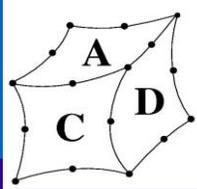
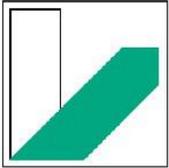


# Übersicht

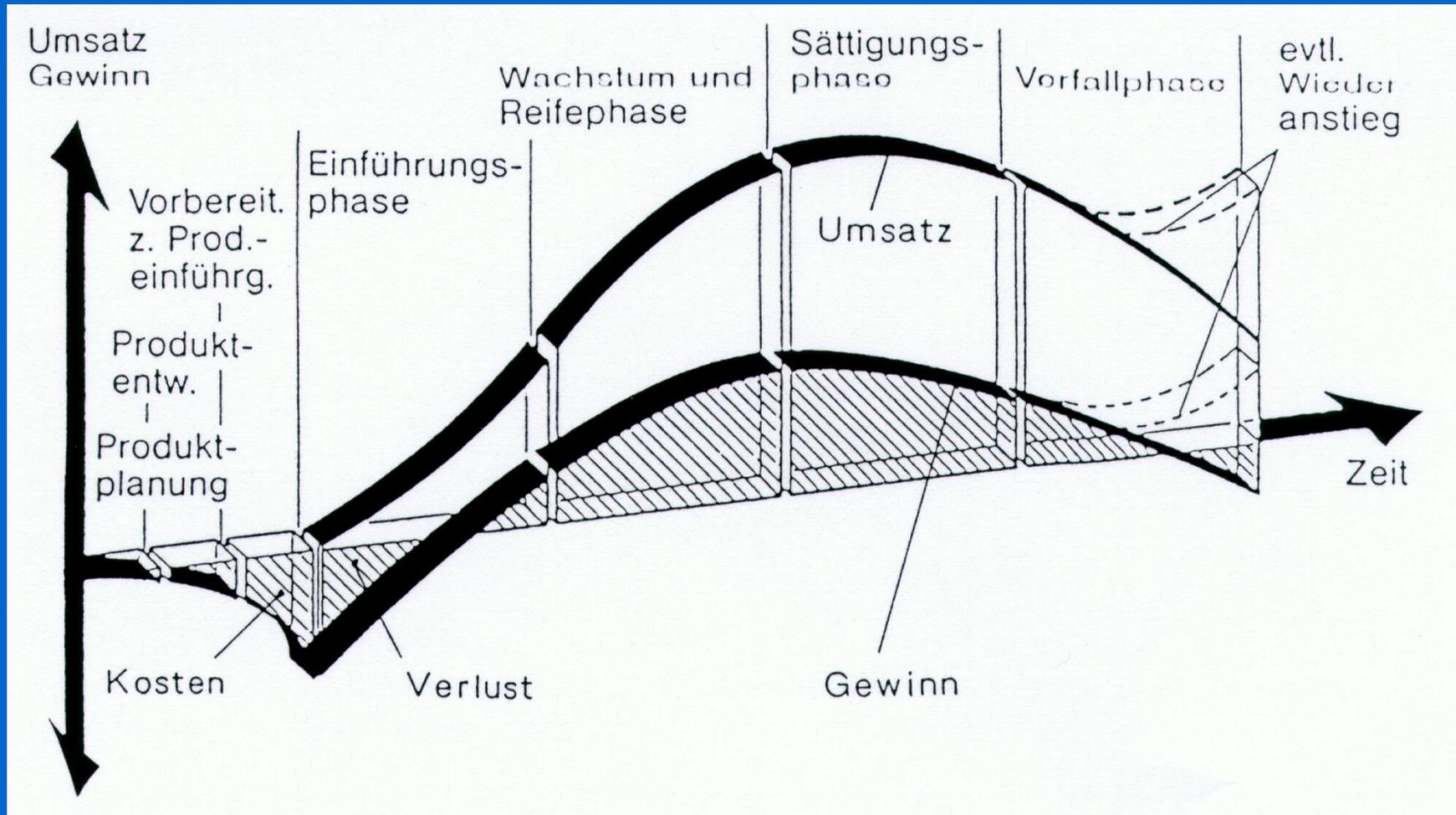
## Numerische Simulation in der Produktentwicklung

### Trends, Ausblicke, Beispiele

Dipl.-Wirtsch.-Ing. Reinhard Hackenschmidt  
Lehrstuhl für Konstruktionslehre und CAD

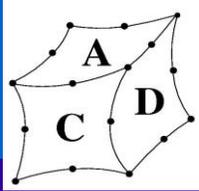
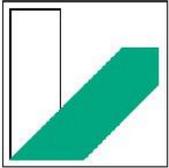


# Produkt Lebenszyklus



Nach Pahl/Beitz



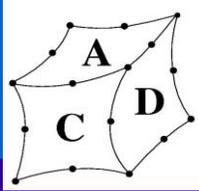
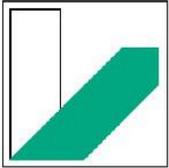


# Der Konstrukteur



Berechnen,  
Entwerfen,  
Dokumentieren,  
Ausarbeiten -  
alles das macht  
der Konstrukteur -  
meist im Team.

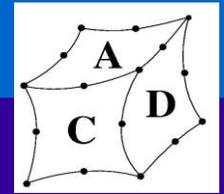
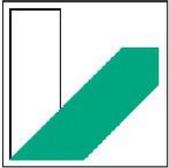
Rechts im Bild  
Karl Maybach.



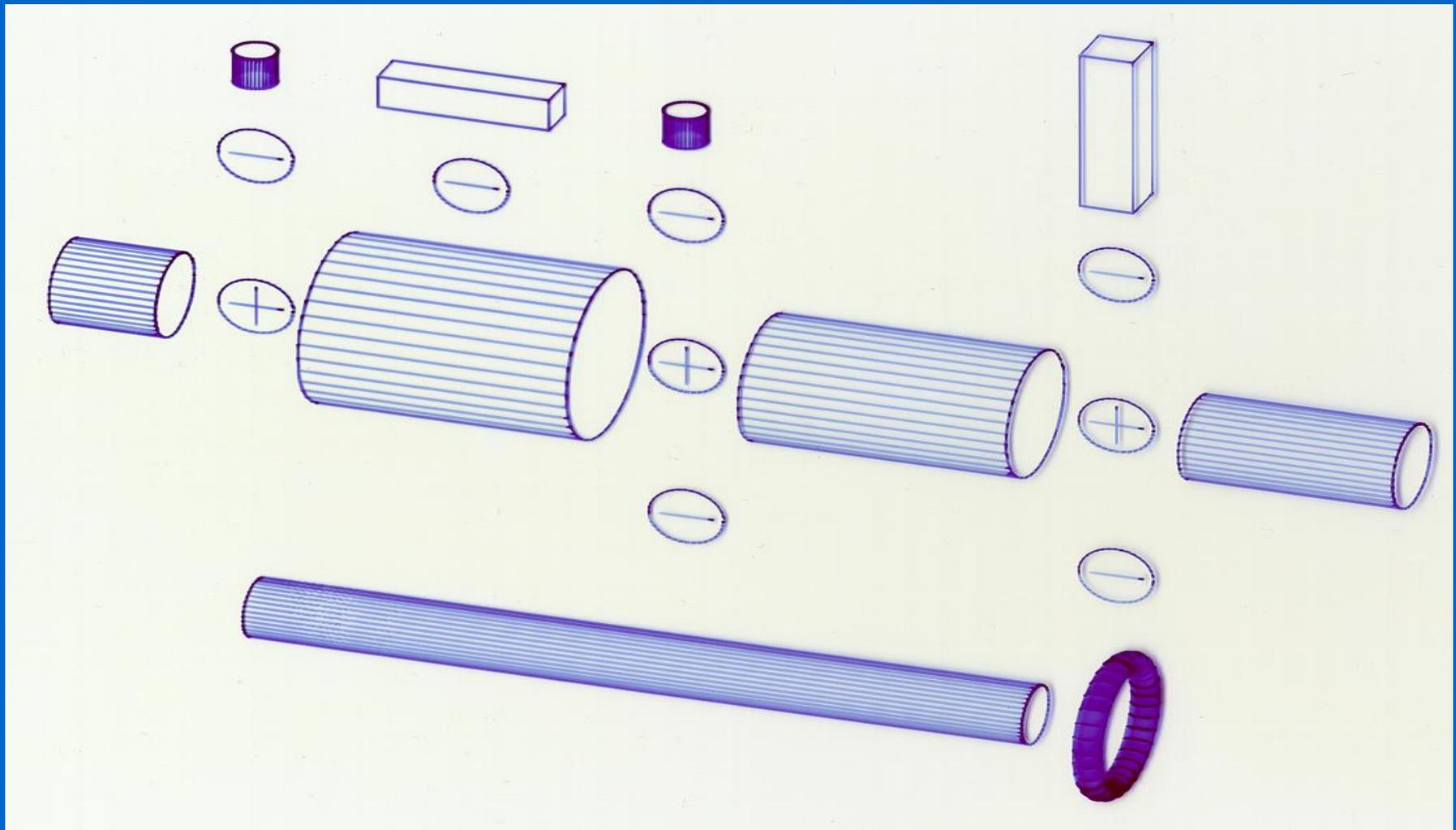
# Der „neue“ Konstrukteur

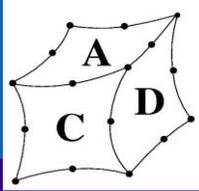
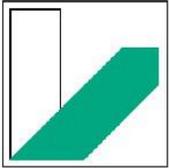


Dassault Systemes

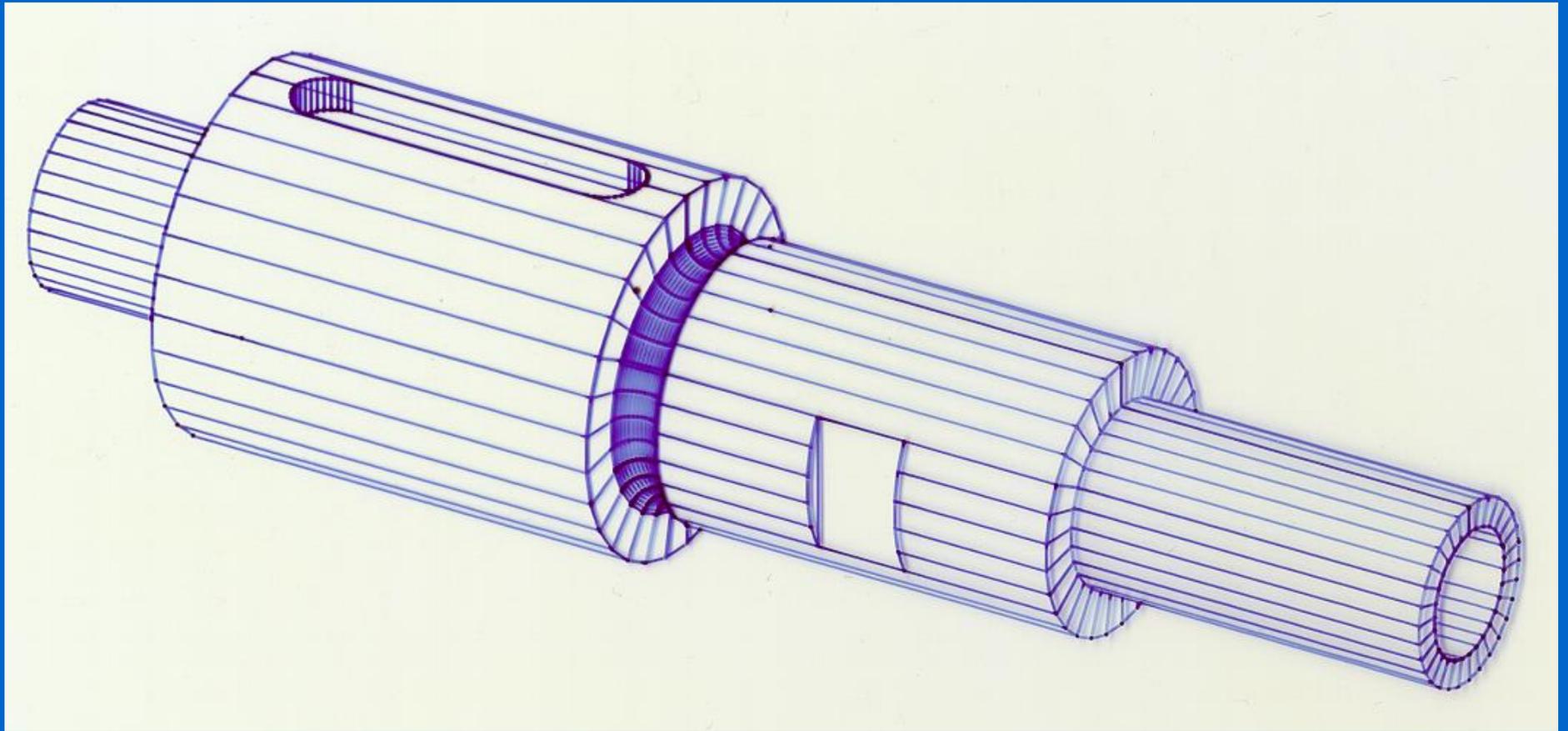


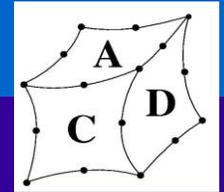
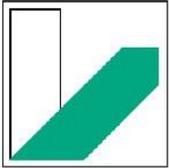
# 3D-CAD mit Boole - Operationen



