Altair HyperWorks

Driving the Product Development Process of Turbomachines

1. Dresdner-Probabilistik-Workshop

Altair Engineering GmbH
Dr. Dominik Schlotz
Director Business Development
Dresden, 09.10.2008

AGENDA

- Company Overview
- HyperWorks – A Platform for Innovation
  - HyperWorks Overview
  - Altair HyperWorks Morphing Technology
  - Design Studies with solver-neutral Software Altair HyperStudy
- HyperWorks Applications
- Summary
- Q&A

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Altair – Global CAE Supplier

- Founded 1985 in Detroit, USA
- ~1400 Colleagues
- 30 Offices worldwide
- More than 3,500 Customers

Seattle, USA	Toronto, Canada	Lund, Sweden	Moscow, Russia	Beijing, China
Los Angeles, USA	Windsor, Canada	Gothenburg, Sweden		Shanghai, China
Austin, USA		Leamington, UK	Delhi, India	
Dallas, USA	Detroit, USA	Manchester, UK	Pune, India	Tokyo, Japan
	Boston, USA	Boeblingen, Germany	Bangalore, India	Osaka, Japan
	Milwaukee, USA	Cologne, Germany		Nagoya, Japan
	Atlanta, USA	Hamburg, Germany		
		Hannover, Germany		Seoul, Korea
		Munich, Germany		
		Paris, France		
	Sao Paulo, Brazil	Sophia Antipolis, France		Melbourne, Australia
		Toulouse, France		
		Torino, Italy		
		Milan, Italy		

Industry Verticals

Automotive	Aerospace	Heavy Equipment	Government / Defense	Life Sciences/ Earth Sciences	Consumer Goods / Oil & Gas
					

Over 3.500 Customers in Various Industries

Altair Technology Groups

Altair Engineering

Technology to analyze, optimize and visualize information for decision makers in business and engineering

Altair HyperWorks

PBS GridWorks

Altair ProductDesign

Computer-aided engineering software suite for product design and manufacturing

- Market leader for modeling, visualization and optimization of complex mechanical systems
- A Platform for Innovation - Powerful, open and easy to program design environment for mechanical engineers in all industries

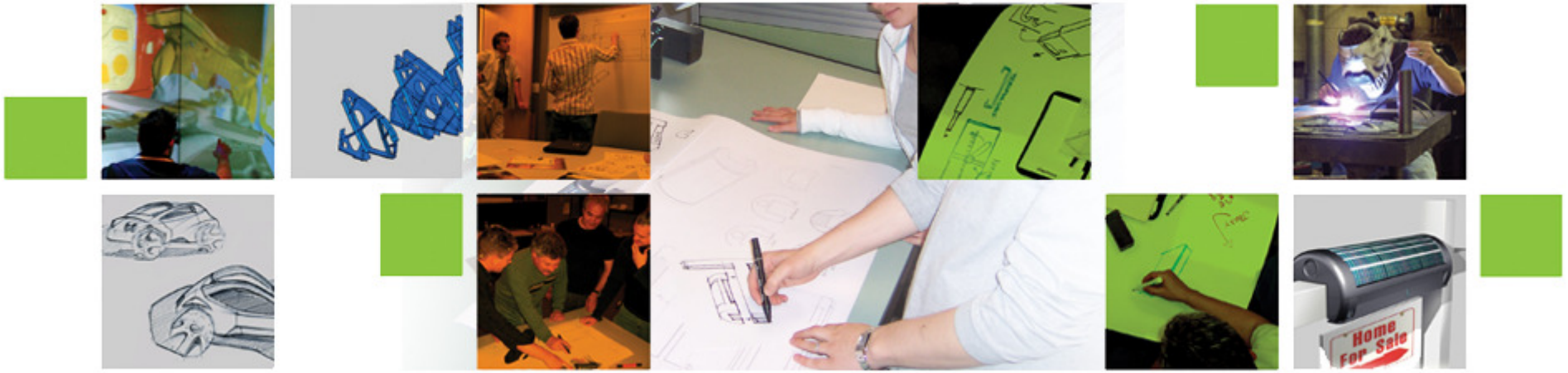
PBS GridWorks

Altair

Grid computing technology that maximizes the ROI of enterprise IT assets

- Market share leader with over 30,000 deployments worldwide
- **PBS Professional** and **OpenPBS**
- Proven scalability and reliability on the largest and most complex data centers
- Mature Eco-System partner network ensures seamless integration and ease of deployment
- ***It's EveryWare!*** - Manages heterogeneous mix of Unix, Linux and Windows systems

The shortest distance between concept and reality



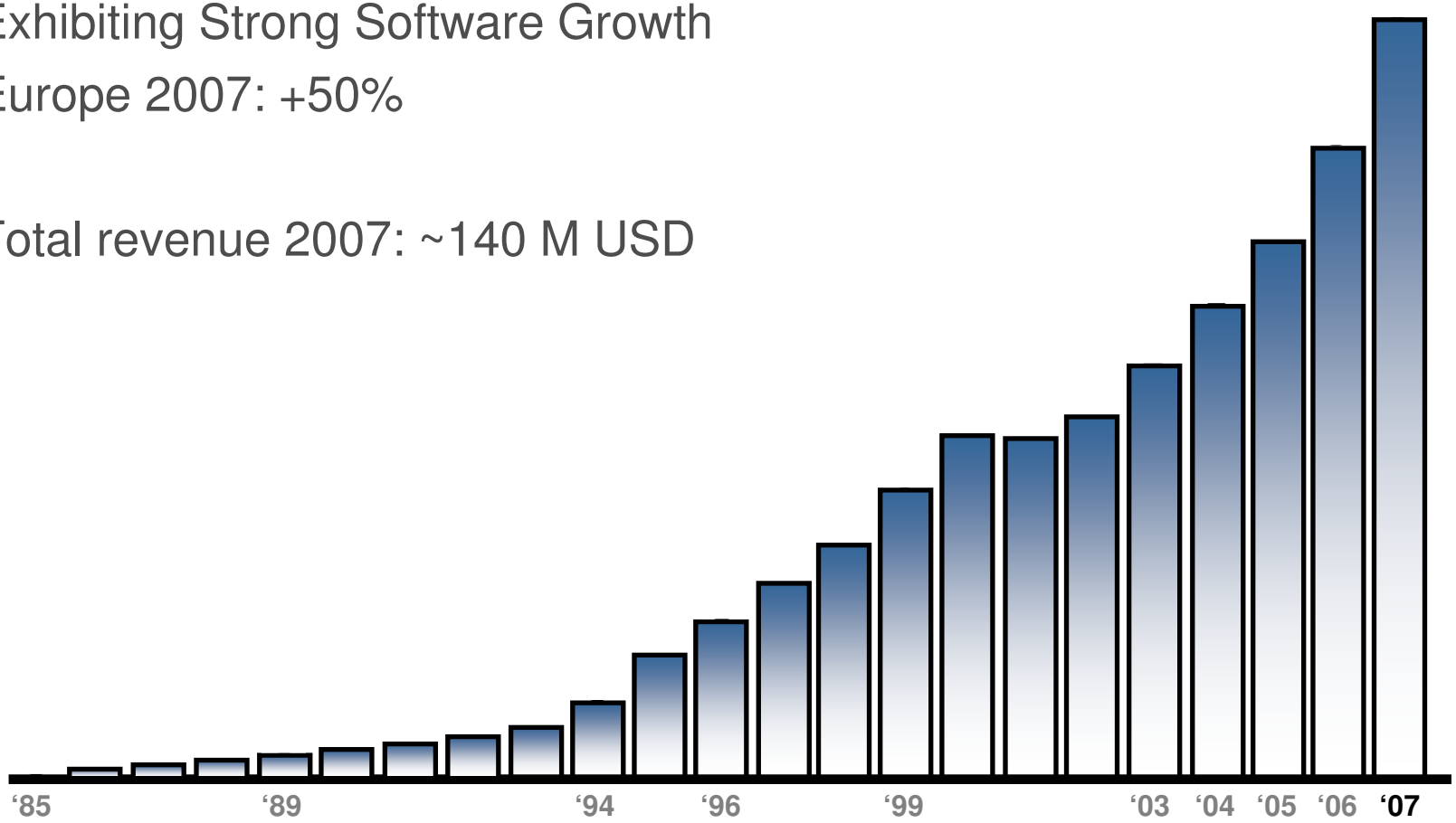
High value and innovative product design, process mapping
and automation consulting services

Altair Engineering Inc.

