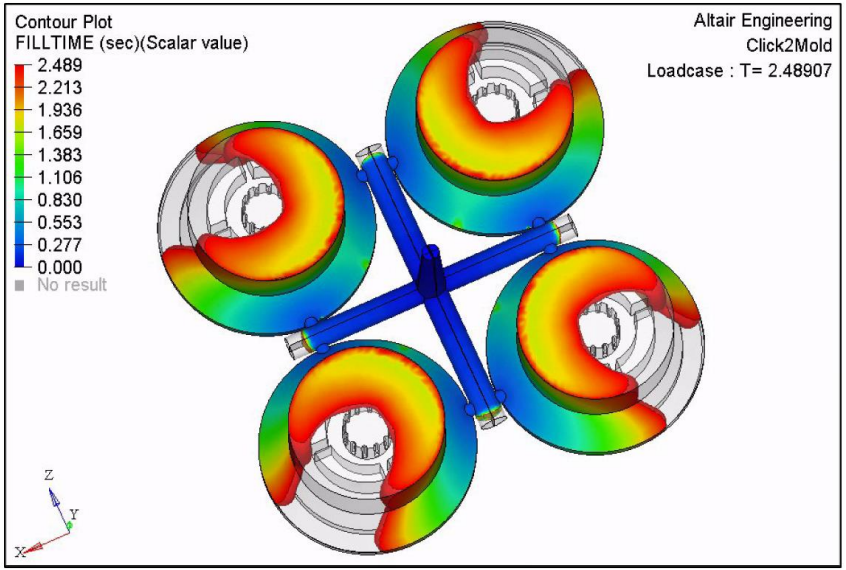
- Explicit FEA based draping



MANUFACTURING SIMULATION – INJECTION MOLDING

Altair Inspire Mold™

- Released in 2019
- Simulates all stages of the injection molding process
  - Filling, Packing, Cooling, Part Warpage (after ejection)
- Help identify product defects
  - Air traps, Sink marks, Weld lines, Short shots, …
- Integration with Altair Multiscale Designer™
  - Mechanical and thermal properties of composite based on simulated fiber orientation distributions
  - Warpage and Strength



