SIEMENS
Ingenuity for life

Advanced composite simulation

Simcenter 3D Launch

Product & technology evolution in the different industries

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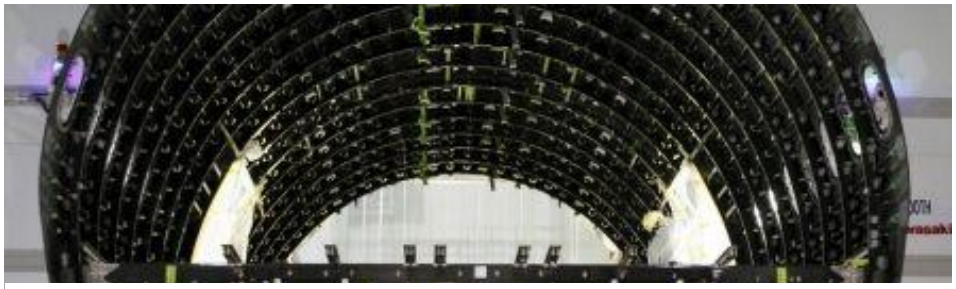
From mechanical components to Smart Systems integrating mechanical, electrical, controls



From known material and production methods to mixed materials, novel production methods

TREND

Increasing product development complexity driven by smart products, new materials and manufacturing methods and increased customization.

IMPLICATION

Current practices inadequate to meet new demands. More unknowns imply longer lead times and greater risk products will not perform as intended leading to lost opportunities and dissatisfied customers.

Issues facing 3D CAE today

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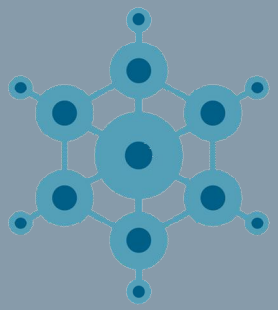
Verification only

Out of synch with design



Disconnected tools & dataflow

Lack of flexibility

Be more efficient

Enable new insights

SIMCENTER 3D: The response to CAE challenges

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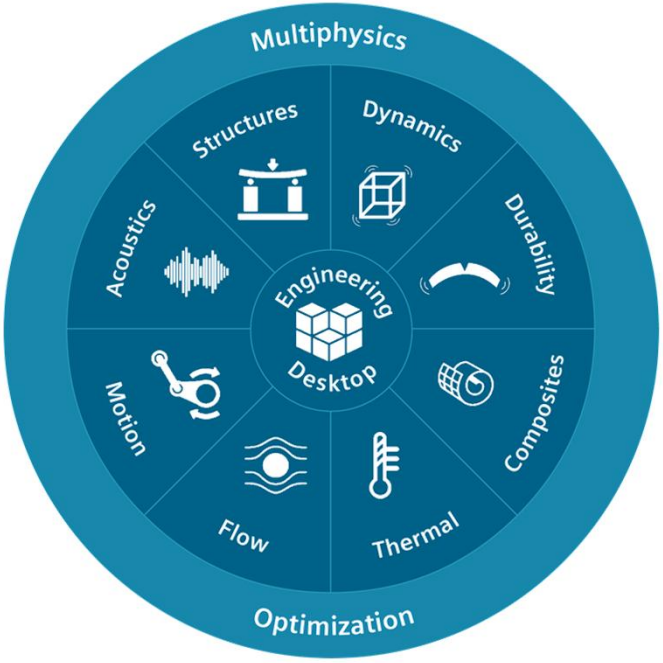

Broad range of physics simulation solutions in a single environment

- Fast and accurate solvers
- Fully coupled multi-physics solutions
- Scalable performance on high performance computing (HPC)
- Licensing flexibility : cloud, tokens
- Backed by Siemens industry expertise