Exhibiting Strong Software Growth

Europe 2007: +50%

Total revenue 2007: ~140 M USD



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Altair HyperWorks - Overview

Modeling & Visualization

Finite Element
HyperMesh/HyperCrash

Multi-Body Dynamics
MotionView

Visualization
HyperView

Analysis

Finite Elements
RADIOSS

Multi-Body Dynamics
MotionSolve

Optimization

Concept & Design
OptiStruct

Multi-Disciplinary
HyperStudy

Manufacturing

Sheet Metal
HyperForm

Extrusions
HyperXtrude

Forging
Altair Forging

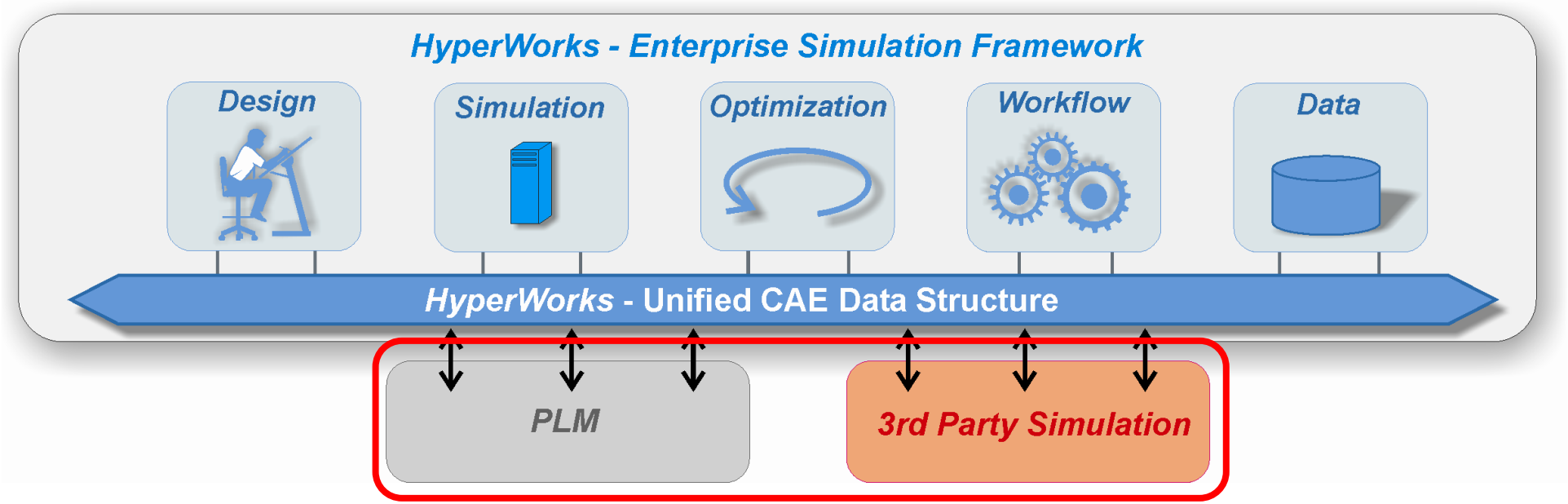
Molding
Altair Molding

Fr. Stir Welding
Altair Friction Stir Welding

CAE Data Management
Altair Data Manager

Process Automation
Altair Process Manager

Open Architecture for Better Integration into Enterprise PLM Architectures

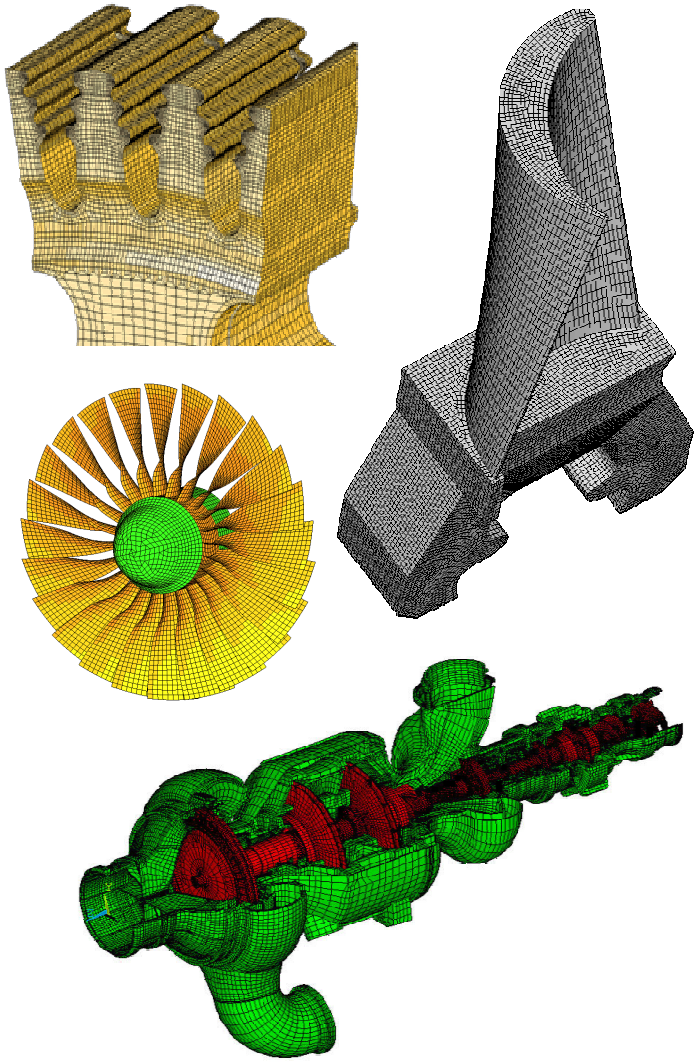


- CATIA
- UG
- Pro/E
- IGES
- STEP
- Adams
- Abaqus
- Ansys
- Deform
- Dyna
- Fluent
- Madymo
- Moldflow
- Nastran
- Permas
- PamCrash
- Radioss
- Simpack
- StarCD

Efficient Preprocessing

- HyperMesh
  - Geometry cleanup, automated or manual
  - Meshing and assembly for rapid FE model development
  - Advanced Hex-meshing
  - State-of-the-art solver interfaces

- BatchMesher
  - Automated “Batch” Meshing and Assembly
  - Performs geometry cleanup and auto-meshing (in a “batch” mode) for CAD files
  - Operates on shell meshes
  - Significantly reduce model cleanup and meshing time

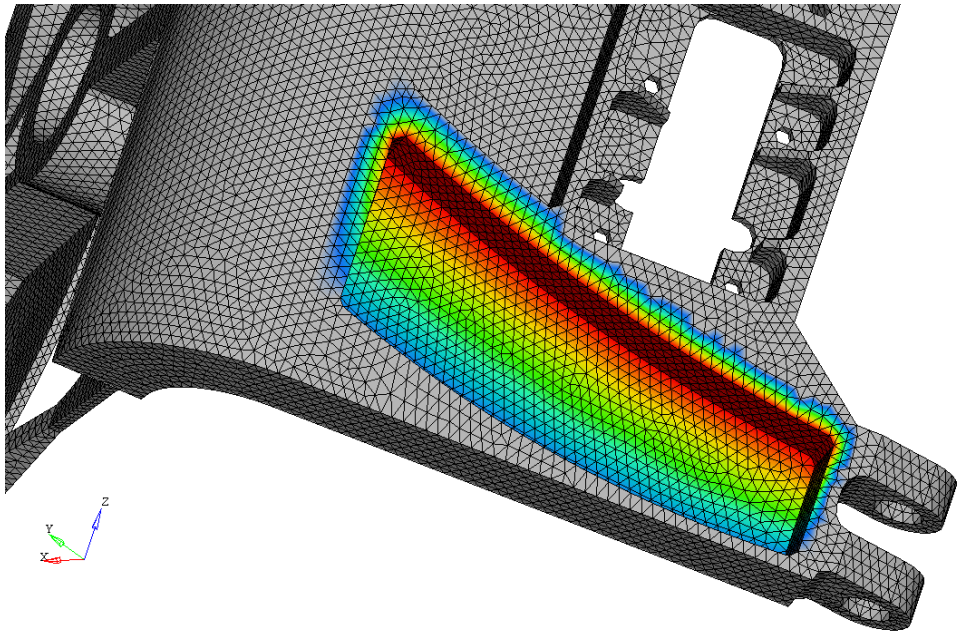


Morphing Technology

- HyperMorph (embedded in HyperMesh)

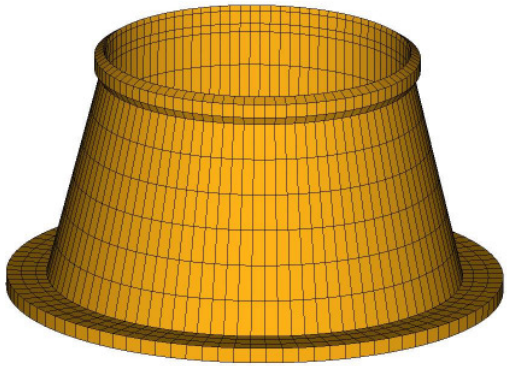
What is morphing?

