
$$\bar{\Pi} = \frac{1}{2} \sum_e \{u\}^T \cdot [K] \cdot \{u\} - \{u\}^T \cdot \{F\}$$

FEM SOFTWARE AND SERVICES

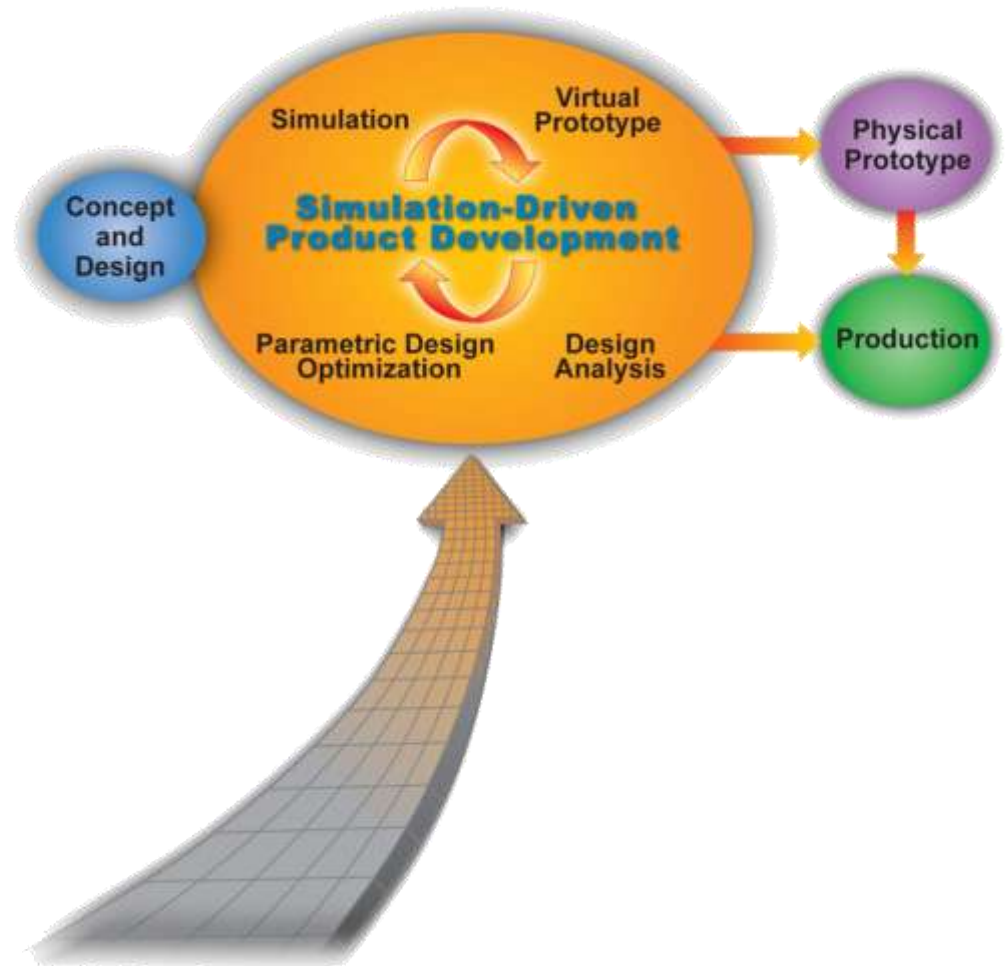


# Product Safety in spite of Scattering in Production and Operation

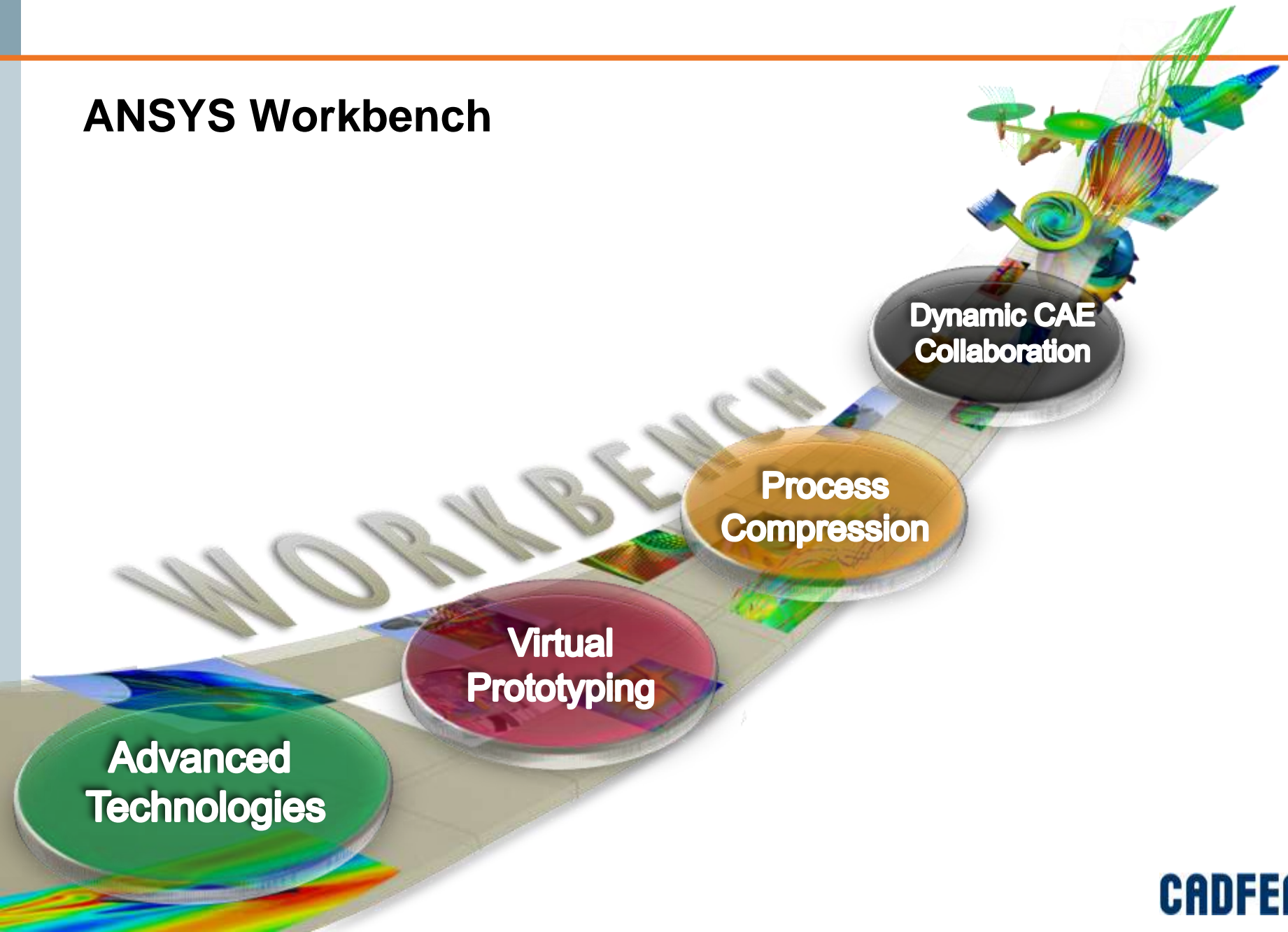
Christof Gebhardt, CADFEM GmbH