Simcenter 3D Engineering Desktop

Single modelling environment open for external solvers and CAD

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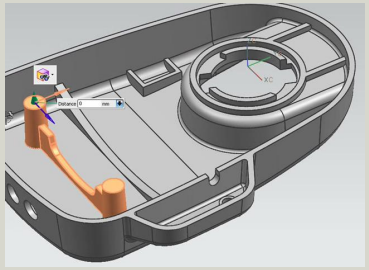
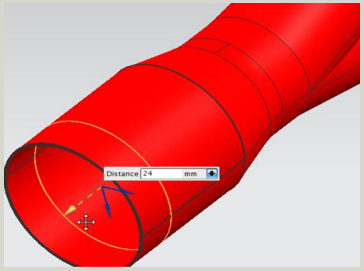
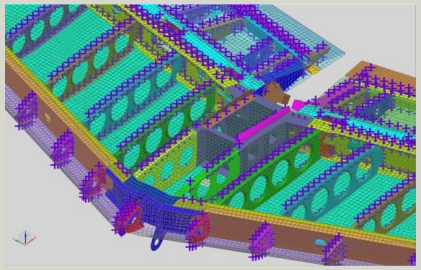
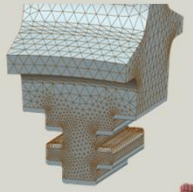
Synchronous Technology for Multi-CAD Geometry Editing