Derive from metamorphose, transformation

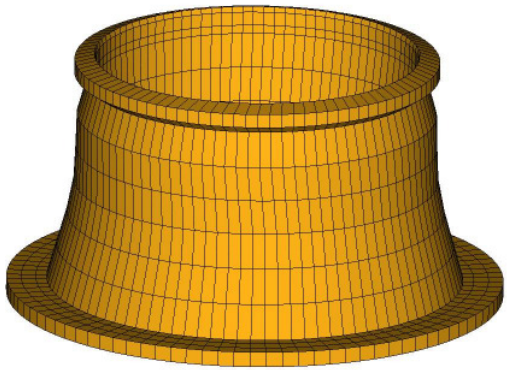


Morphing Existing Models to New Designs

- Description
  - Rapidly change geometry of existing FE model interactively or parametrically
  - Adapt existing FE models to new design data
- Benefits
  - Dramatic reduction in modeling time
  - Enables rapid “What If?” studies
- Application Examples in Gas Turbine Industry
  - “System Level Morphing” - HyperMorph is used to perform morphing of an engine model to allow rapid assessment of bearing and seal location/configuration
  - “Component Morphing” – Turbine blades morphed to “in-operation” shape



before



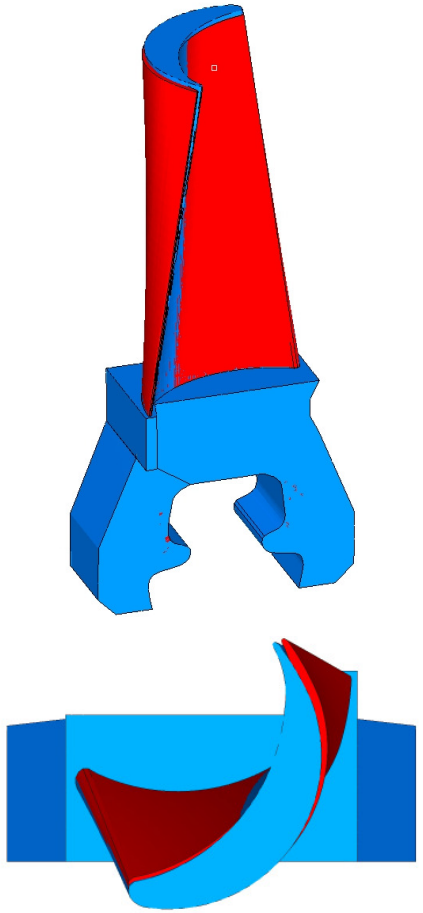
after

Example for cyclic morphing

Rapid Evaluation of “Concessions”

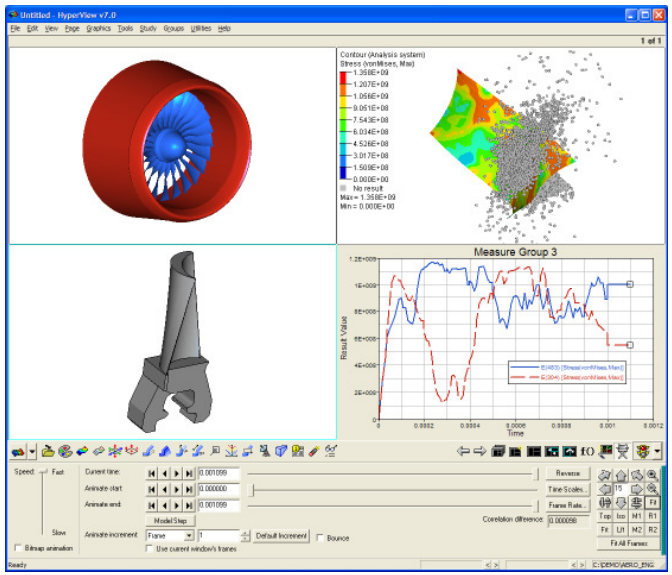
- Description
  - Rapidly assess the usability of out-of-spec high value components
  - FE model is morphed to the “as manufactured” geometry, loads and boundary conditions are retained
  - Assessment usability made within the one week deadline
  - Components on which this has been used include turbine blades and engine casings

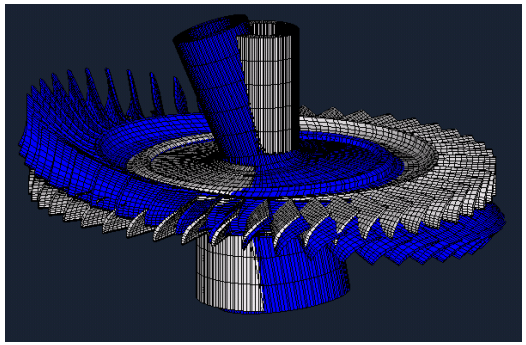
- Benefits
  - Significant cost savings by using high value components that were usually scrapped
  - Just one of the concessions saved by this manufacturer more than covers the price of a HyperWorks license for HyperMesh



Common Post-Processing Environment

- HyperView
  - Engineering analysis of test data and simulation results
  - Report templates
    - Rapid post-processing of design iterations
    - Automated report generation
    - Publish to HTML and MS/Office
  - Results mapping from one analysis to a successive analysis
  - Test data correlation and advanced data analysis
  - Comprehensive support of virtually all commercial solvers, including ANSYS, NASTRAN and LS-DYNA
  - Readers for “in-house” codes can be created

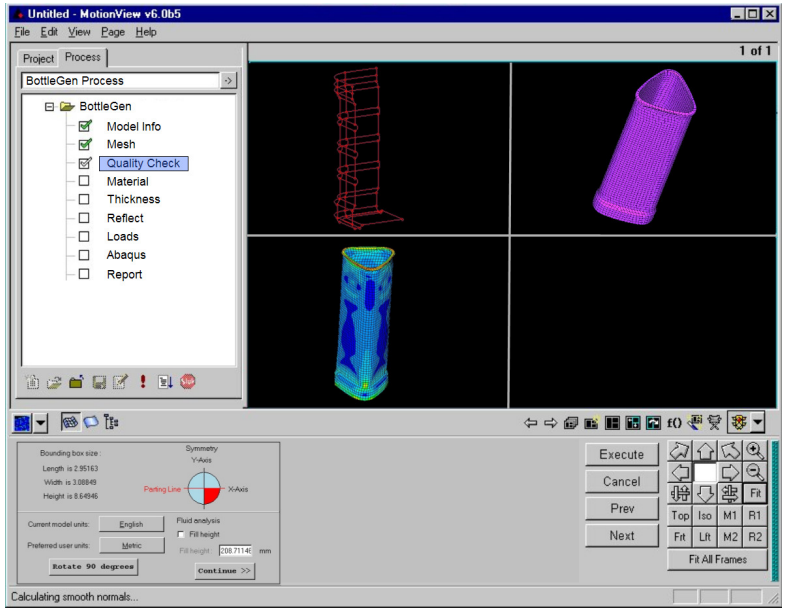




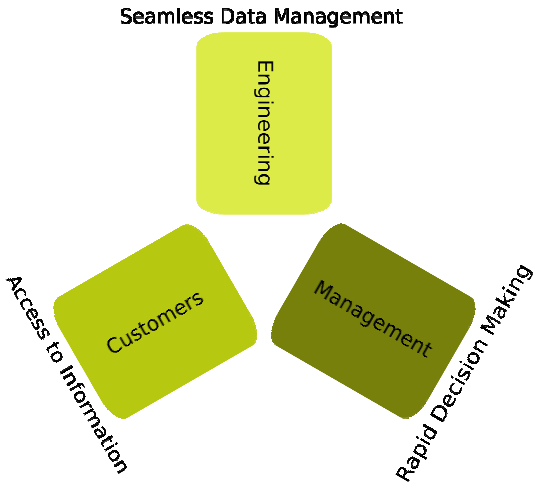
Results overlay

Process Automation and Data Management

- Altair Process Manager
  - Process management and authoring environment to capture best practices for design processes
  - Enables integration of diverse applications (from CAD, to in-house applications, to HyperWorks) in organized work flows

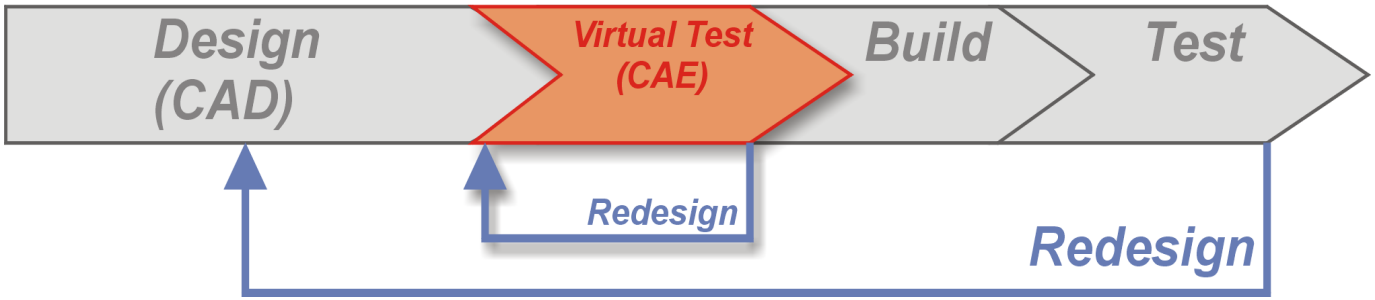


- Altair Data Manager
  - Product performance data management and decision support driven by already established engineering processes
  - Manage engineering work-in-process data in the context of existing PDM system

