

ANSYS®

PADT

Driving Design with Simulation: Past, Present, and Future

ANSYS ARIZONA INNOVATION CONFERENCE

8/15/2016

ERIC MILLER

PADT, INC.

About PADT

ANSYS®

PADT

- ▶ Products and Services for Physical Product Development
- ▶ Simulation, Product Development, 3D Printing
- ▶ ANSYS Channel partner in AZ, NM, CO, UT, NV, and SoCal.
 - ▶ Full simulation consulting
 - ▶ Training & Mentoring
 - ▶ Customization & Automation
- ▶ CUBE HPC Workstations, Servers, and Clusters
- ▶ The Focusblog on all things ANSYS
- ▶ Based in Tempe
 - ▶ Albuquerque, Denver, Salt Lake City, Torrance



stratasys

FLOWNEX®
SIMULATION ENVIRONMENT

Simulation, What is it really

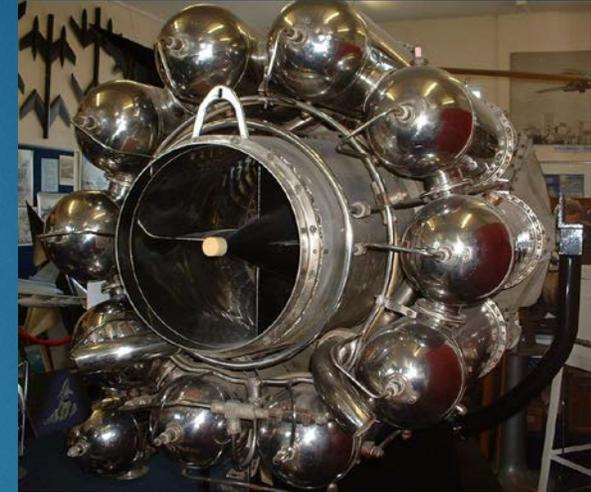
noun | sim·u·la·tion | \,sim-yə-'lā-shən\

- 1 : the act or process of **simulating**
- 2 : a sham object : **COUNTERFEIT**
- 3 **a** : the imitative representation of the functioning of one system or process by means of the functioning of another <a computer *simulation* of an industrial process>
b : examination of a problem often not subject to direct experimentation by means of a simulating device

- ▶ For what we do (my definition): Using math to predict the behavior of a system
- ▶ For this talk: Mostly large numerical models that utilize discretization to build large systems of equations: FEA, CFD, FD, etc...
- ▶ When we talk about simulation we are really talking about using equations to predict behavior
- ▶ Not just FEA/CFD/FD – that describes the mathematical method

Driving Product Design

- ▶ The term “driving” is intentional
 - ▶ Not just steering or informing, but pushing it forward as well
- ▶ Design:
 1. This is a list of what I want to product to do
 2. Come up with a configuration that does what I want
 3. Make sure it does what I want
- ▶ Simulation Answers
 1. What can it do?
 2. Does a certain aspect work and how well?
 3. Does it do what I Want?



Why Simulation?

- ▶ Competition: Test
- ▶ When done right Simulation:
 - ▶ Costs less
 - ▶ Takes less time
 - ▶ Can be done earlier in the process
 - ▶ Is more accurate
 - ▶ Provides deeper insight
- ▶ Some people say experience is better
 - ▶ Experience is imperfect and makes assumption
 - ▶ Experience does not go beyond what was done before

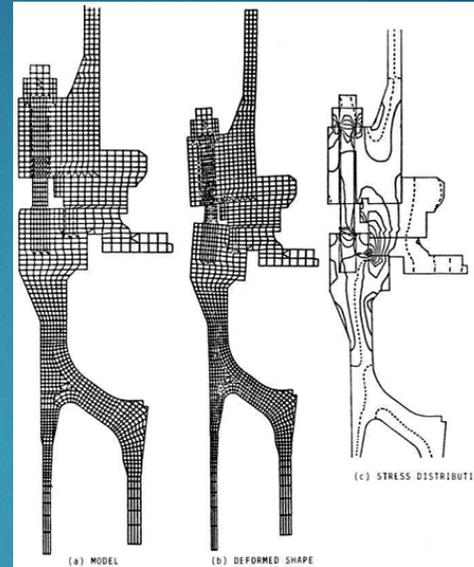


Why this Look?

- ▶ “It’s hard to see the assembly for the nodes”
- ▶ As simulation professionals we are busy doing simulation
- ▶ How did we get here?
- ▶ Where are we?
- ▶ Where are we going?

- ▶ Knowing will allow us to make better strategic decisions and increase the value of Simulation to our employers





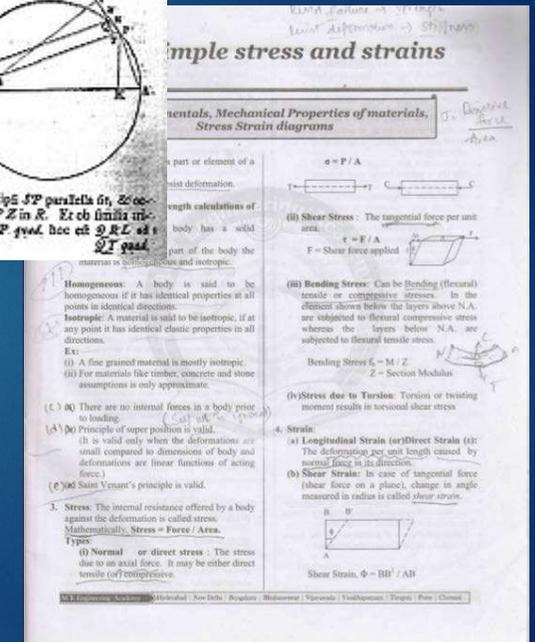
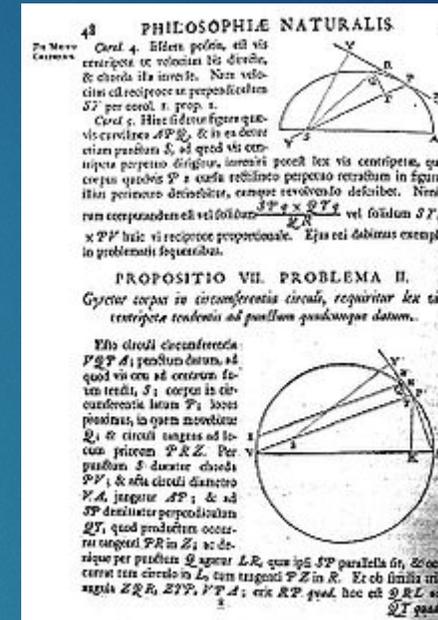
The Past