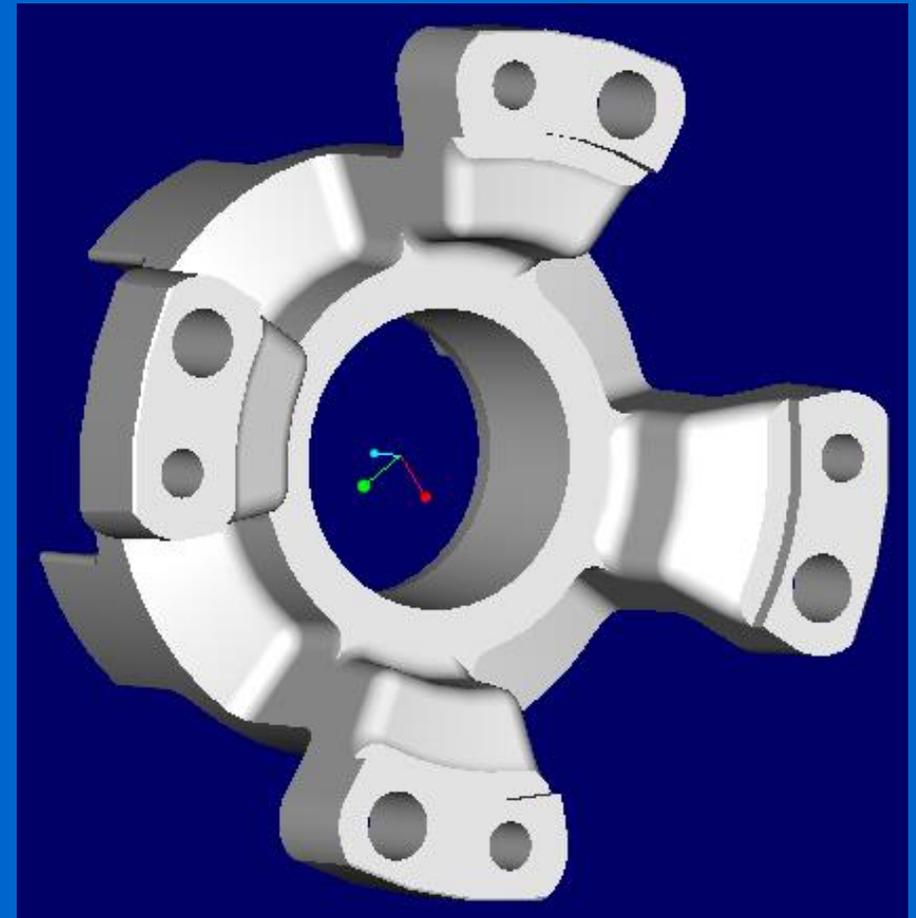
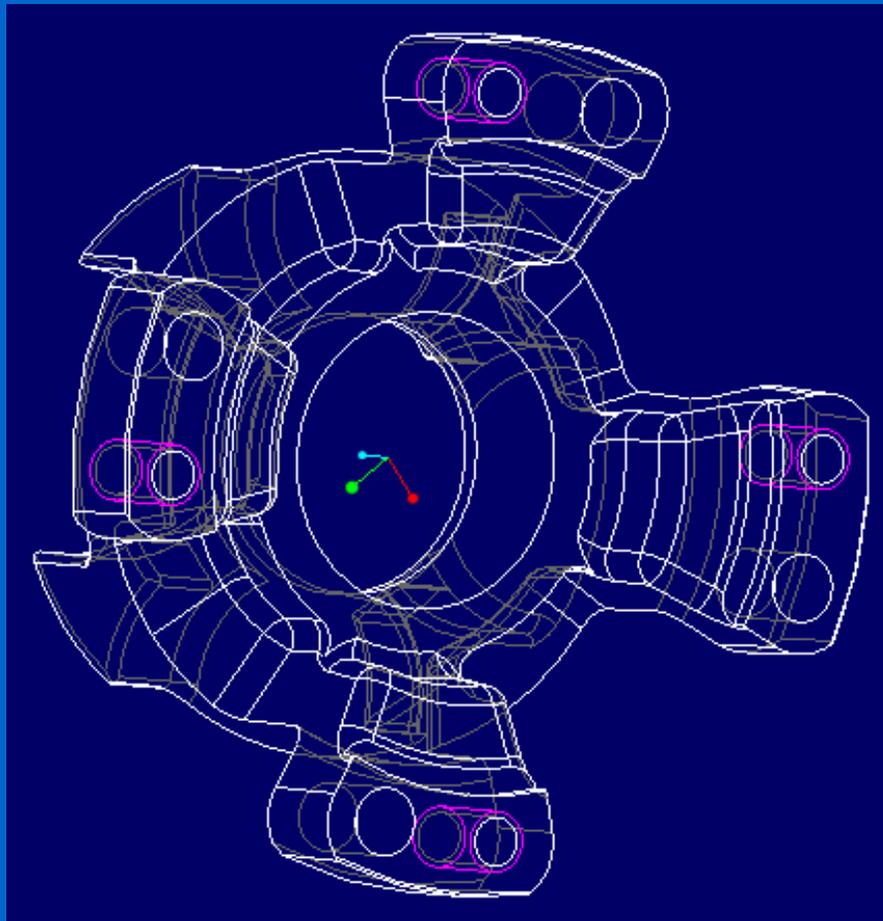


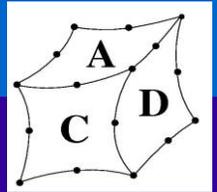
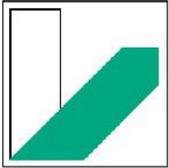
# Frühes 3D-CAD ~ 1990



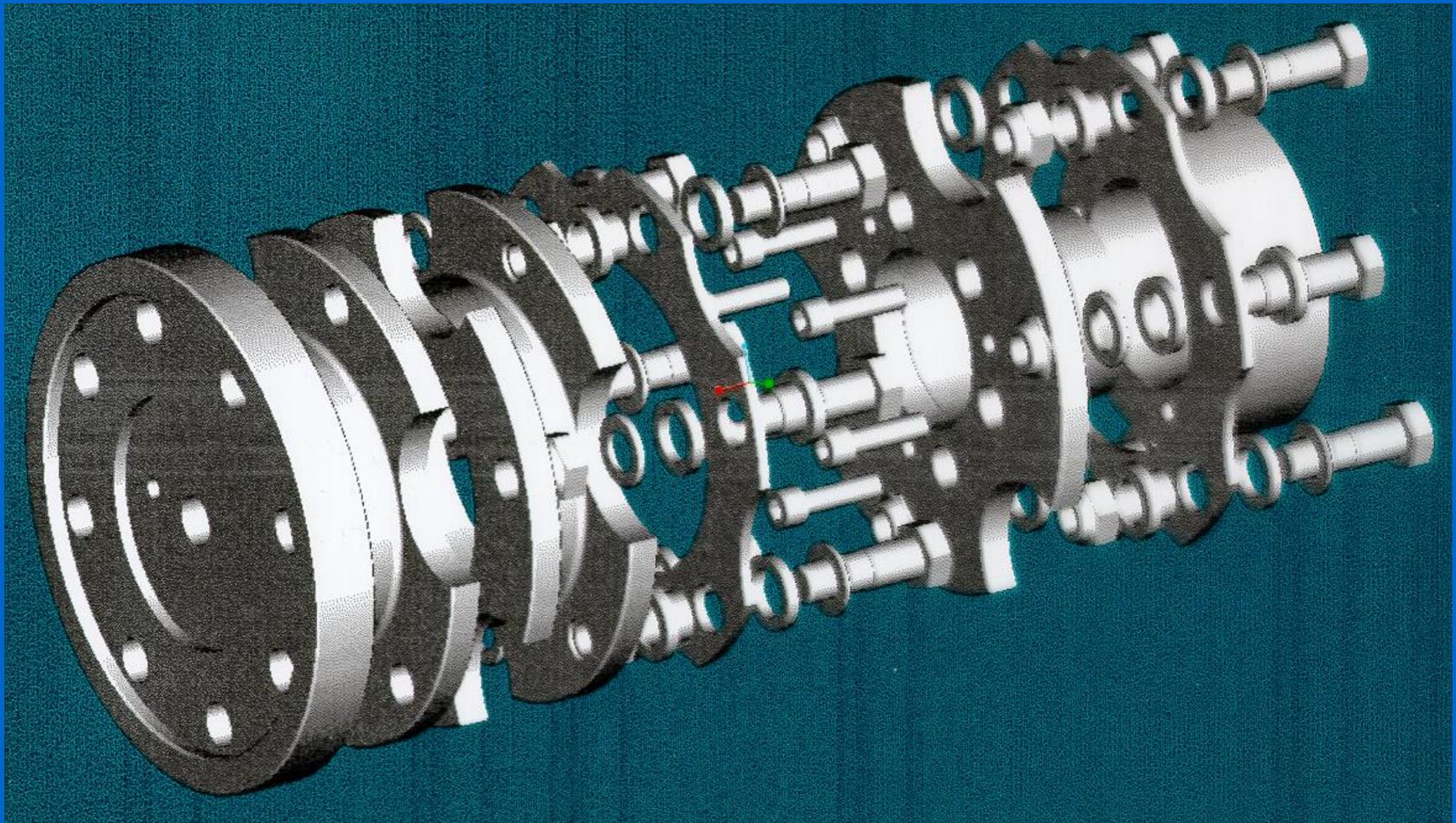


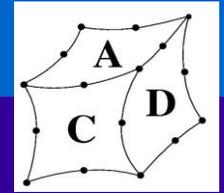
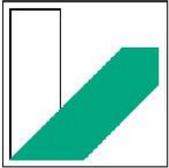
# Bauteile 3D-CAD





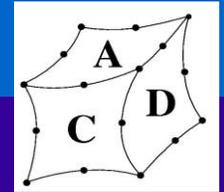
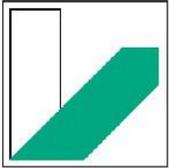
# Baugruppe 3D-CAD



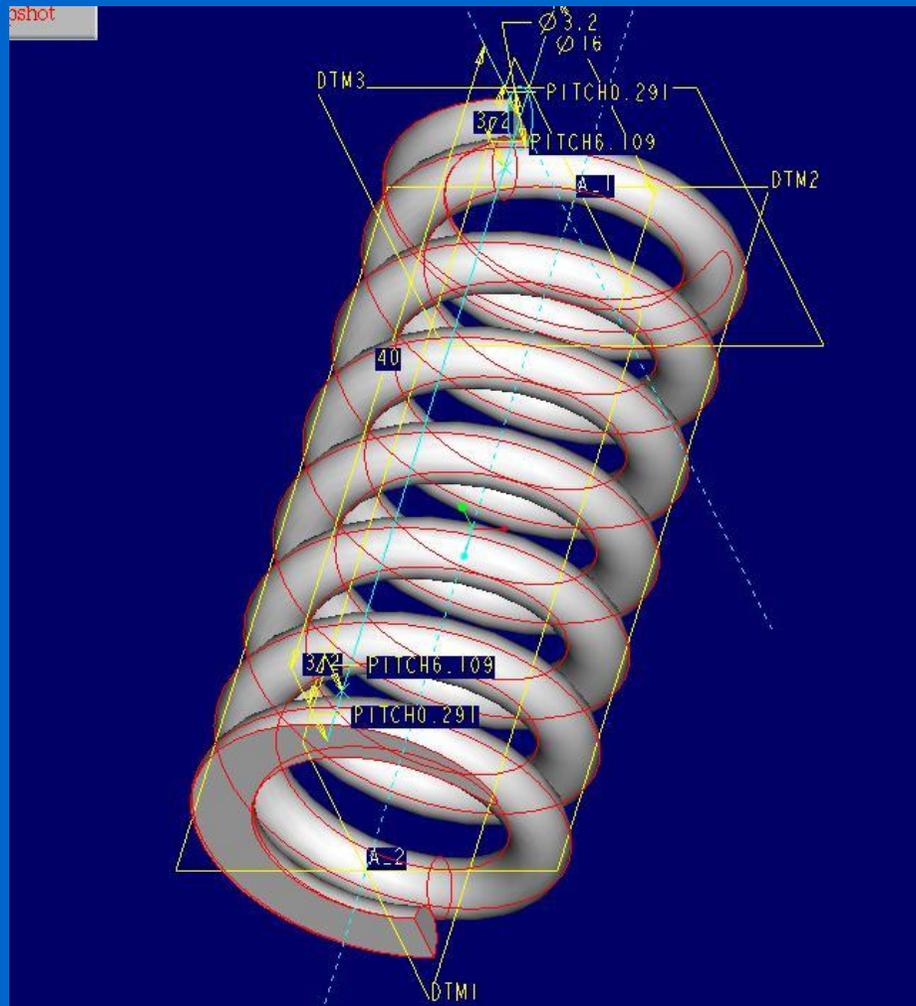


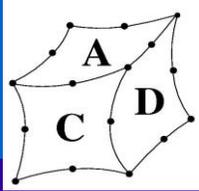
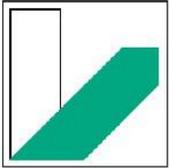
# Nur mit 3D problemlos möglich

- durchgängige Parametrisierung
- Ableiten von Explosionszeichnungen
- photorealistische Bilder => Marketing
- Rapid Prototyping (Stereolithographie)
- Kollisionsprüfungen
- Virtuelle Realität
- Finite- Elemente- Berechnung
- NC- Datenaustausch