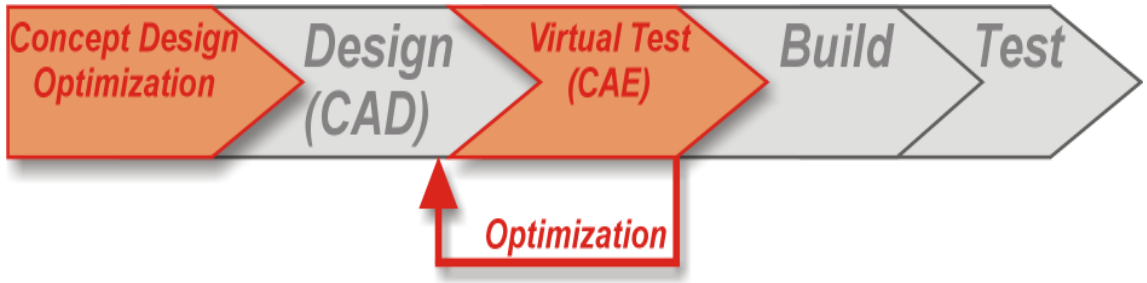


Altair's Vision

Today…



Altair…

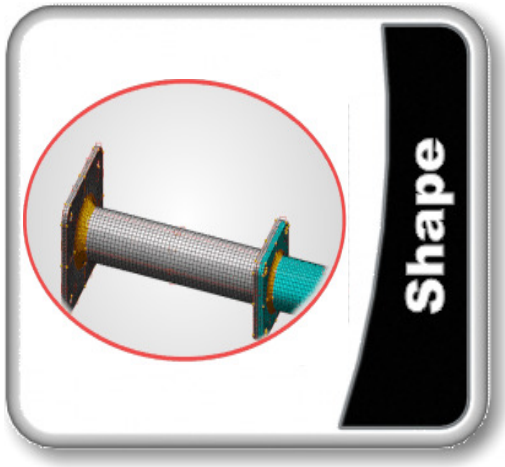


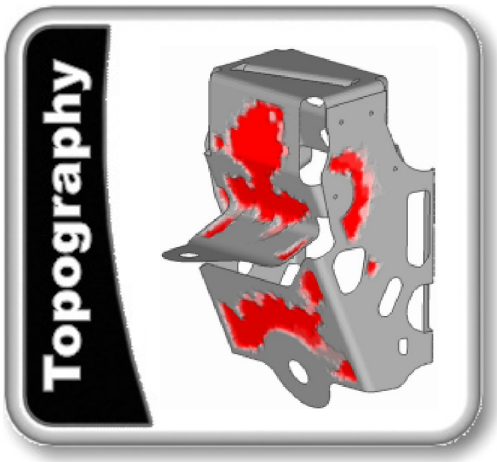
Optimization is Driver in CAE Driven Design Process