# The Role of Simulation in Product Development

„Understand, optimize and innovate your design before it is build“



# ANSYS Workbench



# Product Improvement and Optimization

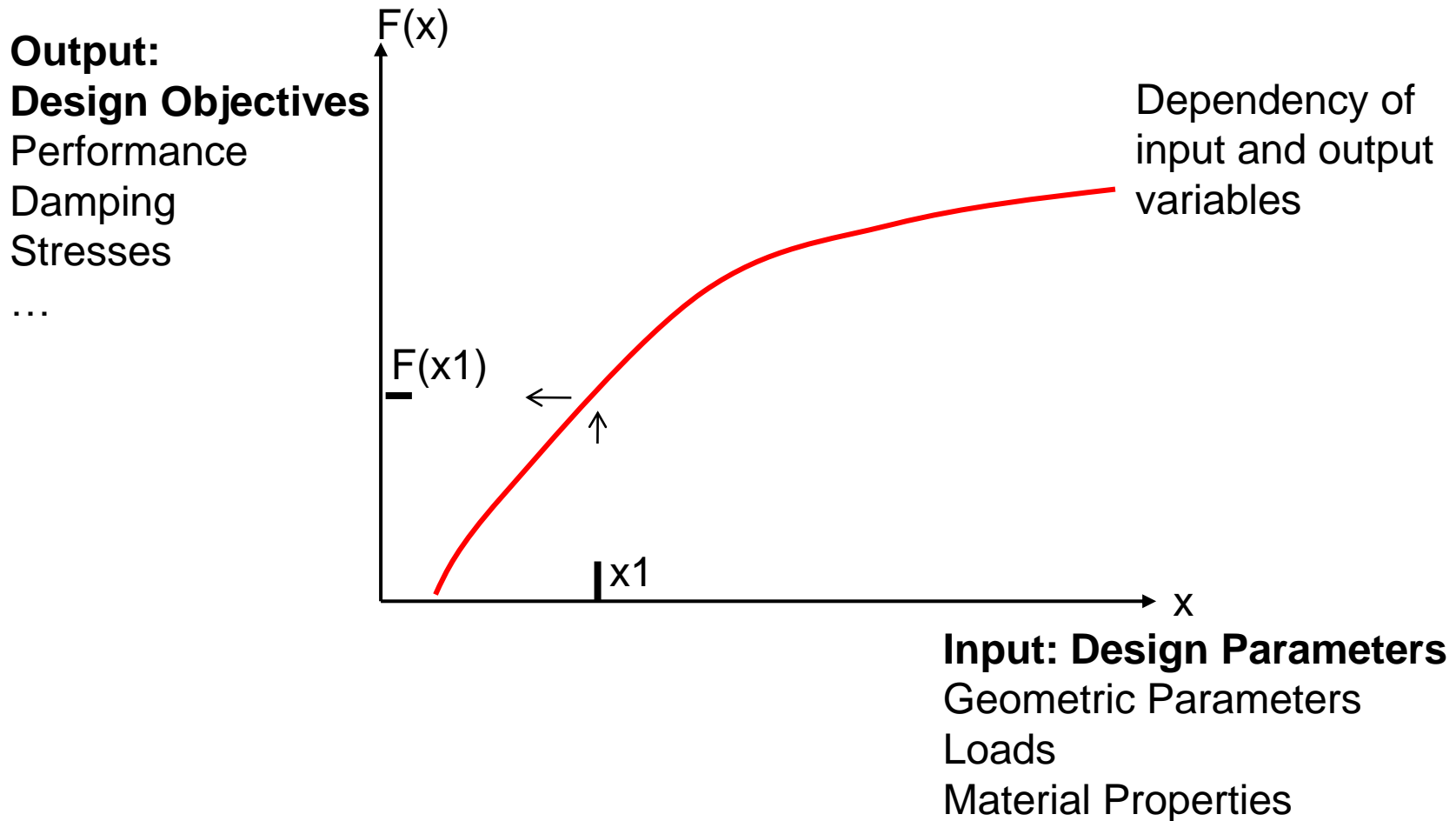
# Challenge Product Reliability

- Example: Connector
  - Mechanics
  - Manufacturing
  - Signal integrity
  - Electric field
  - Thermal conduction