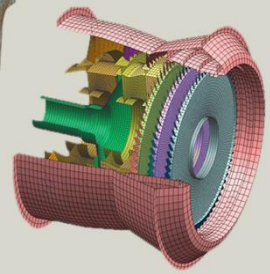




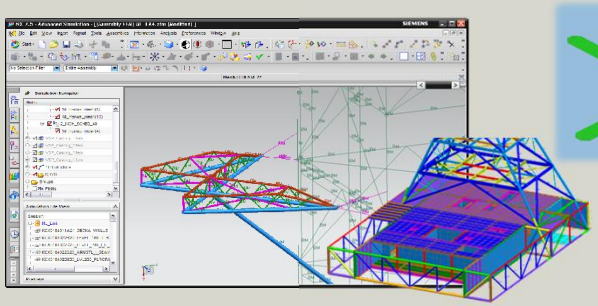
Advanced Meshing, Mid-Surfacing

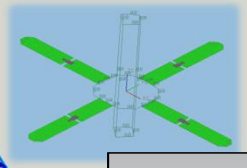


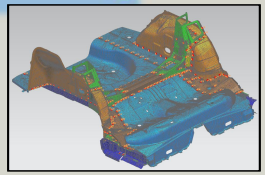




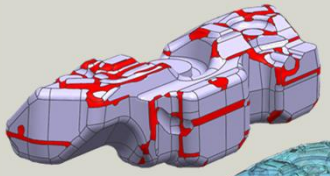
FE Assembly Management

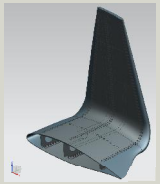


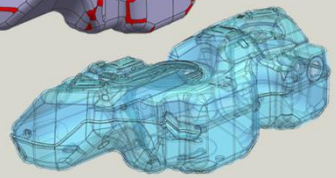


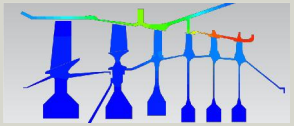


Multi-discipline Modeling









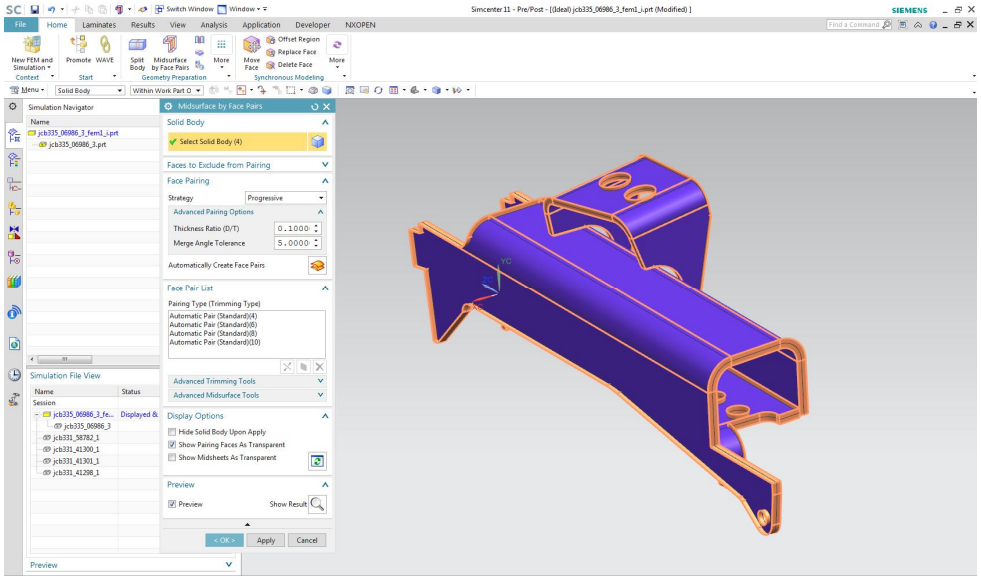
Technical capabilities

Highly efficient for model preparation AND what-if studies

SIEMENS

Simcenter embeds various efficient tools for model preparation with associative meshing.
Bringing engineers: very efficient design change, what-if, up to optimization capabilities.

- **Efficient mid-surfacing** replaces solid geometry with surface geometry faster
- **Automated face-pairing and trimming** with multiple bodies
- **Automatic free edge stitching** reduces manual editing
- **One-click updates** eliminate manual intervention as base geometry changes



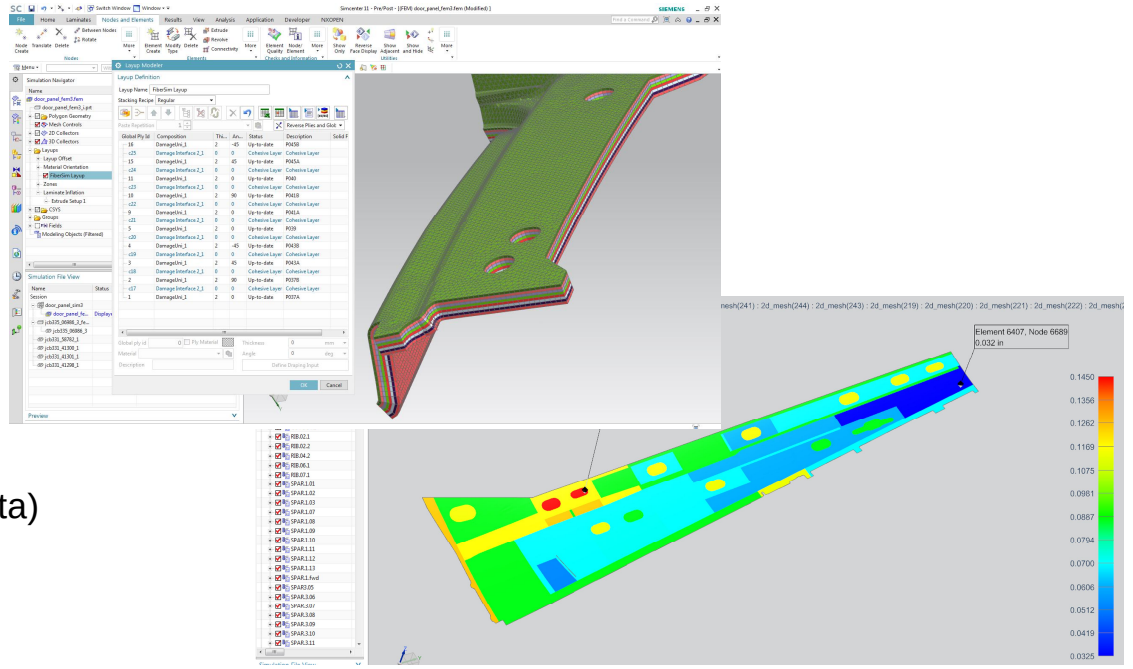
Technical capabilities
Simcenter Laminate Composite

SIEMENS

Fully integrated to the composite development process .
Efficient (drive the complete process), openness (support multiple FE solvers), customizable

Core Capabilities...