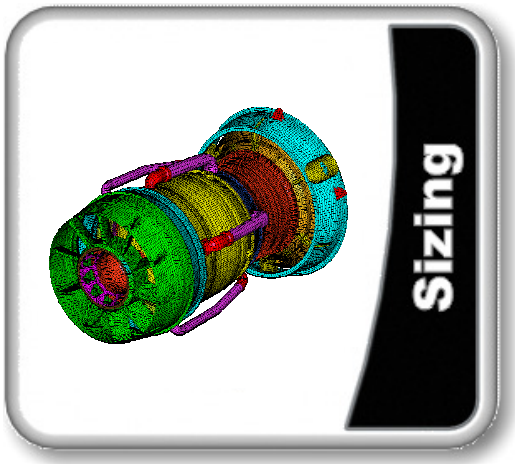
Optimization & Design Studies

Altair

Altair® OptiStruct®







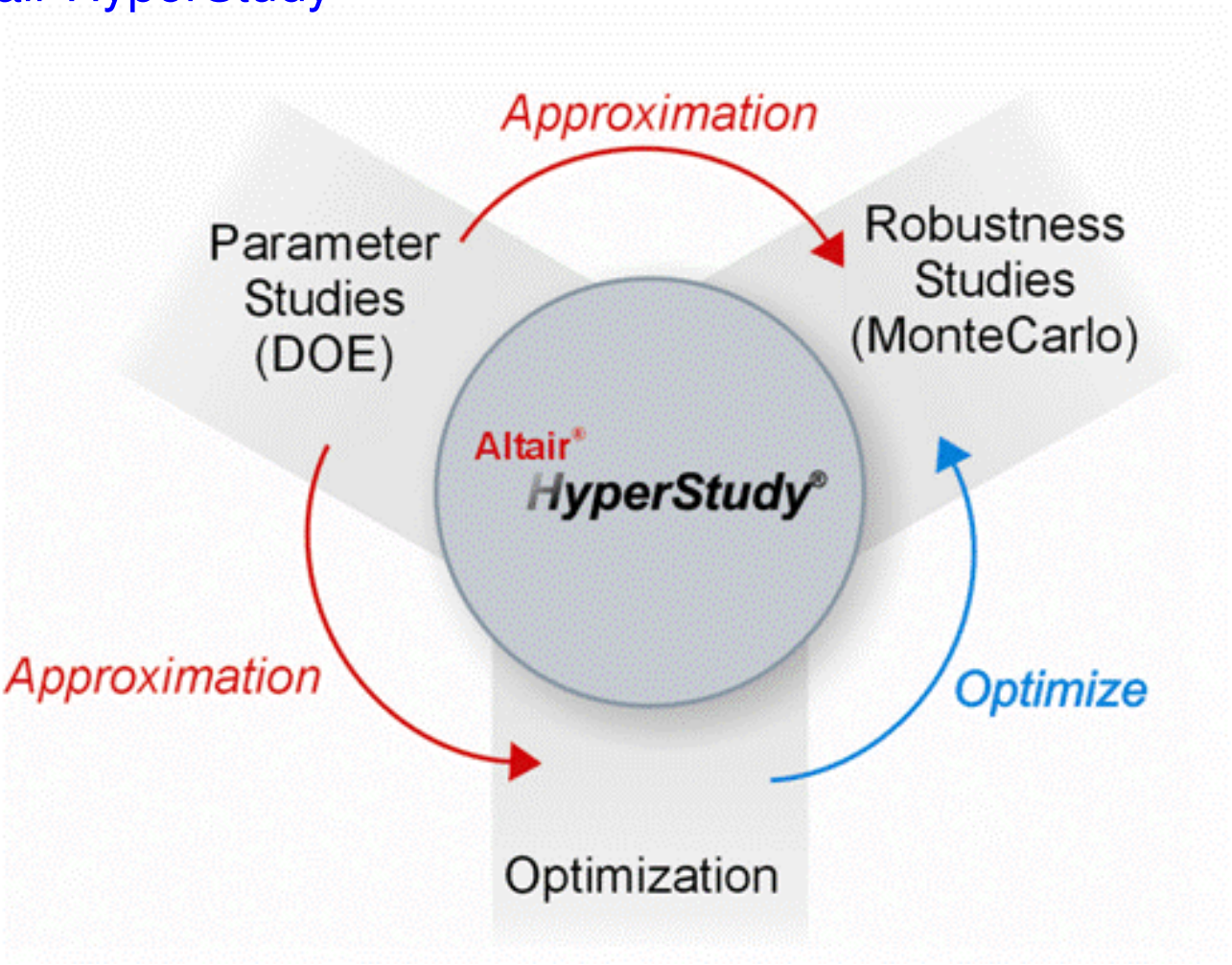
… with integrated FEA solver

Altair® HyperStudy™

… generic study tool for arbitrary solvers, ***includes DOE and Stochastics***

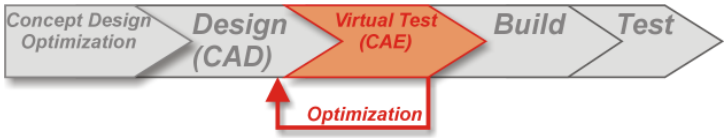
Performing Design Studies

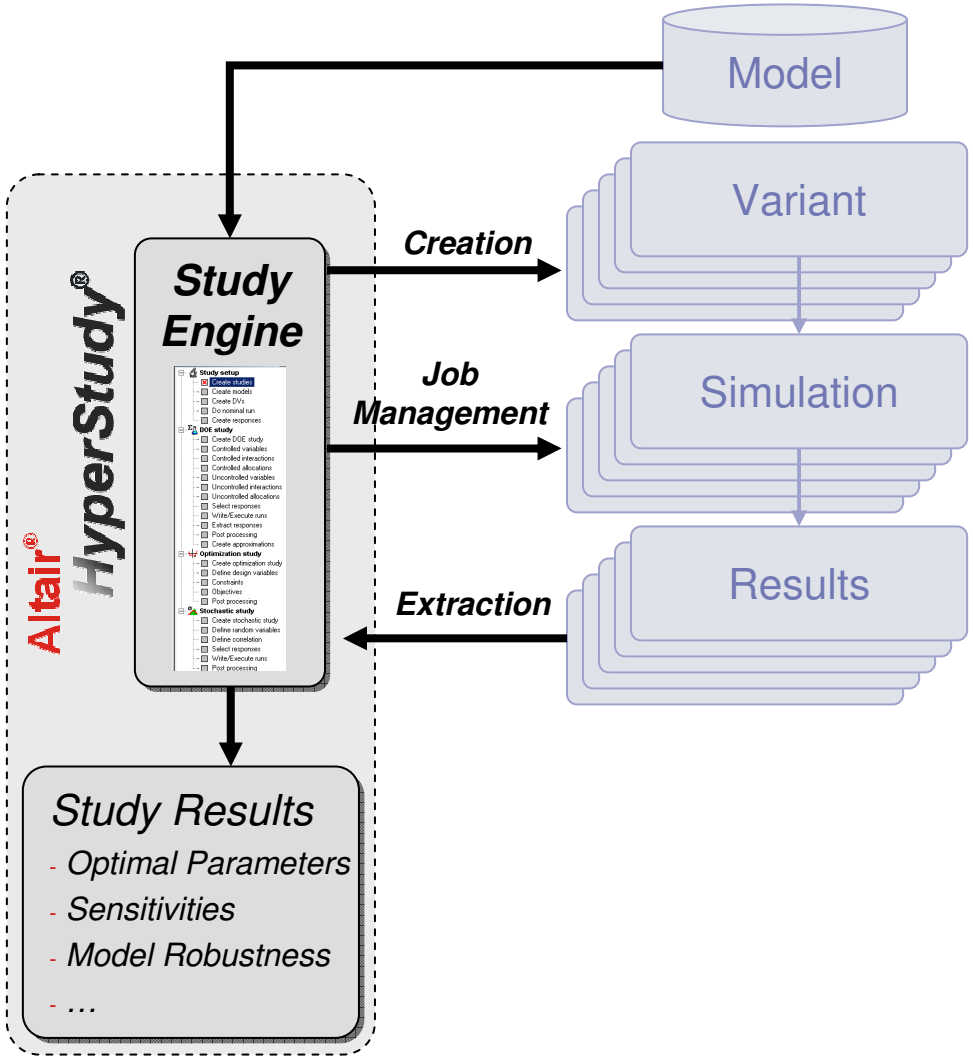
- Altair HyperStudy



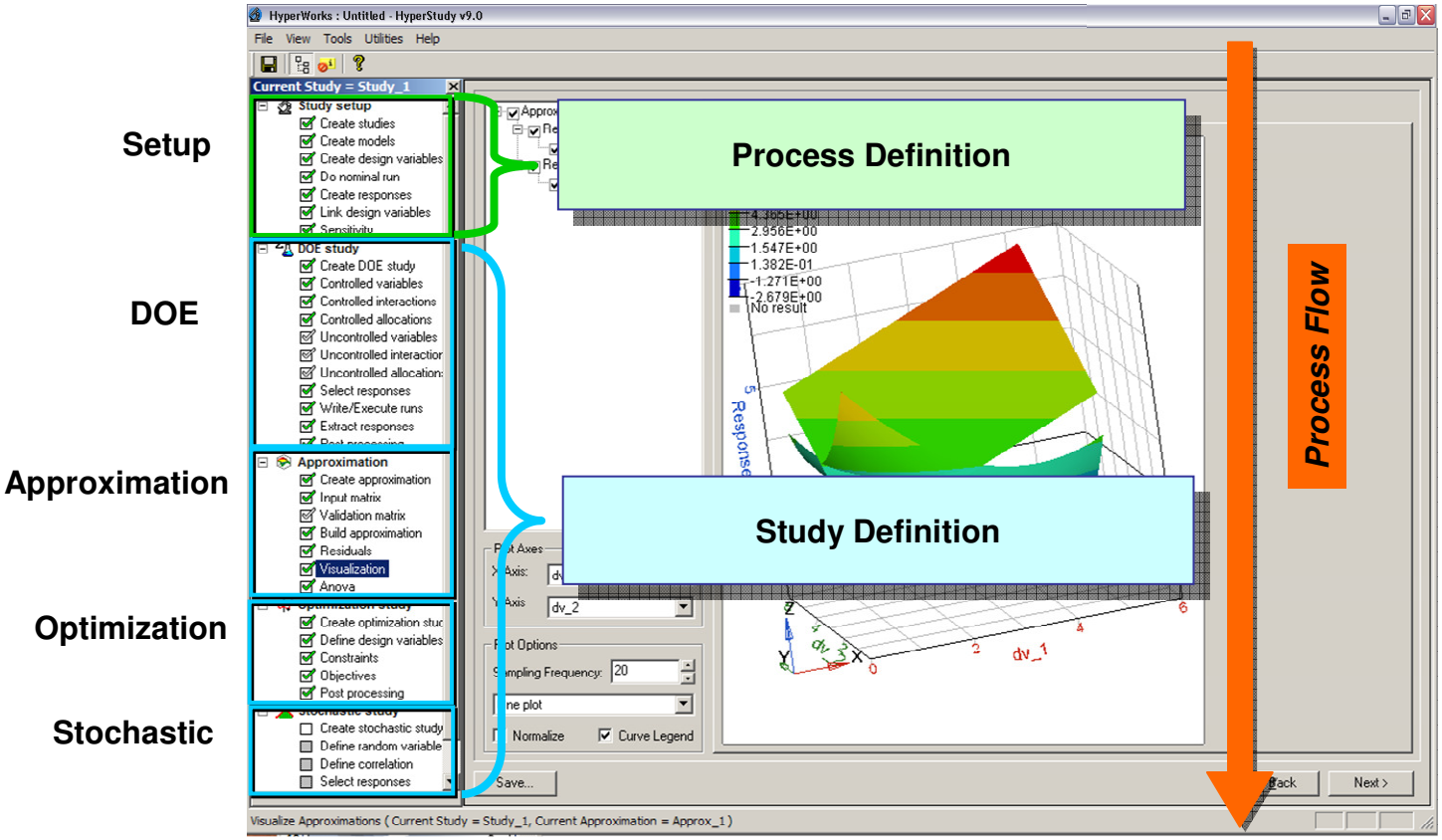
Design Studies with Altair HyperStudy

- Solver Neutral
- Direct parameterization: Automatic transfer of modal parameters from e.g. HyperMesh/HyperMorph
- Integrated with HyperWorks thru HyperMesh, MotionView and direct solver interfaces
- Multi-Solver Study: sequential or parallel
- Integration of grid computing software PBS professional





Process Flow in HyperStudy



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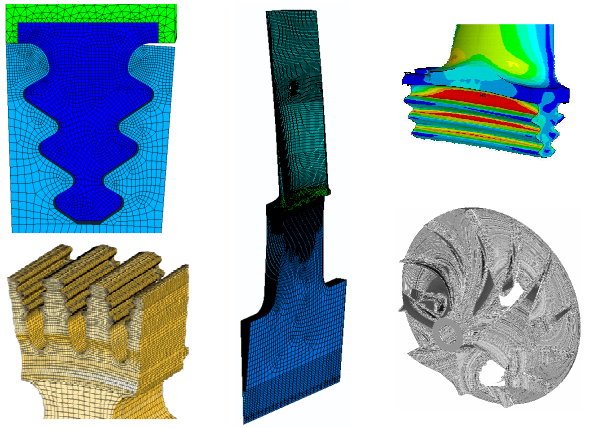
Altair HyperWorks 9
A Platform for Innovation™

