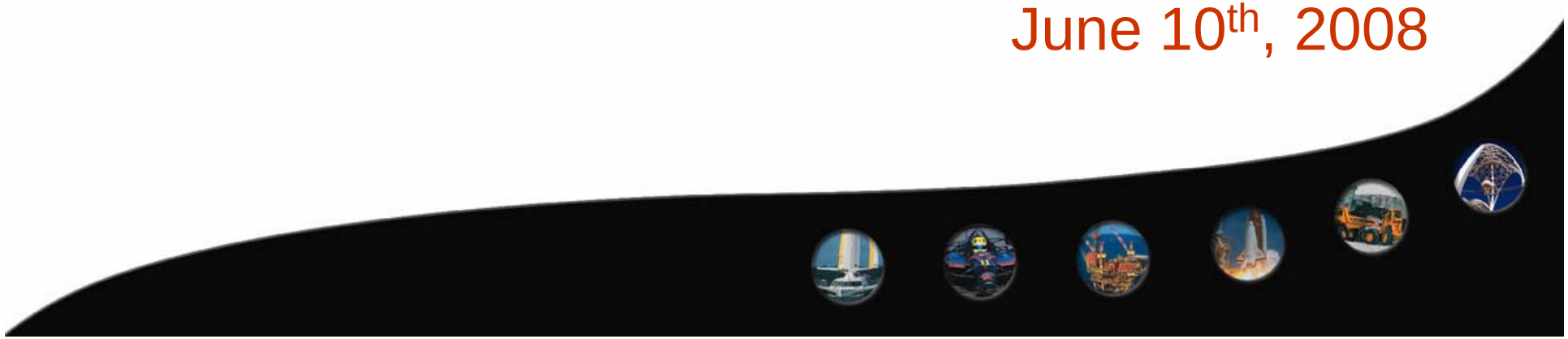
NAFEMS

Management of Design Analysis

June 10th, 2008



Agenda

Management of Design Analysis

June 10th, 2008

9am PDT (Los Angeles) / 12n EDT (New York) / 5pm BST (London)

- Welcome & Introduction (Overview of NAFEMS Activities)
  - Matthew Ladzinski, *NAFEMS North America*
- Management of Design Analysis
  - Vince Adams, *SolidWorks*
- Q&A Session
  - Panel
- Closing

Ladzinski

Adams

THE INTERNATIONAL ASSOCIATION
FOR THE ENGINEERING ANALYSIS
COMMUNITY

An Overview of NAFEMS NA Activities

Matthew Ladzinski
NAFEMS
North American Representative

Planned Activities in North America

- Webinars
  - New topic each month!
    - Multiphysics Simulation using Implicit Sequential Coupling (*July 17th*)
    - Complexity Management: New Perspectives and Challlenges for CAE in the 21st Century
  - Recent webinars:
    - CCOPPS: Fatigue of Welded Pressure Vessels
    - Applied Element Method as a Practical Tool for Progressive Collapse Analysis of Structures
    - AUTOSIM: The Future of Simulation in the Automotive Industry
    - A Common Sense Approach to Stress Analysis and Finite Element Modeling
    - The Interfacing of FEA with Pressure Vessel Design Codes (CCOPPS Project)
    - Multiphysics Simulation using Directly Coupled-Field Element Technology
    - Methods and Technology for the Analysis of Composite Materials
    - Simulation Process Management
    - Simulation-supported Decision Making (Stochastics)
    - Simulation Driven Design (SDD) Findings

To register for upcoming webinars, or to view a past webinar, please visit: www.nafems.org/events/webinars

Planned Activities in North America

NAFEMS NA 2008 Regional Summit

NAFEMS 2020 Vision of Engineering Analysis and Simulation

- ***NAFEMS 2020*** will bring together the leading visionaries, developers, and practitioners of CAE-related technologies and business processes
- Goal: Provide attendees with the best "food for thought and action" to deploy CAE over the next several years
- Location: Embassy Suites Hotel & Convention Center, Hampton, Virginia
- Date: October 29-31, 2008

Abstract Submission Deadline:
June 15th, 2008

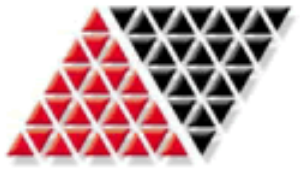
For more information, visit:
www.nafems.org/nafems2020

Keynote Presenters for NAFEMS 2020

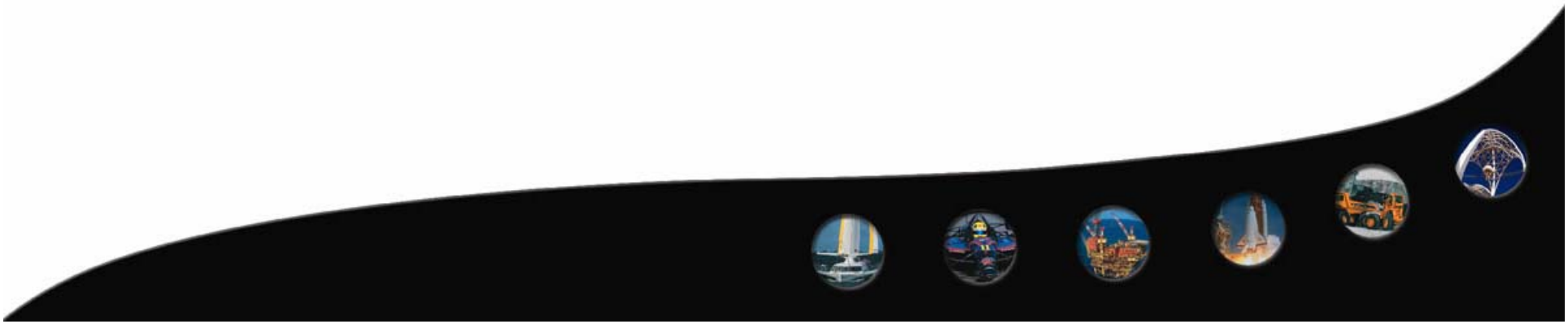
- **Prof. Ahmed Noor**, *Old Dominion University (Director of ODU's Center for Advanced Engineering Environments*

- **Prof. Thomas J.R. Hughes**, *University of Texas at Austin*

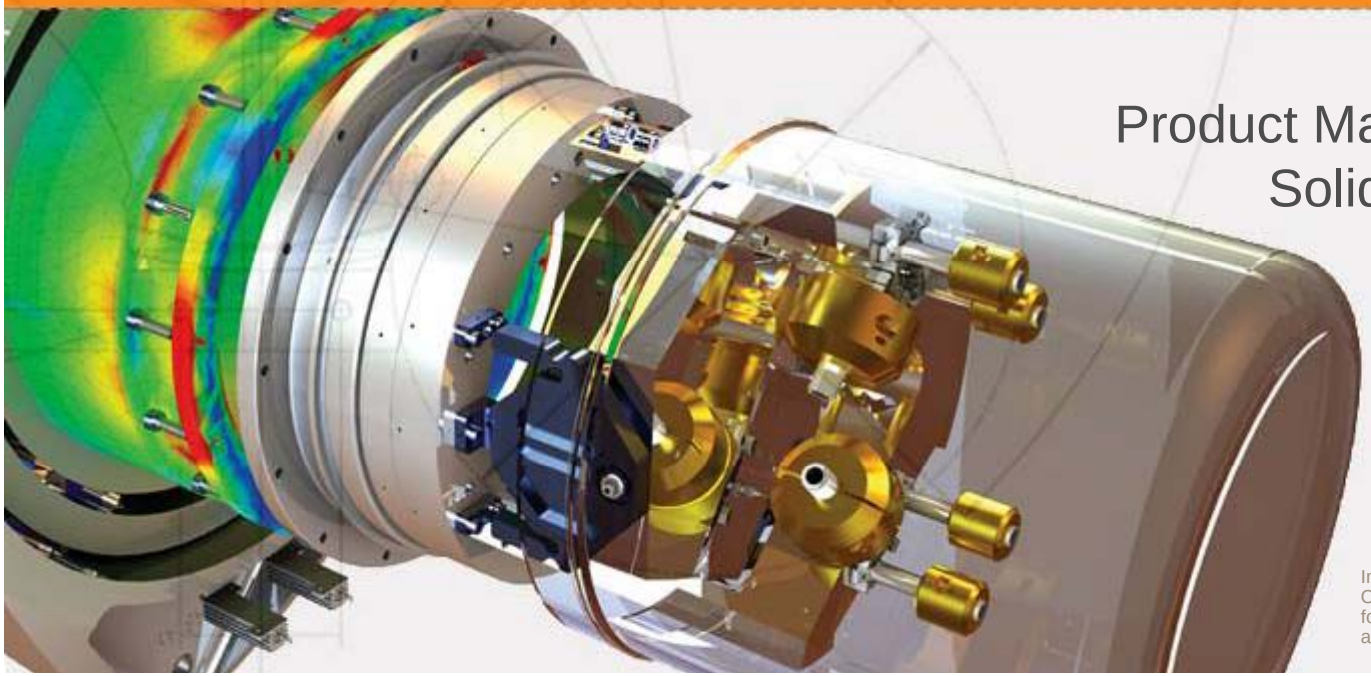
- **Dr. Takeshi Abe**, *Ford Motor Company*




NAFEMS



Welcome to
Managing Design Simulation…

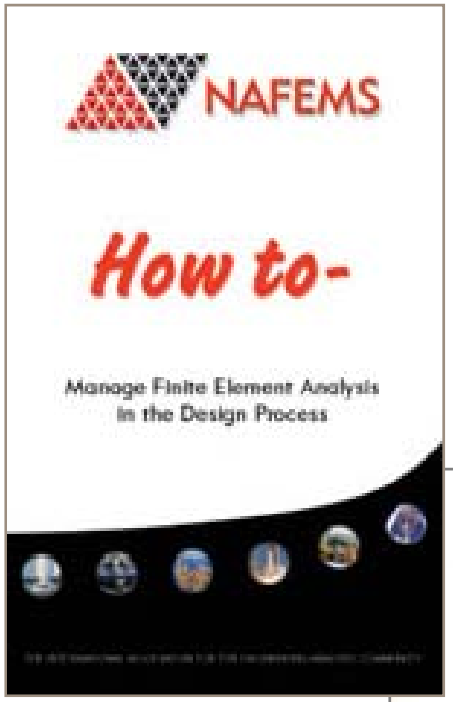


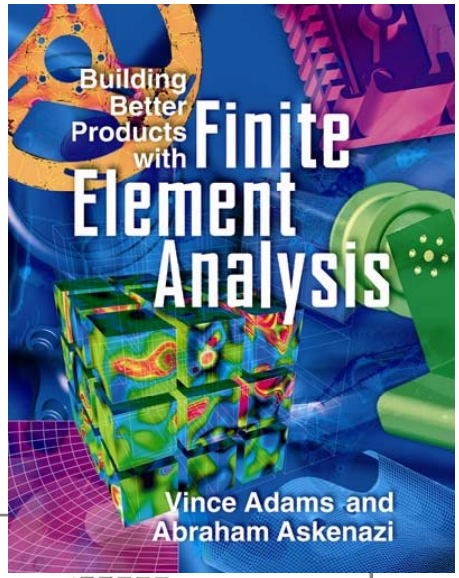
Vince Adams
Product Manager – Simulation
SolidWorks Corporation

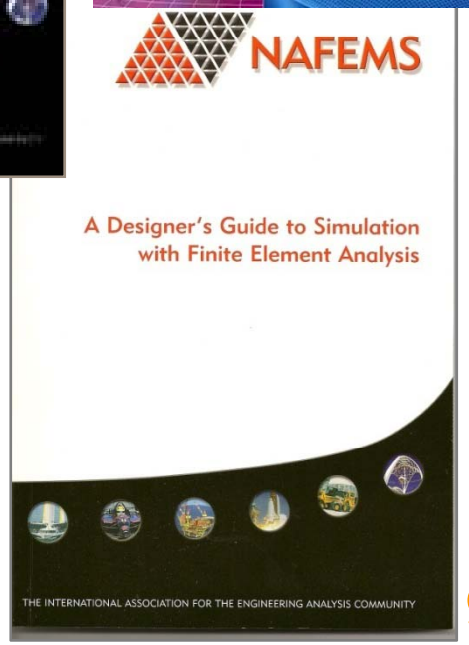
Image courtesy of National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy, under cooperative agreement with the National Science Foundation.