- **Laminate Modeling** (Zone based, Ply based)
- **Composite Materials** (Ply material…)
- **Laminate Failure** (Several criteria + User defined)
- **Laminate Validation** (ADB matrix)
- **SC FE Solver Interfaces** (Samcef, NX Nastran…)
- **Laminates Post Reporting** (3D view, tabulated data)

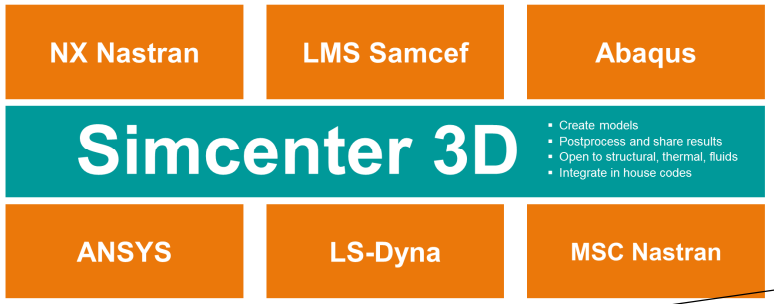


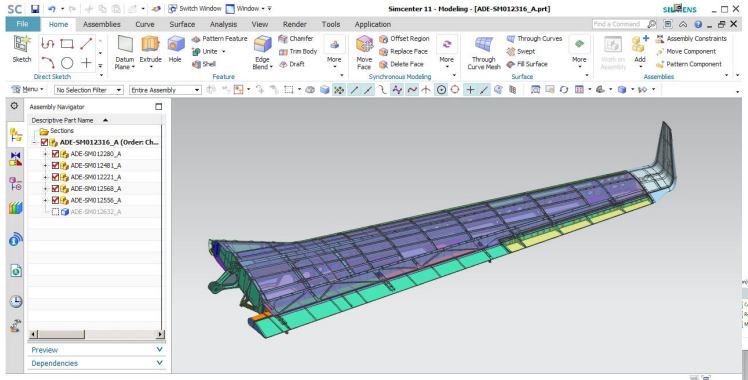
Technical capabilities

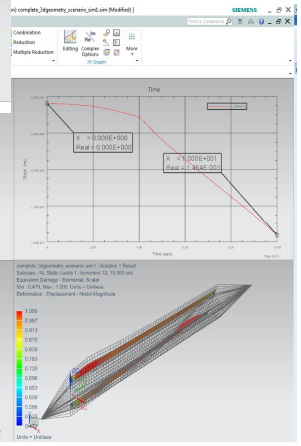
Unique Combination of Range and Depth

SIEMENS

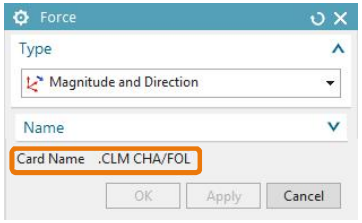
Simcenter is the only product (Pre, Post, Solver) which combines **RANGE** and **DEPTH**
Bringing engineers: a highly efficient process complemented with high fidelity simulations



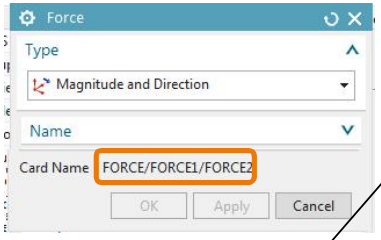




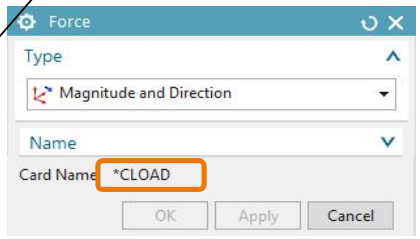
Samcef

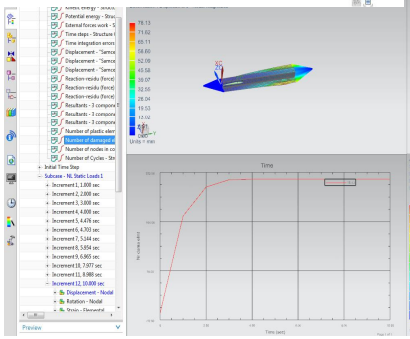


NX Nastran



Abaqus





Ansys
LS-Dyna
...