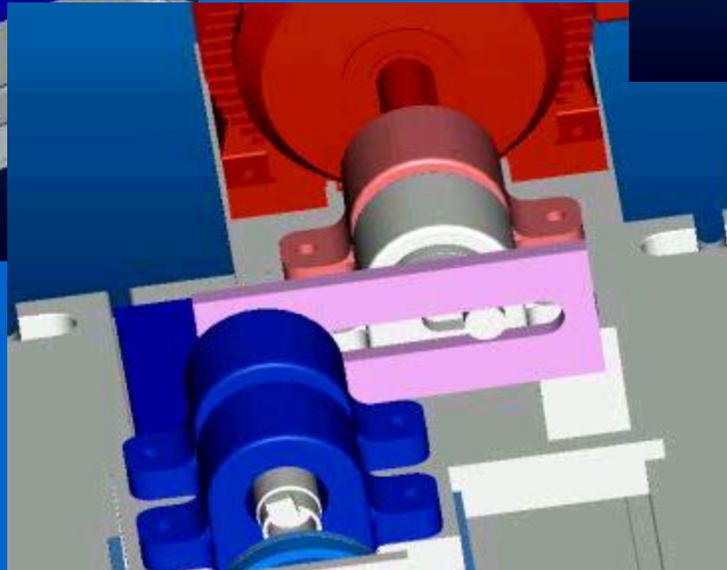
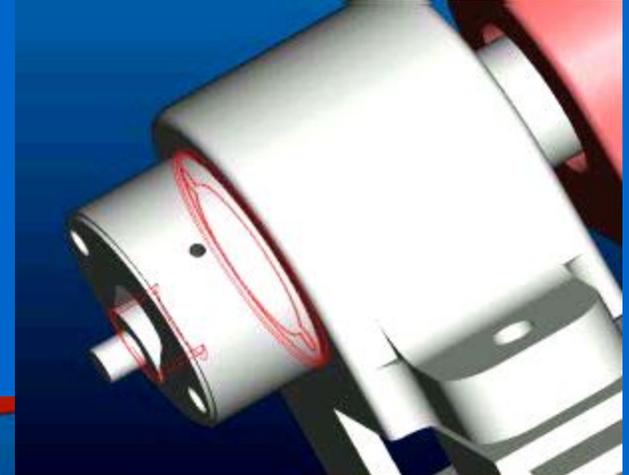
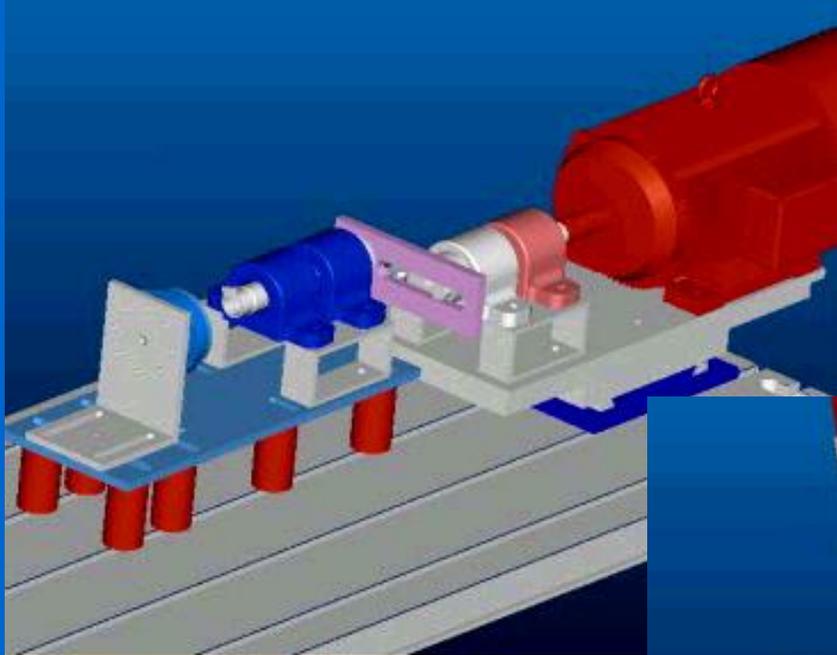


# Parametrik 3D-CAD



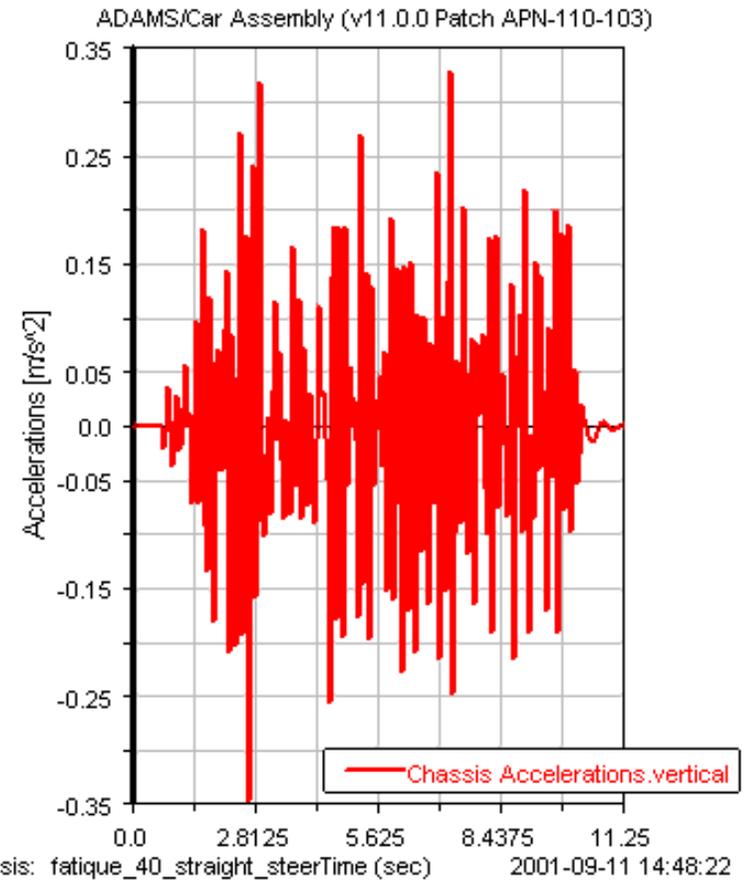


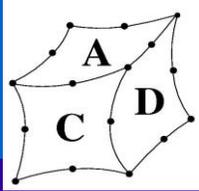
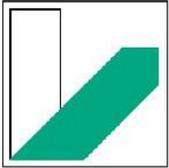
# Digital Mock-up - Zusammenbausimulation



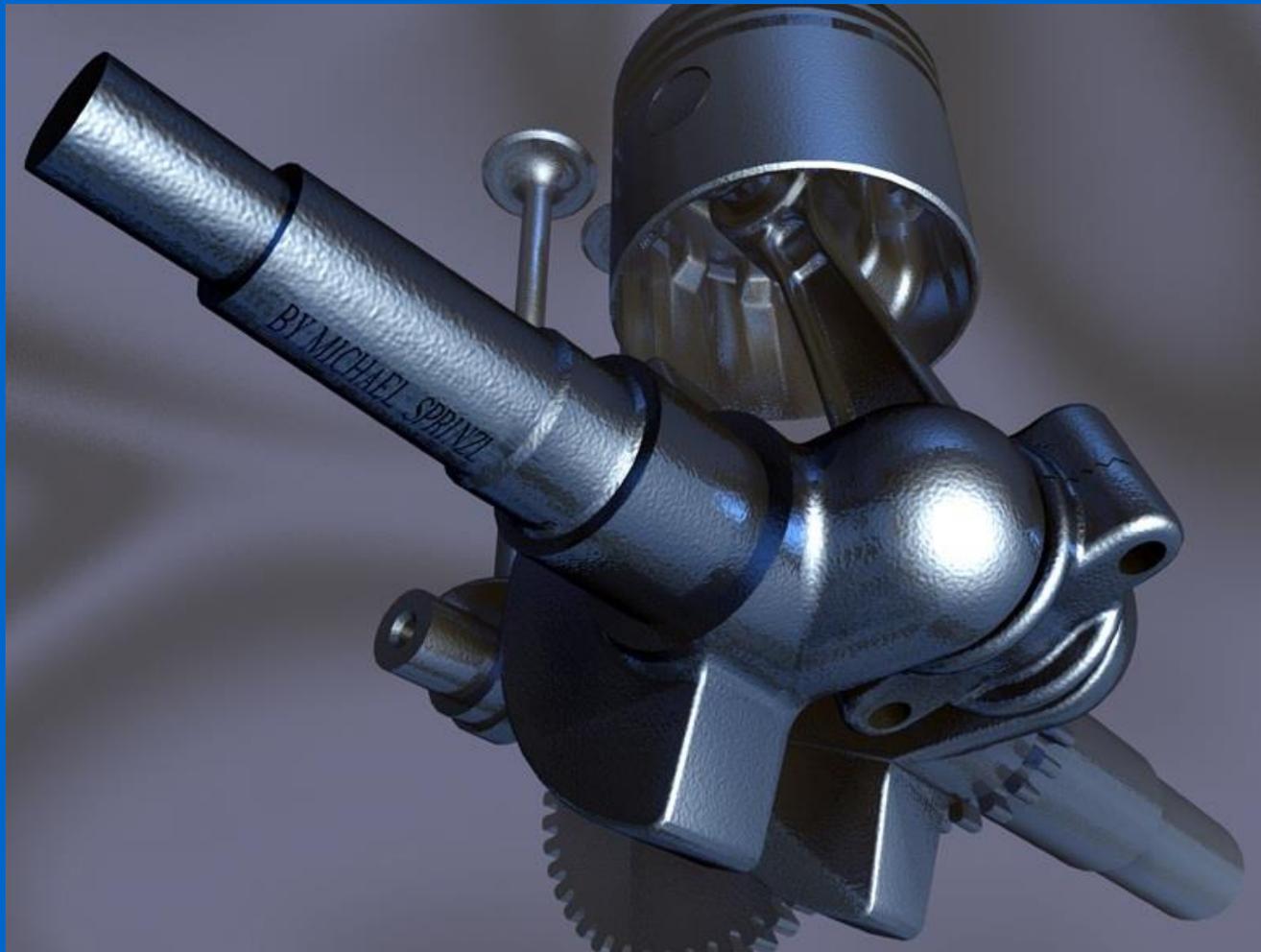
# Kräfte-simulation

fatigue\_40\_straight\_steer Equilibrium Frame=1

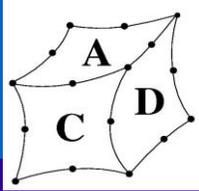
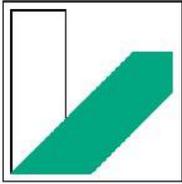




# Photorealistische Darstellung



Diese Motor-  
baugruppe  
haben unse-  
re Studenten  
am Ende des  
2.Semesters  
mit Pro/  
ENGINEER  
konstruiert

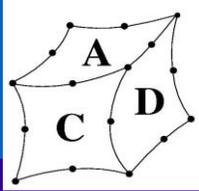
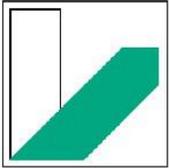


# Computergrafik

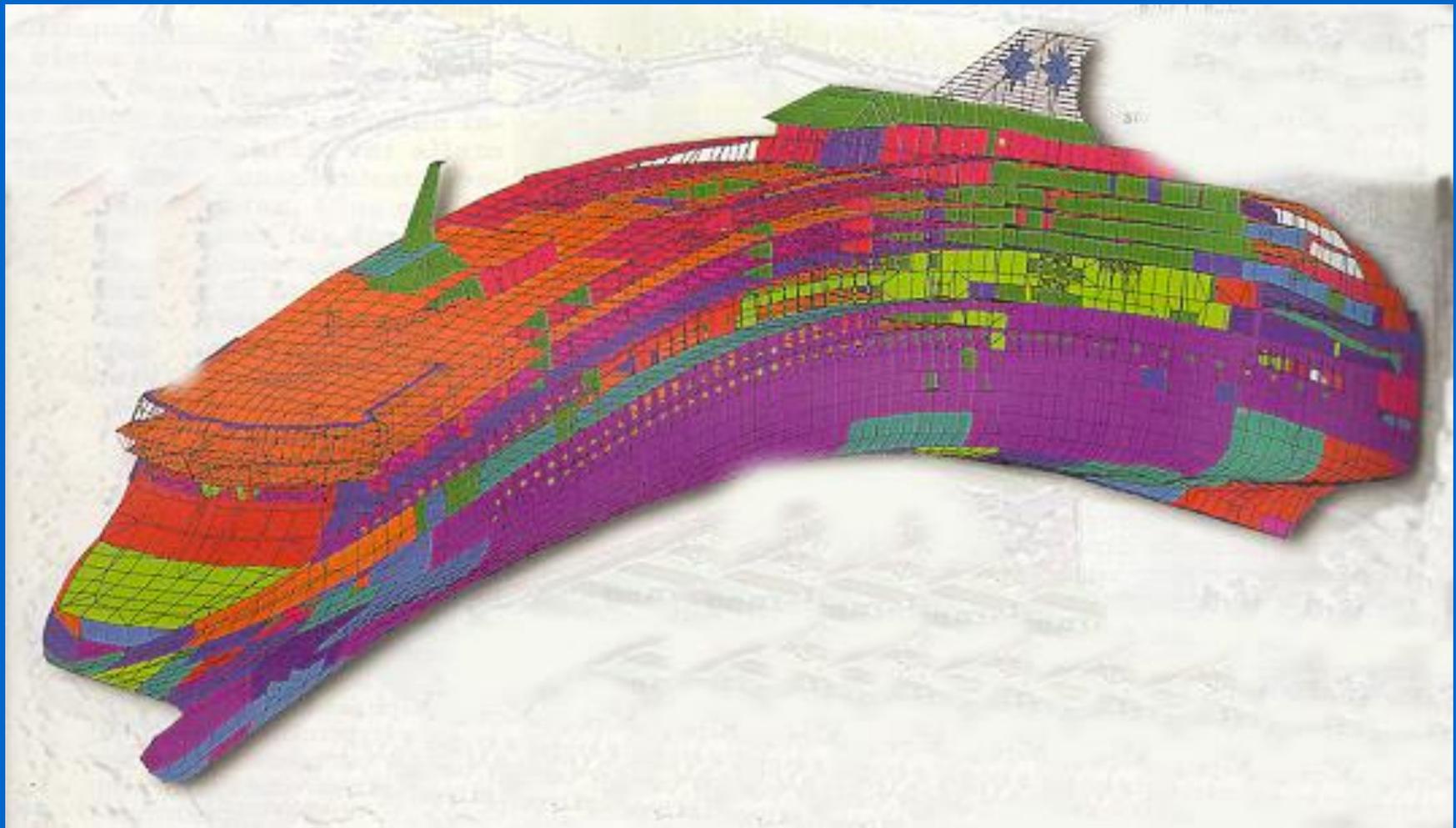


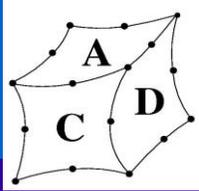
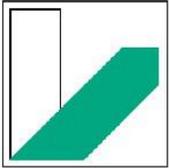
Gigantischer  
Rechenzeitbedarf:  
Phantasy- Filme  
wie Herr der Ringe,  
Krieg der Sterne.