About Vince Adams…

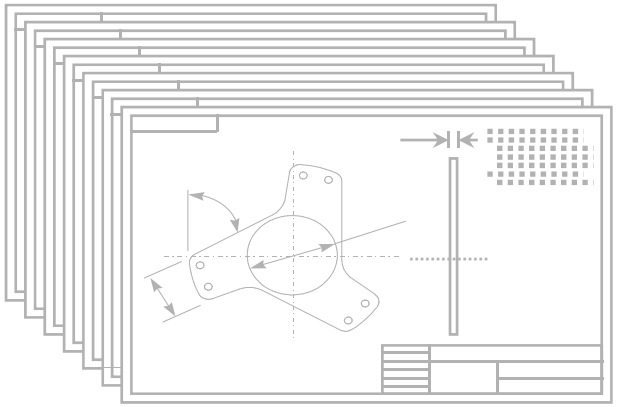
- Former Design Engineer and Engineering Manager
- 6 US and International Patents
- Focused on FEA for 15+ years
- Former NAFEMS North American Chairman
- International speaker on simulation topics
- Authored many articles and texts on simulation in the design process.
- Currently Product Manager for Simulation Products at SolidWorks Corporation

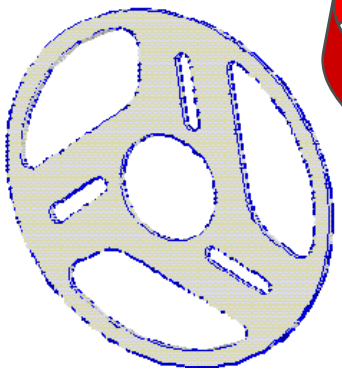


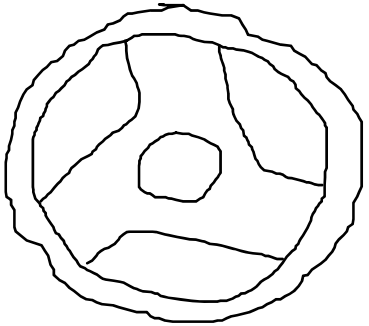


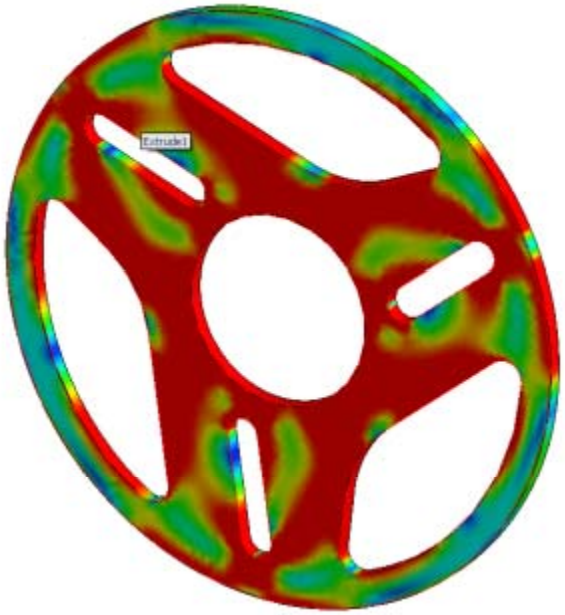


The Product Development Process…



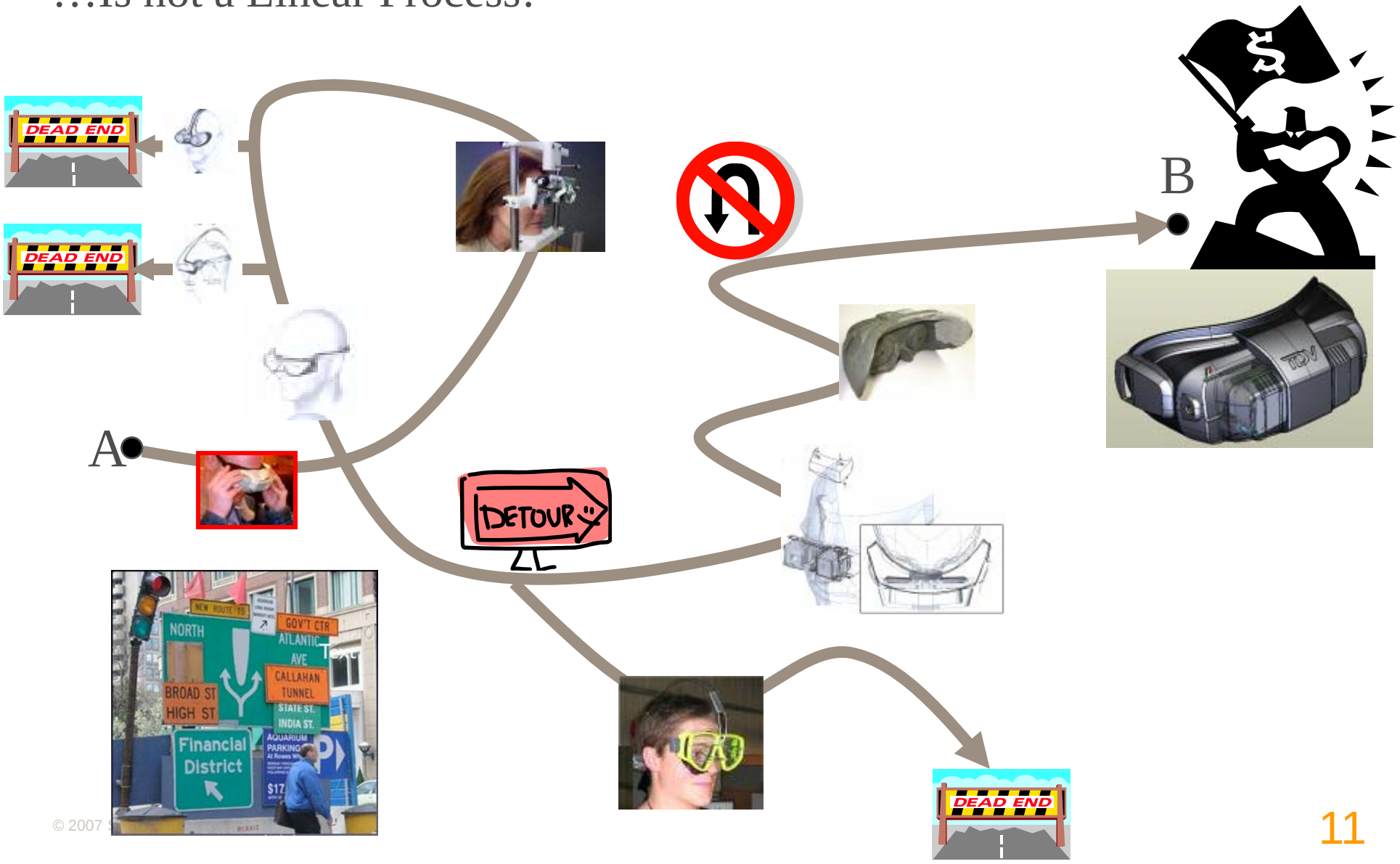




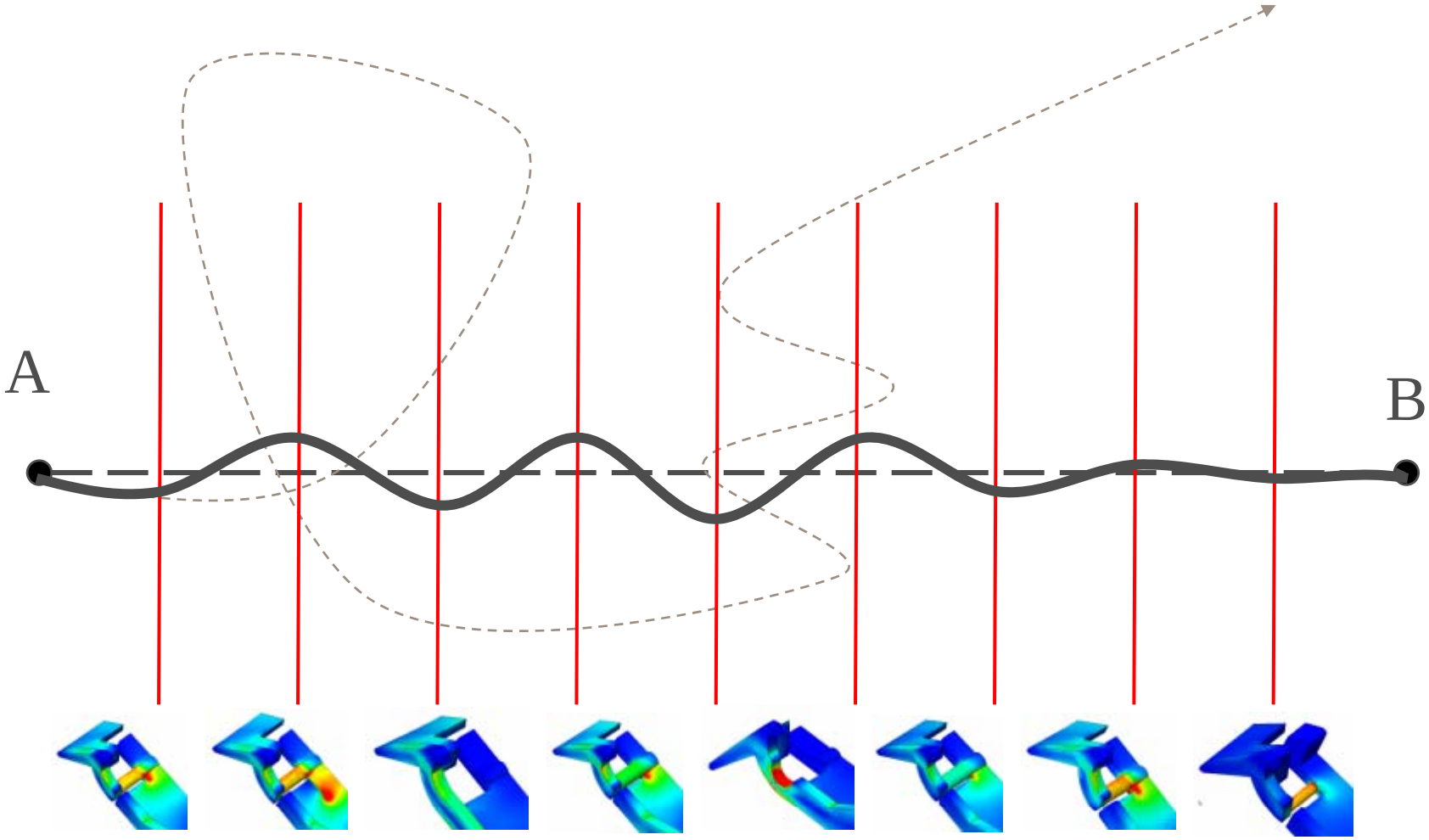


The Product Development Process…

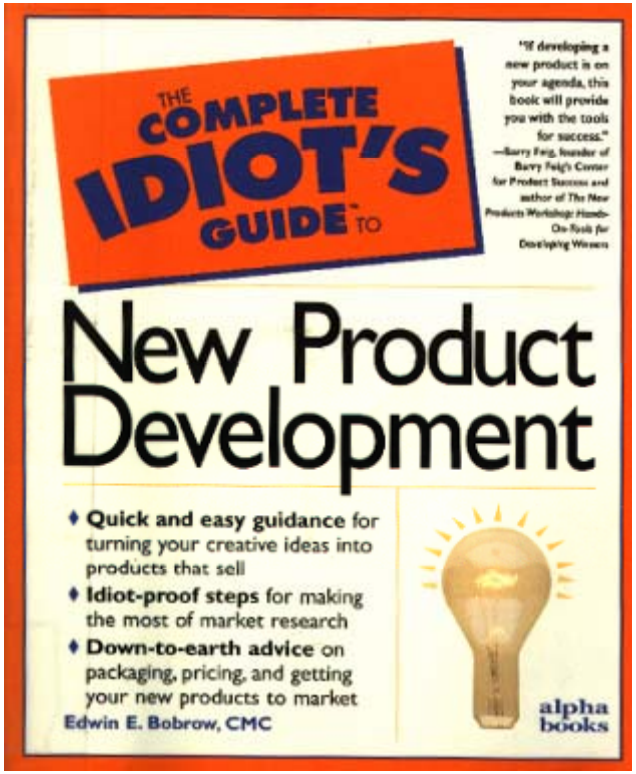
…Is not a Linear Process!



The Product Development Process…



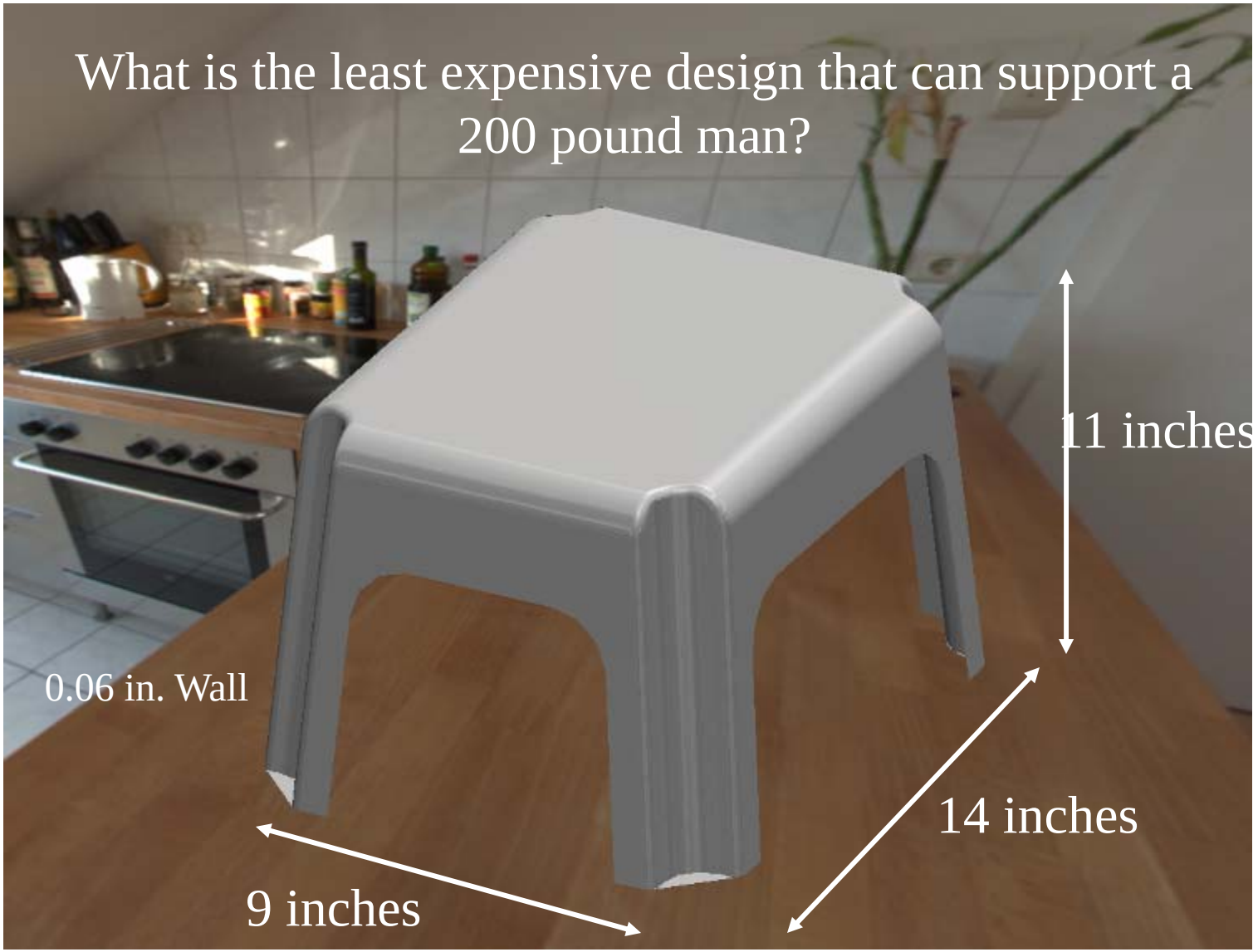
The Product Development Process…



"The single most cost-effective way to speed up product development is…to not make mistakes."