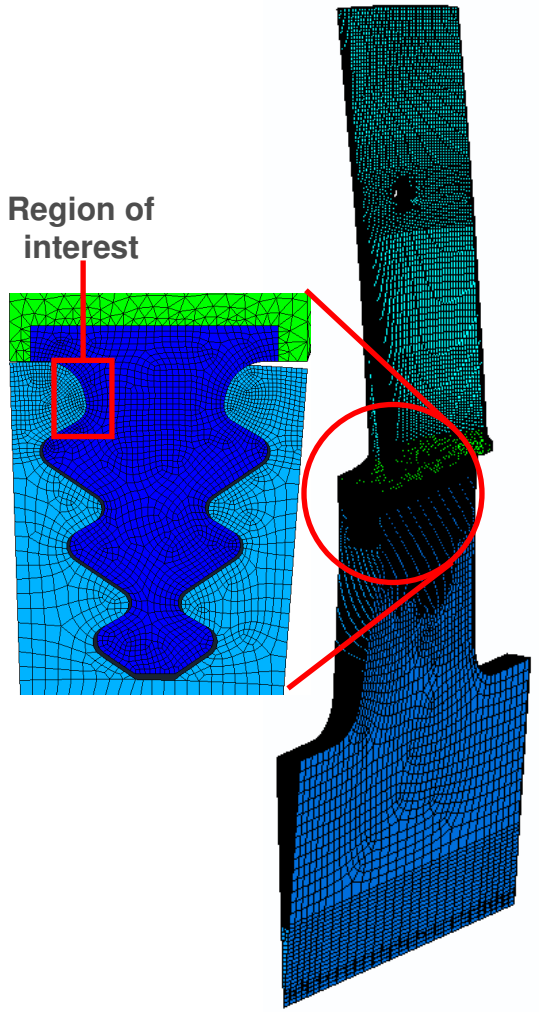


Shape Optimization of a Turbine Blade Root

- Objective

  Minimize stresses and strains at the root of turbine blade where it attaches to the disc to improve fatigue life

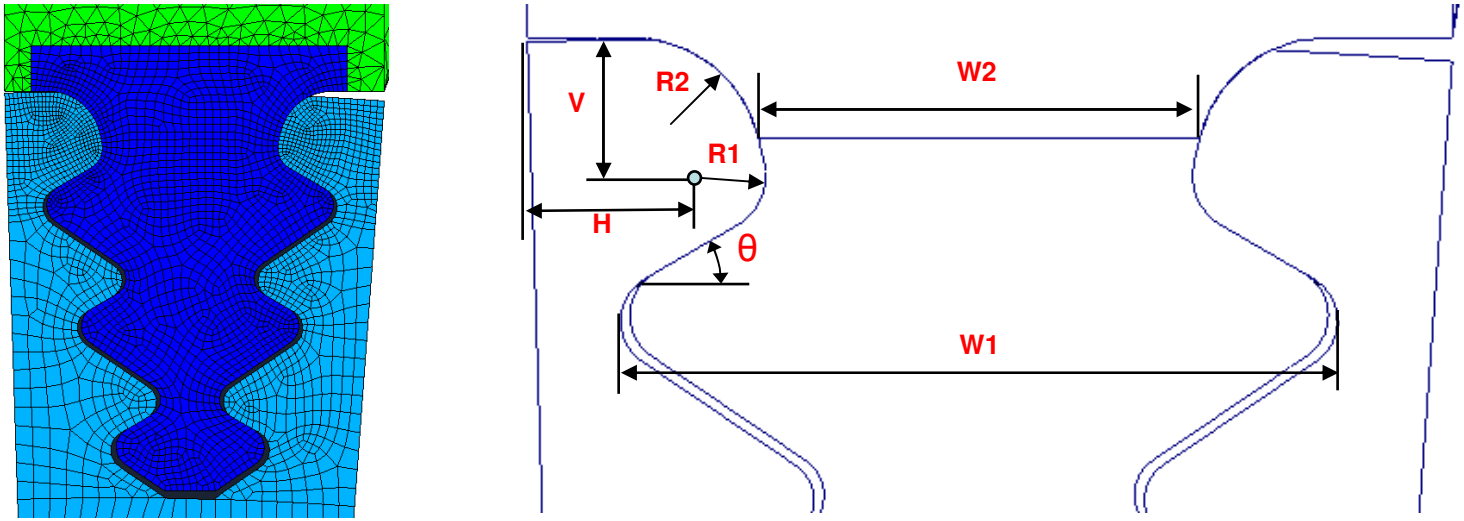
- Software Tools
  - FE Model development – HyperMesh
  - Solver – ANSYS
  - Shape variable definition – HyperMorph
  - Optimization setup – HyperStudy
  - Optimization – HyperStudy
- Cyclic symmetry boundary conditions
- Two cases – 8500 rpm & 4000 rpm



Elements Used:	Solid 45, Solid 95
Total No. Elements:	305,524
Total No. Nodes:	304,061

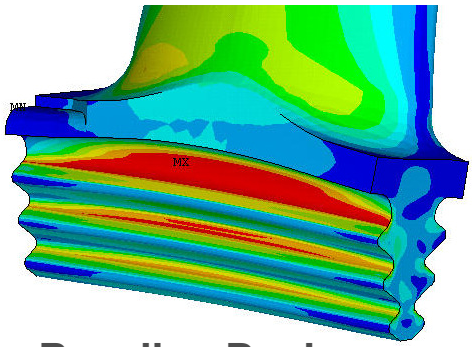
Shape Optimization of a Turbine Blade Root

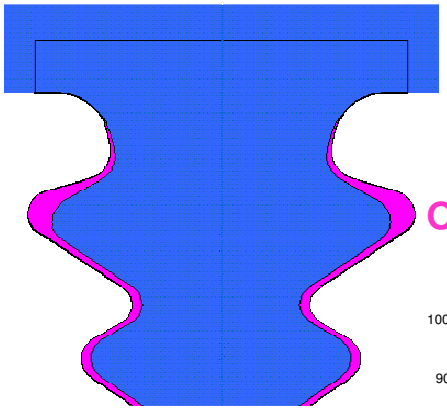
- Shape variables definition with HyperMorph



Shape Optimization of a Turbine Blade Root

- Elastic-Plastic Analysis Optimization Results (8500 RPM)