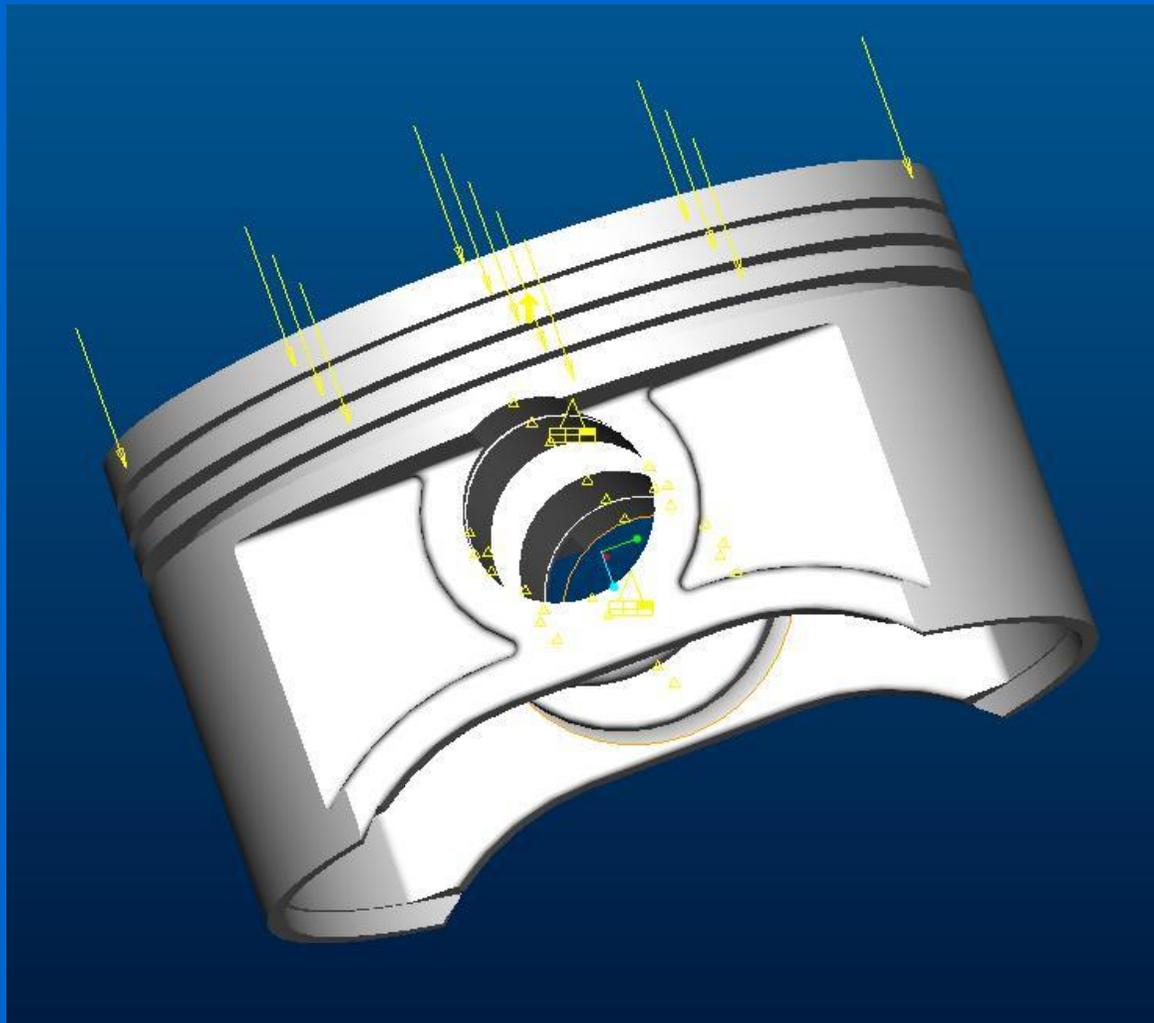


# Finite Elemente Analyse

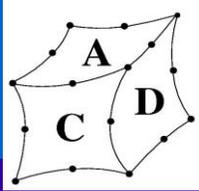
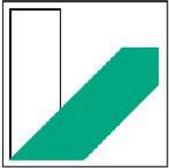




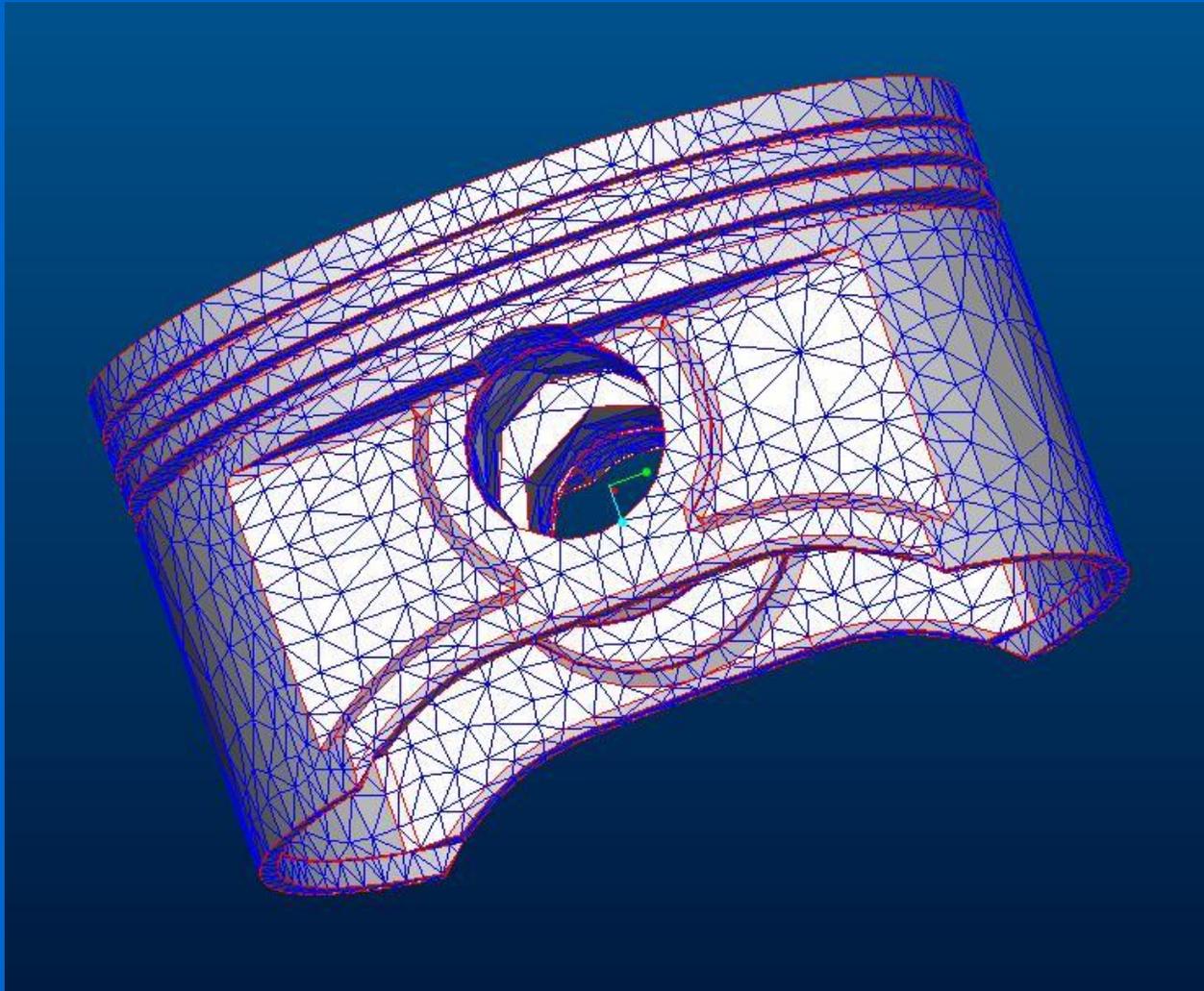
# FEA eines Kolbens



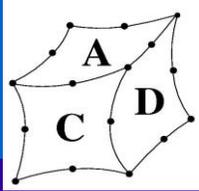
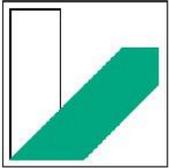
Kolben einer  
BMW F 650  
GS.  
Konstruiert mit  
Pro/ENGINEER



# FEA eines Kolbens

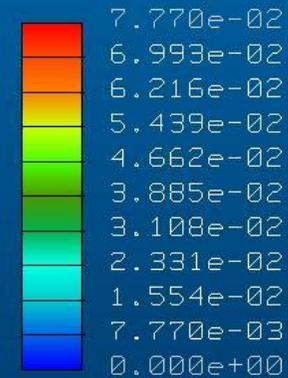
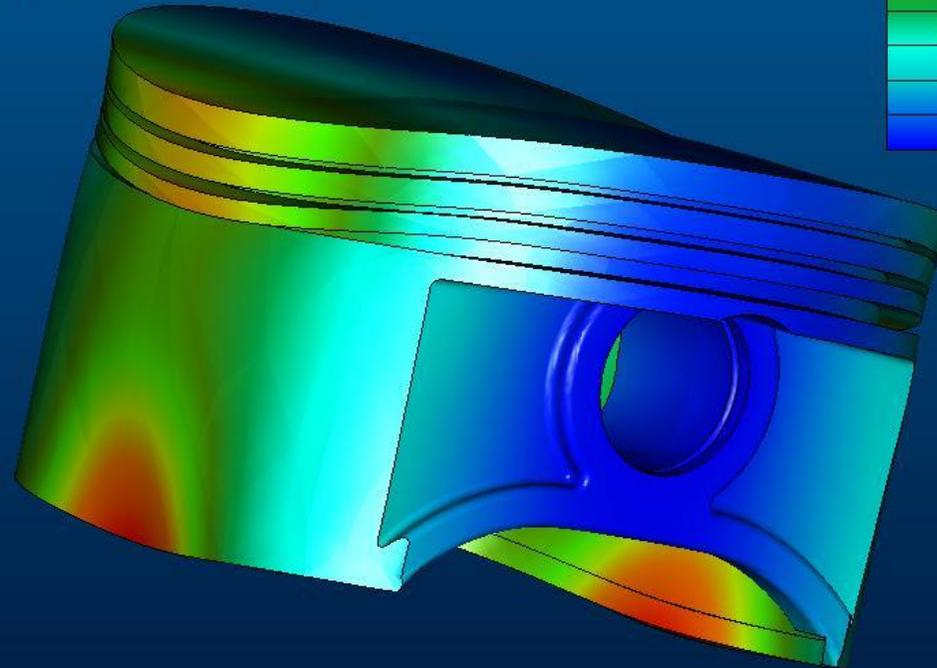


Kolben einer  
BMW F 650 GS.  
FEA- Netz mit  
Pro/MECHANICA

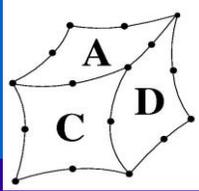
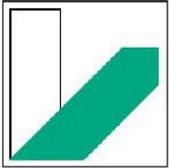


# FEA eines Kolbens

Verformung Betrag  
Verformtes Original Modell  
Max Darst +7.770E-02  
Skala 1.2870E+02  
LoadSet1  
Principal Units:  
millimeter Newton Second (mmNs)



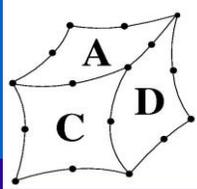
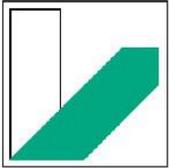
Kolben einer  
BMW F 650  
GS.  
Gerechnet mit  
Pro/ MECHA-  
NICA



# Z88- das freie FEA- Programm

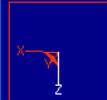
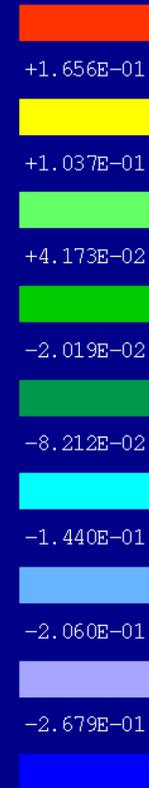
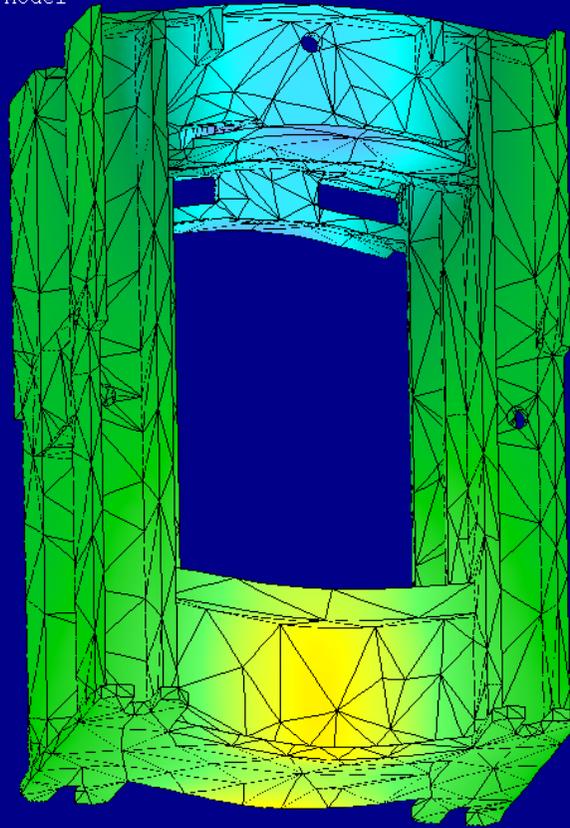


- Entwicklung seit 1985
- 20 Elementtypen
- programmiert in ANSI-C
- beliebig erweiter- und anpaßbar
- steht auf zahlreichen Internet- Servern
- ist Bestandteil der SuSE- LINUX- Distribution
- wird von mehreren Unis und FH eingesetzt
- Rückmeldungen u.a. von Boeing Missile & Defense und Freightliner



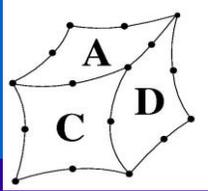
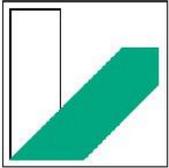
# FEA eines Pressenrahmens

Displacement Z  
Max +2.2750E-01  
Min -3.2981E-01  
Deformed Original Model  
Scale 1.0181E+03  
Load: Combination