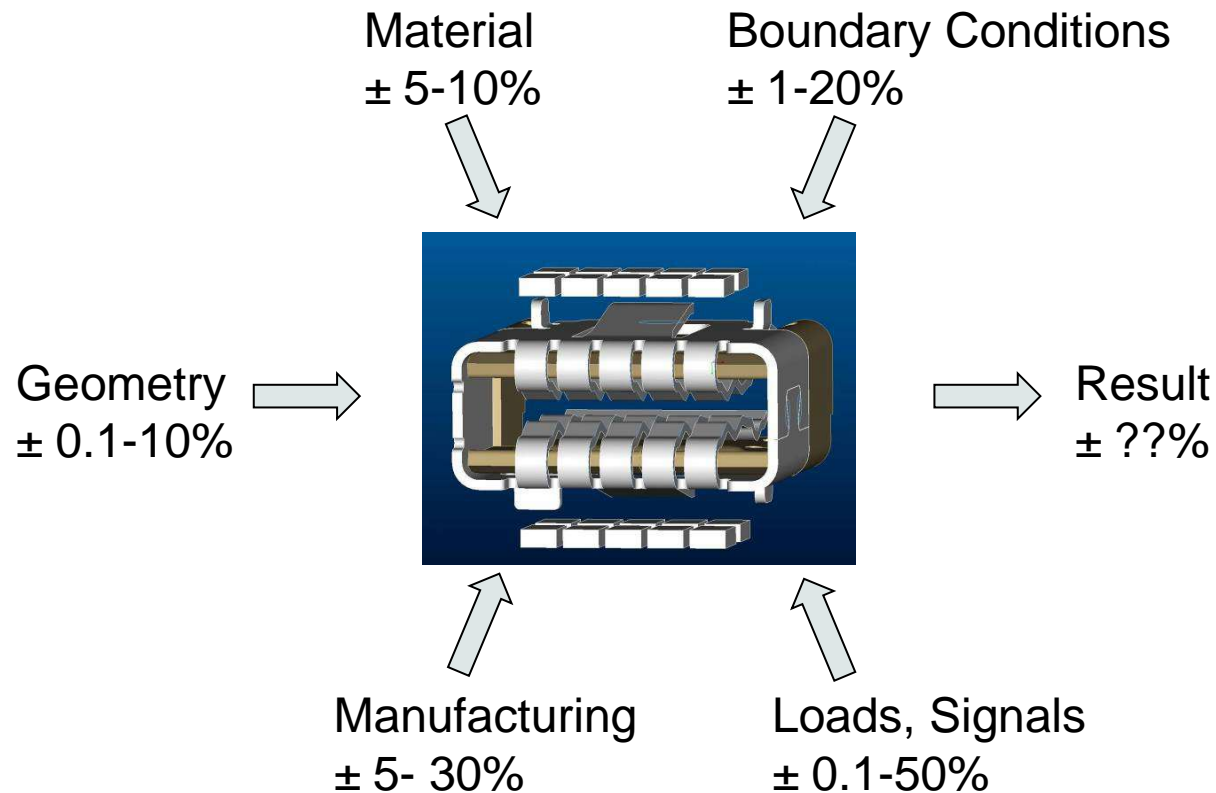
The screenshot shows a news article from Focus Online. The header includes the 'ONLINE FOCUS' logo and navigation links for Home, Politik, Finanzen, Wissen, Gesundheit, Kultur, Panorama, Sport, and Digital. Below this is a secondary navigation bar with links for News, Fahrberichte, Video, Neuheiten, Messen, Gebrauchtwagen, and Ratgeber. The main headline is 'Brandgefahr BMW ruft 120 000 Autos zurück', dated Wednesday, 31.08.2011, 18:21. The sub-headline reads: 'Wegen einer fehlerhaften Steckverbindung am Dieselfilter muss der Münchner Autobauer BMW 120 000 Autos zurück in die Werkstatt rufen. Betroffen sind verschiedene Modelle zweier Fahrzeugreihen.' Social media sharing buttons for Facebook (38), Twitter (12), and Google+ (1) are visible. On the left side, there is a 'ZUM THEMA' section with links to 'Autopilot fürs Auto', 'Neuzulassungen', and a list of related topics: 1er, 5er, BMW, Diesel, Rückruf, Steckverbindung, and 'Meine Themen'. The main text of the article discusses a faulty connection in the diesel filter of BMW's 1er and 5er series, which could lead to fires. It mentions that BMW has not observed any actual fires but is recalling vehicles due to customer complaints and reports. The article is signed 'ala/dapd'.

[http://www.focus.de/auto/news/brandgefahr-bmw-ruft-120-000-autos-zurueck\\_aid\\_660907.html](http://www.focus.de/auto/news/brandgefahr-bmw-ruft-120-000-autos-zurueck_aid_660907.html)