"How do you know you made the right decision?

How do you know which to choose…



How do you know which to choose…

Design Options Proposed

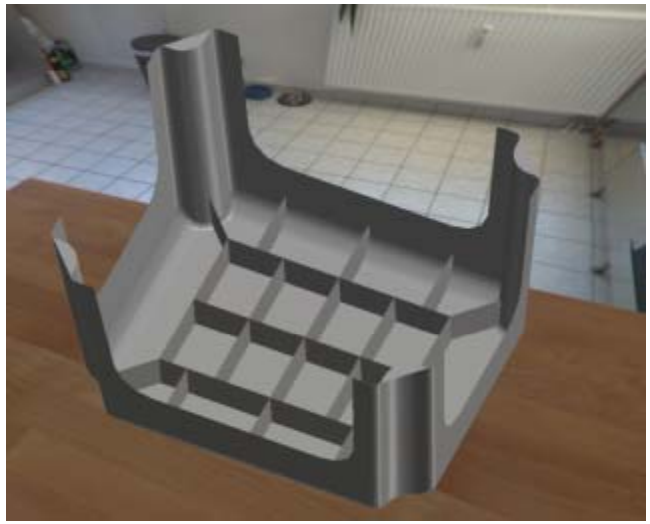
No Ribs

24 in^3
Baseline

Shallow Ribs

26.5 in^3
(+10%)

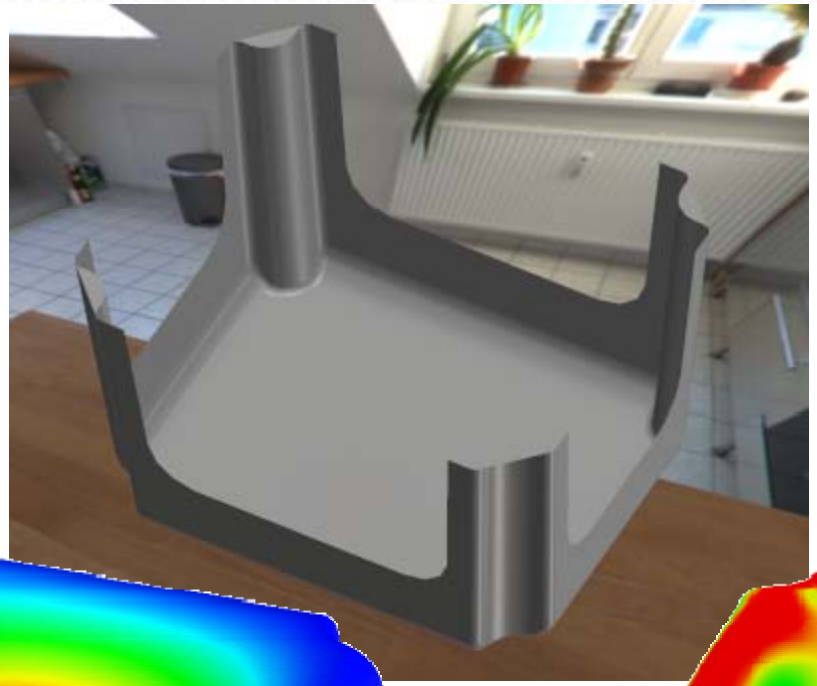
Deep Ribs

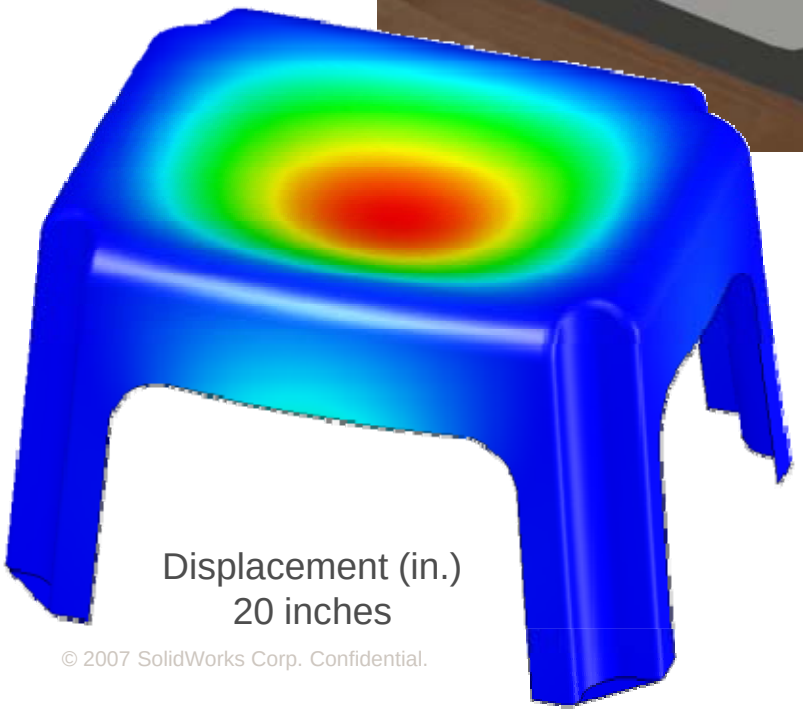


31 in^3
(+30%)