1980 TO AROUND 2005

Analytical Models

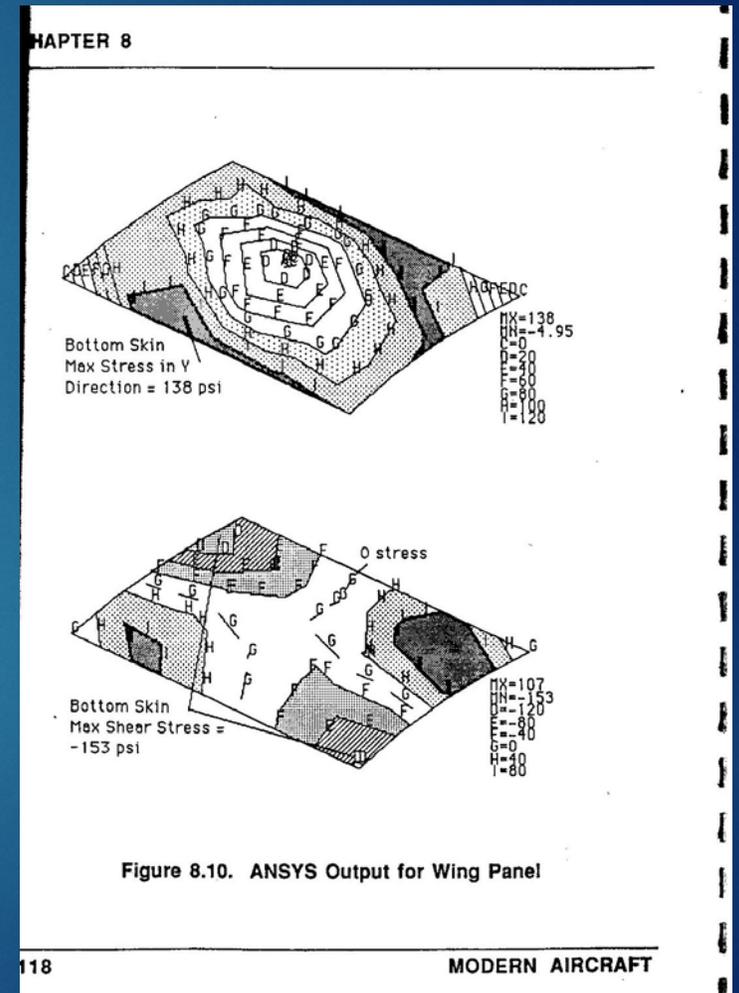


- ▶ Simulation Driven Product Development started with Newton's equations
 - ▶ Artillery
 - ▶ Designing machines with levers
- ▶ More closed form equations developed over time
 - ▶ Structural
 - ▶ Thermodynamics
 - ▶ Heat transfer
 - ▶ Aerodynamics
 - ▶ Electromagnetics
 - ▶ Fluid dynamics
 - ▶ Etc... "So and So's Equations"



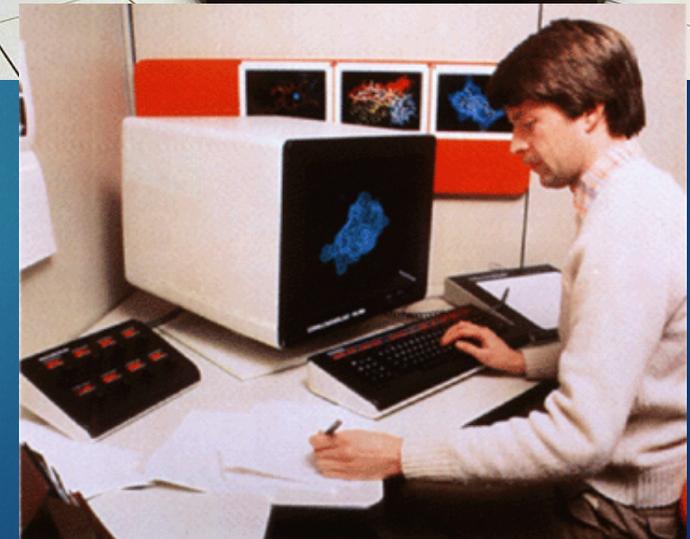
Failure Analysis

- ▶ Initial value in simulation was often for failure analysis
 - ▶ Too slow and expensive to do up front and drive design
 - ▶ After a big failure, useful in understanding why
- ▶ This quickly moved to the next step of changing the design to see if things got better – driving the design