Simcenter 3D Engineering Desktop
Direct access to own and 3rd party solvers

SIEMENS

NX Nastran

LMS Samcef

Abaqus

Simcenter 3D

- Create models
- Postprocess and share results
- Open to structural, thermal, fluids
- Integrate in house codes

ANSYS

LS-Dyna

MSC Nastran

Simcenter 3D for Composite

Finite Element solver

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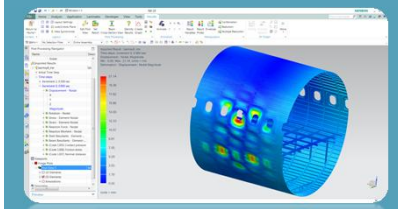
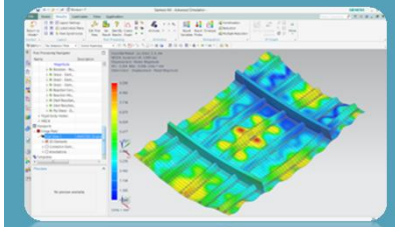
Strength / Stiffness Analysis / Linear Response



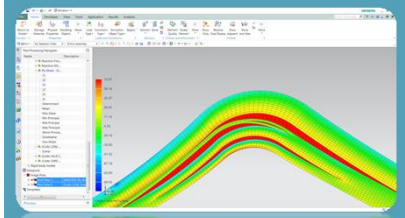
- Displacement
- Stress
- Strain
- Frequencies
- …

Buckling and Post Buckling analysis



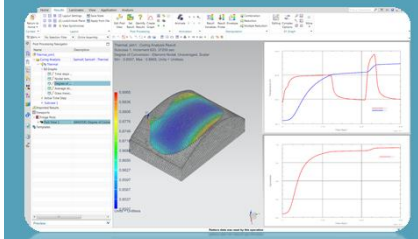
- Nonlinear with large displacements/rotations, large strains & various types of contact and gluing conditions
- Dedicated algorithm for buckling, post-buckling

Progressive damage simulation



- Classic Failure criteria computed directly by FE solver (performance): critical ply, value, load case
- Progressive damage simulation for inter- or intra-laminar damage modeling

Manufacturing simulation



- Curing analysis (spring-back)
- Effects on the mechanical behavior and the tolerance for assembly.