ADVANCED SOLVERS FOR COMPOSITE DESIGN & ANALYSIS

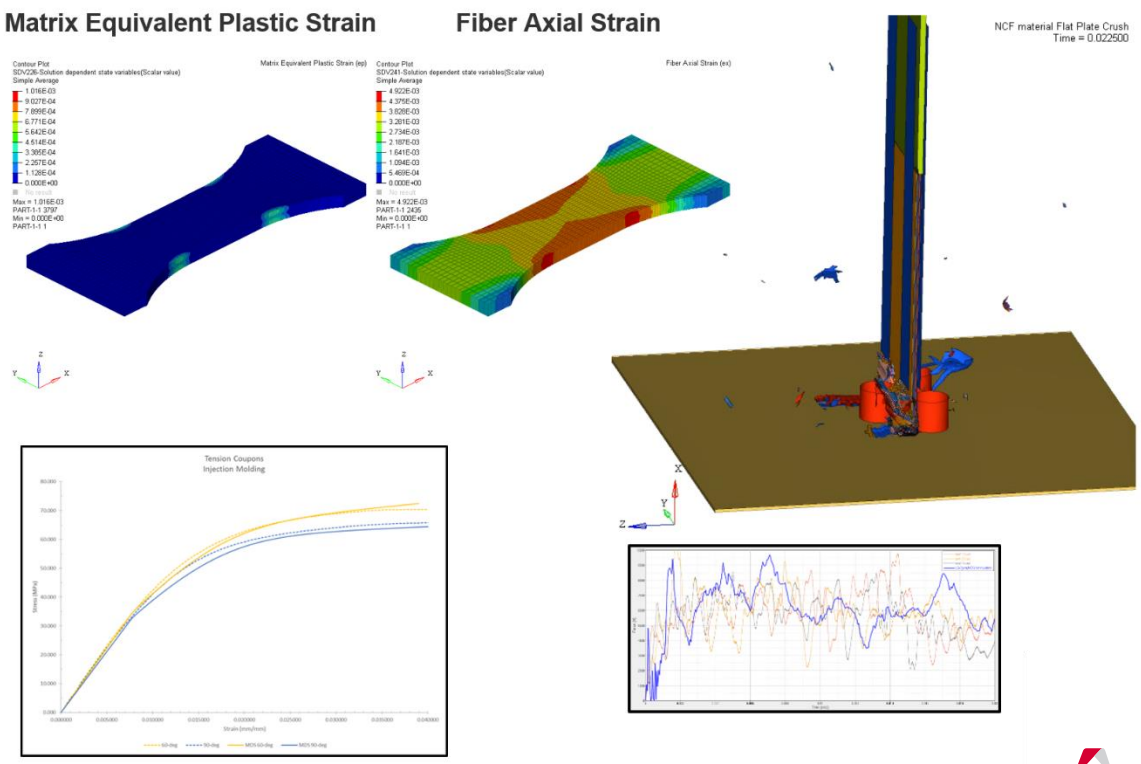
Altair OptiStruct™

- Implicit Linear and Nonlinear

Altair Radioss™

- Explicit Impact and Crash

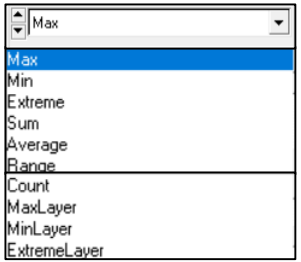
- Large Displacement
- Material Models with Failure (Damage & Plasticity)
- User Defined Materials
- Contact
- …

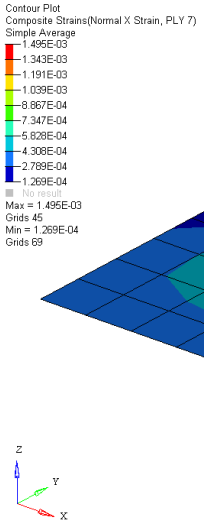


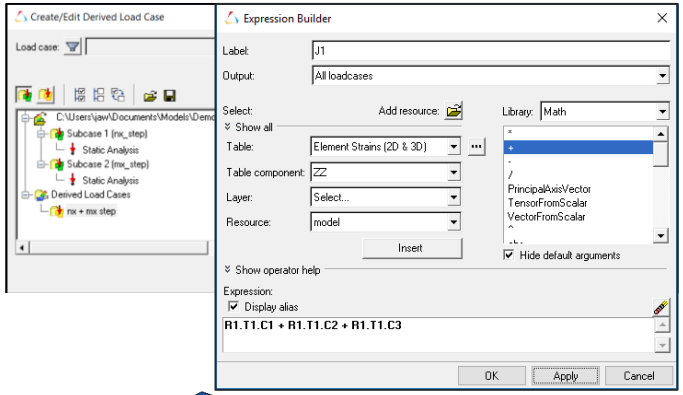
ADVANCED POST FOR COMPOSITE DESIGN & ANALYSIS

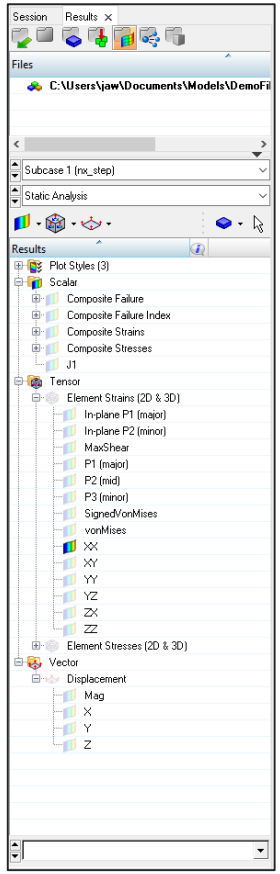
Altair HyperView™

- Ply-Based Results
  - Stress/Strain Tensor Components
  - Principal/Invariant Stress/Strain
  - Traditional Failure Theories (Max Strain, Tsai-Wu, …)
  - Derived Load Cases
  - Derived Results
  - Enveloping