# Traditional Deterministic Simulation Approach



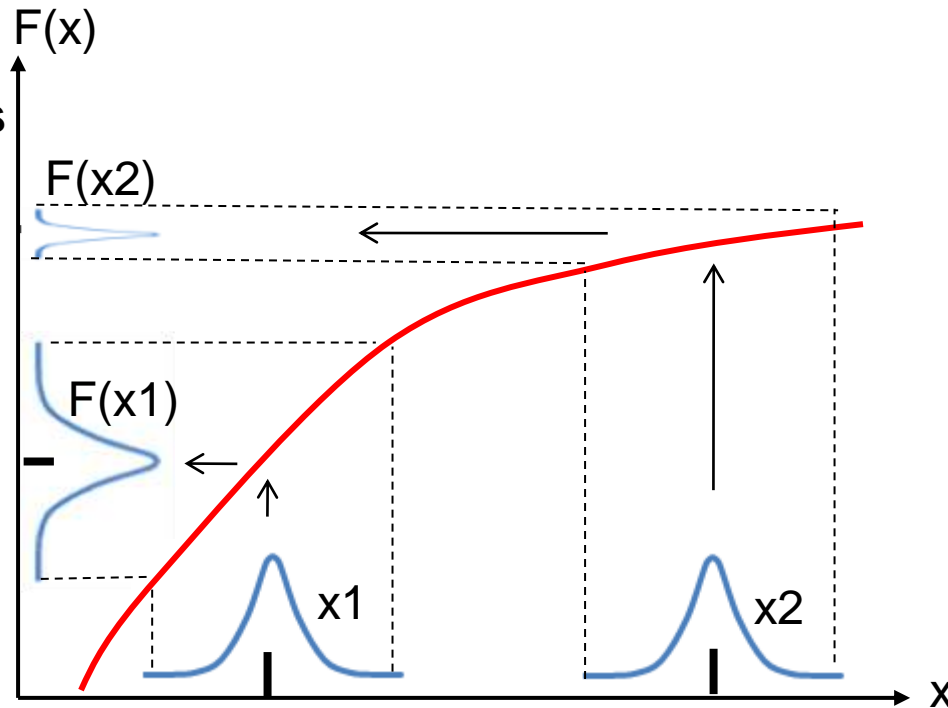
# Reality



# Robust Design - Stochastic Simulation Approach

## Output: Design Objectives

Performance  
Damping  
Stresses  
...



## Input: Design Parameters

Geometric Parameters  
Loads  
Material Properties

# optiSLang – Product Safety by Simulation

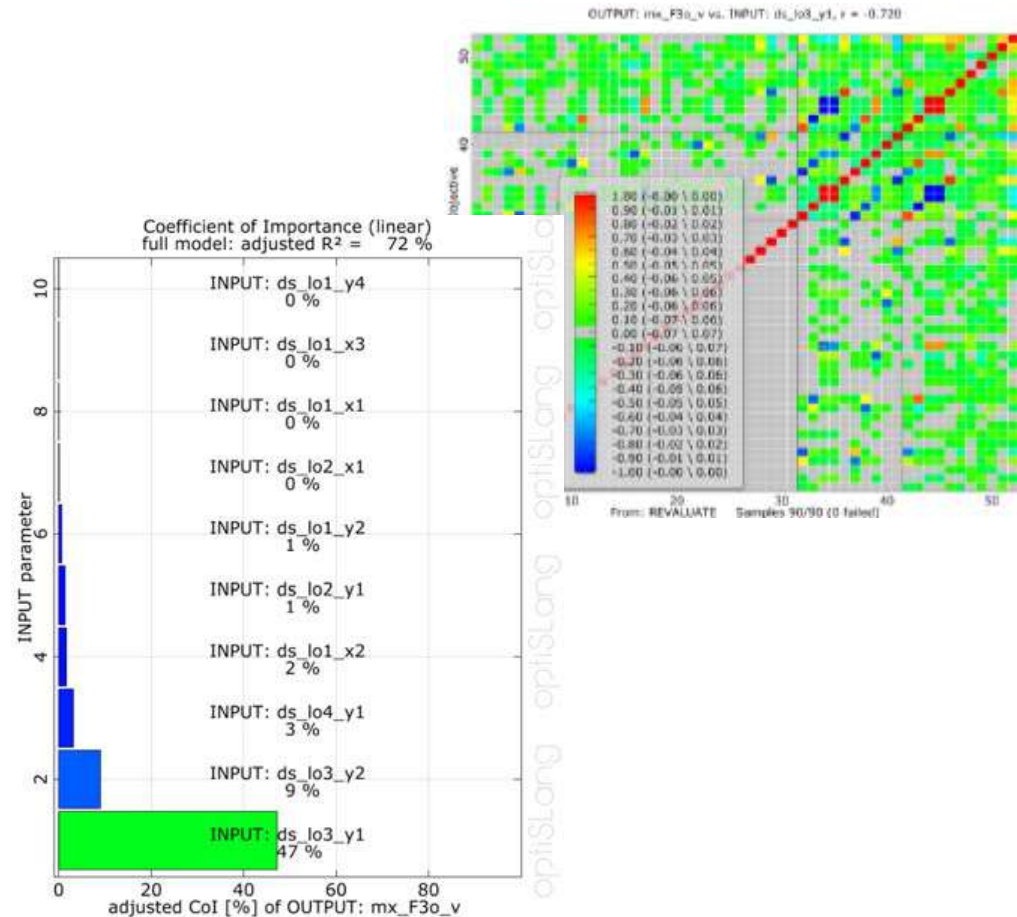
- Easy to use – Safe to use
- Efficient workflow
  - Parametric ANSYS Workbench simulation workflow
  - Associative CAD connection
  - Associative simulation definitions
- Sensitivity – Understand your design and driving parameters
- Optimization – Use the full potential of your design
- Robustness – Ensure the functionality under real world conditions





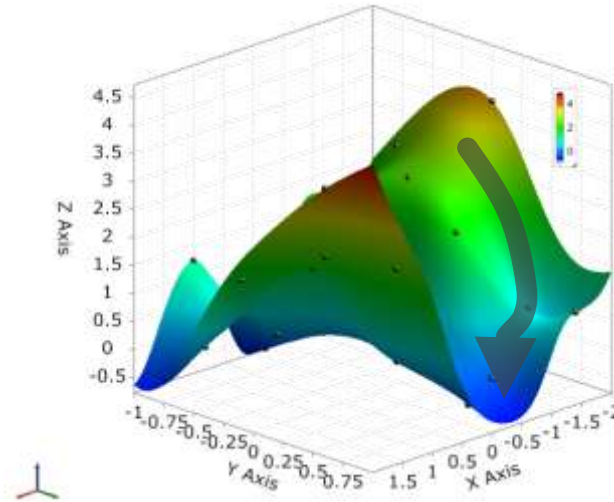
# Case Study Tyco Electronics

- Step 1: Sensitivity
  - Efficient Design of Experiments (DoE) scheme
    - Automated
    - „no run too much“
  - 90 designs computed
  - Initial failure probability 89%
  - Identification of the critical contact forces and driving parameters
- Understand the design