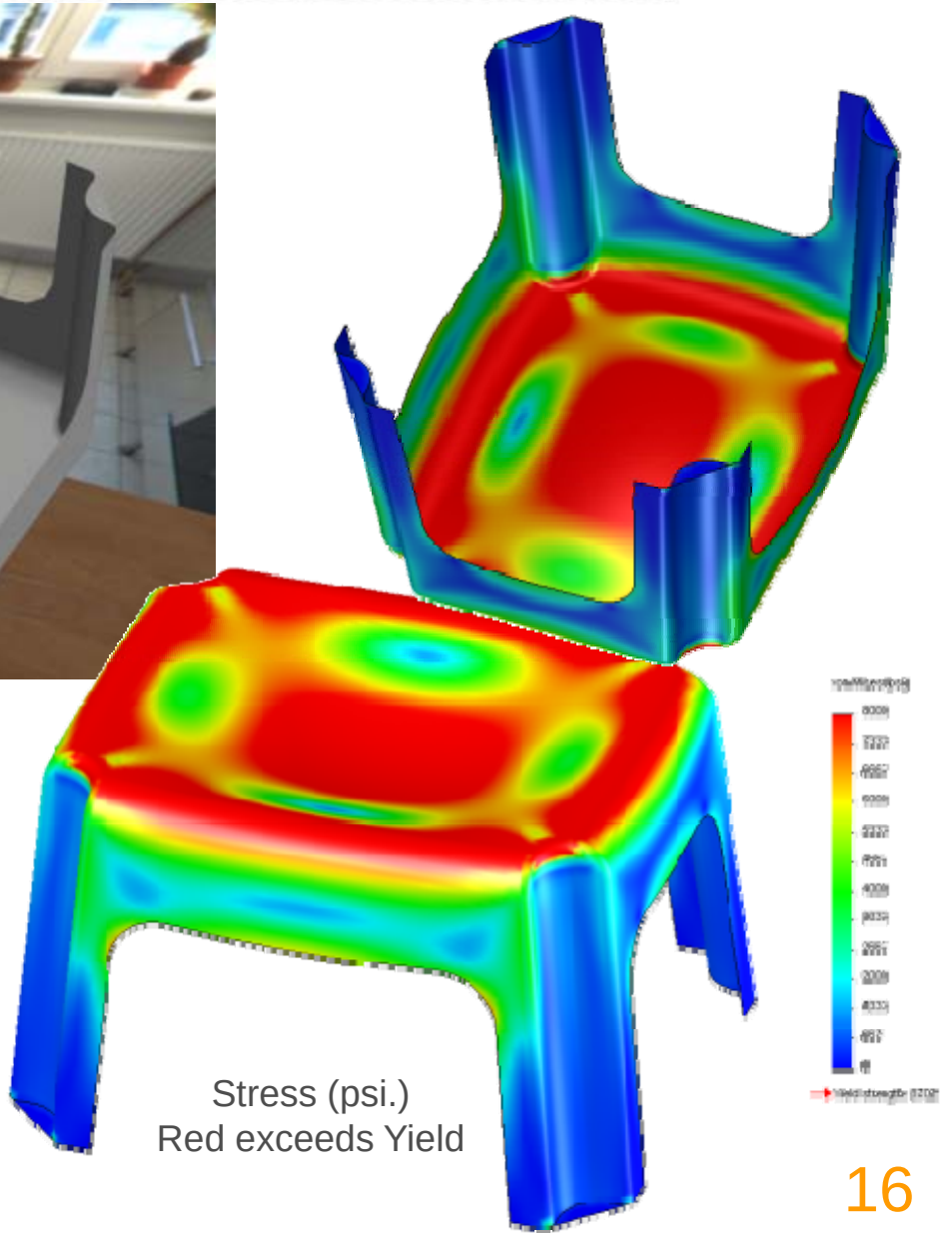
Baseline Design – No Ribs

$24\ in^3$





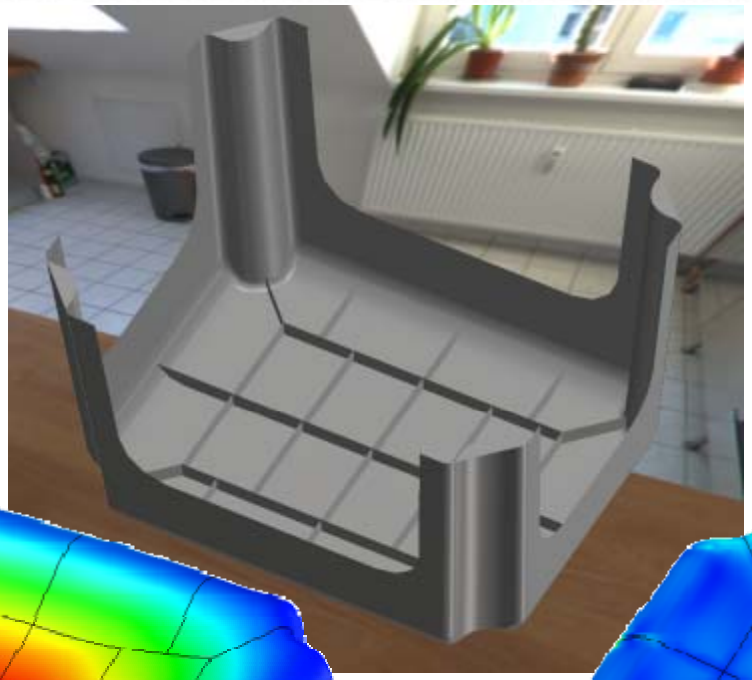
Displacement (in.)
20 inches

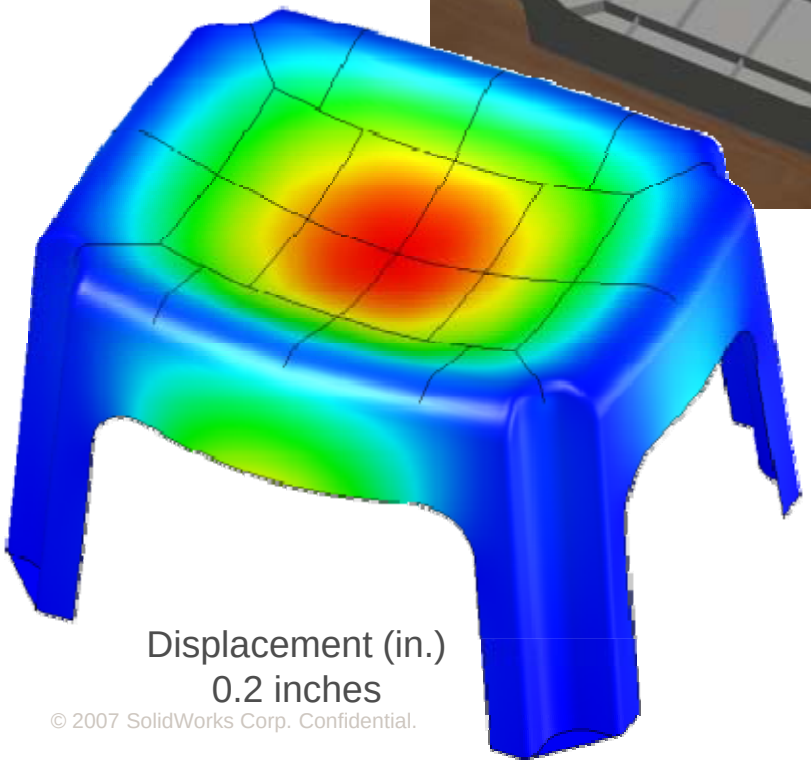


Stress (psi.)
Red exceeds Yield

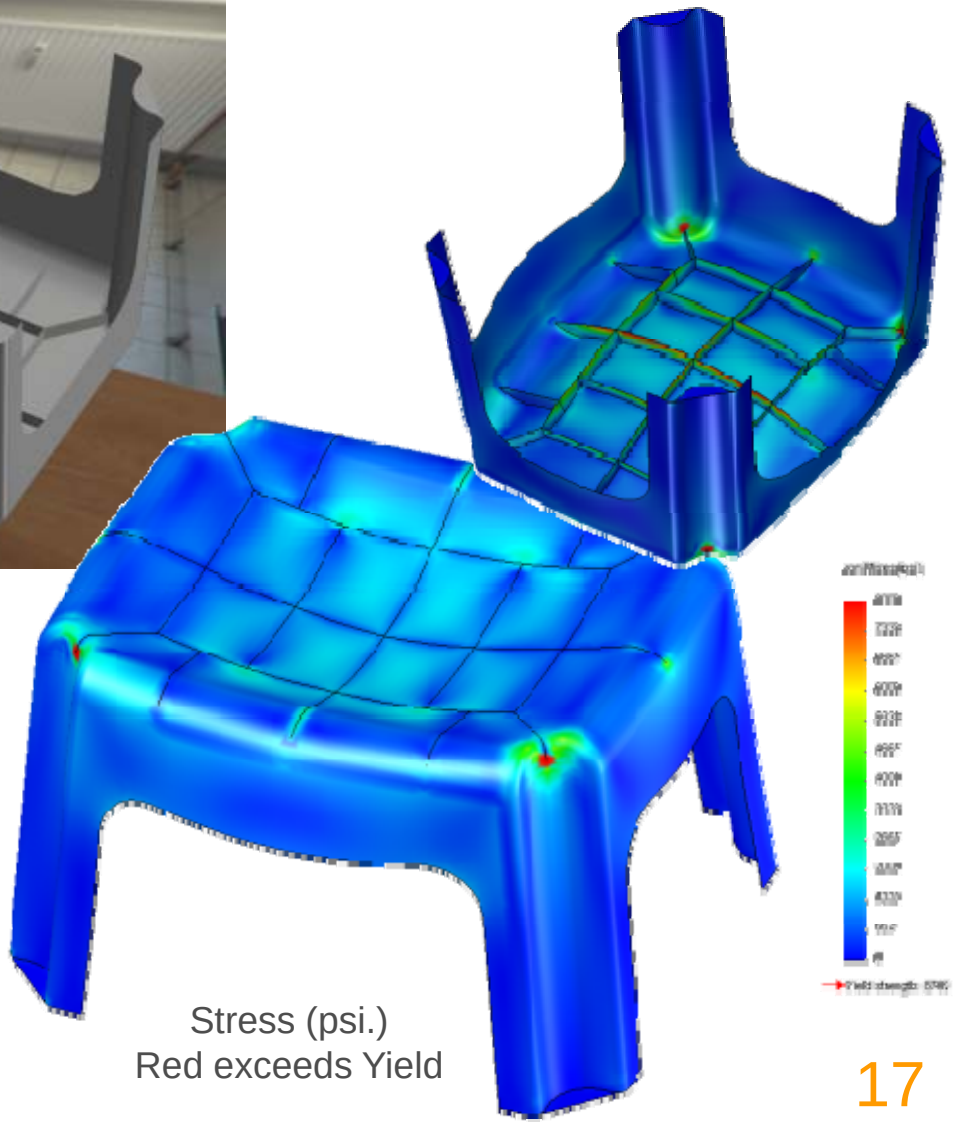
Option 2 – Shallow Ribs

$26.5\ in^3$
(+10%)





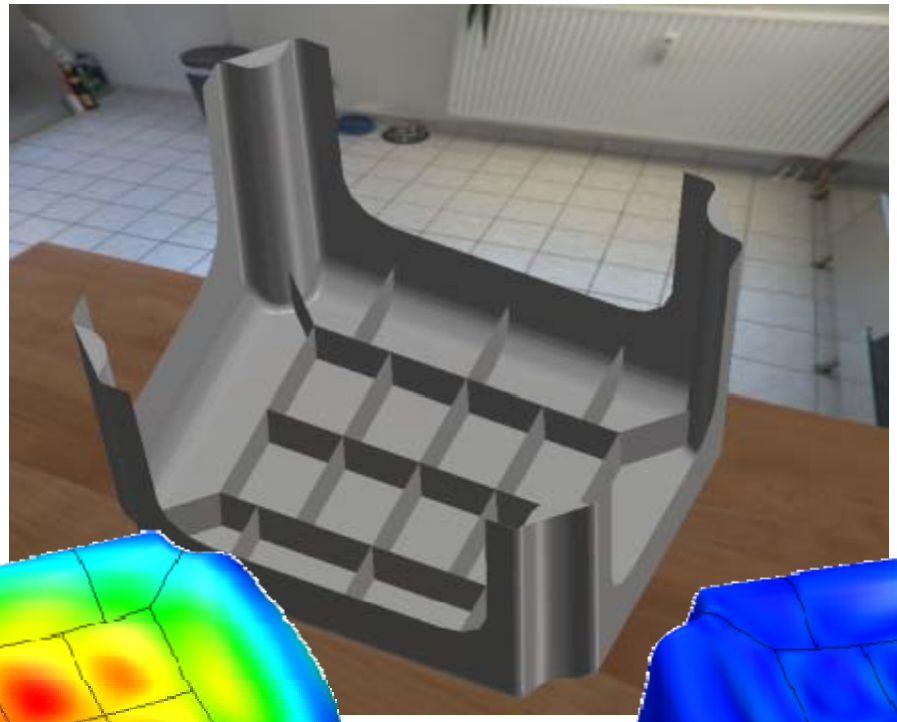
Displacement (in.)
0.2 inches

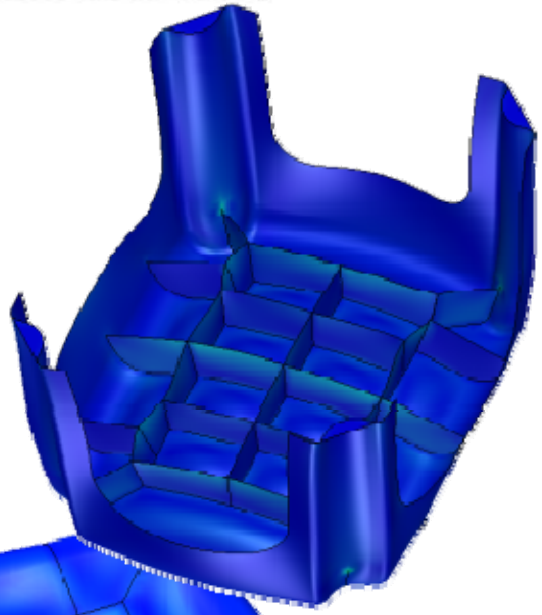


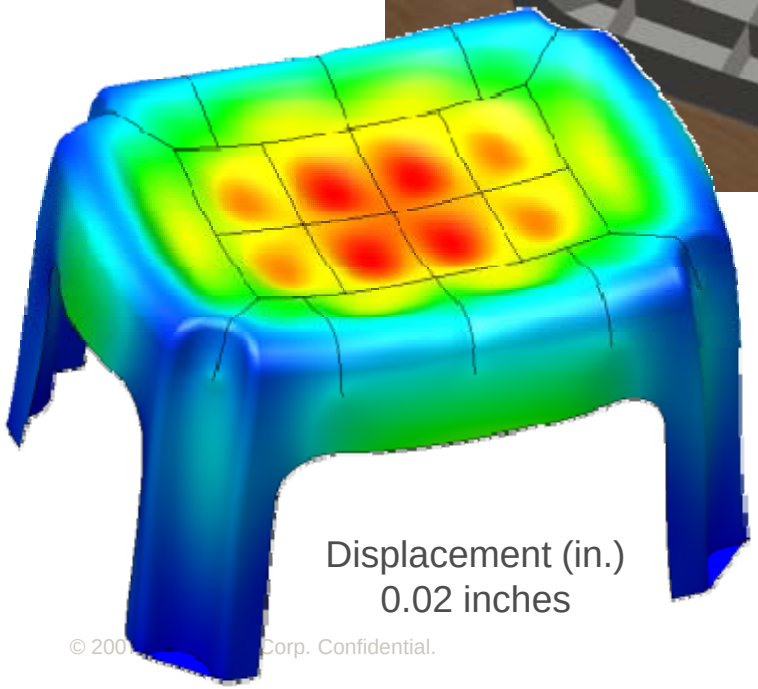
Stress (psi.)
Red exceeds Yield

Option 3 – Full Ribs

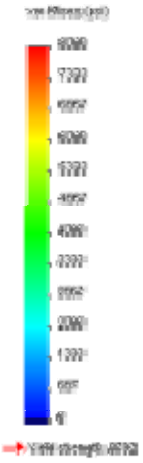
31 in^3
(+30%)







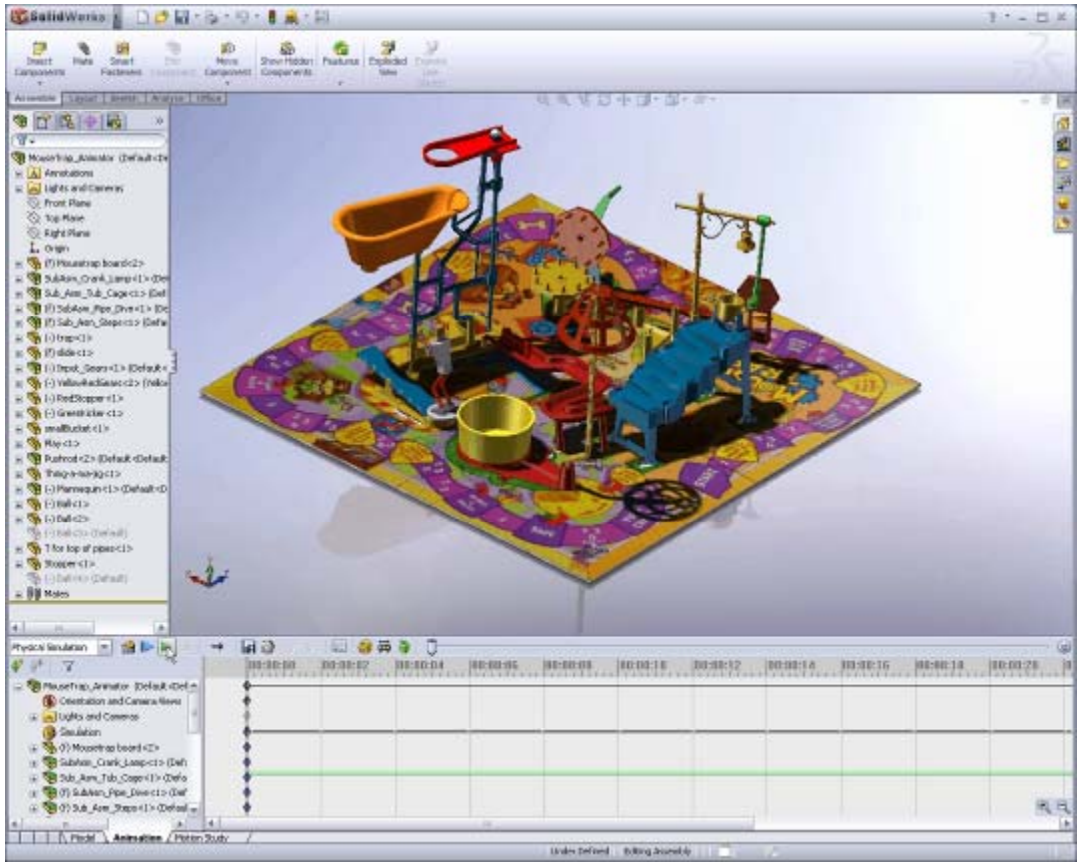
Displacement (in.)
0.02 inches



Stress (psi.)
Nothing exceeds Yield

The Product Development Process…

Will it work?



Is it good enough?