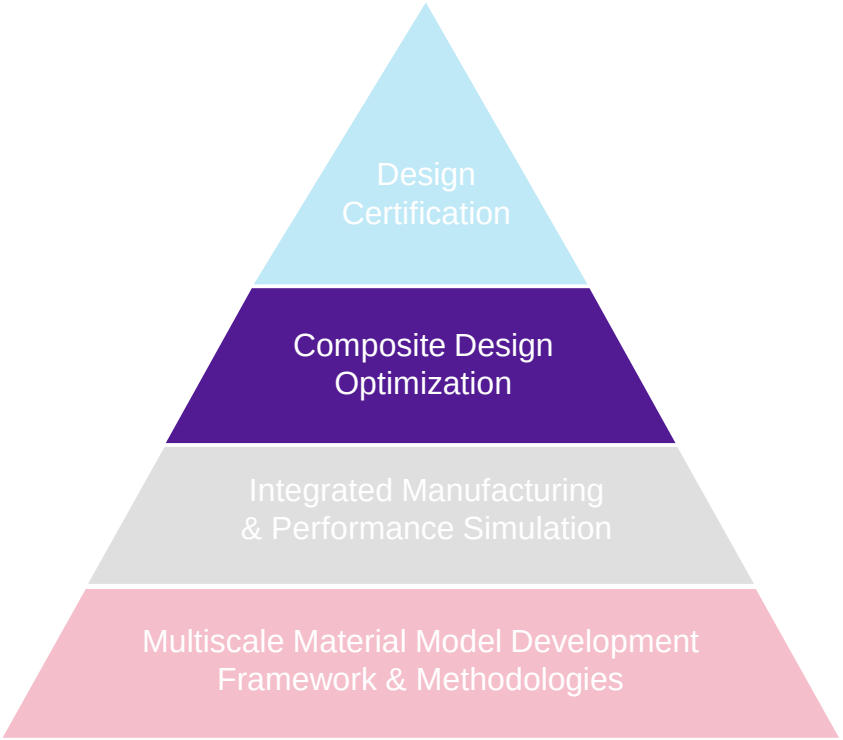








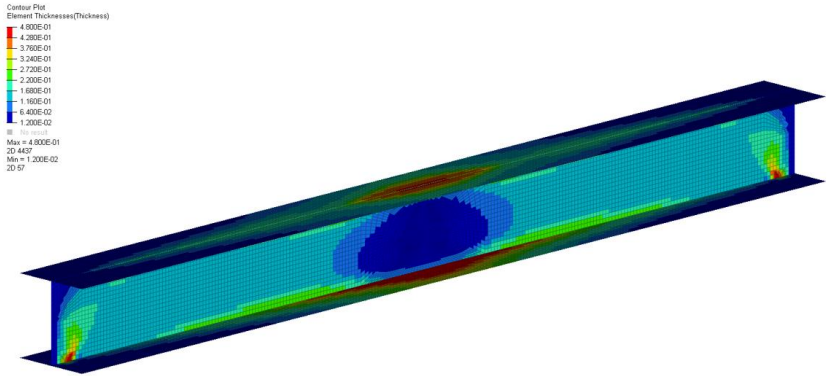
COMPOSITE DESIGN OPTIMIZATION



COMPOSITE DESIGN OPTIMIZATION

Altair OptiStruct™

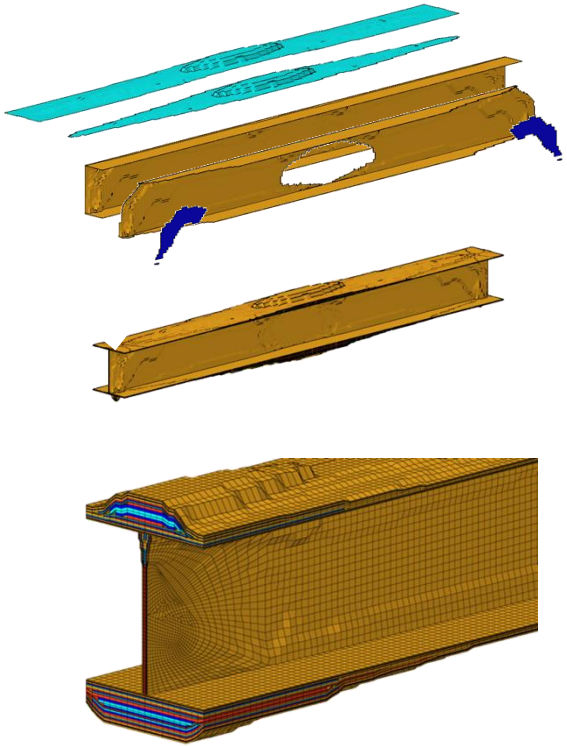
- Topology
- Composite Free-Size / Size Optimization
  - What are the most efficient ply shapes?
  - How many of each ply shape required?