# Case Study Tyco Electronics

- Step 2: Optimization
  - Focus on the 15 dominating parameters
  - Use optiSLang optimization routines to improve the performance
    - Gradient based
    - Nature inspired
- Improve the performance by 30%



Gradient based  
Optimization

Courtesy of Dynardo GmbH

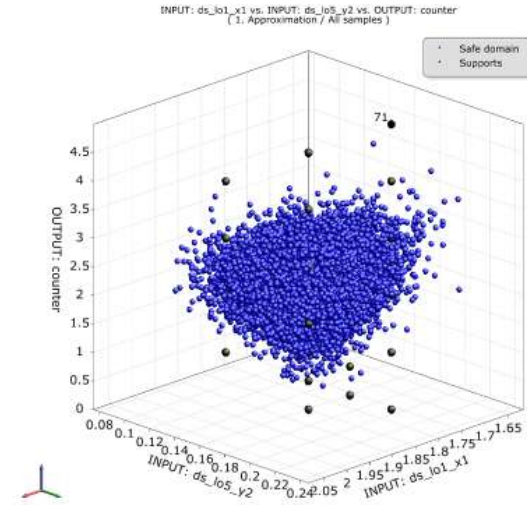


Nature inspired  
Optimization

Courtesy of iStockfoto.com

# Case Study Tyco Electronics

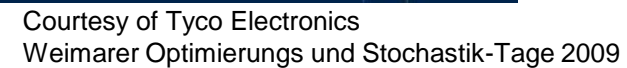
- Step 3: Reliability Analysis
  - Verification of the optimized design with advanced algorithms
  - No failures in 300.000 numerical samples
- Achievement „Design for Six Sigma“
- Secured product safety




Courtesy of Tyco Electronics  
Weimarer Optimierungs und Stochastik-Tage 2009



- Identification of driving parameters
- Proper numerical adjustment and significant reduction of costs
- Deeper understanding about variation
- Minimizing the effect of noise
- Design for Six Sigma in product development




$$\bar{\Pi} = \frac{1}{2} \sum_e \{u\}^T \cdot [K] \cdot \{u\} - \{u\}^T \cdot \{F\}$$

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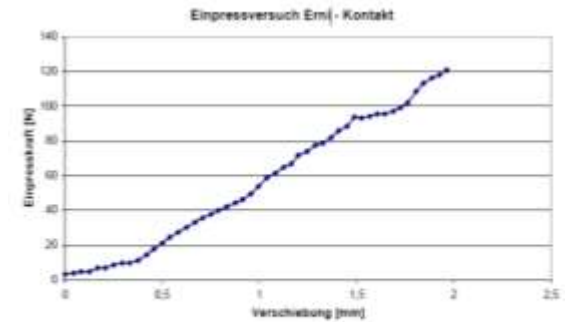
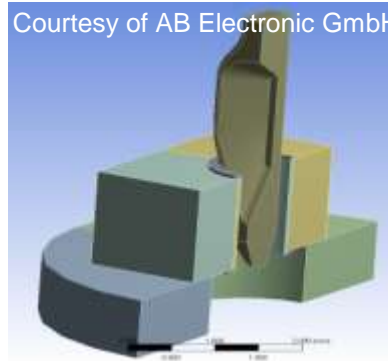


# Robust Design Optimization for Connectors

# Mechanics

- Plug and unplug forces
- Contact forces and area
- Strength & fatigue life
  - Static load
  - Shock
  - Vibration
  - Modeling of complex material behavior
    - Stress and strain based fatigue life
    - Creep of solder joints
    - Fiber reinforced plastics
- Encapsulation & Sealing
- Mechanism of locking systems
- Scatter
  - Material
  - Geometry
  - Loading

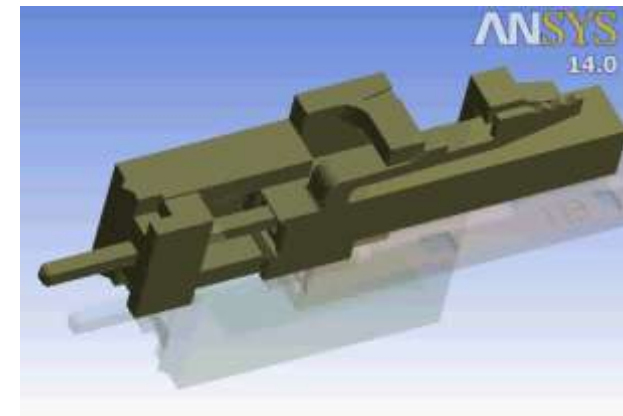
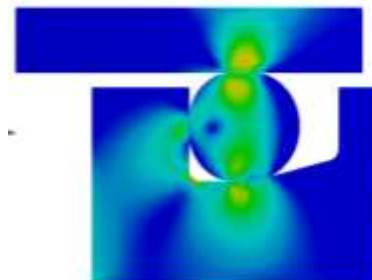
Courtesy of AB Electronic GmbH