Curing simulation
Physical mechanism

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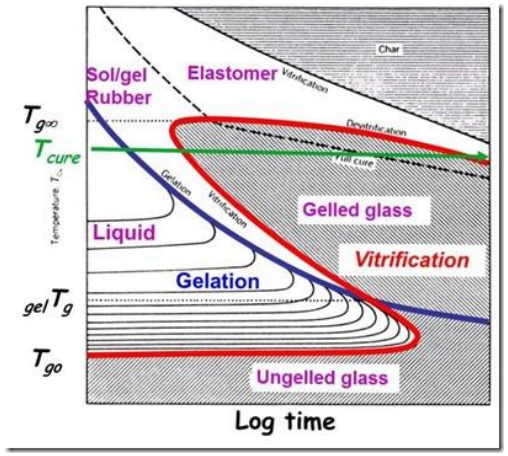
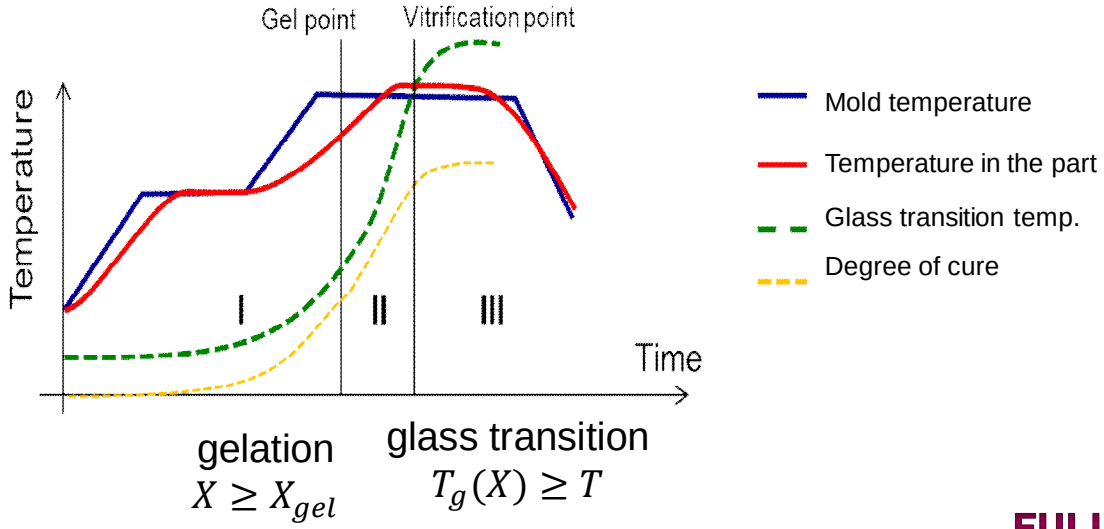
Thermal modeling: evolution of temperatures, degree of cure, T_g over time and space





gelation
$X \geq X_{gel}$

glass transition
$T_g(X) \geq T$

UNCURED RESIN → **Purely viscous** → **no load, no residual stress** → **I. LIQUID**

→ **Visco-elastic** → **stress generation but relaxation** → **II. RUBBERY**

→ **Elastic** → **linear behavior** → **III. GLASSY** → **FULLY CURED RESIN**

Simcenter 3D for Composite
Manufacturing Simulation

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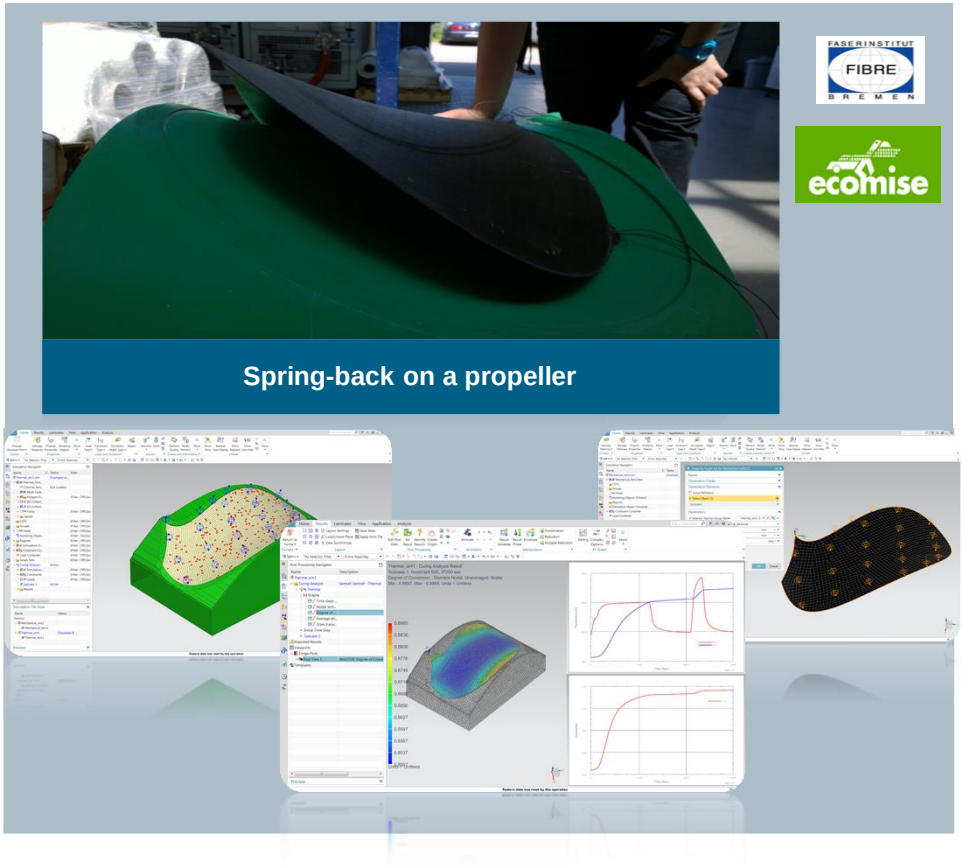
Challenge
- Predict the effects of the manufacturing process
- Predict the performances of the part, taking into account the effects of the manufacturing process