COMPOSITE DESIGN OPTIMIZATION

Altair OptiStruct™

- Topology
- Composite Free-Size / Size Optimization
  - What are the most efficient ply shapes?
  - How many of each ply shape required?
- Actual plies
- Repeat laminates
  $[(\theta/0/-\theta/90)_n(\phi/0/-\phi/90)_m]_s$



COMPOSITE DESIGN OPTIMIZATION

Altair OptiStruct™

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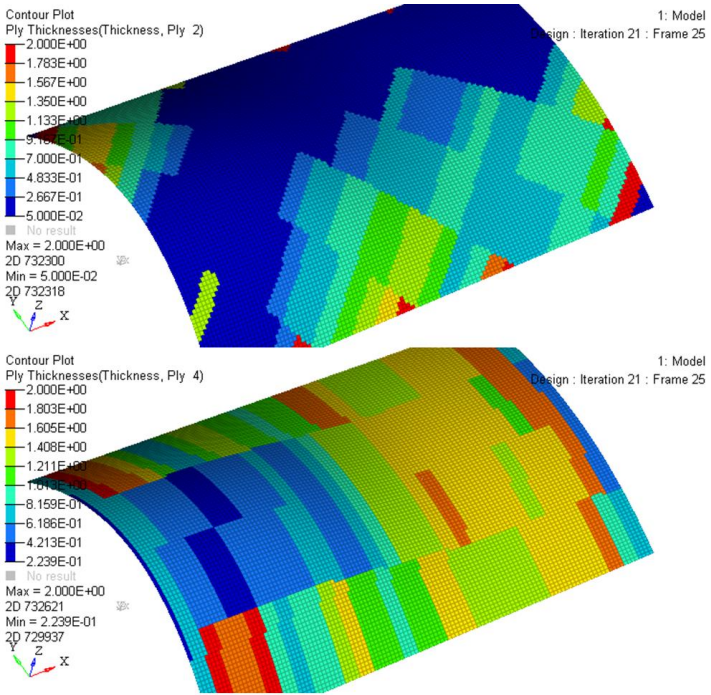
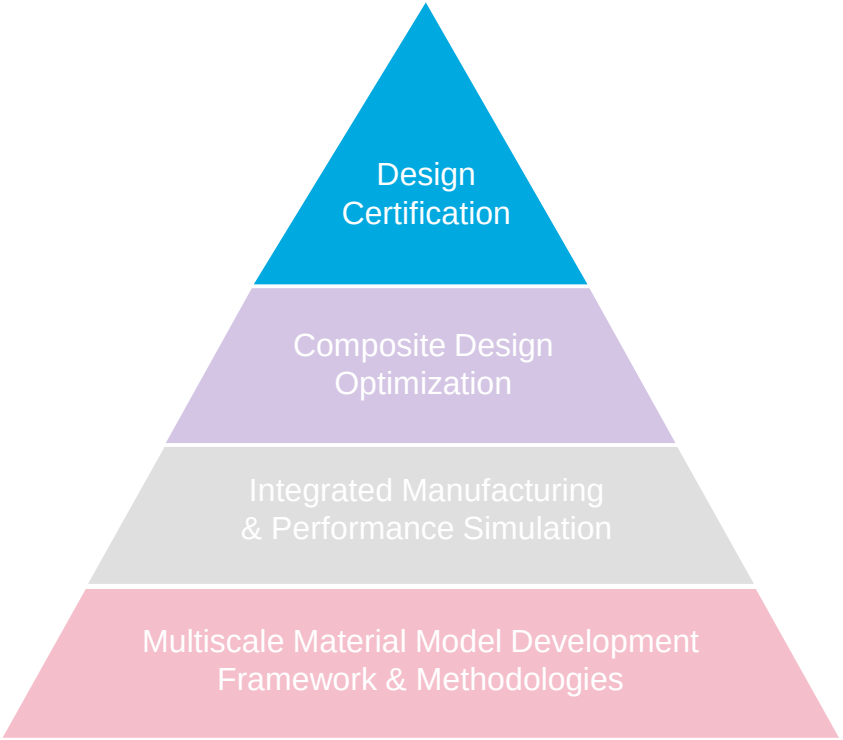
  - What are the most efficient ply shapes?
  - How many of each ply shape required?
- Actual plies
- Repeat laminates $[(\theta/0/-\theta/90)_n(\phi/0/-\phi/90)_m]_s$
- Automated Tape Laying (ATL)