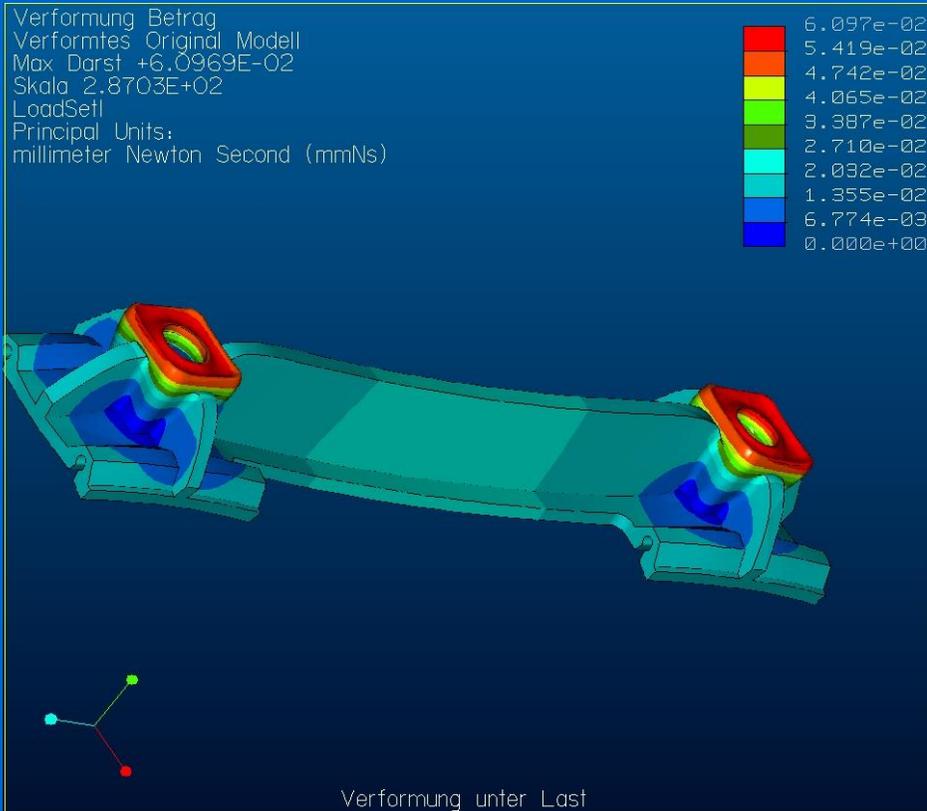


"window5" - study4 - anlys4

Fa. Burkardt,  
Bayreuth

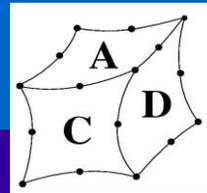
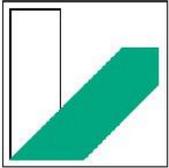


# FEA Kunststoff

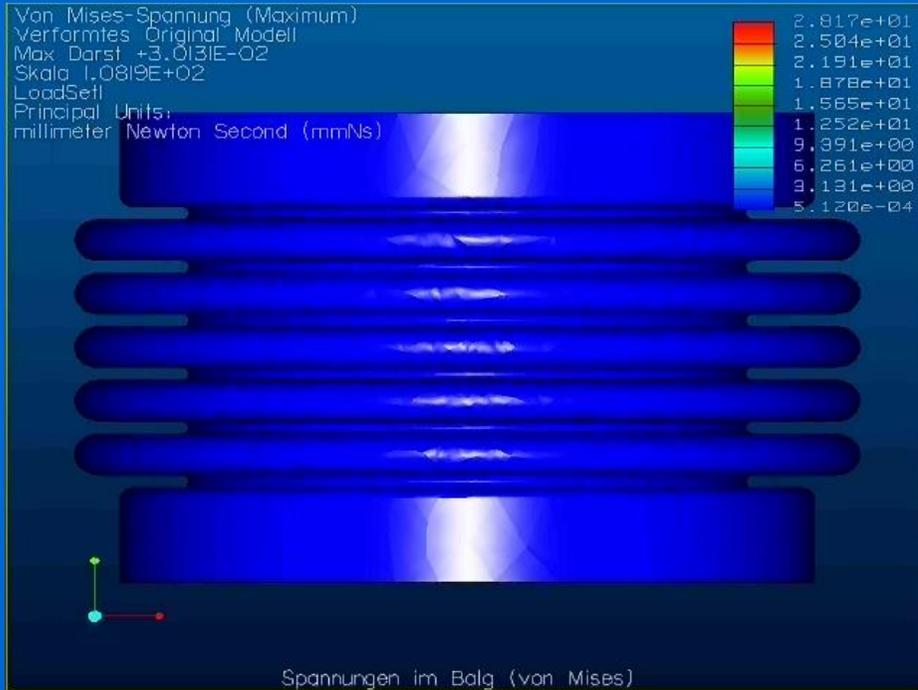


Schott Solarkollektorträger

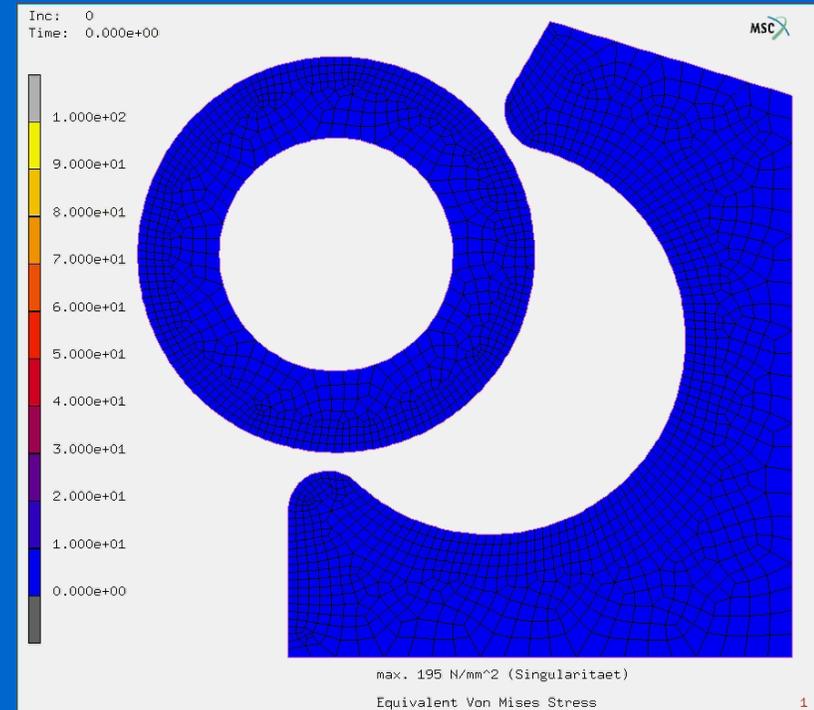




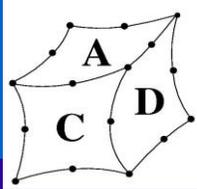
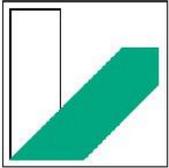
# FEA animierte Simulation



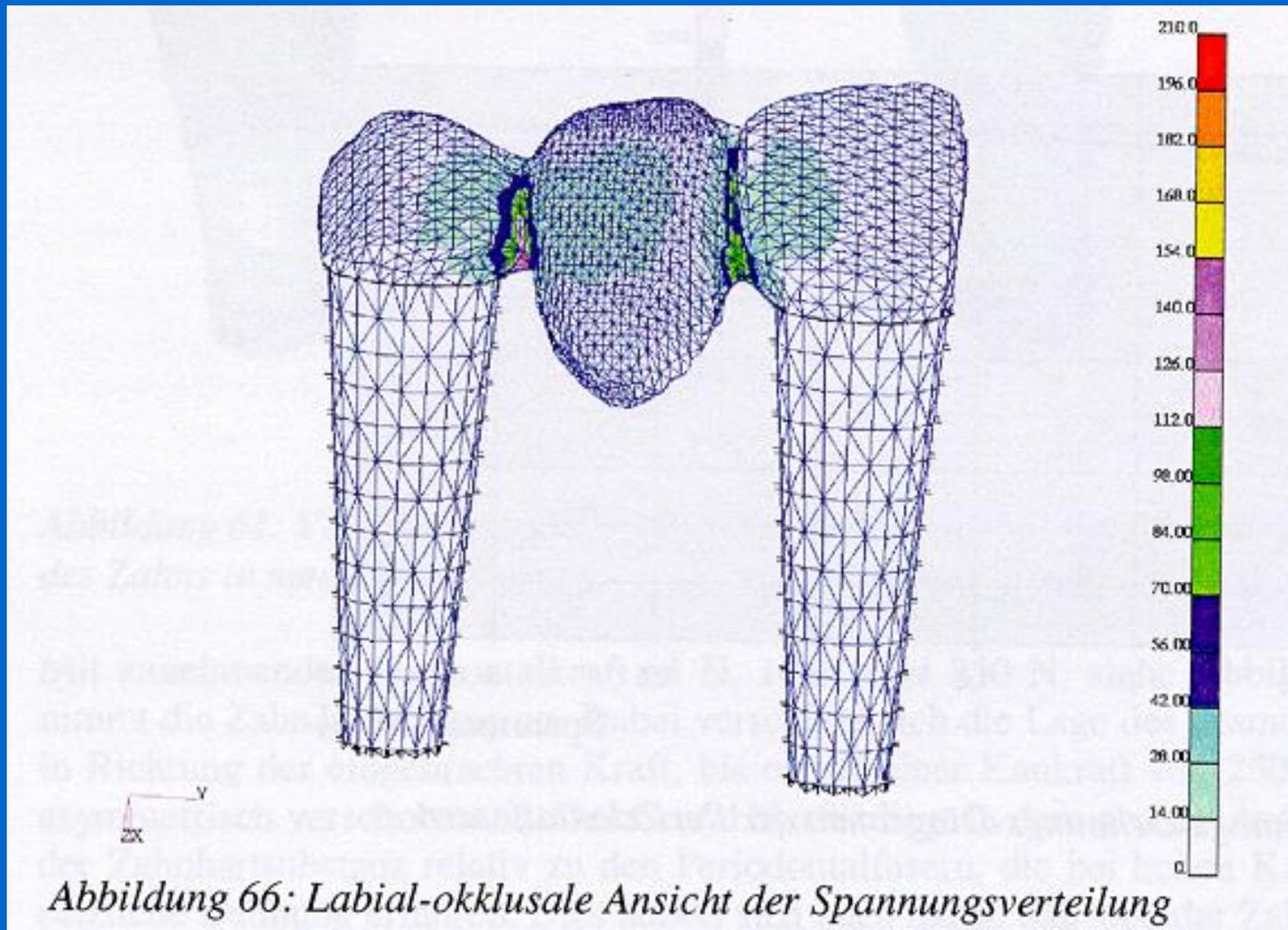
R+W Metallbalg

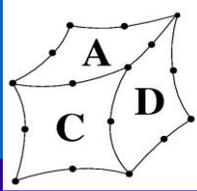
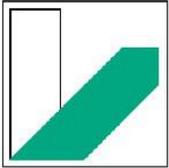


Loewe, Montagekräfte

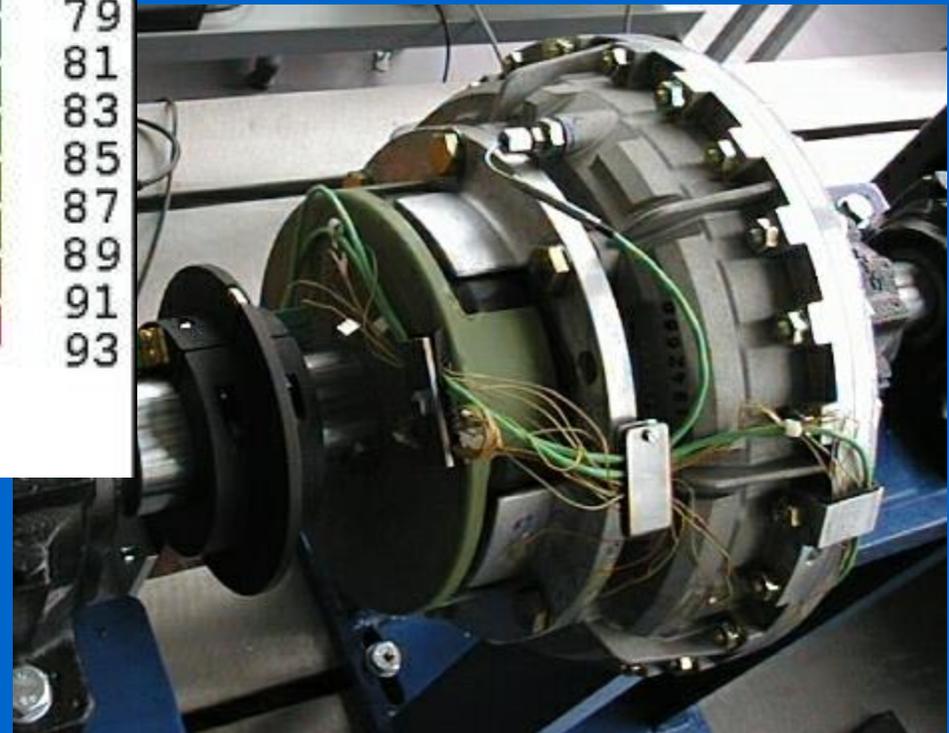
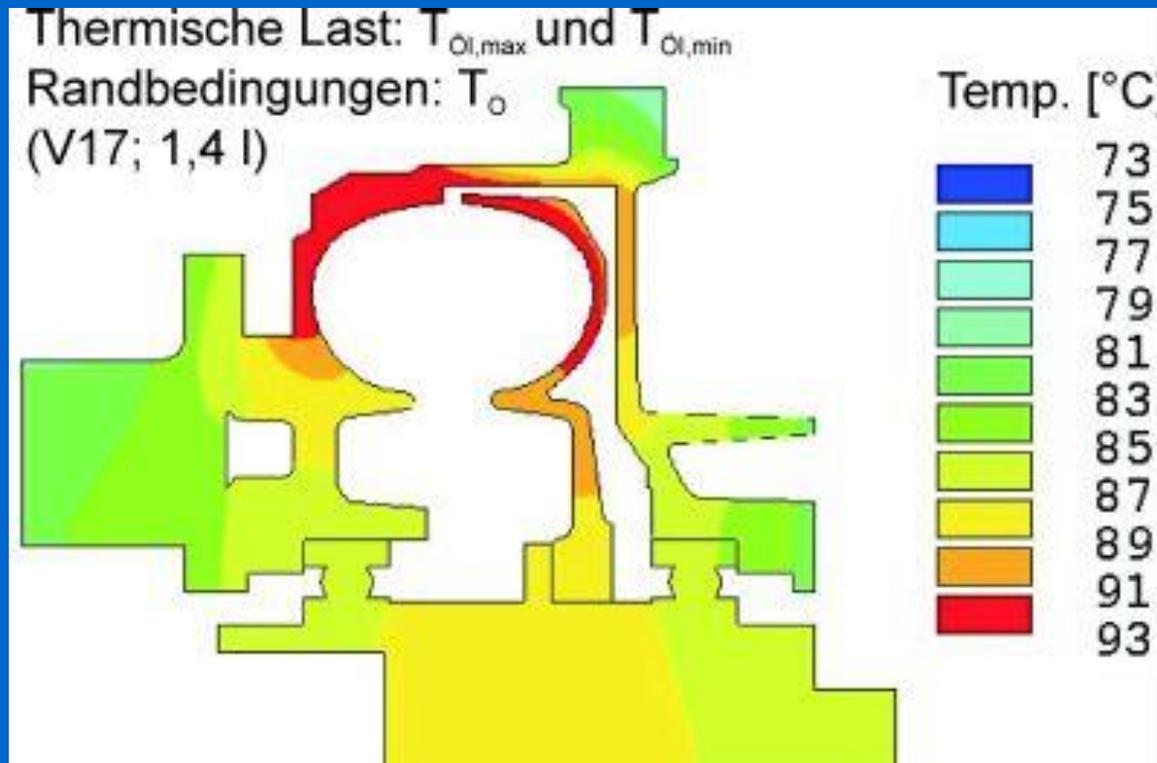