Solution
- Coherent virtual process (draping approach, a sequential coupled thermochemical, thermo mechanical analysis)
- Parameterized solution

Benefits
- Better knowledge of the composite structural performance: “As-Planned” vs “As-Built”
- Accurate values and the correct estimation of the residual stress of the component



Spring-back on a propeller

NAFEMS Seminar: Simulation von Composites, 2014
“Virtual process chain combined with online process monitoring for first time right manufacturing of composite structures” Brauner C., Miene A., Hermann: FASER Institute, Bremen University
Bruyneel M., Pascon F: SAMTECH (Siemens Company), Liège

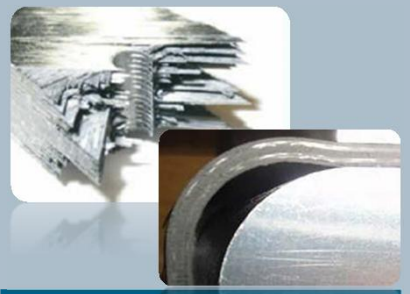
Simcenter 3D for Composite

Progressive damage simulation

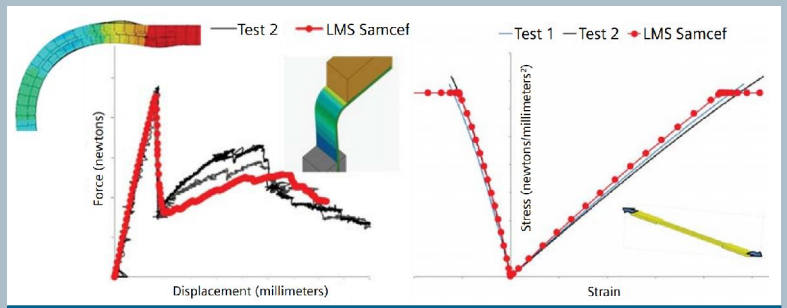
SIEMENS

- **Predictive damage models at the coupon level and at composite subsystem design concept level**
- **Development of the parameter identification procedure, based on a limited amount of physical tests on coupons**

Target: reaching 50 percent weight reduction by 2020 or 2030



Damage on a specimen after test



Innovative methodology for progressive damage analysis of composites

- LMS Samtech Samcef Mecano non-linear finite element solver
- LMS Engineering Services for composite damage model identification

"Not only at Honda, but many engineers in this field think that we can still make vehicles that have a 50 percent lighter body structure using composites while maintaining the mechanical properties of the replaced metallic parts."

Yuta Urushiyama, Composite body innovation programs Honda R&D Co., Ltd.