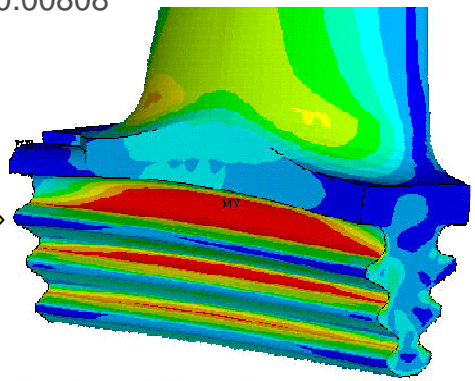


Baseline Design

Max SEQV = 768 MPa

Max Strain = 0.00808

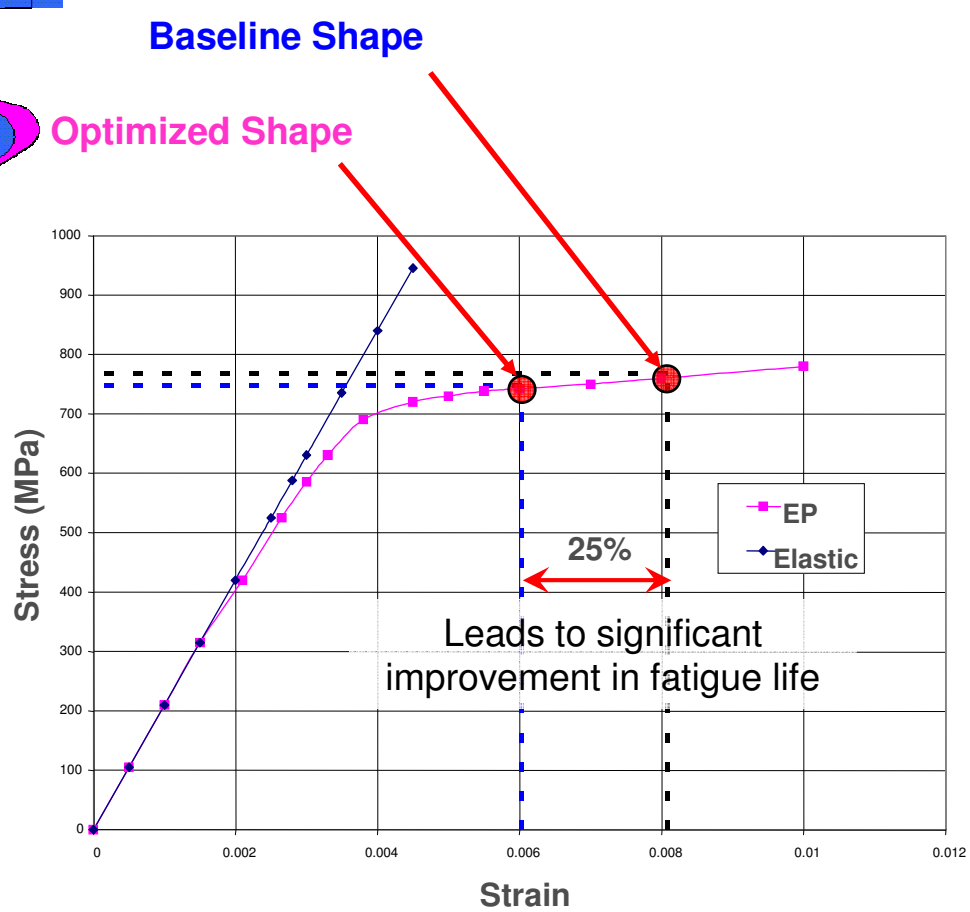
25% reduction in strain



Optimized Design

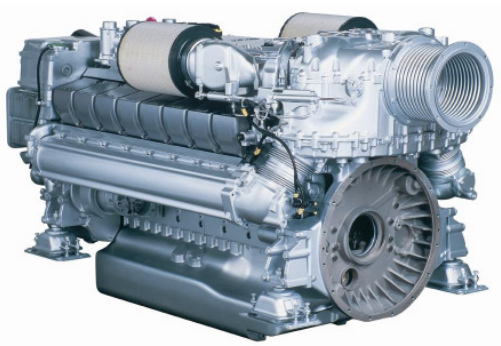
Max SEQV = 746 MPa

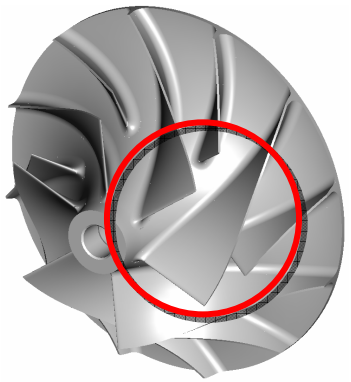
Max Strain = 0.00603



Engine Compressor Blade Optimization

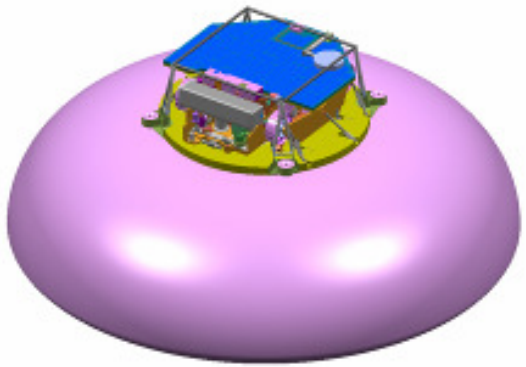
- Challenge
  - Increase pressure ratio of radial compressor through optimized blade design
- Solution
  - CFD optimization using HyperStudy
  - Shape optimization with morphing
  - Objective: maximize pressure relation between inlet and outlet
- Results
  - 5.6% increase in pressure ratio, which leads to better fuel efficiency and higher engine power





"Including HyperWorks and CFD in the design process cuts development time and enables us to perform automated design and optimization studies."
Dr. Mario Dittmann, MTU Friedrichshafen GmbH

Optimization and Reliability Analysis of a Mars Lander



ESA Aurora Exploration Program Launch in 2011 or 2013

New Lander Design Concept

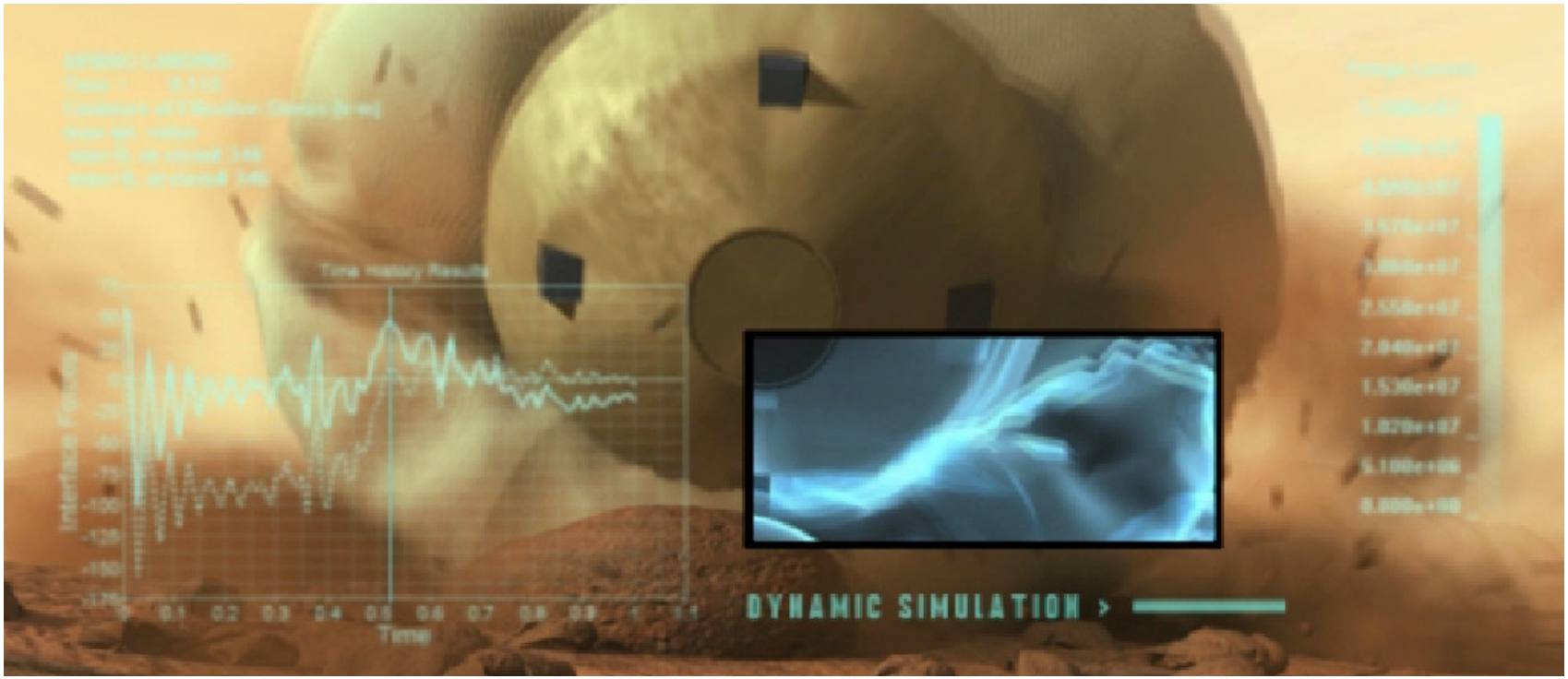
- Vented airbag, coming to rest on 2nd bounce
- Traditional concepts come to rest after 10 to 20 bounces

Failure modes

- Roll-over (payload overturns),
- Dive-through (payload impacts rock)
- Rupture (fabric tears)

Full scale terrestrial testing expensive/difficult: Therefore virtual design approach