# Finite Elemente und Gesundheit



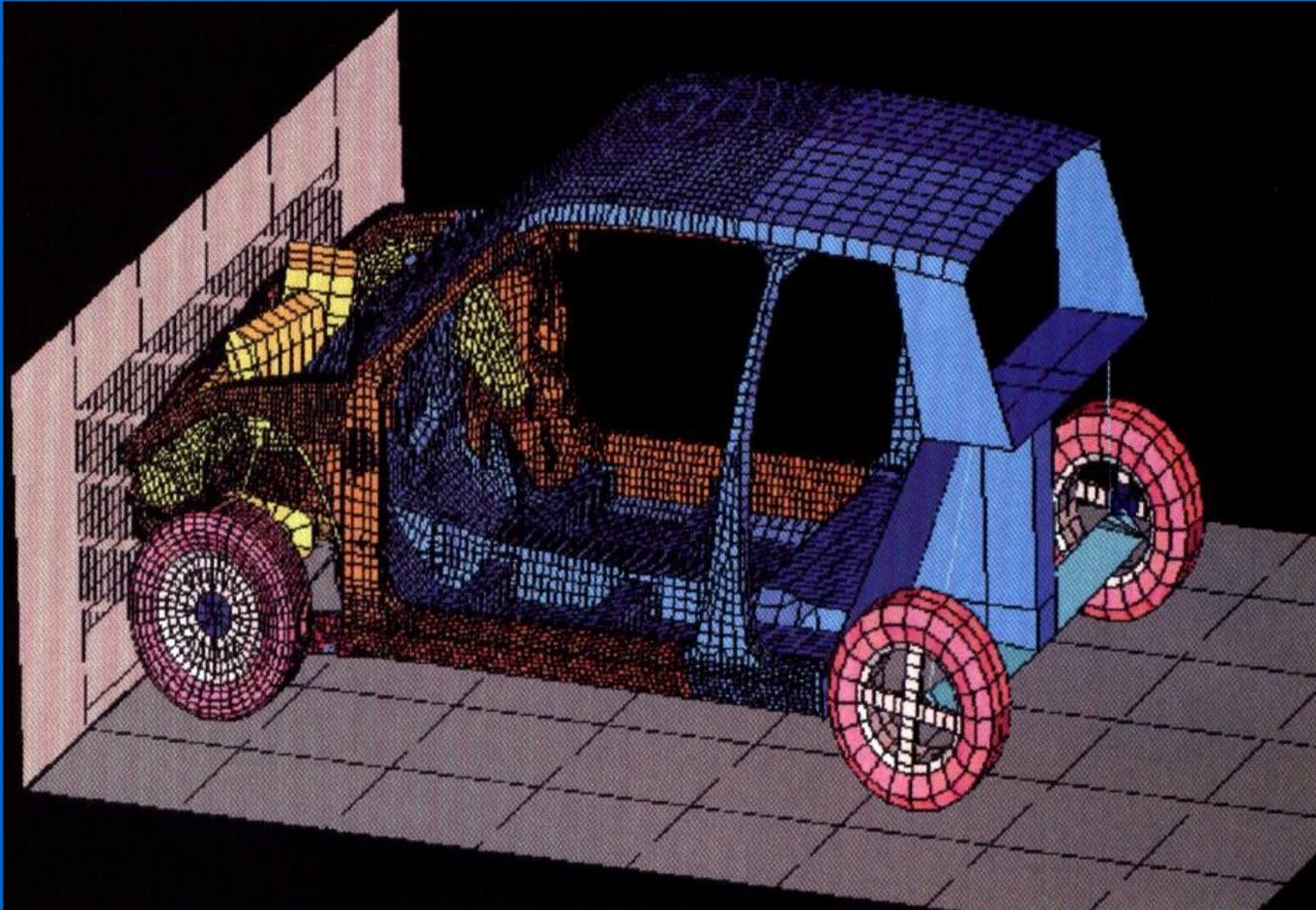


# FEA Temperaturverlauf



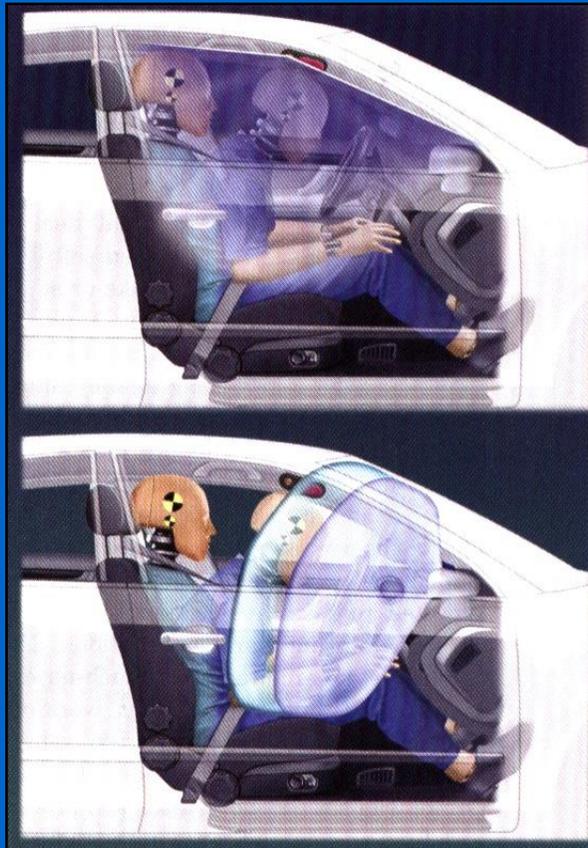
Voith Turbokupplung

# Crash-Simulation



Quelle: Stiff Test,  
Automotive Engineer,  
10/2002

# Crash-Simulation (2)

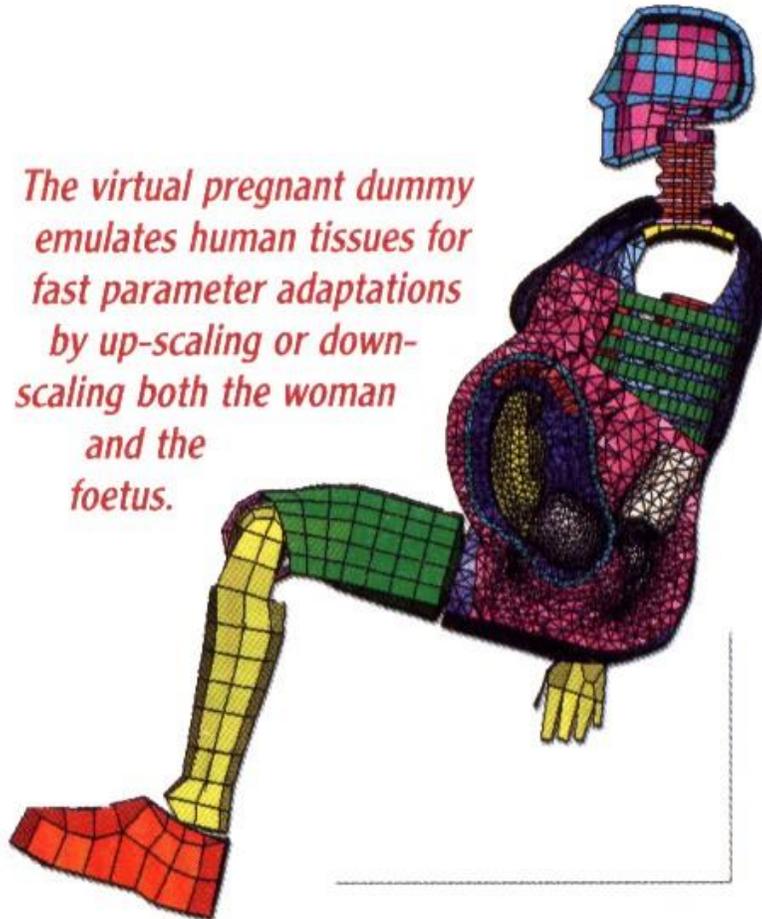


Following information fed back from a laser scanner, the inflated size of the passenger airbag depends on the distance between the passenger and the instrument panel

Quelle: Safety powered by  
Electronics, Automotive Engineer,  
05/2003

# Crash-Simulation (3)

*The virtual pregnant dummy emulates human tissues for fast parameter adaptations by up-scaling or down-scaling both the woman and the foetus.*

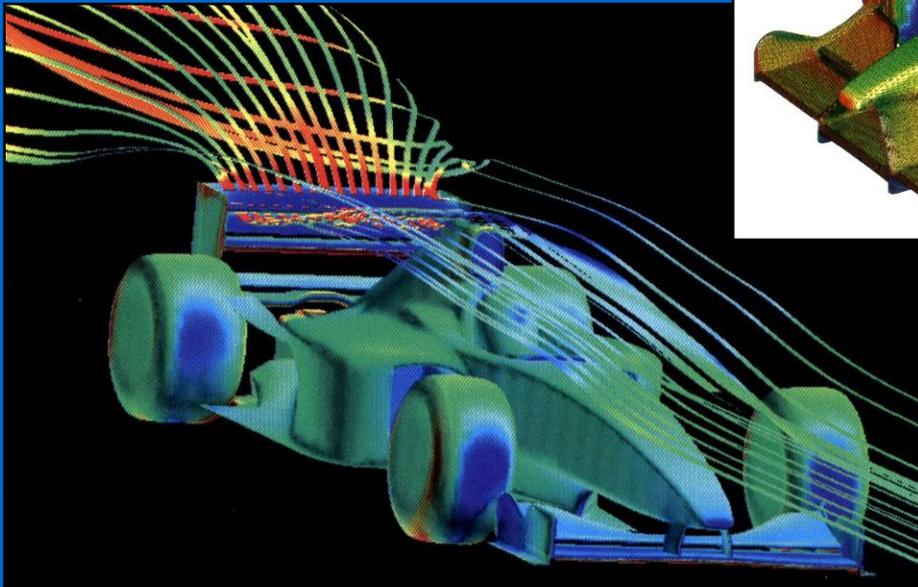
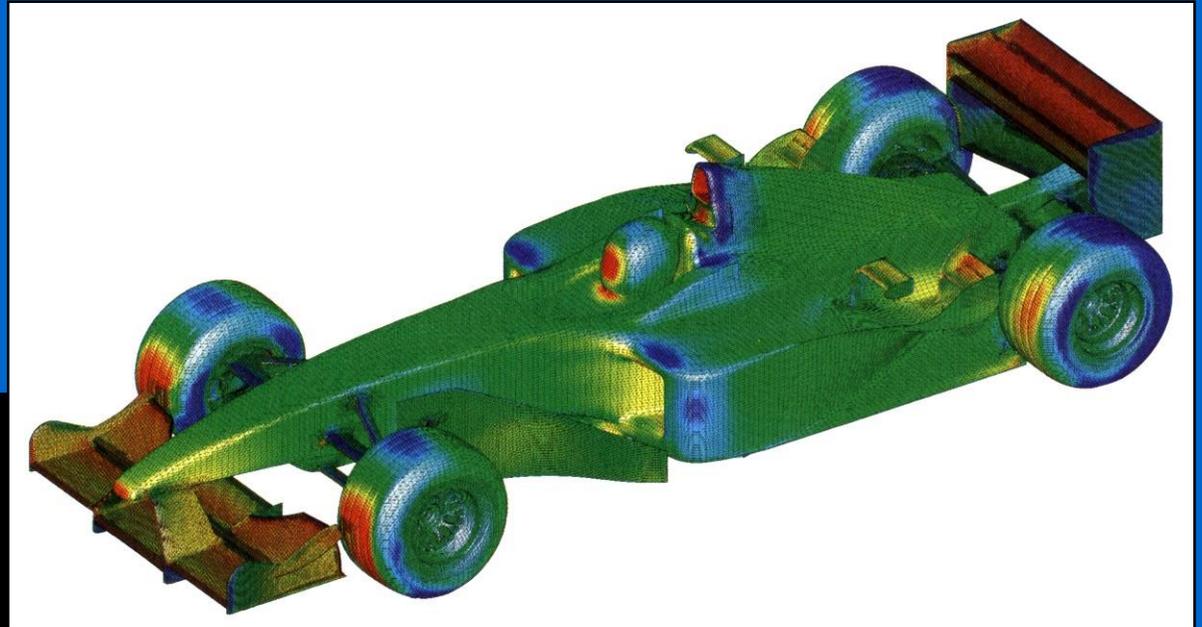


Quelle: Virtual Pregnant Crash Dummy, AutoTechnology, 04/2003

# Strömungssimulation (1)

## Formel 1

Quelle: Go with the Flow,  
Automotive Engineer, 07-08/2001

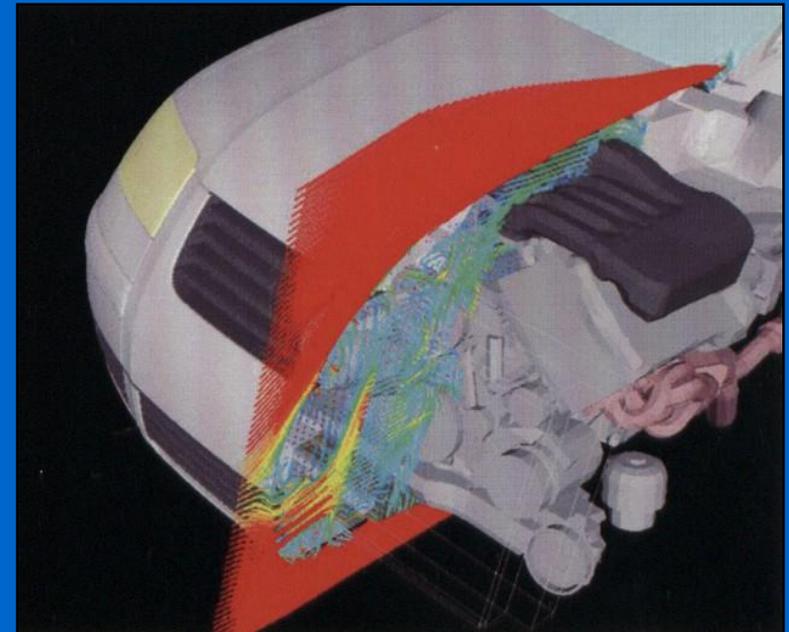


Quelle: Knowledge-Based Expert Systems for  
Better Vehicle Aerodynamics Simulation,  
AutoTechnology, 02/2003