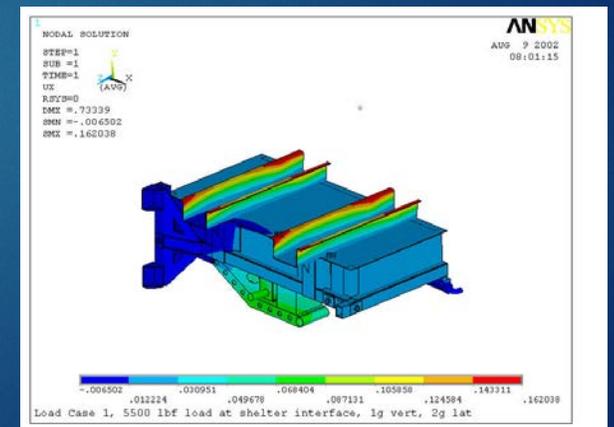
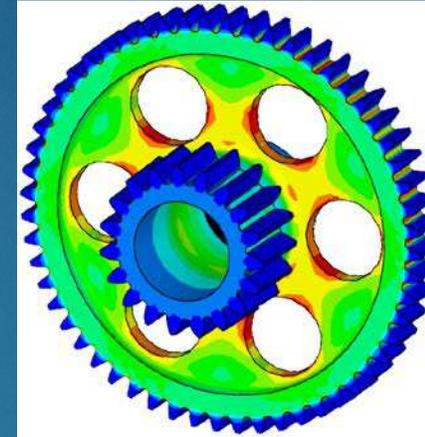
Answering Questions for Design

- ▶ Even with high computer costs and clunky interfaces, doing FEA and CFD was valuable enough to drive designs
- ▶ Special cases:
 - ▶ No way to test
 - ▶ Testing is very expensive
 - ▶ People might die
- ▶ Large expensive structures
 - ▶ Rockets & Spacecraft
 - ▶ Airplanes & Turbine Engines
 - ▶ Buildings and Bridges
 - ▶ Nuclear Reactors



Understanding Behavior

- ▶ Things got faster and more accurate: start looking at behavior
- ▶ Instead of “is this good enough” explore variations to understand why
- ▶ Adding non-linearities and more accurate materials
- ▶ Optimization starts playing a role
- ▶ Big change: No longer one or two runs, but a study



Automation

ANSYS®

PADT

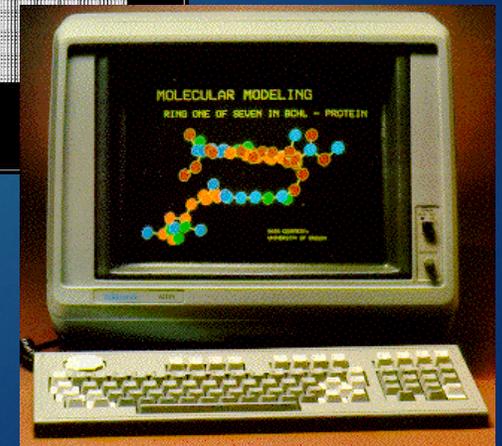
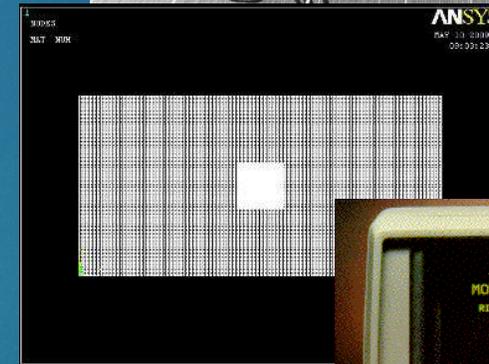
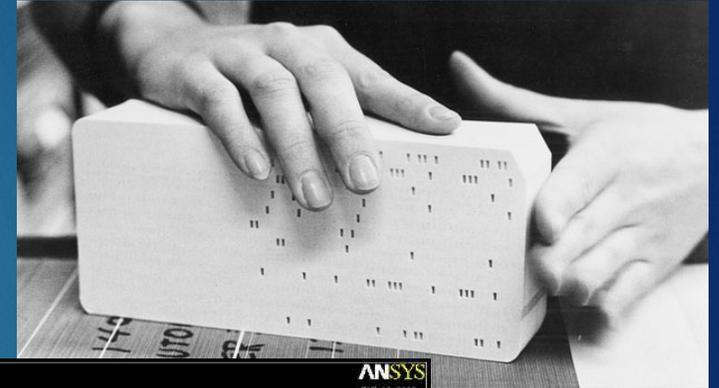
- ▶ Early simulation required programing
- ▶ Geometry definition and meshing were manual
- ▶ No or primitive Graphical User Interface
- ▶ Programs and scripting were critical to success
- ▶ Enabled faster – studies
- ▶ Repeatability
- ▶ Automation transferred into tools
 - ▶ Direct geometry import from CAD
 - ▶ Automatic meshing
 - ▶ Geometry based loading
 - ▶ Multiple commands combined into one