Gemessene Einpresskennlinie für einen Kontakt



Dehnungsverteilung in direkter Umgebung der Kontaktierungen

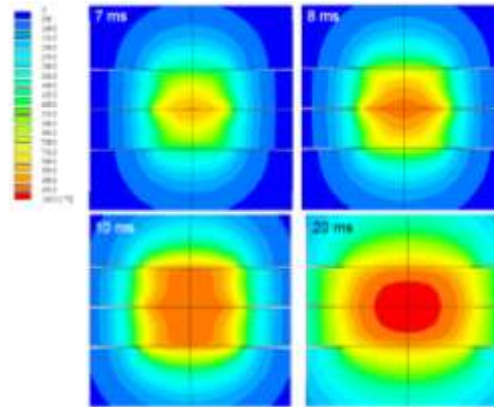


Courtesy of grabcad.com

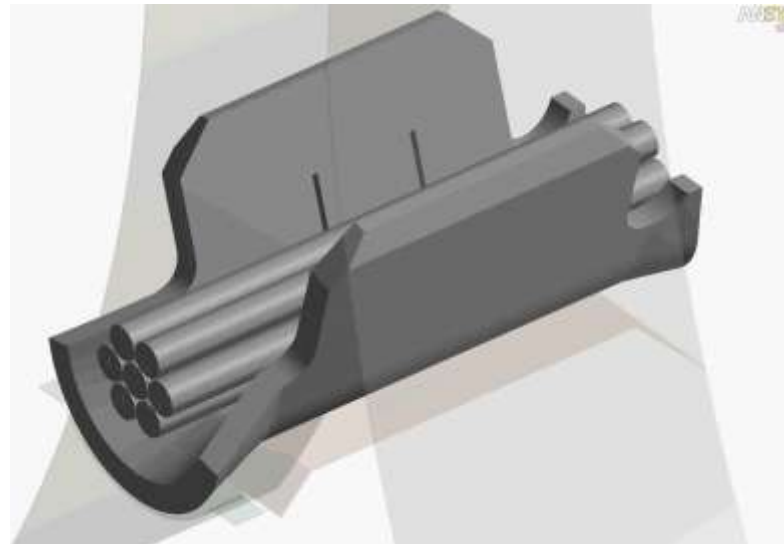
**CADFEM**

# Manufacturing

- Welding
  - Thermal stresses
  - Microstructure
- Sheet metal forming
  - Blank computation
  - Nesting
  - Thickness and strain
- Crimping
  - Results
    - Crimping force
    - Contact area
    - Contact force
- Scatter
  - Material
  - Process parameters
  - Geometry



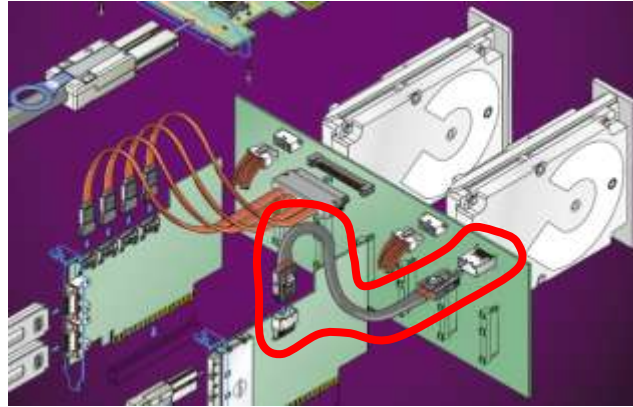
Courtesy of  
MPA Stuttgart



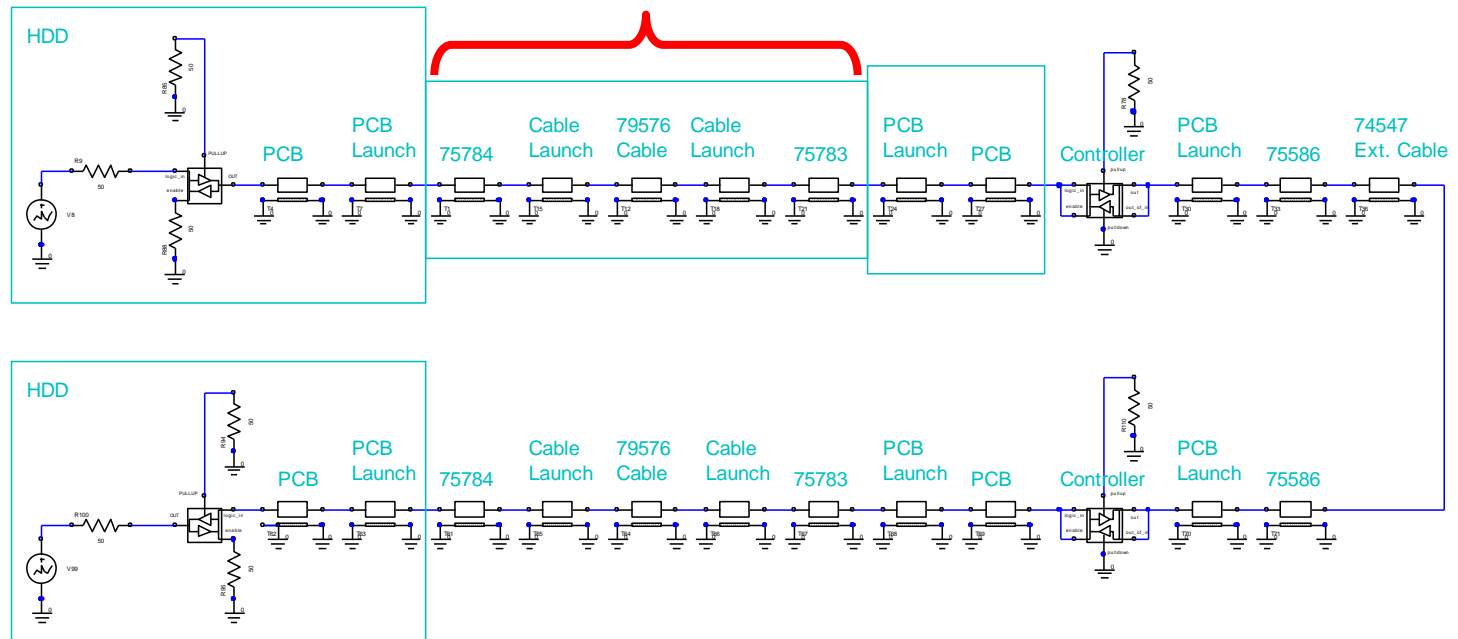
Courtesy of  
 Tyco Electronics

# Circuit Simulation

- Robust Design requires all relevant details
- Equivalent models based on 3D component simulation