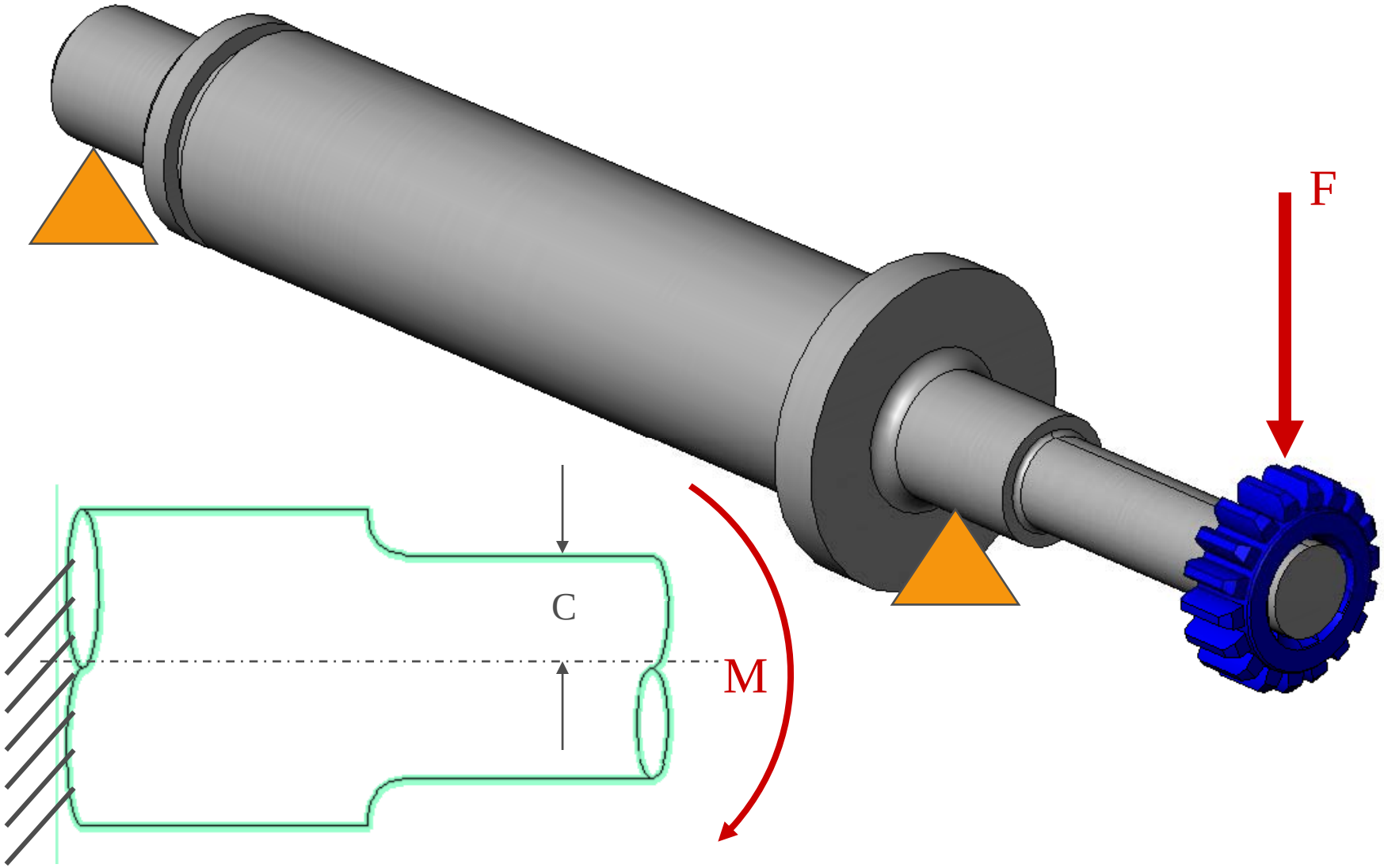
Can it be…

Better? Faster? Cheaper?

How Do Your Engineers Get Answers?

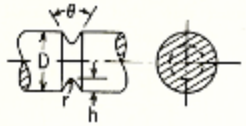
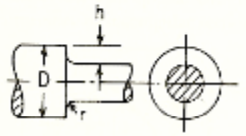
- “We look at a design that worked and scale up/down”
- “We use spreadsheets or MathCAD”
- “We do some quick hand calculations”
- “We test prototypes”

Is Simulation “Riskier” than a Hand Calc?



Is Simulation “Riskier” than a Hand Calc?

TABLE 37 Factors of stress concentration for elastic stress (k) (*Continued*)

Type of form irregularity or stress raiser	Stress condition and manner of loading	Factor of stress concentration k for various dimensions
16. V-notch in a circular shaft 	16c. Elastic stress, torsion	The stress concentration factor for the V-notch, k_v, is the smaller of the values $k_s = k_U \quad \text{or} \quad k_s = 1.065k_U - \left[0.022 + 0.137\left(\frac{\theta}{135}\right)^2\right](k_U - 1)k_U$ for $\frac{r}{D-2h} \le 0.01$ and $\theta \le 135°$ where k_U is the stress concentration factor for a U-notch, case 15c, when the dimensions h, r, and D are the same as for the V-notch and θ is the notch angle in degrees. (Refs. 1 and 44)
17. Square shoulder with fillet in circular shaft 	17a. Elastic stress, axial tension	$k = K_1 + K_2\left(\frac{2h}{D}\right) + K_3\left(\frac{2h}{D}\right)^2 + K_4\left(\frac{2h}{D}\right)^3$ where

	$0.25 \le h/r \le 2.0$	$2.0 \le h/r \le 20.0$
K_1	$0.927 + 1.149\sqrt{h/r} - 0.086h/r$	$1.225 + 0.831\sqrt{h/r} - 0.010h/r$
K_2	$0.011 - 3.029\sqrt{h/r} + 0.948h/r$	$-1.831 - 0.318\sqrt{h/r} - 0.049h/r$
K_3	$-0.304 + 3.979\sqrt{h/r} - 1.737h/r$	$2.236 - 0.522\sqrt{h/r} + 0.176h/r$
K_4	$0.366 - 2.098\sqrt{h/r} + 0.975h/r$	$-0.630 + 0.009\sqrt{h/r} - 0.117h/r$

(Refs. 1, 19, and 47)

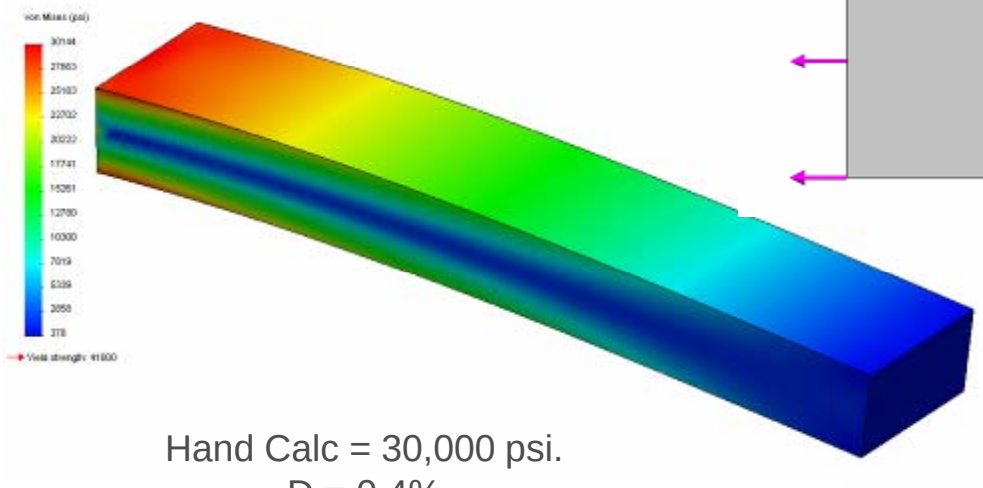
Stress condition and manner of loading	Factor of stress concentration k for various dimensions
17b. Elastic stress, bending	$k = K_1 + K_2\left(\frac{2h}{D}\right) + K_3\left(\frac{2h}{D}\right)^2 + K_4\left(\frac{2h}{D}\right)^3$ where

	$0.25 \le h/r \le 2.0$	$2.0 \le h/r \le 20.0$
K_1	$0.927 + 1.149\sqrt{h/r} - 0.086h/r$	$1.225 + 0.831\sqrt{h/r} - 0.010h/r$
K_2	$0.015 - 3.281\sqrt{h/r} + 0.837h/r$	$-3.790 + 0.958\sqrt{h/r} - 0.257h/r$
K_3	$0.847 + 1.716\sqrt{h/r} - 0.506h/r$	$7.374 - 4.834\sqrt{h/r} + 0.862h/r$
K_4	$-0.790 + 0.417\sqrt{h/r} - 0.246h/r$	$-3.809 + 3.046\sqrt{h/r} - 0.595h/r$

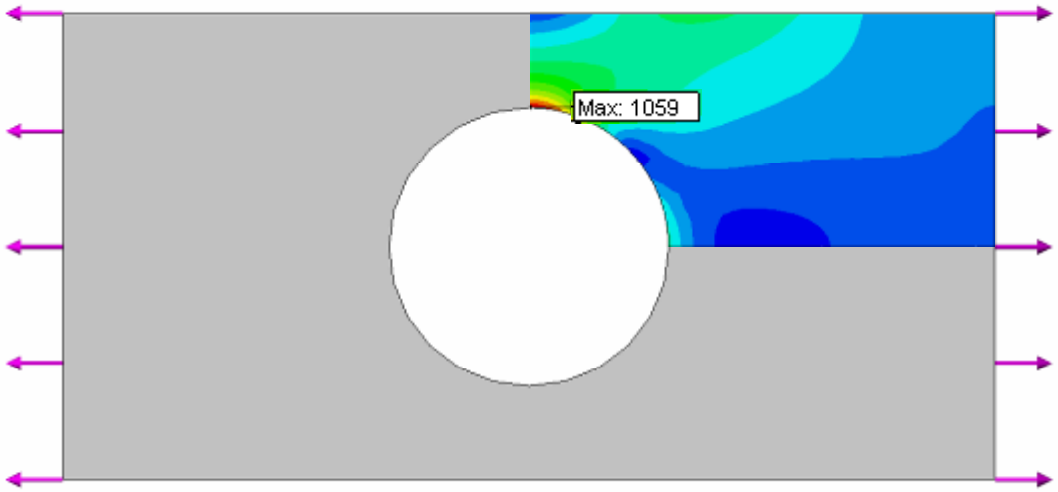
(Refs. 1, 20, and 48)

OK…that’s pretty clear…

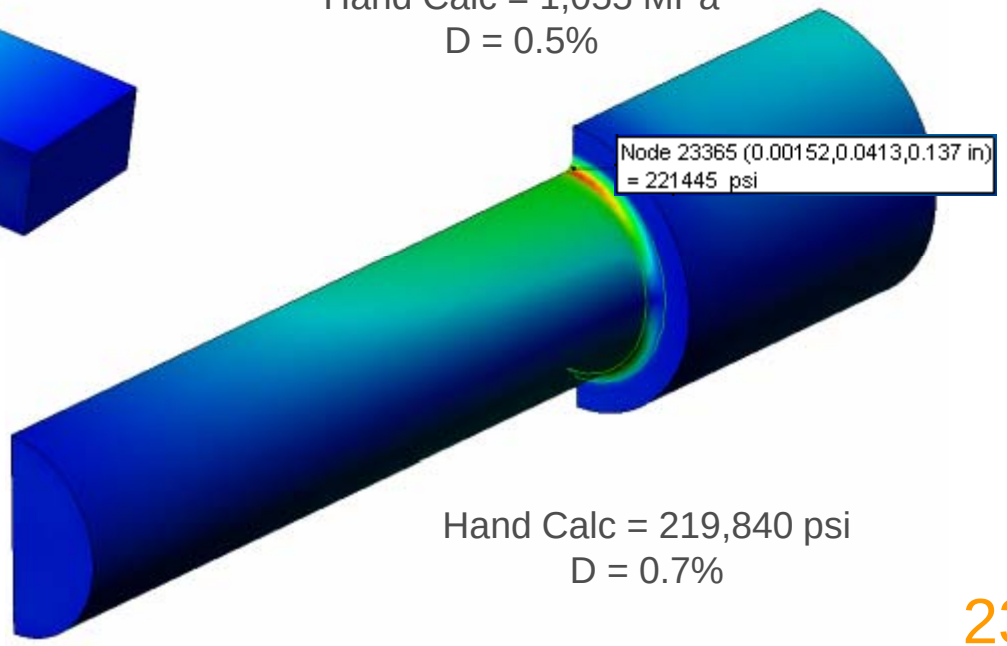
Is Simulation “Riskier” than a Hand Calc?