Problems



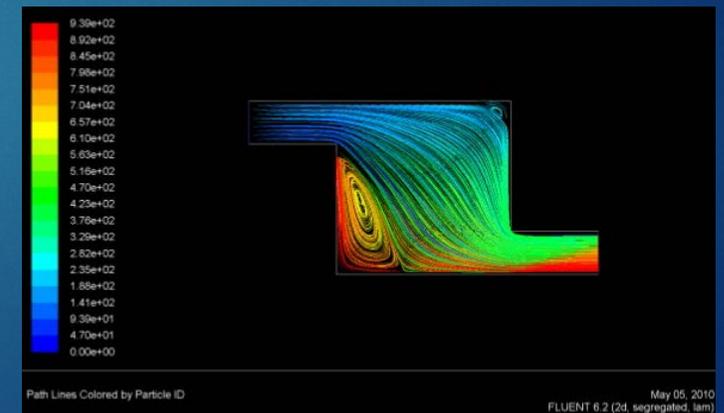
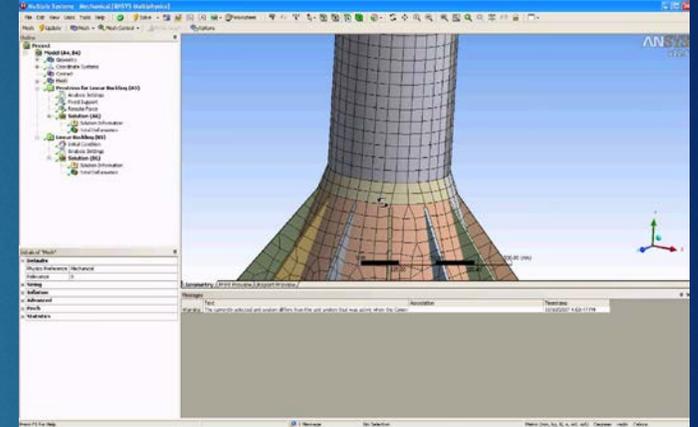
- ▶ Computer cost
- ▶ Expert users needed
 - ▶ Understand the math and the physics
 - ▶ Be able to program
 - ▶ Fundamental understanding of geometry
- ▶ Dedicated users
 - ▶ Full time job
- ▶ Time
- ▶ Limits on size limited accuracy

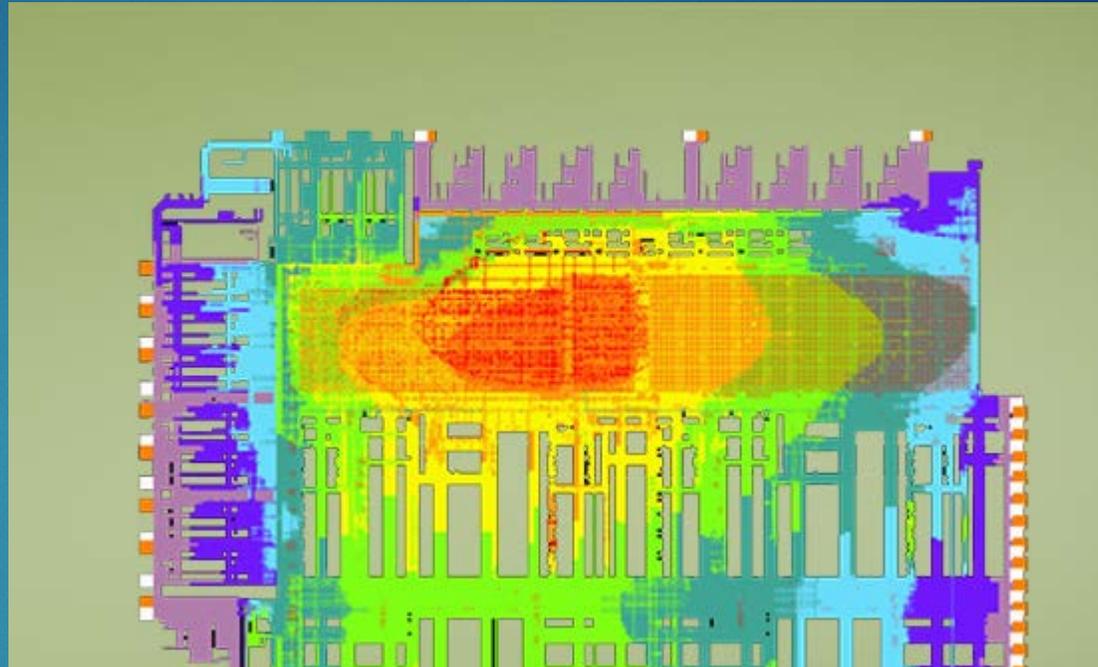


Successes



- ▶ With all the cost, time, and expertise: It Worked!
- ▶ Information could be gathered that had no other source
- ▶ Amazing progression in software and hardware
 - ▶ GUI's really become dominant
 - ▶ Automatic meshing
 - ▶ Connection to geometry
 - ▶ Advanced materials and non-linearities
 - ▶ Much larger models on affordable hardware
- ▶ Automation and transition from 2D to 3D
- ▶ CFD becomes practical for day-to-day application
- ▶ HF Emag simulation grows beyond initial adopters