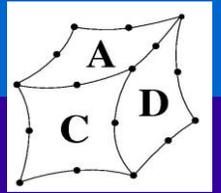
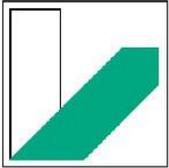
# Volkswagen AG (2)

## Der virtuelle Motor

- Schwingungsanalyse mit Hilfe von Mehrkörpersystem-Programmen
  - Bsp.: Modellierung von Nockenwelle und Ventilen des W8 – Dynamiksimulation über gesamtes Drehzahlband
- Struktur- und Festigkeitsanalyse
  - Bsp.: Kurbelwelle – Simulation von Höchstbelastungen über gesamten Drehzahlbereich am Rechner



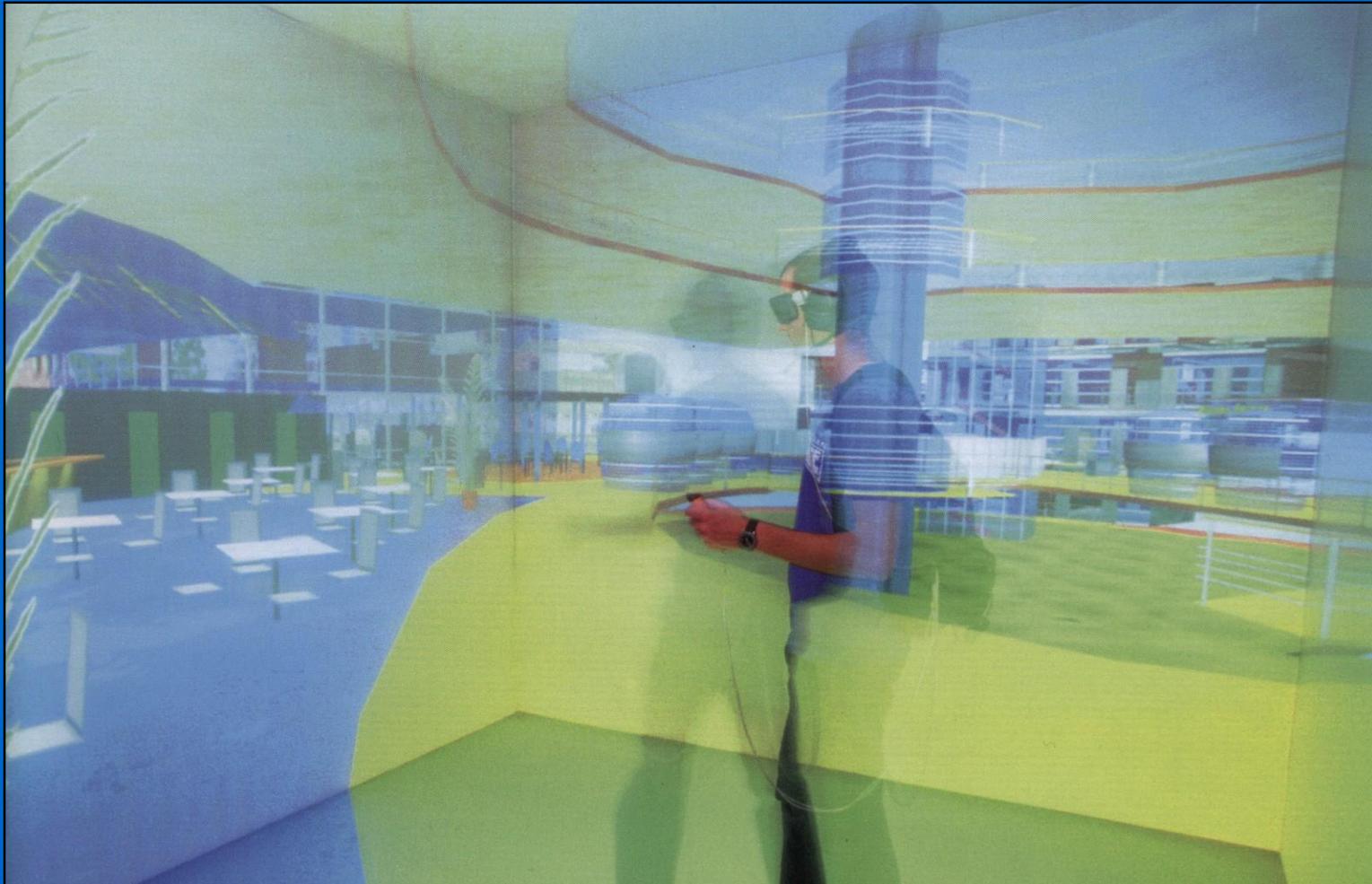
Quelle: Blick in die Zukunft,  
VW Magazin, 12/2002



# Trends

Virtual Reality

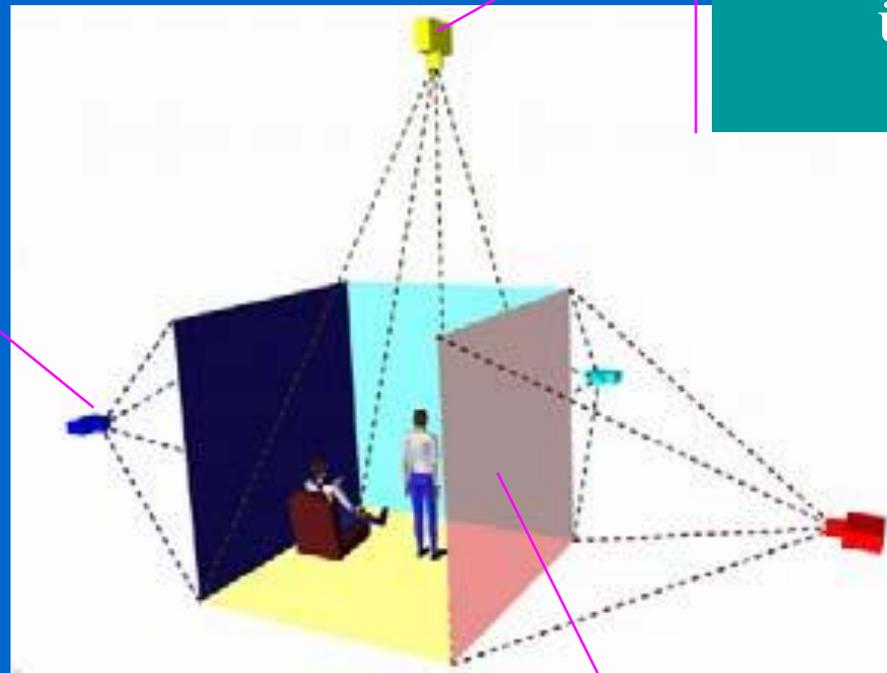
# The Cave



Quelle: Wandern  
durch virtuelle  
Welten, VW  
Magazin, 02/2003

# The Cave (Aufbau)

Projektionswände



Bewegungserfassung  
über Sender  
(Tracking)

Projektionswände

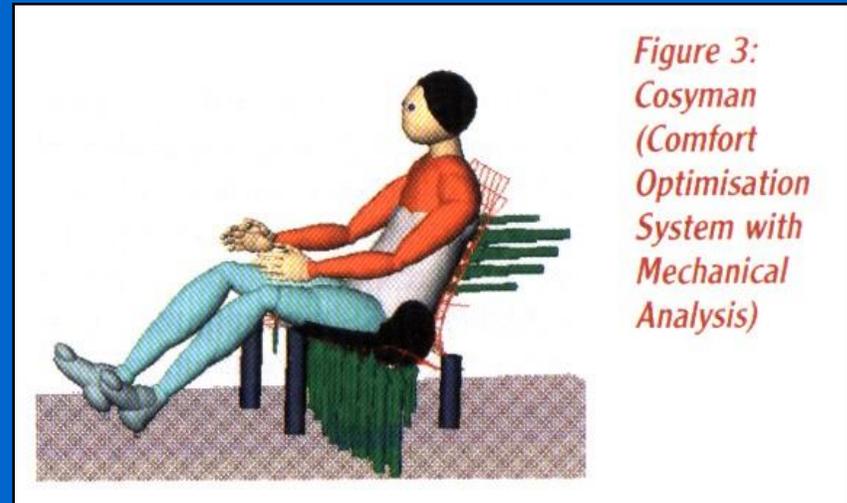
# Interior Design



Quelle: Virtual Reality for  
Industrial Applications, Dai,  
1998

# Interior Design (2)

Siemens VDO offers different systems for passenger classification. In the event of an accident, the airbags are activated on the basis of the collected data

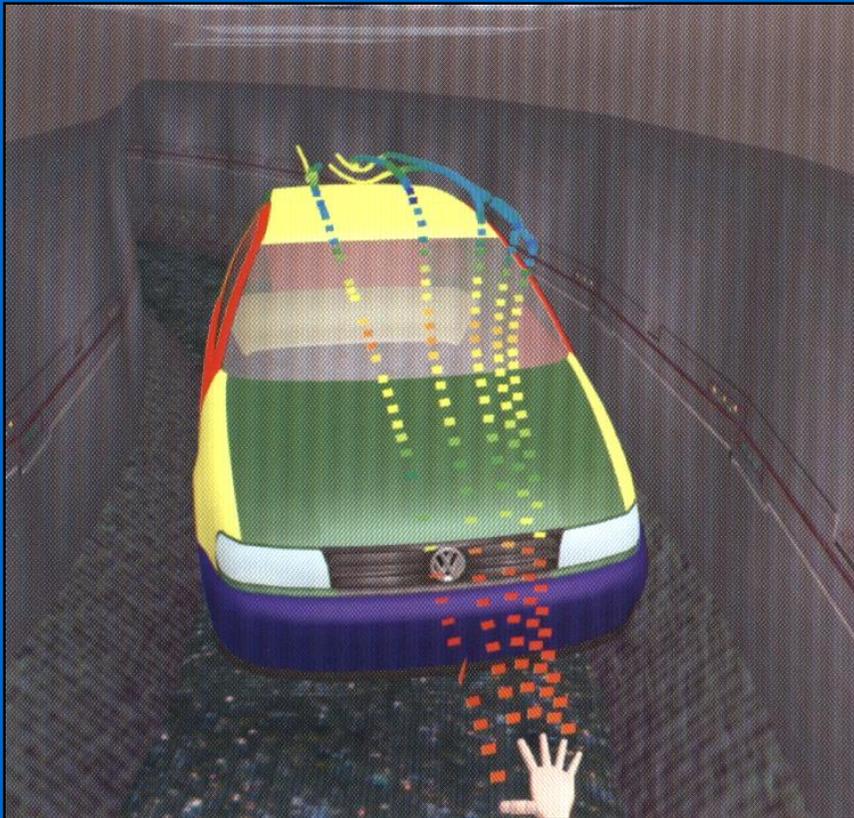


*Figure 3:  
Cosyman  
(Comfort  
Optimisation  
System with  
Mechanical  
Analysis)*

Quelle: Simulating Comfort Before the  
Car Seat Exists, AutoTechnology,  
08/2002

Quelle: Safety powered by  
Electronics, Automotive Engineer,  
05/2003

# Volkswagen AG (1)



Quelle: Virtual Reality for  
Industrial Applications, Dai, 1998



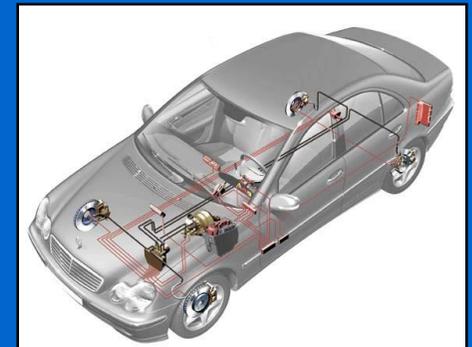
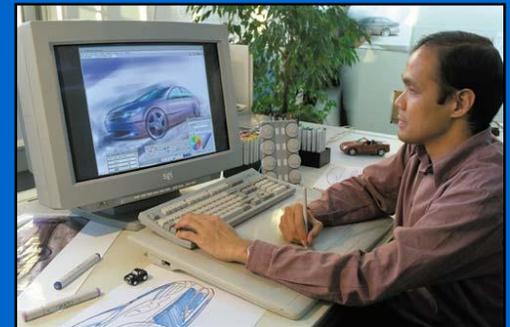
Quelle: Virtual Reality for  
Industrial Applications, Dai, 1998

# DaimlerChrysler AG

## Virtual Reality Center bei DaimlerChrysler

- Powerwall: 7 x 2,5 m Visualisierungsfläche
- Cave: Würfel mit Deckel, Boden und drei Wänden von je 2,5 m Kantenlänge
- Rundprojektion: 7 x 4,4 m große, zylinderförmige Projektionsfläche
- Hochleistungssystem Onyx2 InfiniteReality 2 von SGI
  - Geclustertes System
  - 60 CPUs
  - 15 GB Hauptspeicher
  - 14 voneinander unabhängig arbeitende grafische Hochleistungspipes
  - Memorybandbreite: 22,4 GB/s
  - Etwa 200fache Leistung eines heutigen PCs

Quelle: <http://www.sgi.de>



# Datenhandschuhe – „Gloves“

- Handbewegungen werden direkt interpretiert
- Position und Ausrichtung im 3D-Raum werden durch Tracking-Sensoren erfasst