Hand Calc = 30,000 psi.
D = 0.4%



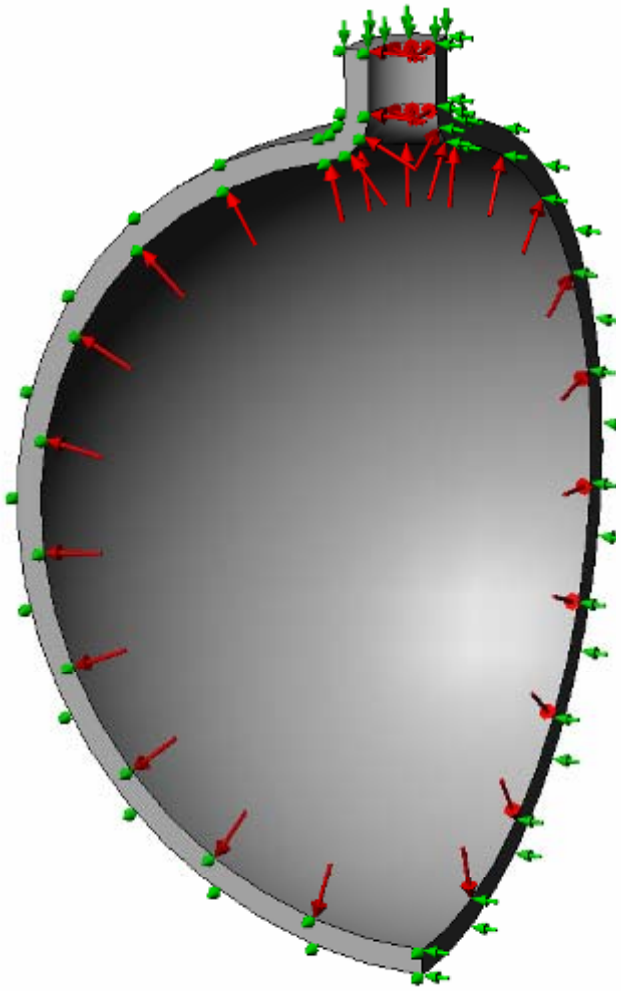
Hand Calc = 1,055 MPa
D = 0.5%

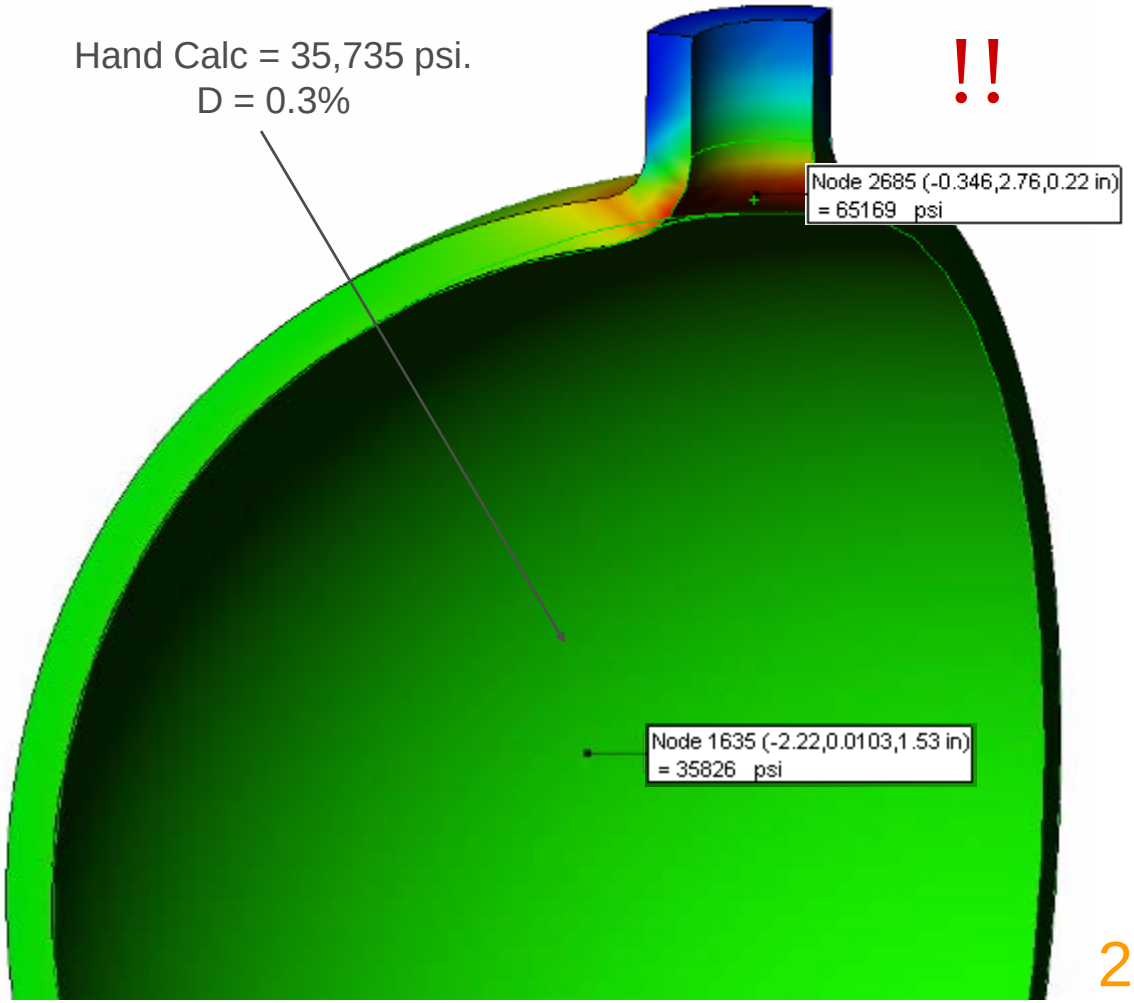


Hand Calc = 219,840 psi
D = 0.7%

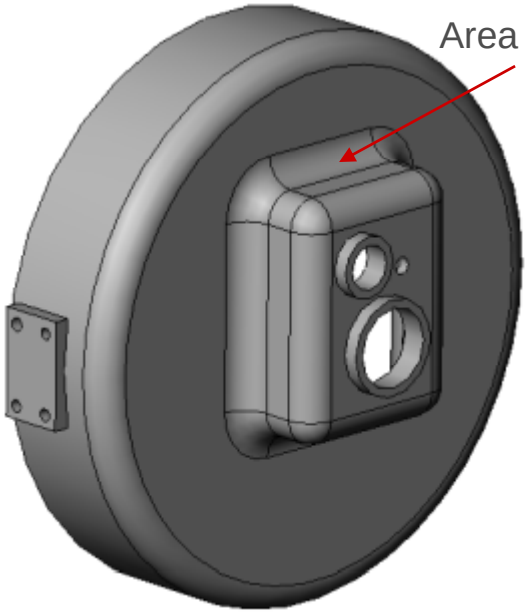
Is Simulation “Riskier” than a Hand Calc?

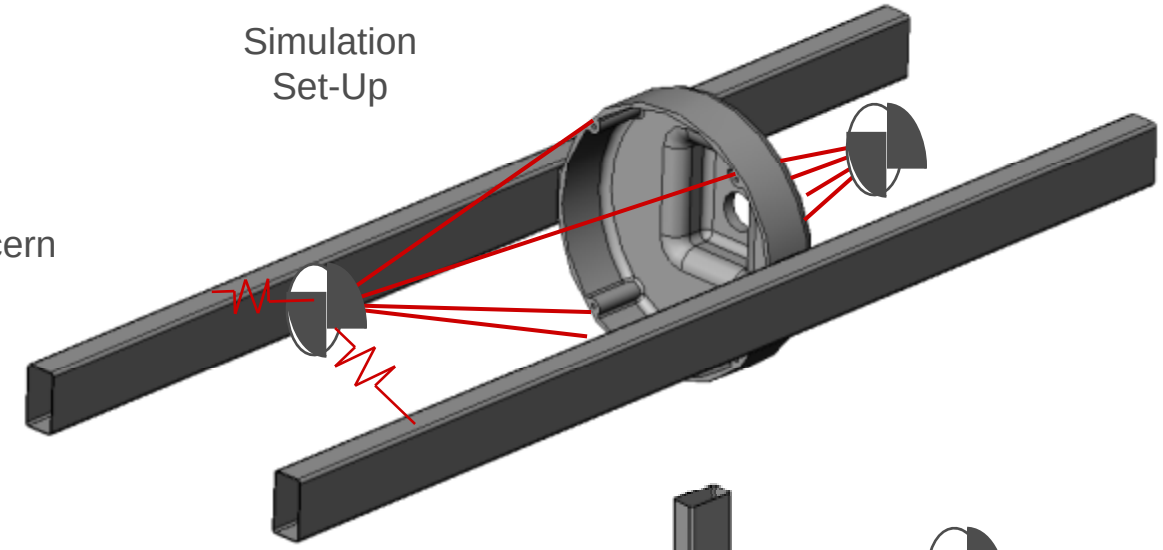
s=PR/2t = 35,735 psi

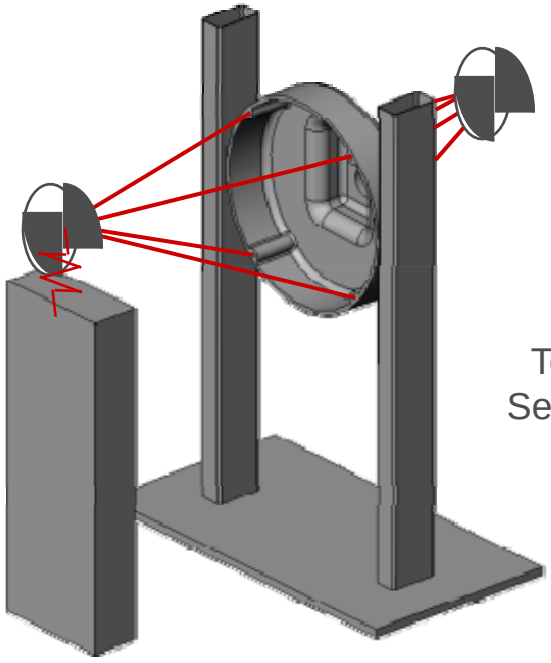




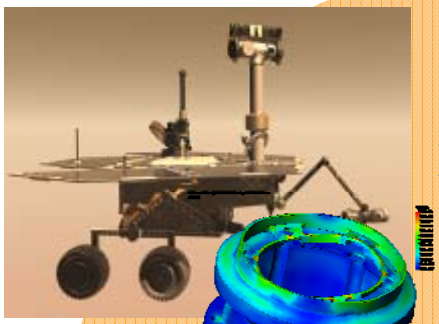
Is Testing More Reliable Than Simulation?



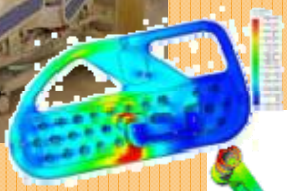


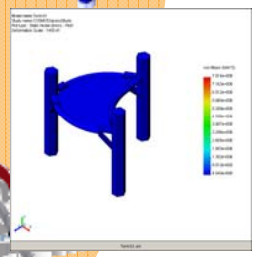


So…What is Simulation?

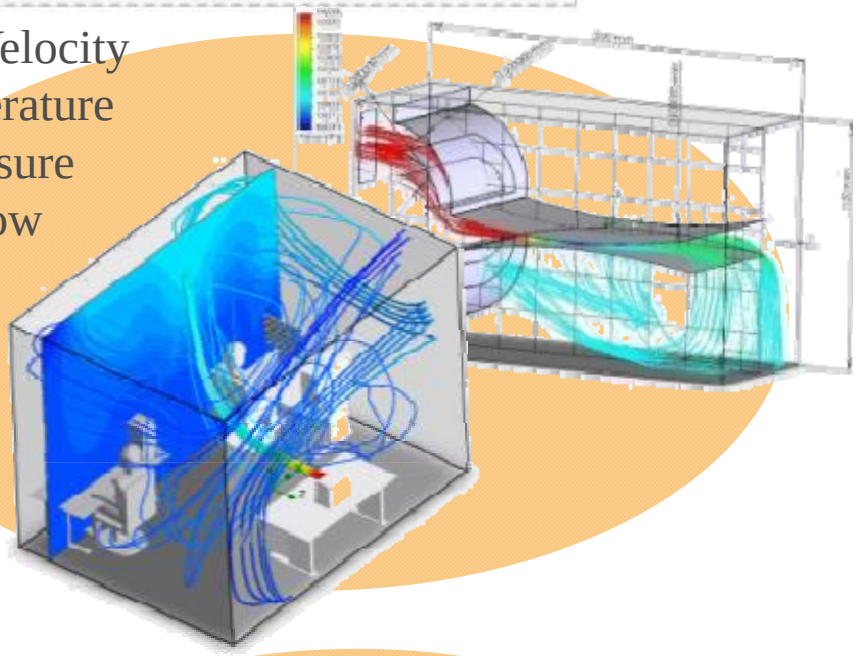


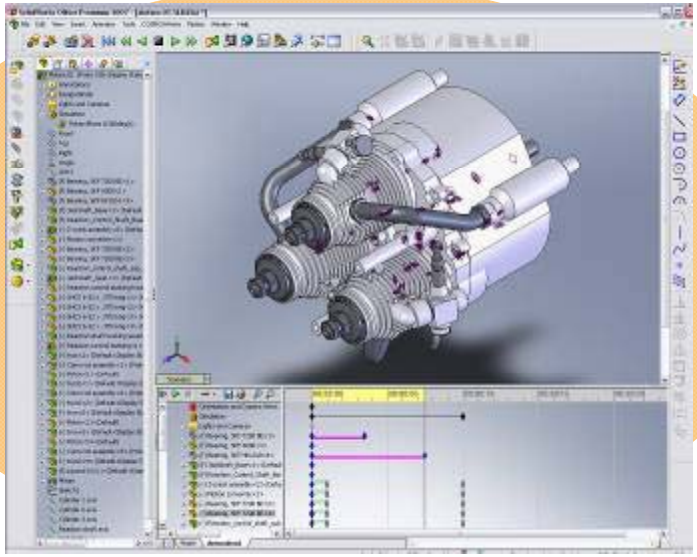
Stress
Displacement
Vibration
Buckling





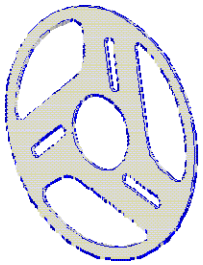
Fluid Velocity
Temperature
Pressure
Flow

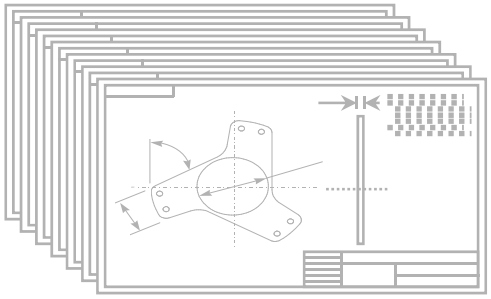


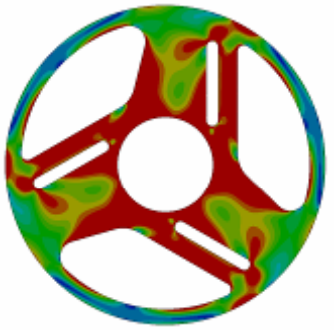


Velocity
Acceleration
Force
Path

Test vs. Simulation vs. Design Simulation



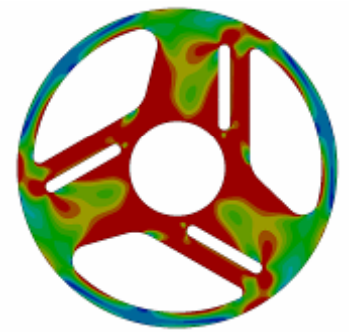


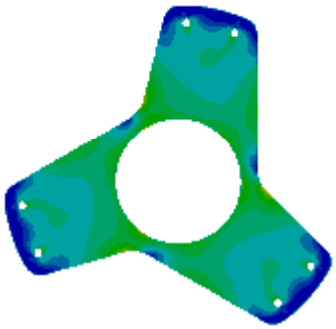


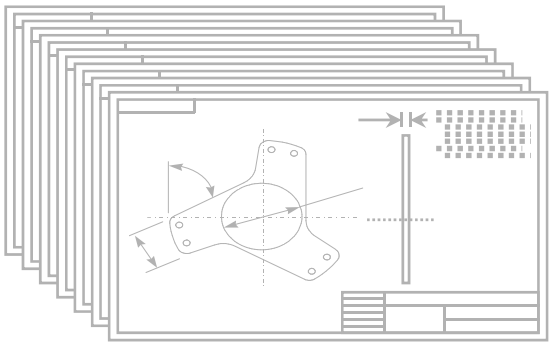
Decide Commit Validate

?