The Present

BARRIERS HAVE BEEN REMOVED

Computers

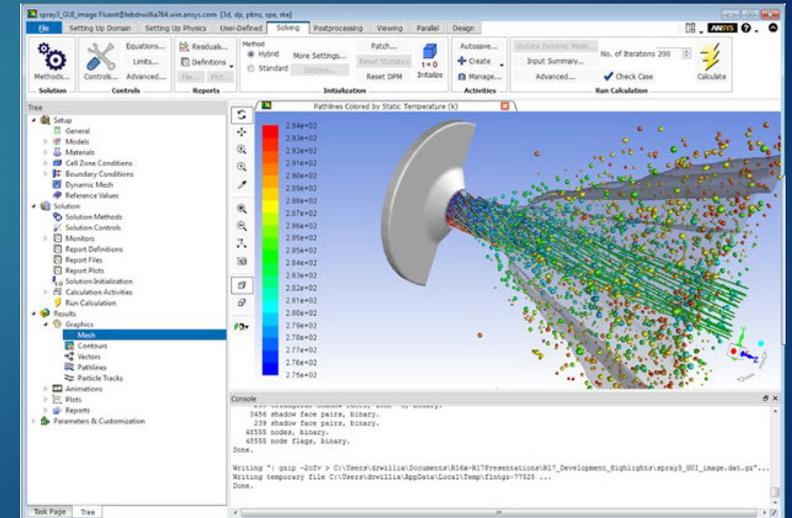
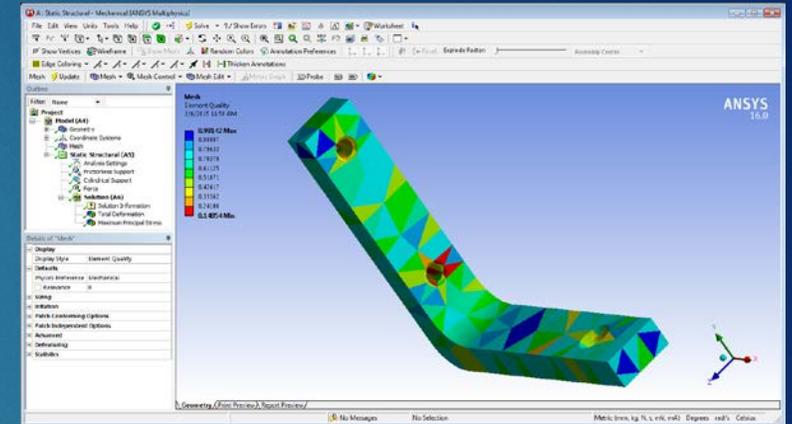
- ▶ The most significant change to Simulation Software is the advance of Computers
- ▶ We faced a problem – struggling to make a single CPU faster
- ▶ Solutions:
 - ▶ Multi-core
 - ▶ Multi-chip
 - ▶ Combine operations within a clock tick
 - ▶ High speed interconnect
 - ▶ GPU's
 - ▶ More memory available per CPU
 - ▶ Lower cost of everything



User Interfaces

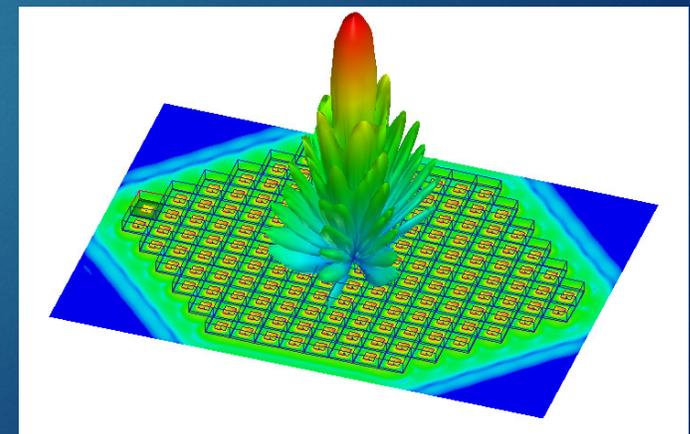
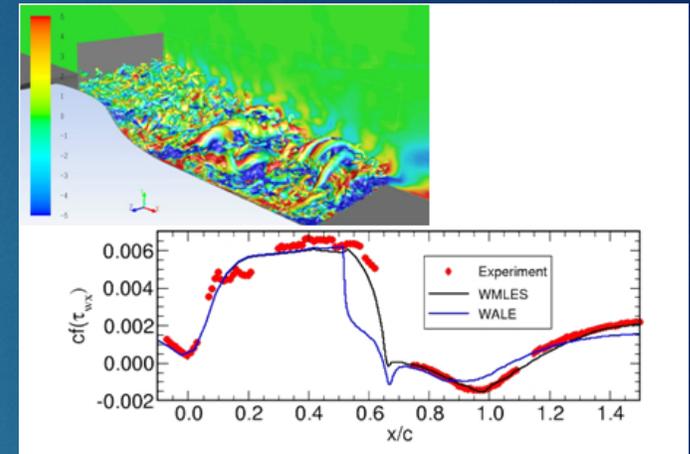


- ▶ Wow
- ▶ Many significant advantages of modern user interfaces
 - ▶ Combine multiple steps
 - ▶ Easy to use
 - ▶ Easy to remember
 - ▶ Workflow based approach
 - ▶ More consistent with other software tools
- ▶ Resulted in
 - ▶ Faster process
 - ▶ Less searching, training, fumbling
 - ▶ Enables occasional users
 - ▶ Better understanding of the simulation



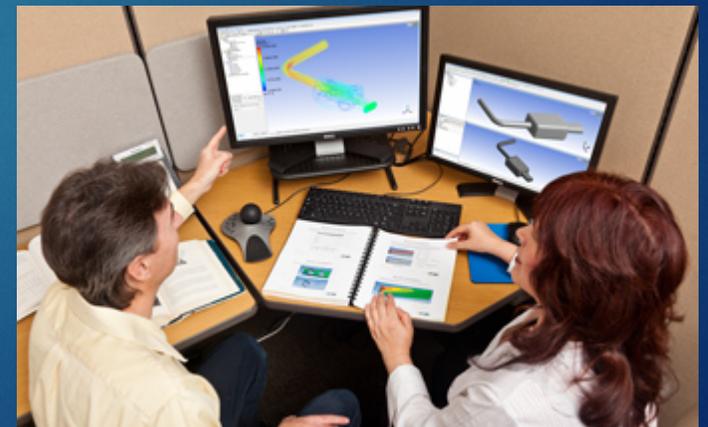
Greater Accuracy

- ▶ Bigger Models
 - ▶ Finer discretization – better accuracy
- ▶ Faster Solvers
 - ▶ Smaller time steps, include more physics or non-linearities
 - ▶ Previously inefficient models can be used
 - ▶ Converged models
- ▶ Better Models
 - ▶ More and more accurate math
- ▶ Multiphysics
 - ▶ Loads from one simulation accurately transferred
 - ▶ Interaction of physics not approximated or assumed away
- ▶ Probabilistic & Optimization