Altair HyperStudy™

- Platform for Design Exploration

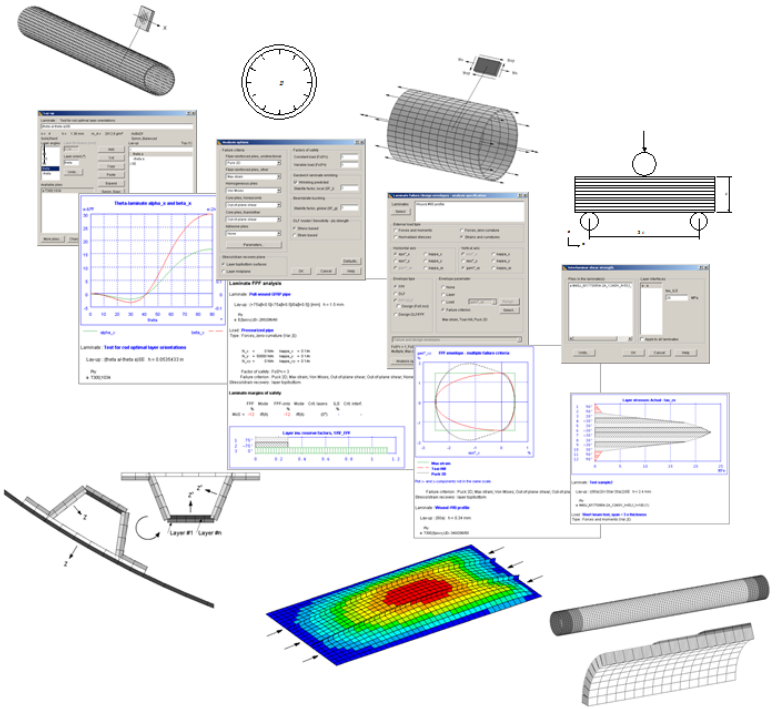
COMPOSITE DESIGN CERTIFICATION



COMPOSITE DESIGN CERTIFICATION

”Analytical Methods” for Design Certification

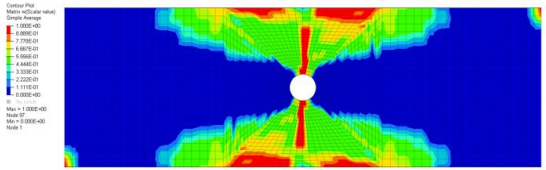
- Altair ESAComp™
  - Stress toolbox for composite design and analysis
  - Parametrically defined structural elements
  - Failure hypotheses for First Ply Failure analyses and sandwich failure modes
  - Probabilistic laminate analyses, Delamination,…
  - Full HyperWorks integration under way

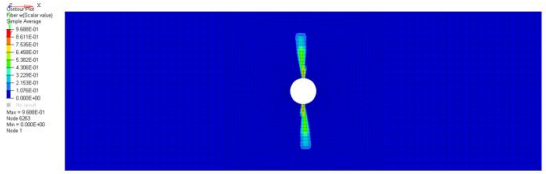


COMPOSITE DESIGN CERTIFICATION

Advanced Design Certification

- Altair Multiscale Designer™





NEW COMPOSITES ADDITION TO THE ALTAIR PARTNER ALLIANCE PORTFOLIO:

QSD® BY CETIM

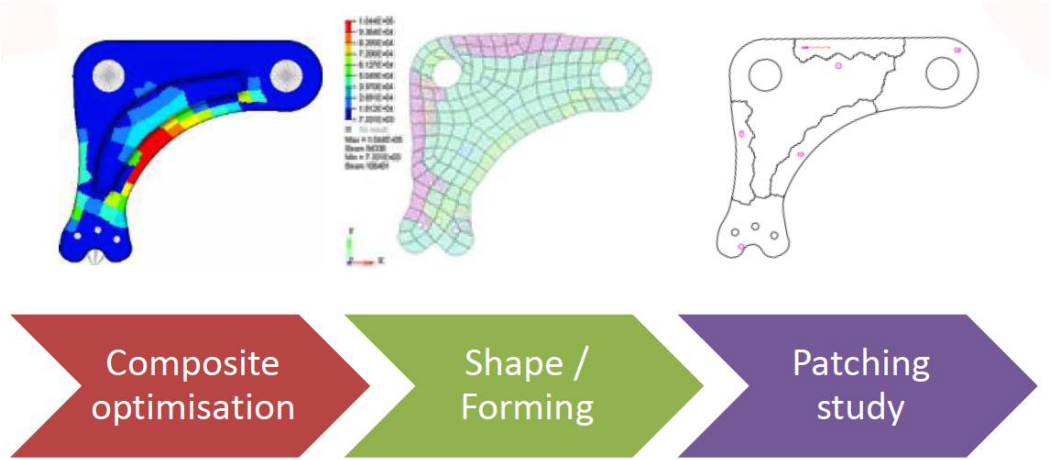
QSD® NOW AVAILABLE THROUGH THE ALTAIR PARTNER ALLIANCE

- QSD® by Cetim is intended for designers of composite material and multi-material parts.
- Offers Altair HyperWorks™ enabled designers an intuitive workflow within the Altair HyperMesh™ environment that benefits from Altair OptiStruct™ advanced technologies for a smart composite design with optimum thicknesses, fiber orientation and reduced material scraps.
- Aims at designing efficient structural parts manufactured from hot-pressed, multi-thickness preforms of thermoplastic plies. The QSD method fits with all processes creating "tailored preform" (tape placement, QSP, hand lay-up).