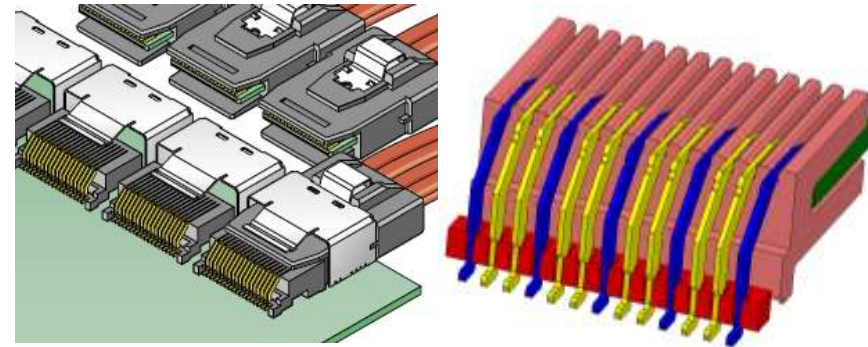


Courtesy of  
Molex

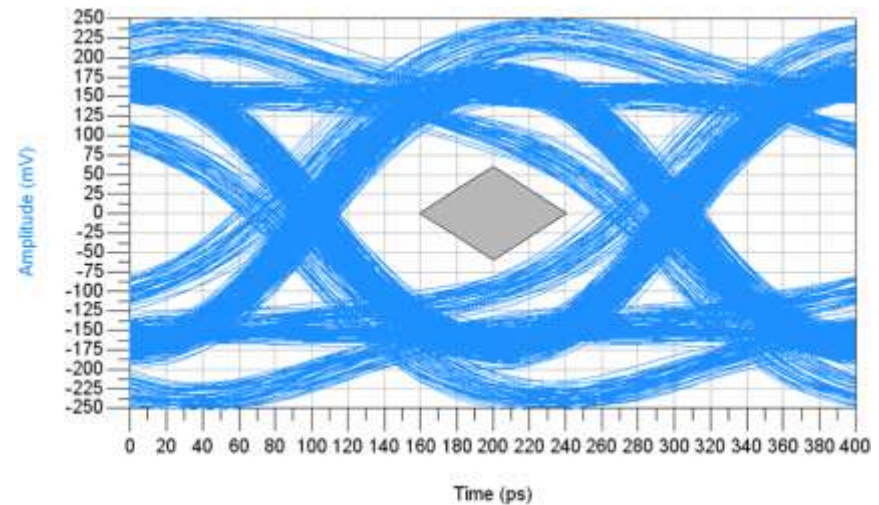


# Signal Integrity

- 3D field simulation for transmission and reflection
- Computation of S-, Z- and Y-parameters
- Visualization of field variables
  - Find Hot Spots
  - Improve EMC
- Scatter
  - Signals
  - Contact situation
  - Geometry

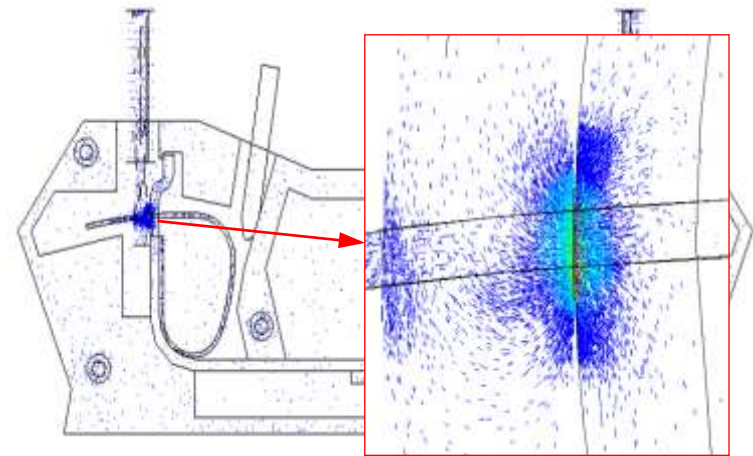


Courtesy of  
Molex

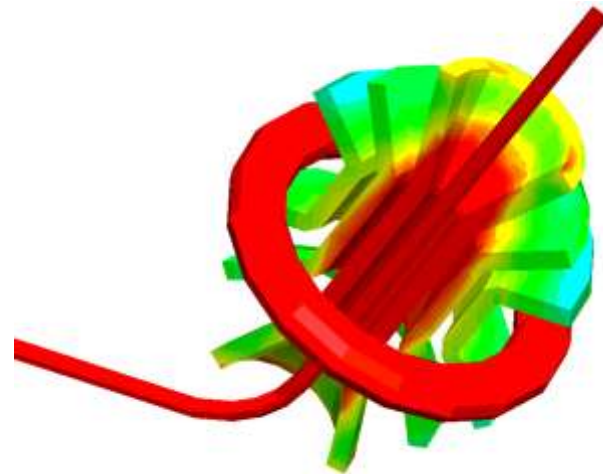


# Electric Field

- Compute current path
- Find local hotspots
- Improve electric conductivity
- Improve dielectric strength
- Coupling to other physics
  - Contact
  - Joule heating
  - Temperature dependend material
  - Lorentz forces
- Scatter
  - Material properties
  - Contact situation
    - Area
    - Forces
    - Surface