Greater Access

- ▶ Biggest achievement of our industry:
 - ▶ Everyone making a physical product can use simulation to drive their product development
 - ▶ Increased who in a company
 - ▶ Increased industries
- ▶ Barriers to usage have been taken down
- ▶ Cost of needed compute hardware reduced
- ▶ Ease of use
 - ▶ GUI, Workflow, Automation
- ▶ Better understanding of how to use Simulation

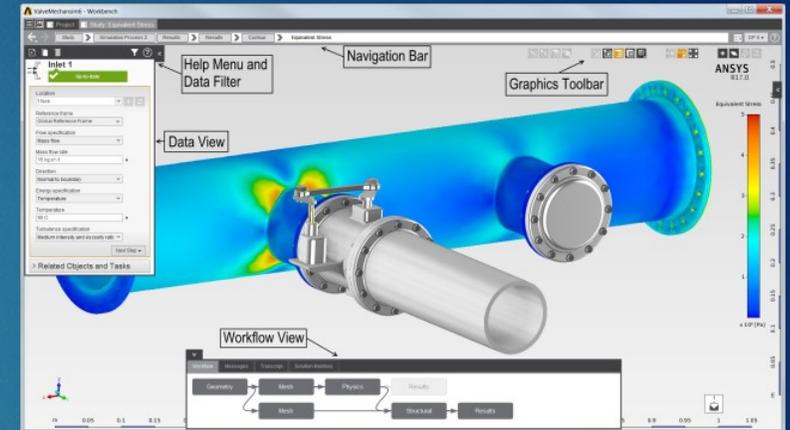


Automation

ANSYS®

PADT

- ▶ Automation has changed
 - ▶ From tools to make a step faster
 - ▶ To tools to make users faster and give them access to more advanced features
- ▶ Applications that sit on top of Simulation tools
- ▶ Integration with other tools
- ▶ Workflow automation
- ▶ Much less scripting by individual users needed

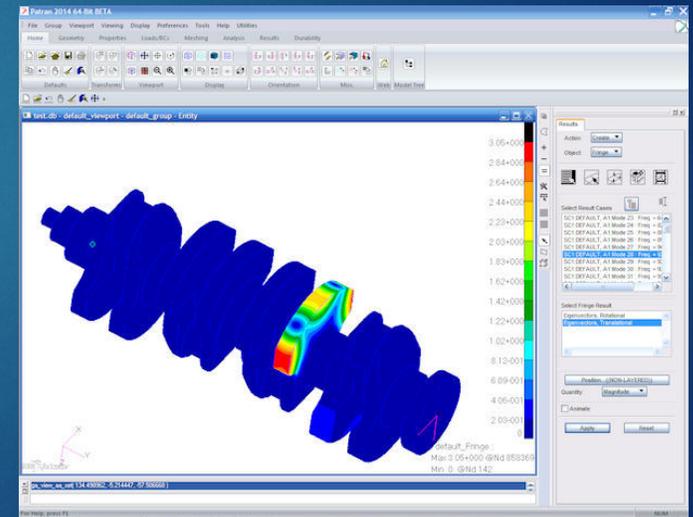
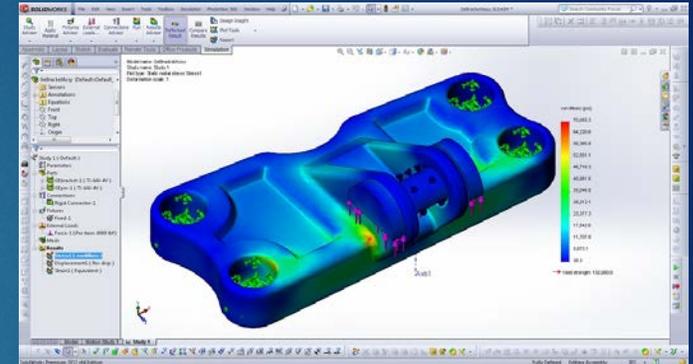


Problems

ANSYS

PADT

- ▶ Some applications could use more automation
- ▶ Multiple interfaces across product families
- ▶ Lesser used physics need to be brought up
- ▶ Power tool's could use more accessibility
- ▶ Adding more cores is not always the answer
- ▶ Data management
- ▶ Most CAD embedded solutions are still written "down"
- ▶ Some acquired tools are stagnant