Optimization and Reliability Analysis of a Mars Lander

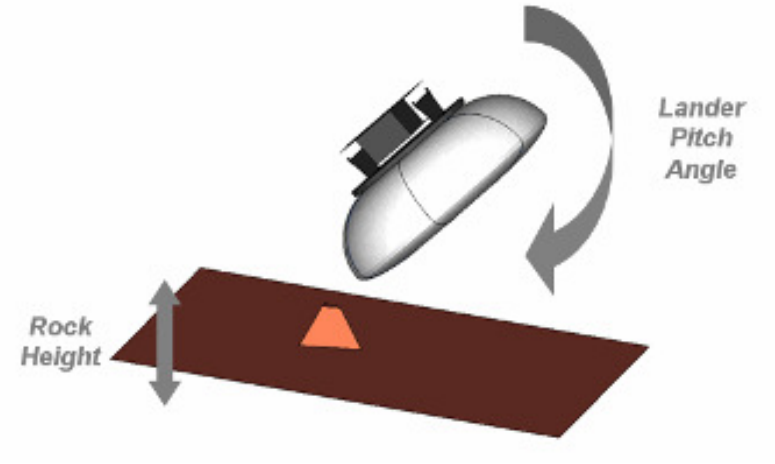


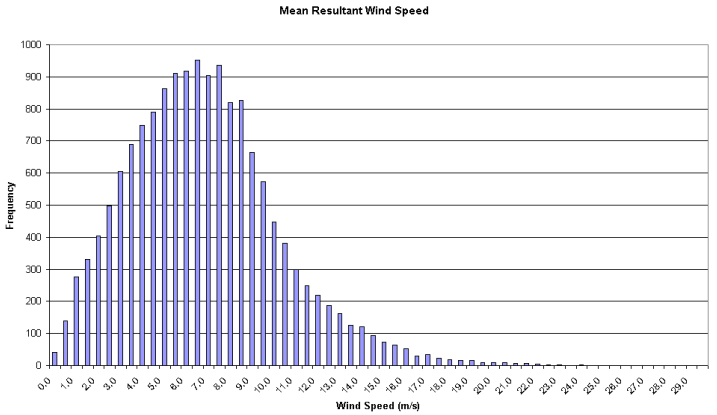
Reliability Study: Range of Conditions

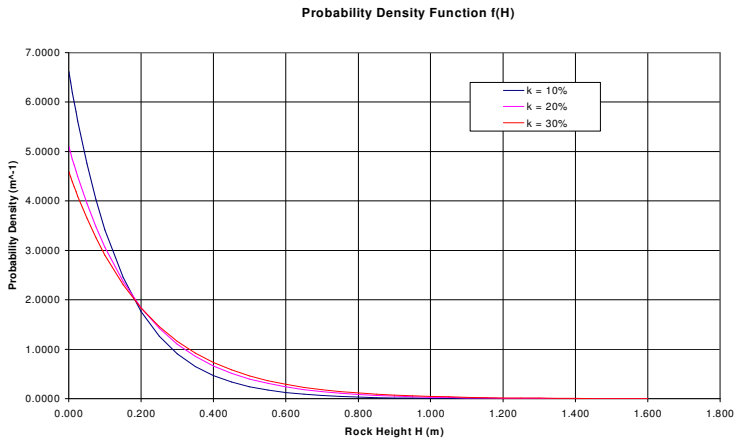
Only rock impact load case considered

Controlled/Uncontrolled conditions

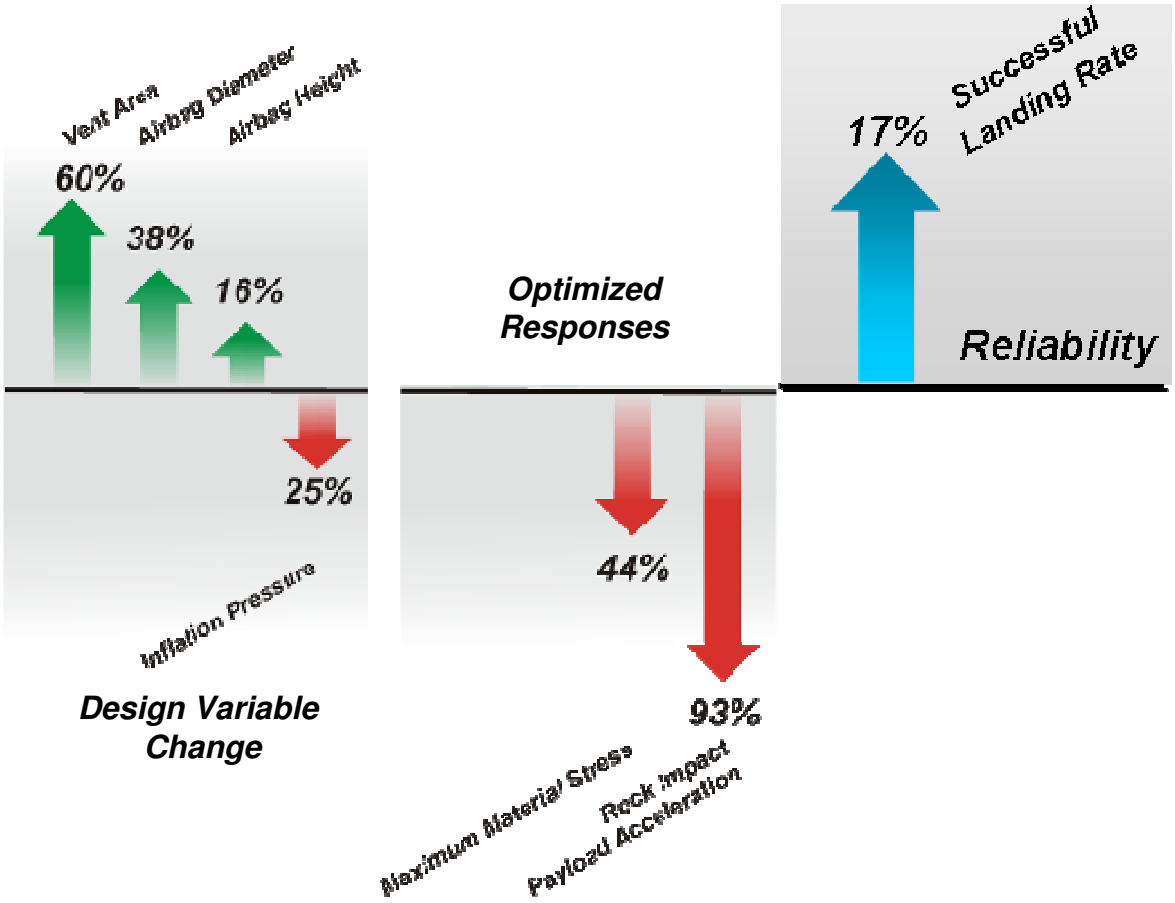
- Wind speed (Weibull)
- Rock Height (Exponential)
- Lander pitch attitude (+/- 20 deg)
- Lander pitch rate (+/- 30 deg/s)







Results



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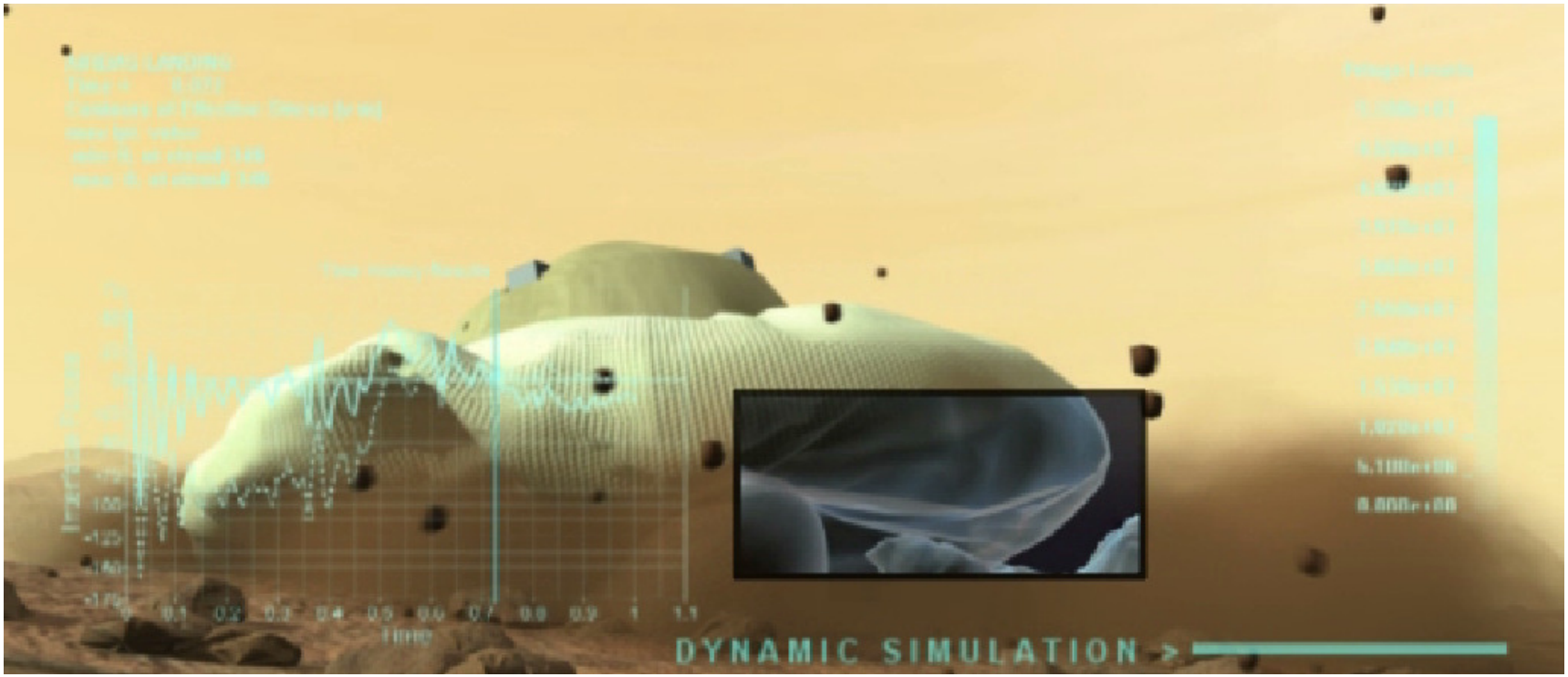

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Summary

- Deep Knowledge of CAE Design Processes
  - CAE Process Automation / Integration
  - How to Best Exploit CAE Software and Methods
  - Provide Mentoring and Best Practices – Comfortable with Technology Transfer

- HyperWorks, Integrated Suite of CAE Tools to Drive Product Innovation
  - HyperMesh: Highly Advanced Preprocessor Increasing your Efficiency
  - BatchMesher: Fully Automated Geometry Cleanup and Shell Meshing
  - HyperMorph: Allowing Rapid Design Changes Resulting in Dramatic Cost Savings
  - HyperStudy: DOE, Multi-disciplinary Optimization and Stochastic Simulation Engine

- Altair is a Reliable Business Partner – Exhibiting Strong Growth
  - Flexible HyperWorks Licensing Concept Reducing Software Costs
  - Passing on Business Benefits to Customer, e.g. HyperWorks Enabled Partner Program

Thank You For Your Attention!

Another Morphing Example

- **Q&A**