$





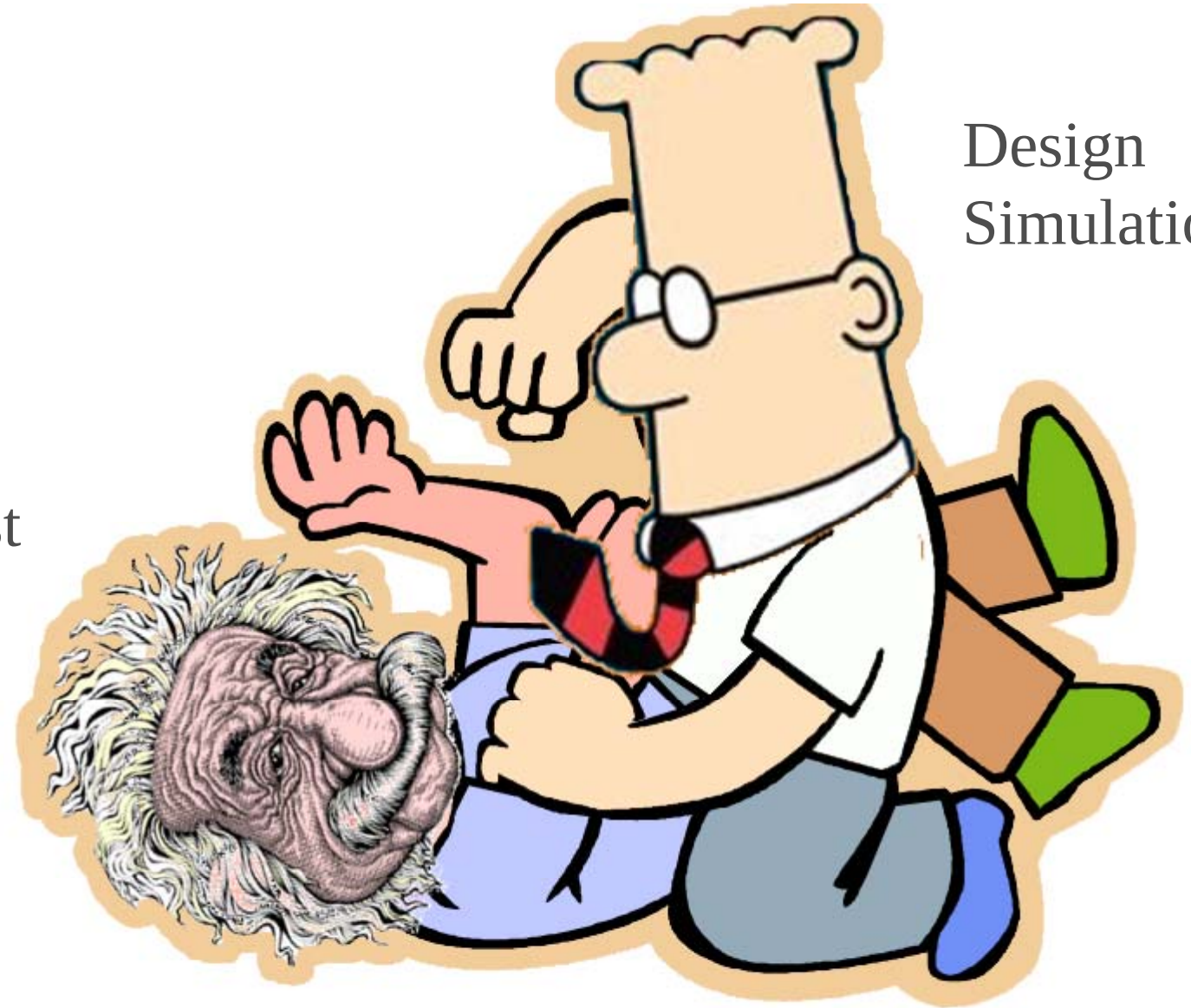


Decide Validate Optimize Commit

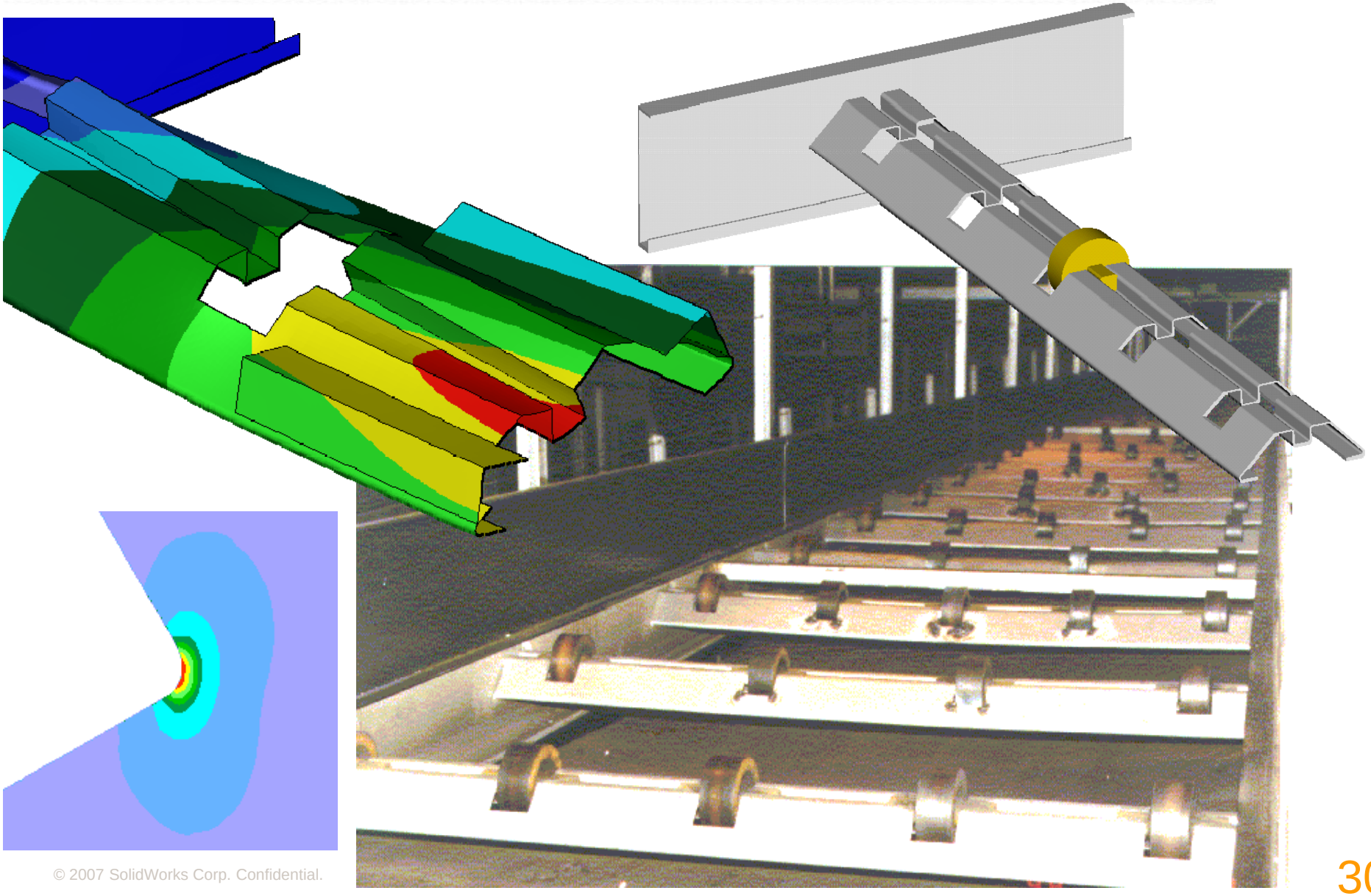
We Don’t Need Design Simulation…

- “We don’t need it #1 - Our parts never break”
- “We don’t need it #2 - We always get the **best** design on the first try”
- “Simulation takes too long”
- “It doesn’t apply to our parts”
- “We don’t know how to use it”
- “It requires a specialist”