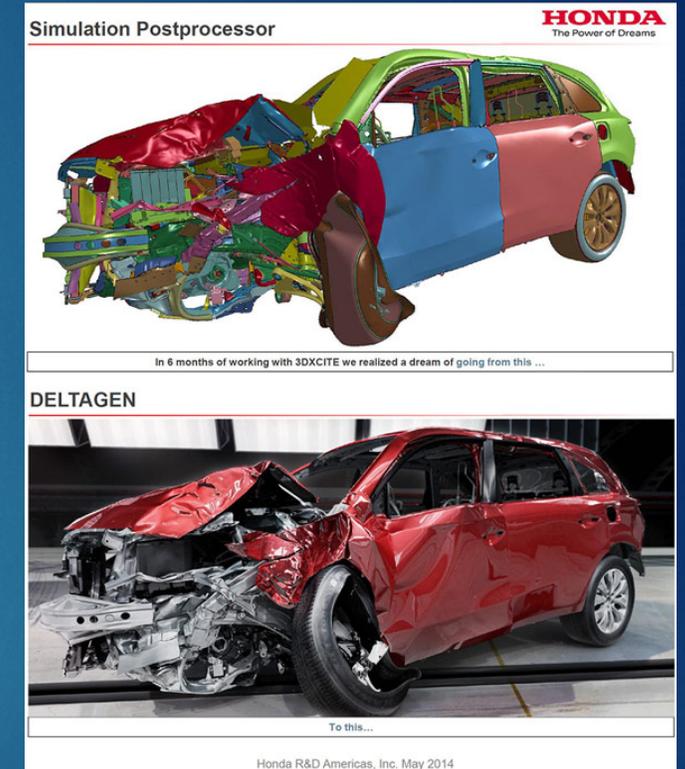
Successes

ANSYS®

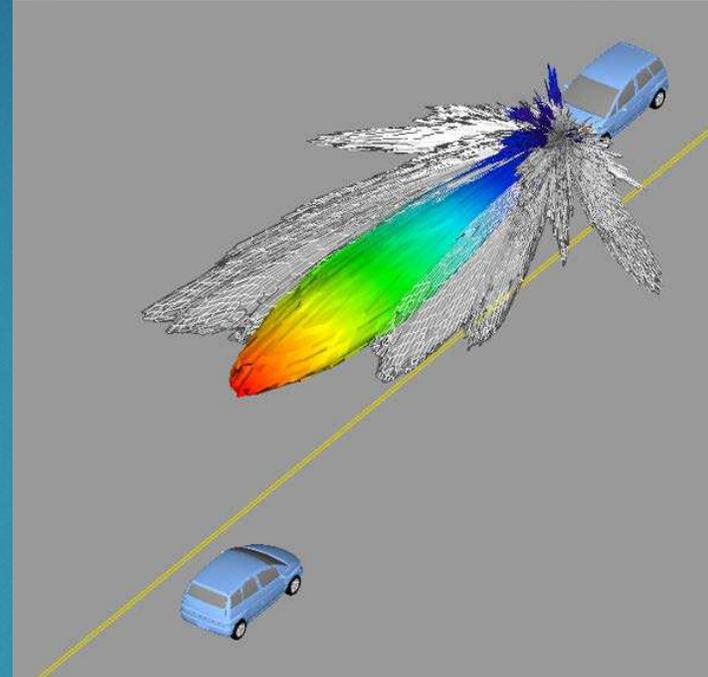
PADT

- ▶ Democratization of accurate simulation across physics
- ▶ Fast
- ▶ Accurate
- ▶ Easy to use and Remember

- ▶ Simulation:
 - ▶ Adds value to almost every industry
 - ▶ Adds it earlier
 - ▶ Adds it in more places



The Future



Less Modeling, More Answers

- ▶ Direct CAD to Results is the goal
 - ▶ Model physical characteristics of design
 - ▶ Define physical environment
 - ▶ Select physics to evaluate
 - ▶ “Go simulate”
 - ▶ Automatically: Discretize, load, check, solve, converge, get results, further process results
 - ▶ Review Results
- ▶ Probabilistic and Optimization automatic
- ▶ Barriers:
 - ▶ AI algorithms for simulation
 - ▶ Faster hardware
 - ▶ Need to find and prove out new algorithms and processes



Systems & Multiphysics

- ▶ Already started on this road
- ▶ Parts and assemblies exist in systems
 - ▶ Mathematical model for each component in the system and how they interact
- ▶ Physics interact in the real world
- ▶ Greater accuracy within physics and understanding of interaction
- ▶ Barriers:
 - ▶ Need to solve non-software problems
 - ▶ Different physics people use different languages
 - ▶ Getting people to work together
 - ▶ Who controls the process
 - ▶ Cross vendor interaction of tools
 - ▶ Different solver times



University of Washington Libraries, Special Collections, FAR016

Computers

ANSYS®

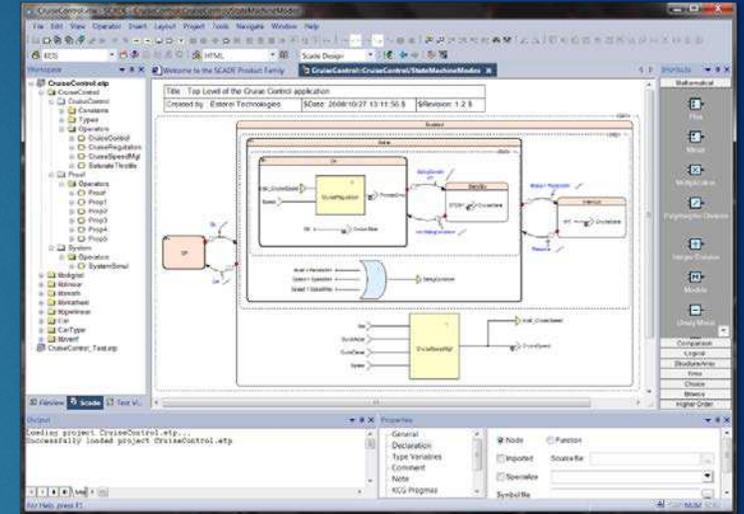
PADT

- ▶ More cores and memory for less money
- ▶ Direct memory connection between nodes
- ▶ Some increases in clock speed
- ▶ More per cycle
- ▶ Specialty processors
- ▶ Cloud???
- ▶ Changes to user interaction:
 - ▶ Mobile
 - ▶ Virtual Reality and/or Augmented Reality
 - ▶ Touch