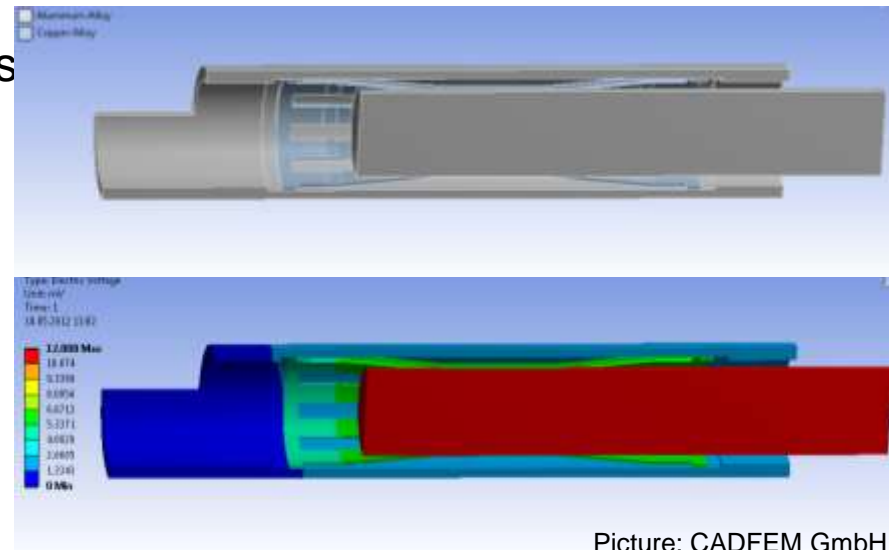
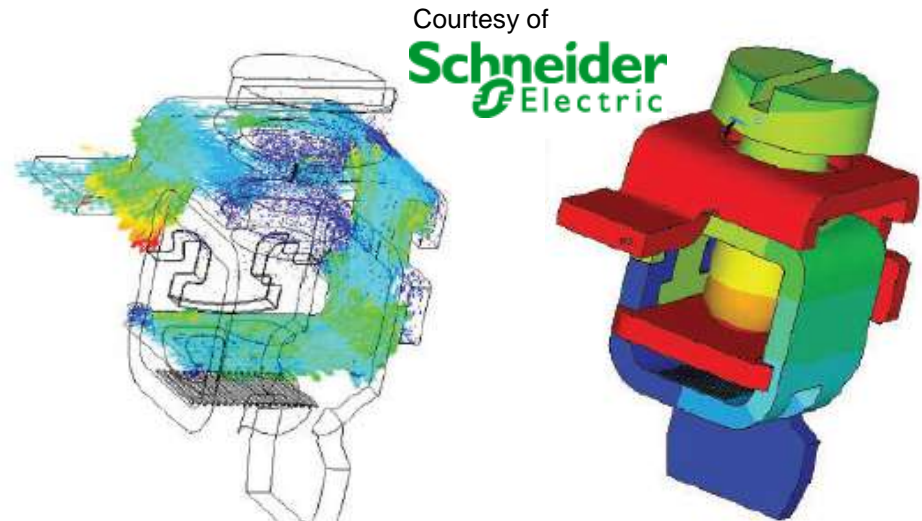


Picture: CADFEM GmbH



# Thermal

- Coupling to other physics
  - Contact
  - Joule Heating
  - Temperature dependend material
- Compute local heat generation
- Find local hotspots
- Improve thermal conductivity
- Steady state and transient temperatures cause stresses
- Scatter
  - Contact situation
  - Area
  - Forces
  - Surface

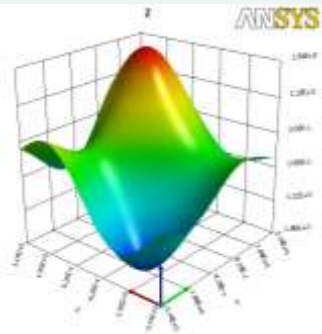


Picture: CADFEM GmbH

# ANSYS Workbench Highlights

## Parameterized simulations

- Robust Design
- Optimization



## Direct access to CAD data

- Bi-directional associativity
- Major CAD systems and file formats are supported



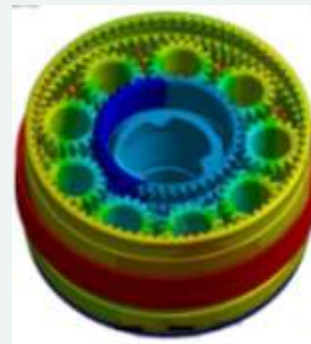
## Powerful Meshing

- Physics-based
- Intelligent
- Robust
- Automated



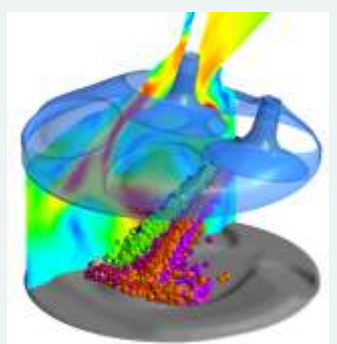
## Efficient to use

- Automatization
- Customizing
- Flexibility
- Solver Performance
- Data Management



## Multiphysics platform

- Structural
- CFD
- Thermal
- Electromagnetism
- System simulation



# optiSLang – Product Reliability by Simulation

- Easy to use – Safe to use
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# CADFEM – Simulation Software and Engineering Services

## CADFEM Software

- ANSYS Channel Partner since 1982



- Complementary Products
  - LS-Dyna
  - Digimat
  - optiSlang
  - FTI Forming Suite
  - Hardware

## CADFEM Training & Support

- Technical Support via Phone, Email and Webex
- Class-room seminars for over 50 topics
- Individual on-site training
- EsoCAET – Master Course

## CADFEM Consulting & Development

- Wide range of consulting expertise
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- Development of new methods and workflows
- Application customization
- Know How Transfer via individual project training
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100+ engineers  
13 offices

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