Quelle: Wandern durch virtuelle Welten, VW Magazin, 02/2003

# Datenhandschuhe – „Gloves (2)“

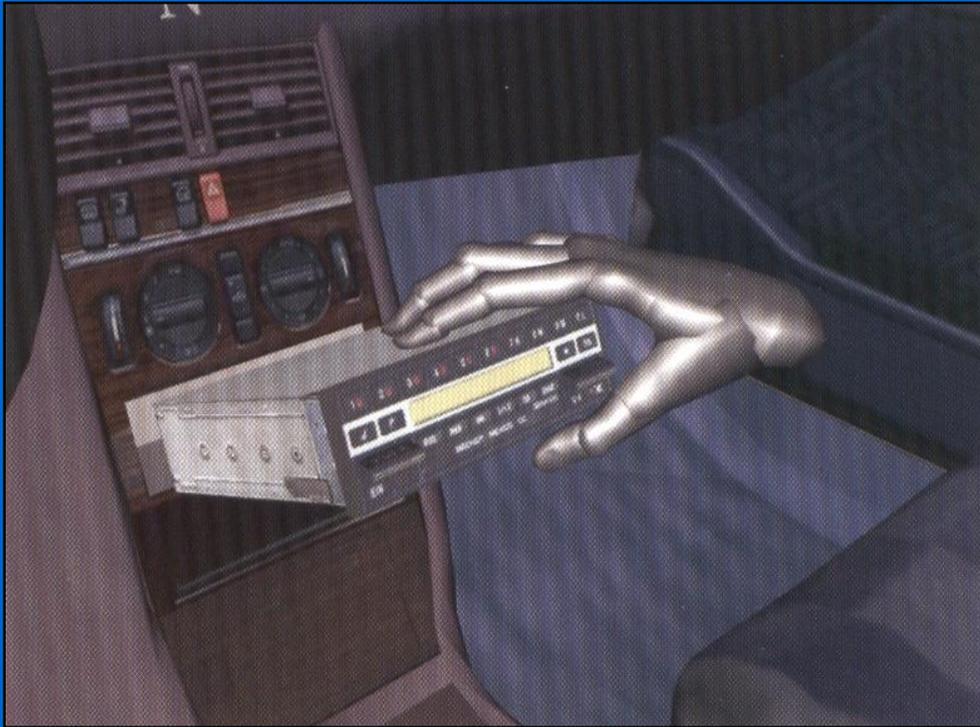


Quelle: Virtual Reality for  
Industrial Applications, Dai, 1998



Quelle: Maschinen mit  
Fingerspitzengefühl,  
Innovation, 11/2003

# Datenhandschuhe – „Gloves (3)“



Quelle: Virtual Reality for  
Industrial Applications, Dai, 1998



Quelle: Virtual Reality for  
Industrial Applications, Dai, 1998



Beispiel

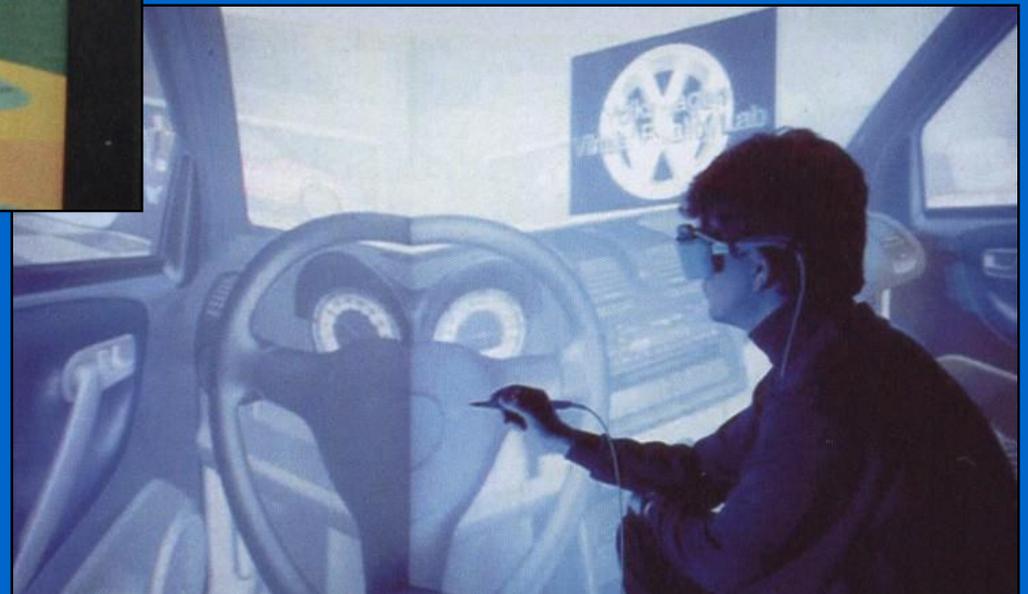
# Volkswagen AG (2)



Quelle: Wandern durch virtuelle Welten, VW Magazin, 02/2003

## Virtual Training Center

Quelle: Wandern durch virtuelle Welten, VW Magazin, 02/2003



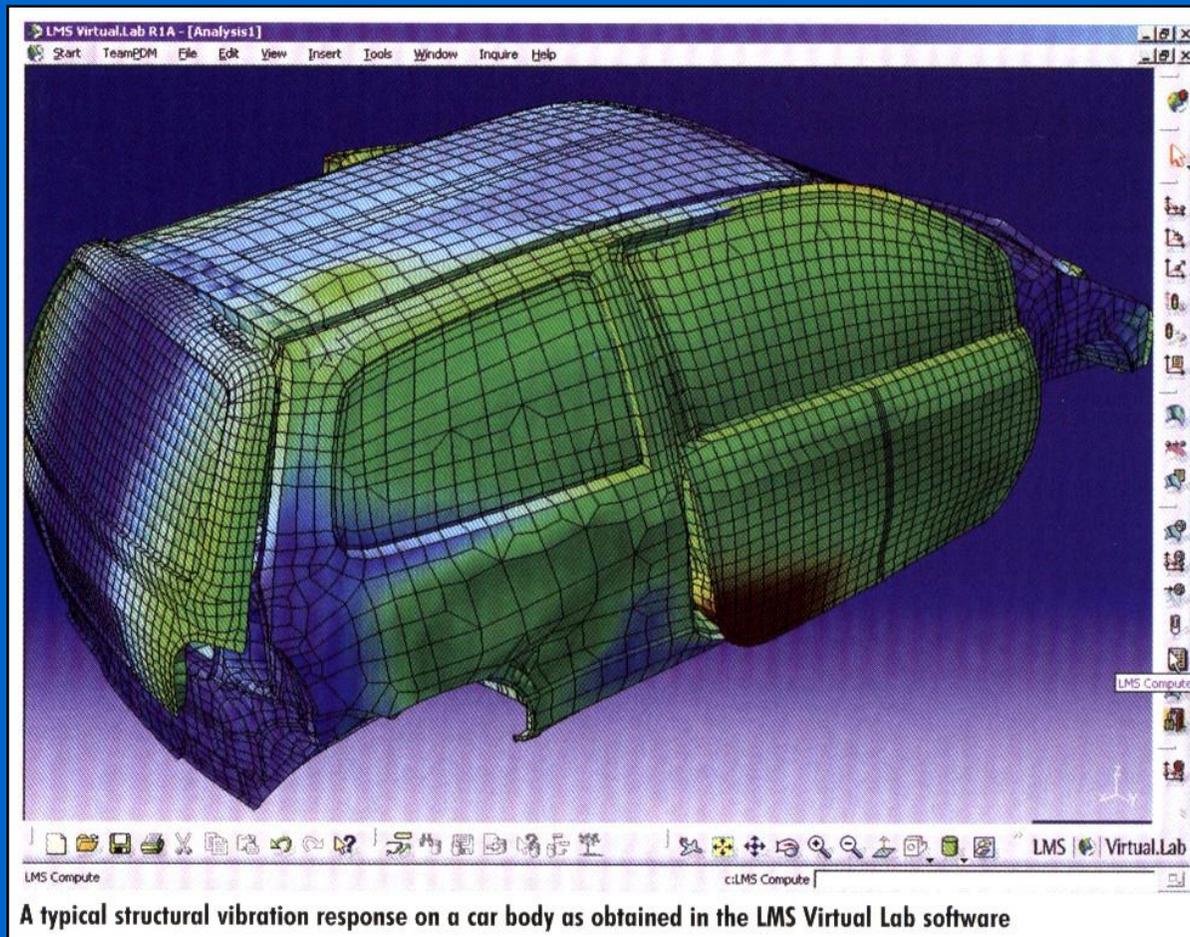
# Virtual Reality in der Medizin



Quelle: Wandern durch virtuelle  
Welten, VW Magazin, 02/2003

# Schwingungsanalyse

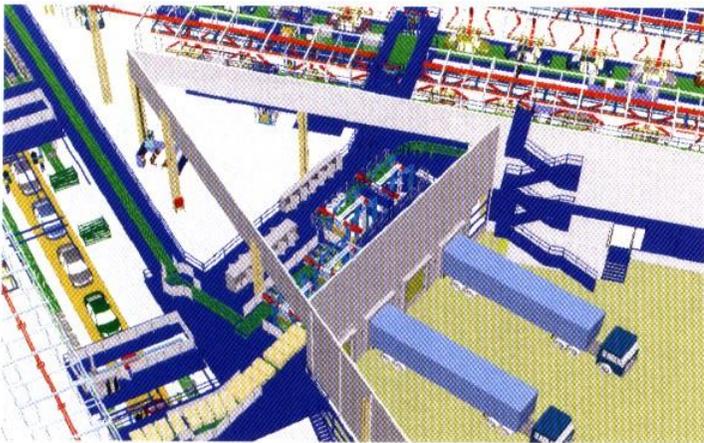
LMS Virtual Lab von Dassault Systems



Quelle: New light on vibration analysis, Automotive Engineer, 04/2003

# Virtuelle Produktionsplanung (2)

## Das Neue Opel Vectra-Werk in Rüsselsheim/D



*The parts are delivered by truck directly to the respective docking stations for the final and finish assembly. These are located in the immediate vicinity of the assembly points on the assembly line, where 73 sequenced components and assemblies are immediately taken from trucks and installed.*

Quelle: The New Opel Vectra-The World's Most Modern Car Production Plants, AutoTechnology, 02/2002



*3D computer animation makes it possible to achieve an almost 100 % simulation of reality.*

Quelle: The New Opel Vectra-The World's Most Modern Car Production Plants, AutoTechnology, 02/2002

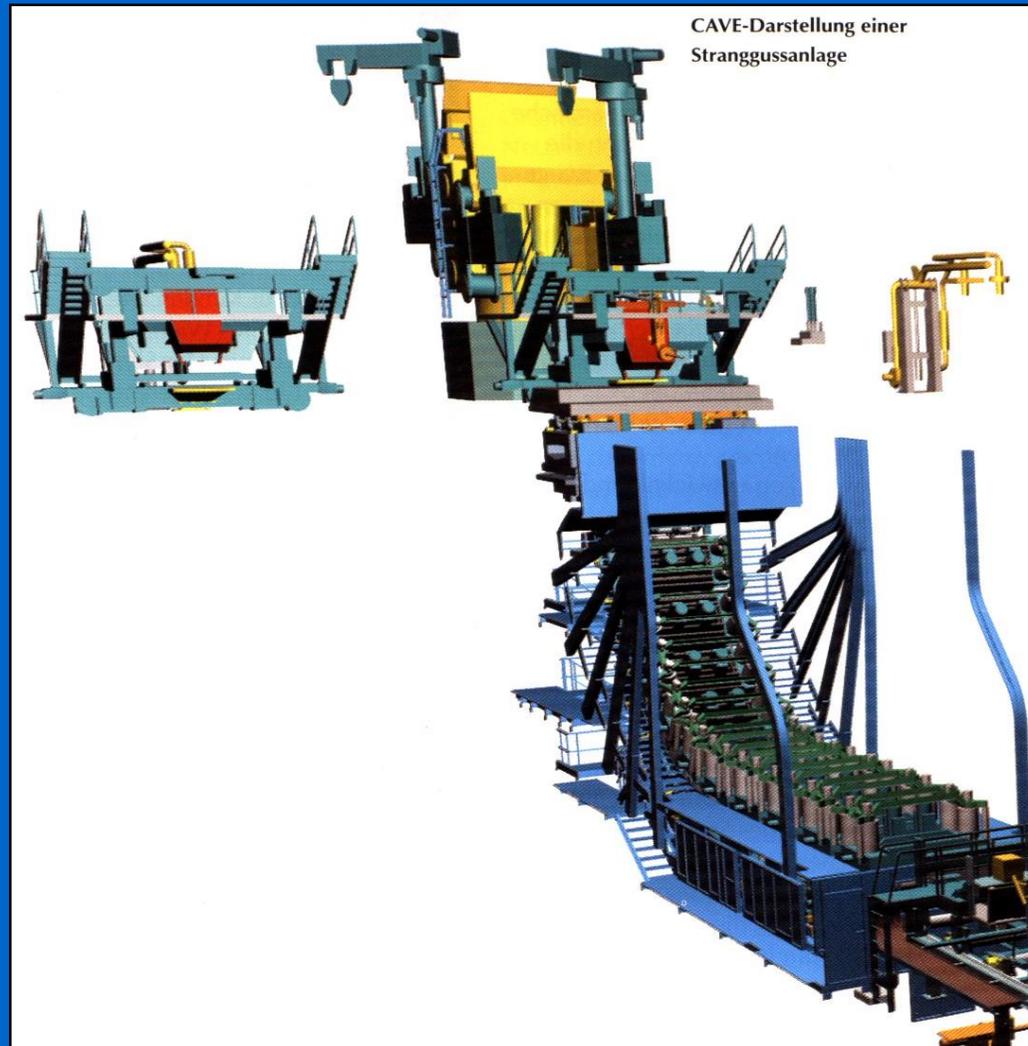
# Virtuelle Produktionsplanung (3)



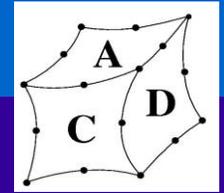
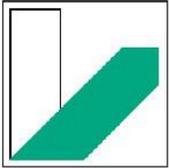
**Fabriksimulationen aus dem Computer**, wie hier im Karosserierohbau, geben den Planern Sicherheit bei der Gestaltung neuer Produktionsanlagen. Foto: imk Automotive

Quelle: Digitale  
Planung bringt  
Sicherheit, VDI  
Nachrichten,  
31.10.2003

# Virtuelle Produktionsplanung (4)



Quelle: 3D-Visualisierung für  
Maschinen- und Anlagenbau,  
Technik in Bayern, 09-10/2003



Sind Sie überzeugt?

Numerische Simulation in der  
Produktentwicklung -  
Ein spannendes Thema!