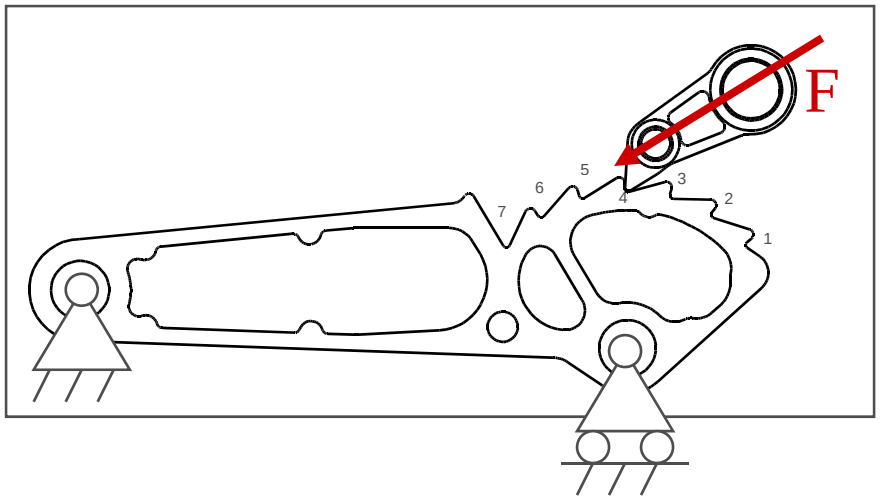
We Don’t Need Design Simulation…

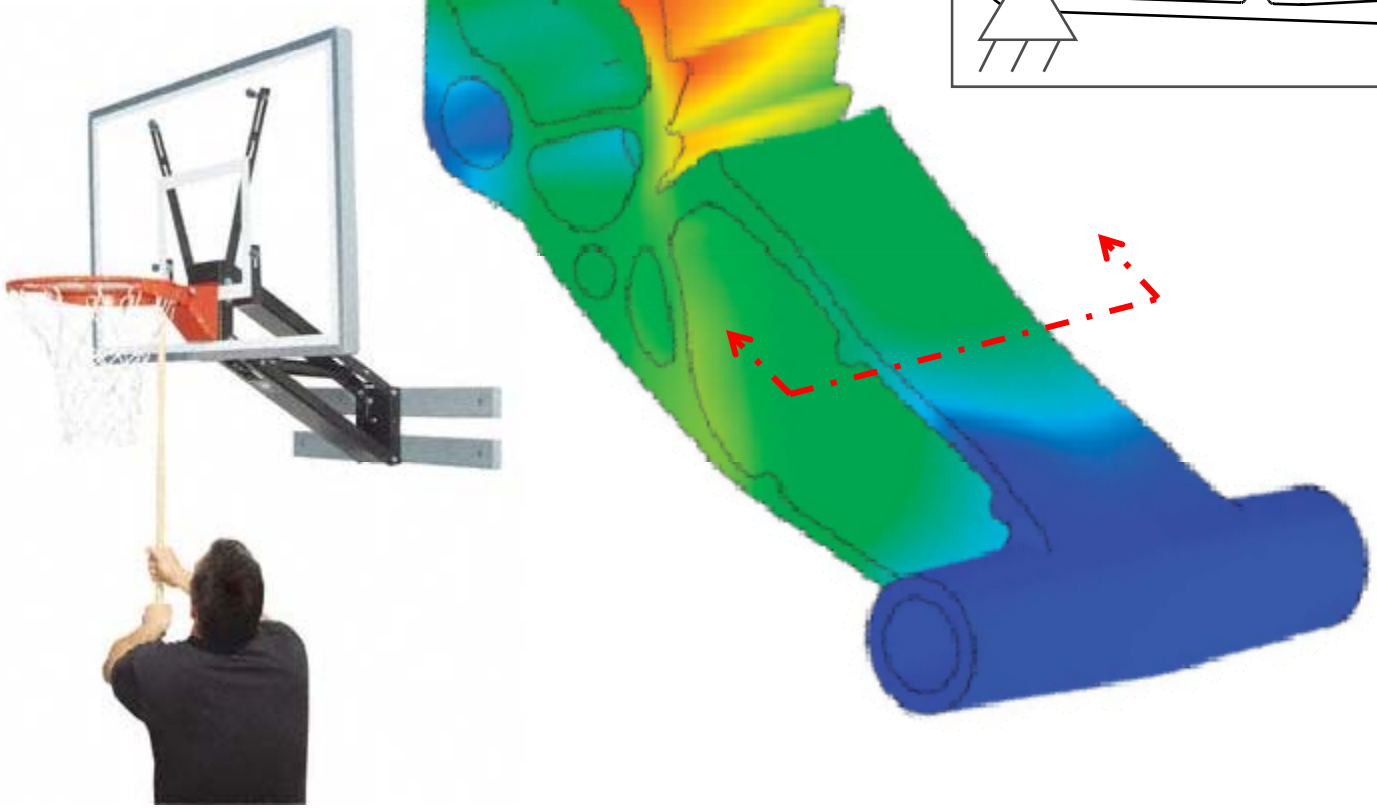


Asking Too Late…



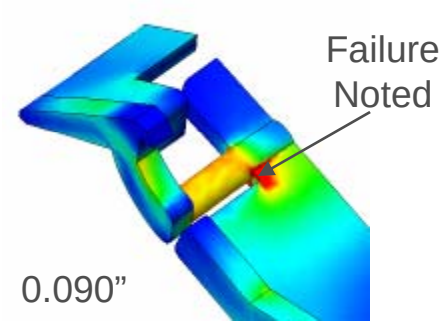
Asking the Wrong Question…



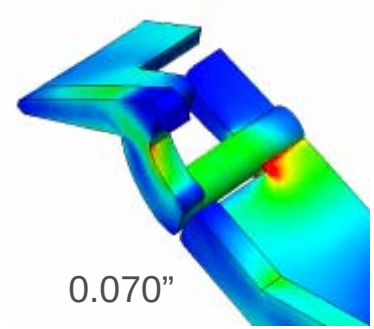


When Design Simulation is Leveraged…

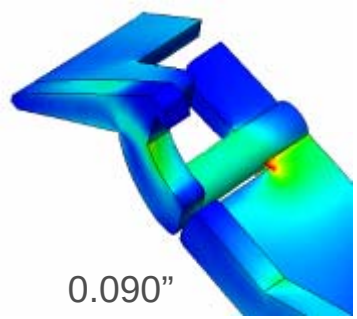
TAB



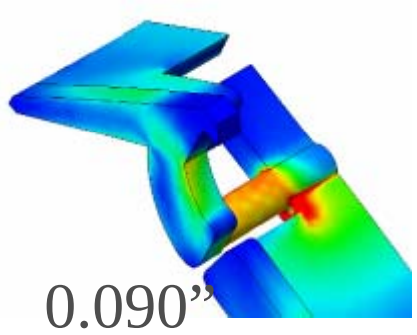
Original Design



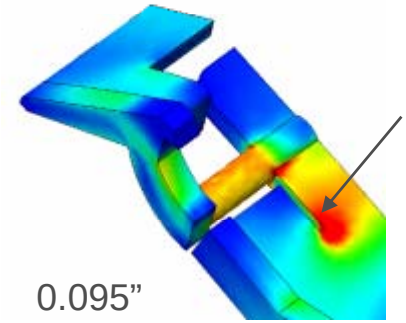
Increase Diameter by 20%



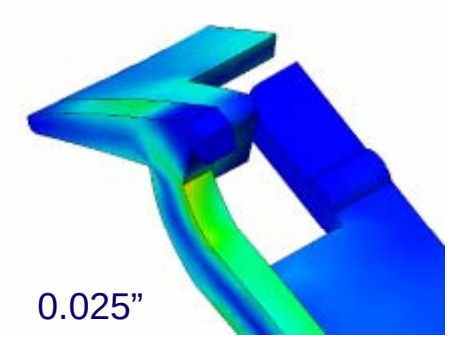
Use Acetal with 10ksi Yield



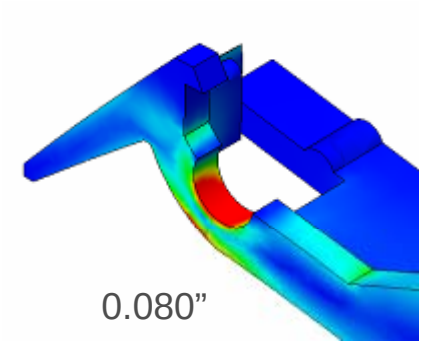
Increase Blend Radii to Max possible



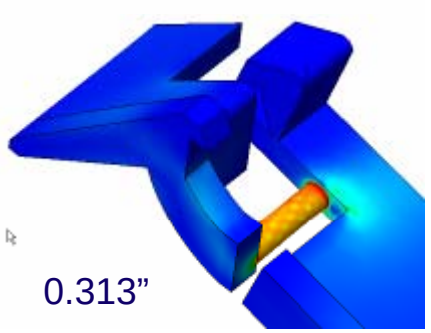
Add Slot



Use Cantilever instead of Torsion Bar



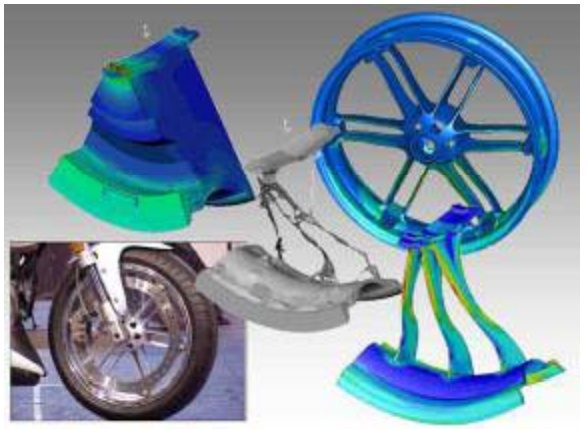
Thin Cantilever to Increase Pivot

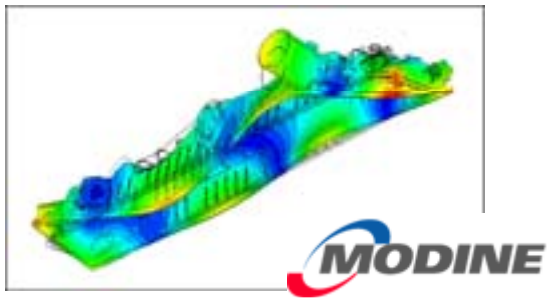


Decrease Diameter by 20%

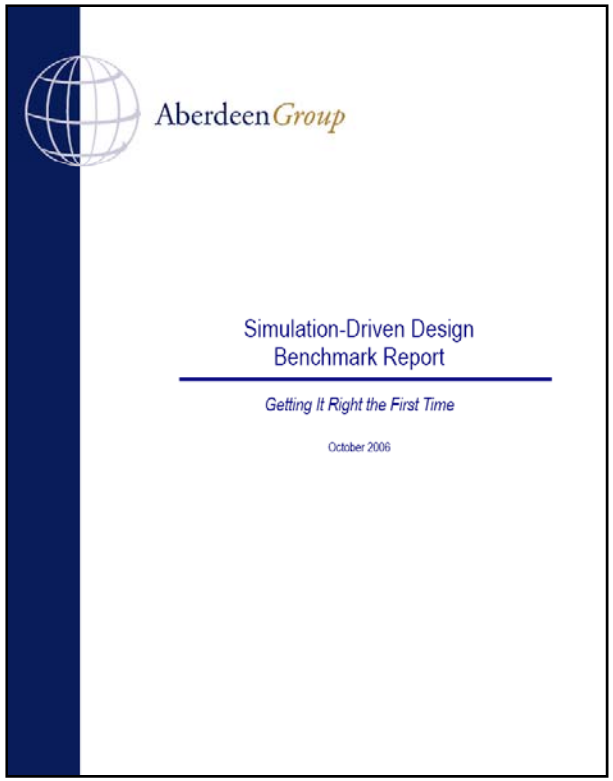
Does Design Simulation Work?

- Buell Motorcycle Company
  - *"Simplicity Through Sophisticated Engineering"*
  - Adopted an "Analysis-Driven Design" Strategy that subordinates all design tasks to simulation
- Modine Manufacturing
  - *"CFD/FEA is an expectation by our clients"*
  - Custom app for Sales Engineers allows front-line people to explore iterations without involving experts for FEA & CFD saving nearly $10K and weeks of development time per iteration
- Rockwell Automation
  - *"Inventive Design"*
  - "Analysis results provide insights to solutions that might otherwise have gone unnoticed"
- John Deere
  - *"Expect to be surprised and disappointed when a new failure mode is discovered in field testing"*
  - Use full machine testing to validate simulation





Does Design Simulation Work?



- Simulation-Driven Design Benchmark Report – Getting It Right the First TimeBest in class manufacturers hit their revenue, cost, launch date, and quality targets for **86%** or more of their products.
- Best in class manufacturers average **1.6 fewer prototypes** than all others.
- Best in class manufacturers of the most complex products get to market 158 days earlier with $1,900,000 lower product development costs.
- Best in class manufacturers of the simplest products get to market 21 days earlier with $21,000 lower product development costs.

NAFEMS

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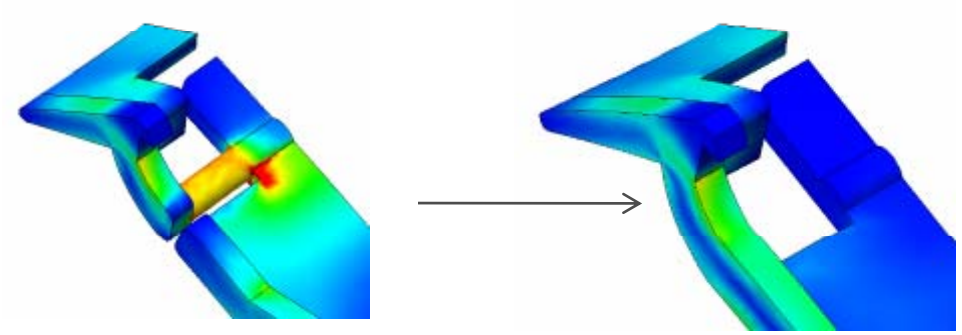

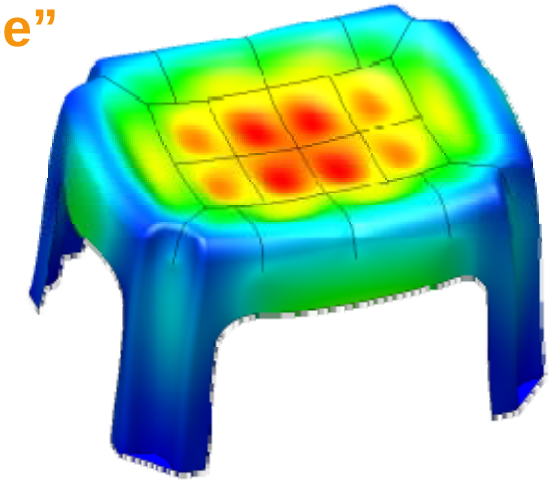

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- Testing is still the final decision-maker for design validity
  - **“The Proof is in the Prototype”**
  - **“The Risk is in building the wrong Prototype”**
- Don’t use design simulation **only** as a glorified “spell-checker” – Use it to drive innovation and optimization at the earliest decision making stage

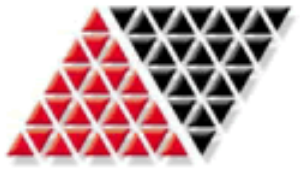
Closing Remarks…

- Design Simulation is ready for Mainstream use!
- If your company isn't seeing the benefits, consider the implementation
- For maximum benefit, explore all behaviors that can be predicted – Don't limit the tools; Expand the capabilities
  - Remember tool need is driven the questions you need to ask – Not user experience
- Get your "hands dirty" & be a "Devil's Advocate" to really appreciate the opportunities available to you and your company

Thanks!

vadams@solidworks.com

NAFEMS



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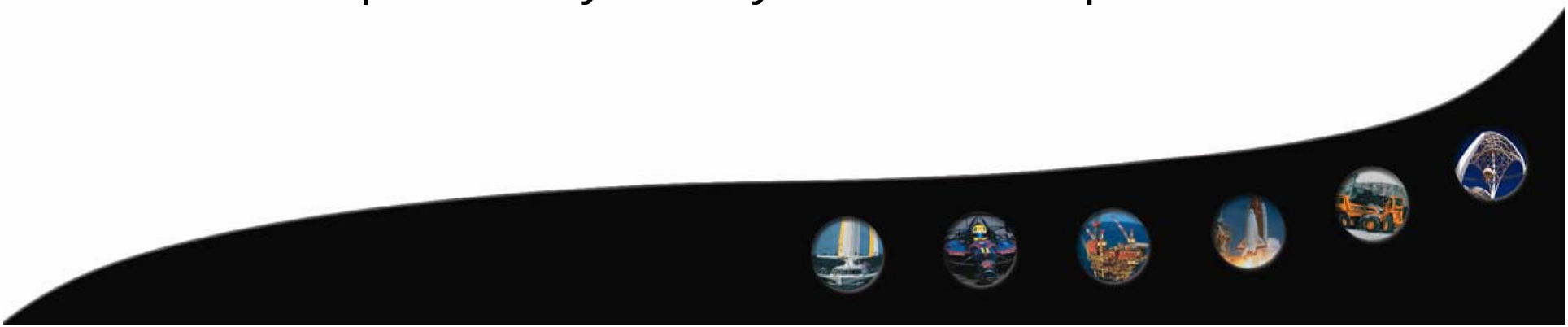
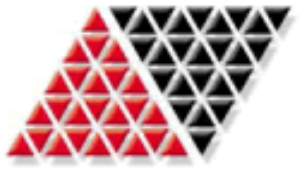
Q&A Session

Using the Q&A tool, please submit any questions you may have for our panel.



NAFEMS



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Thank you!

matthew.ladzinski@nafems.org