Learn more at altairhyperworks.com/partner/qsd

QSD® CHARACTERISTICS

- Based on an innovative methodology for composite materials optimization: “Stiffness matching”
- Reduced CPU time
- Easy identification of the maximum performance for your application
- Integration of the forming manufacturing process by means of Drape Estimator®
- An algorithm which identifies the optimum lay-up (thickness/orientation) and integrates the design/manufacturing compromise



Learn more at altairhyperworks.com/partner/qsd

Altair

JEC WORLD 2019 The Leading International Composites Show
March 12-13-14, 2019 | PARIS-NORD VILLEPINTE

Technical Demonstrations Program
Altair Booth G97 - Hall 5

Tuesday March 12, 2019

11:00 am **CKP Engineering / Micado/iNumlab Partner Presentation**

Structures lightweighting : How to improve technical functionalities, optimize cost and lead time reduction without modifying initial function of a water ski

3:30 pm **Altair Presentation**

Virtual test lab - Optimal experiment to simulation ration to minimize cost and time

4:00 pm **Altair Presentation**

Process and structural simulation of an injection molded fiber- reinforced composite part

4:30 pm **Altair Presentation**

Modeling & crash simulation of an automotive component

5:00 pm **Altair Presentation**

Modeling, optimization and structural simulation of an aerospace component

Wednesday March 13, 2019

10:30 am **Altair Presentation**

Virtual test lab - optimal experiment to simulation ration to minimize cost and time

11:00 am **Altair Presentation**

Process and structural simulation of an injection molded fiber- reinforced composite part

11:30 am **CETIM QSD® Partner Presentation**

The design-to-cost software solution to optimize your composite parts (also available on the CETIM Booth #D85 – hall6)

13:30 pm **CKP Engineering / Micado/iNumlab Partner Presentation**

Structures lightweighting : How to improve technical functionalities, optimize cost and lead time reduction without modifying initial function of a water ski

2:00 pm **Altair Presentation**

Modeling & crash simulation of an automotive component

2:30 pm **Altair Presentation**

Modeling, optimization and structural simulation of an aerospace component

Thursday March 14, 2019

10:30 am **Altair Presentation**

Modeling & Crash Simulation of an Automotive Component

11:00 am **Altair Presentation**

Modeling, Optimization and Structural simulation of an Aerospace Component

11:30 am **CETIM QSD® Partner Presentation**

The design-to-cost software solution to optimize your composite parts (also available on the CETIM Booth #D85 – hall6)

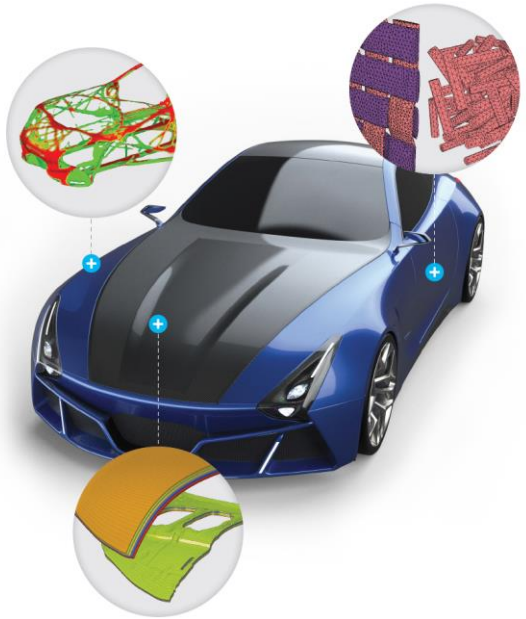
2:00 pm **Altair Presentation**

Virtual Test Lab - Optimal Experiment to Simulation Ration to minimize cost and time

2:30 pm **Altair Presentation**

Process and Structural Simulation of an injection Molded Fiber- reinforced Composite Part

THANKS!



altair.com/composites

Markku Palanterä <markku@altair.com>