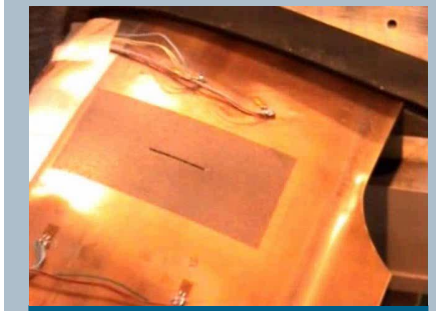
Simcenter 3D for Composite

Progressive damage simulation

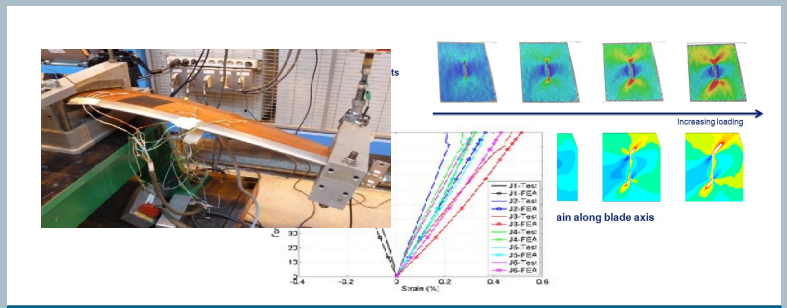
SIEMENS

- **Facilitated the engineering and analysis of complex composite structures**
- **Used improved understanding of composites to increase lead over competitors**
- **Enhanced ability to perform composite damage analysis**

Leveraging the value of composites with Simcenter 3D



Damage on a composite helicopter blade



Validate by correlation between simulation and test results

- Identify delamination and damage in composite structures
- Use nonlinear analysis to determine adequate safety margins

"Thanks to the implementation into LMS Samcef of advanced composite material laws […] Airbus Group gained much deeper physical insights, thus extending the gap with its competitors by positioning itself as the first and leading research department able to offer such advanced expertise."

Didier Guedra-Desgeorges, VP "Materials, Structures & Manufacturing Technologies" Airbus Group Innovations

Simcenter 3D for Composite

Buckling and Post Buckling analysis

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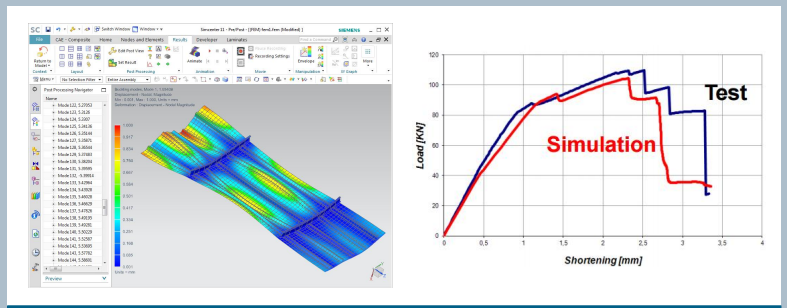
- **Virtual prototype of the stiffened panels**
- **Better knowledge of the non linear structural behavior to predict the buckling, post buckling and collapse of the structure**
- **Accurate results and fast solution procedure**

Leveraging the value of composites with Simcenter 3D

Damage on a composite stiffened panel



Correlation between simulation and test results

- Non linear analysis of thin-walled damaged stiffened composite panels: buckling, post-buckling and collapse

"In the aeronautical industry it is very important to verify that there is no risk of failure in a structural component that is allowed to buckle in flight. For that, […], it is absolutely needed to capture by analysis the most critical scenario. […] In the collapse phase, the best behavior was given by the code SAMCEF that has found the right buckling mode "

"Garteur(SM) AG-25 Post-buckling and collapse analysis", M.H. Van Houten and A. Zdunek

Simcenter 3D for Composite

A step forward in the simulation process

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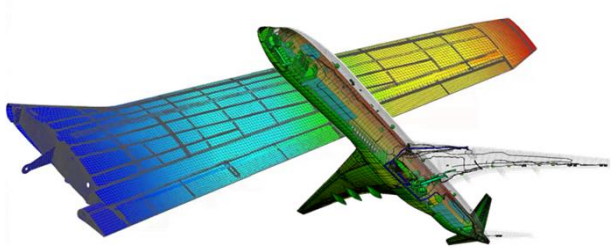
Fibersim™ for draping process

Manufacturing data set

Manufacturing optimization

Structural Analysis



Simulate as manufactured

Spring back, curing

Thermal Analysis

Production

Laminates, plies, materials definitions

Damage tolerant design

Real light weight design