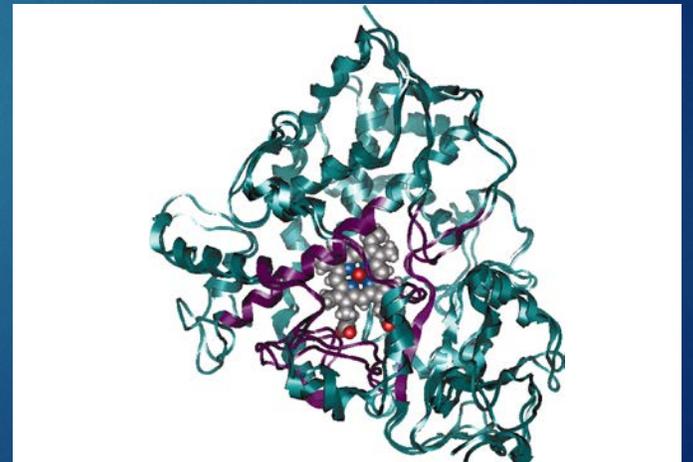
Access & Integration

- ▶ Seamless integration across software and geography
- ▶ Workflow based task specific user interfaces
- ▶ Integration beyond MCAD
 - ▶ ECAD, symbolic, schematic
- ▶ Integrate product software into the system
- ▶ True collaboration throughout the process
- ▶ Barriers
 - ▶ All the previously mentioned ones
 - ▶ Companies adopting the new possibilities



Deeper and Broader

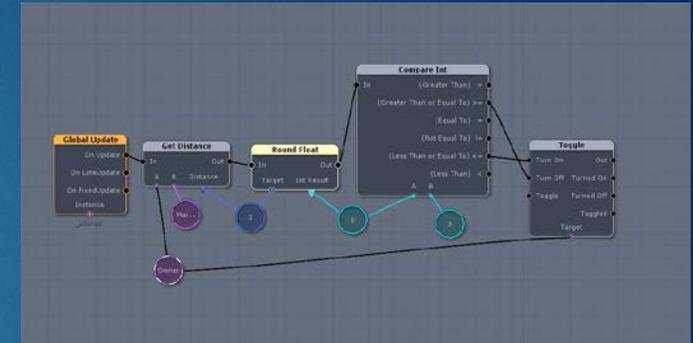
- ▶ More complex mathematical models
- ▶ Models in new areas that we have not looked at before
- ▶ Greater accuracy of mathematical models
- ▶ New physics we have not looked at before
- ▶ Software product simulation, even without a mechanical component
- ▶ Barriers
 - ▶ Need computers to keep getting faster
 - ▶ Research needs to find new ways of developing the equations
 - ▶ Probably need new or different numerical methods



Automation



- ▶ “App” concept will take hold
 - ▶ Marketplaces and exchanges
- ▶ User automation will be GUI based
 - ▶ Drag and drop scripting
- ▶ Tools and standards for data integration and Management
- ▶ Integration of AI in Automation
- ▶ Barriers
 - ▶ Vendors need to create tools and marketplaces
 - ▶ Need a step forward in how we do scripting
 - ▶ Need standards and tools for data



Output

Name	Size	Type
comparison Report -Mix 1-2	4064	Comparison Report
mix1-report	1717	Report Book
mix1.cas.gz	33118	Fluent Case
mix1.dat.gz	45197	Fluent Data
mix1.jpg	75131	JPEG Image
mix2-report	1717	Report Book
mix2.cas.gz	33119	Fluent Case
mix2.dat.gz	45142	Fluent Data
mix2.jpg	77219	JPEG Image

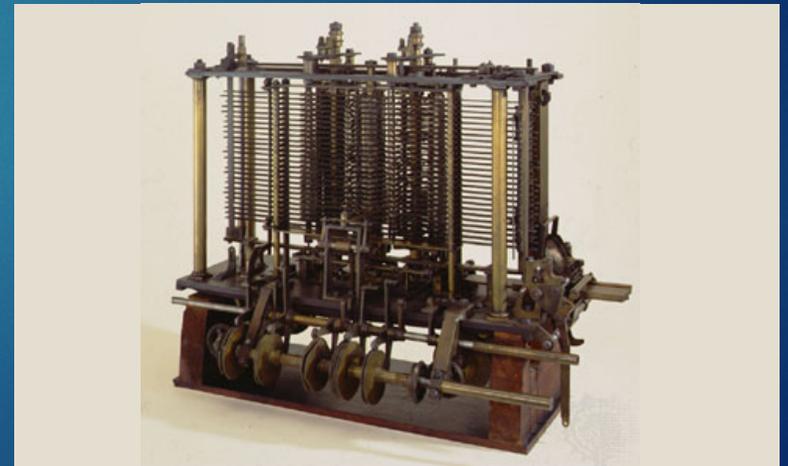
Comparison of results

No.	File Name	Condition	Value
1.	Report for mix2	Axial Velocity	0.2 (m/s)
2.	Report for mix1		0.1 (m/s)
1.	Report for mix2	Swirl Velocity	0.2 (m/s)
2.	Report for mix1		0.1 (m/s)
1.	Report for mix2	Radial Velocity	0.2 (m/s)
2.	Report for mix1		0.1 (m/s)

Comparison of Flow Pattern

Problems?

- ▶ Different disciplines don't work together
- ▶ Customers go for low cost options – easy and cheap over accurate
- ▶ Computers stop growing in ways that Simulation can use
- ▶ People don't agree on standards
- ▶ Too many dead-ends get chased
- ▶ Pressure on price reduced R&D budgets



Successes?

ANSYS®

PADT

- ▶ Digital Twin works
- ▶ Simulation is a step(s) in every product development process
- ▶ “ANSYS, please tell me the predicted life of part ‘lower flange’ and external electromagnetic and acoustic noise of ‘motor drive assembly’ using load environment ‘cold weather lifecycle’”



Conclusion

- ▶ Simulation has come a long way
- ▶ Computer capability drives the industry
- ▶ Simulation really can drive product development and can return significant value
- ▶ Much to be done in the future to get to goal of fully automatic simulation

- ▶ Simulation is a powerful and valuable tool
- ▶ The value you get from it is mostly driven by how well you implement it
- ▶ Limitations in software and hardware are disappearing