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Keynote Presentation

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LOCKHEED MARTIN

Simulation Evolution

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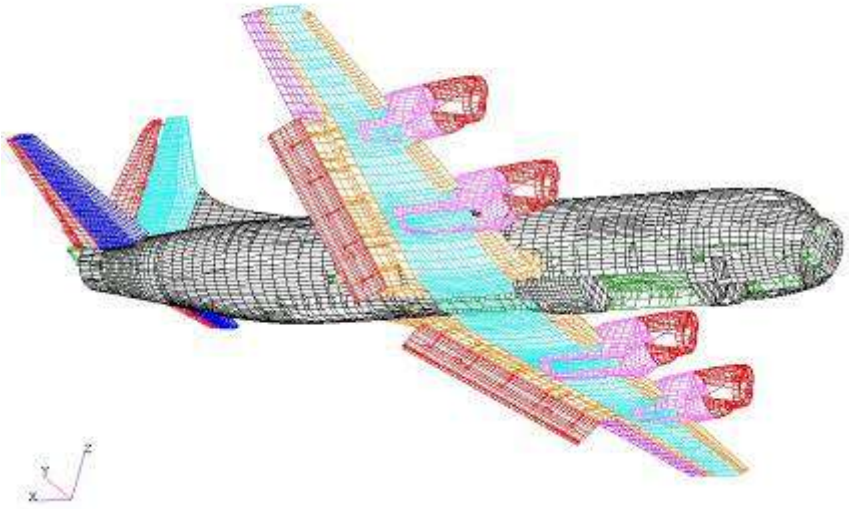
Who Am I?

- 19 Years Engineering/Analysis/Design Experience
- 6 years membership in NAFEMS
- Active in the North American Steering Committee
- Former leader of the Mechanical Analysis Working Group at Lockheed Martin
- B.M.E, M.S.M.E and a Registered Professional Engineer

- NAFEMS Papers Published:
  - "How Modeling and Simulation Engineers Can Add Business to their Skills" published in the July 2005 issue of BENCHmark Magazine.
  - "The Future of Mechanical Analysis" published in the April 2004 issue of BENCHmark Magazine.

Food For Thought Presentation

I don’t have the answers – maybe we can ask the right questions on how the simulation and modeling world is going to change.



In The Beginning

How Analysts View the World

Finance

Design Engineers in General

Design Engineers Doing Analysis Work

At one time it did take PhD in math and another PhD in computer science to do analysis or Computer Aided Engineering (CAE)

Historical Perspective

Time Period	CAD A Historical Prospective of the Computer Aided Design (CAD) Process (Design Methods):	CAE A Historical Prospective of the Computer Aided Engineering/Analysis (CAE) Process (Analysis Methods):
Pre 1960s	Hand drawings	Hand calculations (99% of analysts time spent on developing pre-processing – mesh generation/cleaning, boundary conditions, loading, etc)
1960s	Hand drawings	Customized Programming on large main frames with simple manual made models (95% of time for pre-processing)
1970s	Hand drawings	Customized Commercial Programs on large main frames with more complex manual made models (90% of time for pre-processing)
Early 1980s	Computer generated 2-D drawings	Introduction of PC based analysis programs. Importation of CAD geometry (75% of time for pre-processing). "Make and break" verification.
Late 1980s	Computer generated 3-D drawing/models (primitives, 3D wire frames)	Introduction of PC based analysis programs. Importation of CAD geometry (75% of time for pre-processing). "Make and break" verification.
1990s	Computer generated 3-D models/Parametric design feature based modeling (design intent)	Linkage of CAD designs for analysis (60% of time pre-processing). "Model and simulate" verification.
The future	Model Centric Design (no drawings, imbedded dimensions, everyone uses the model). Functional and Voxel modeling.	Optimization (full linkage of design and analysis). Multiphysics. Automatic pre-processing of the CAD design. Rapid prototyping.

The Perception of Analysis in Design… (FEA = Pain)

- CAE has little or no impact on time-to-market or establishment of market share...
  - *Grant Thornton; The Enterprise-Wide Impact of Computer-Aided-Engineering on Manufacturers (1996)*
  - *Management Roundtable; Product Development in the 1990's (1997)*
- FEA slows down the rapid product development process and should only be used after careful consideration of its need…
  - *Developing Products in Half the Time; Preston and Reinertsen (1998)*
- …despite the efforts to create an integrated CAD/analysis product-development process, FEA remains today in the hands of specialists.
  - *Industry Week Magazine (December 11, 2000)*
- Less than 1/3 of companies surveyed felt digital simulation was an important factor in improving innovation or increasing revenue
  - *The Product Innovation Agenda; AberdeenGroup (2005)*

Where does Analysis fit in…

- Designing – and verifying the design – to be just good enough, quickly, would be Nirvana
- Real Time and fast Optimization – but don't slow us down
- Heuristics and rules of thumb start us on the right path, but only the rigor of FEA will confirm it
  - Requires the "right" pre/post-processing
  - Enough licenses, but not too many

Until FEA becomes do-able inline and painless, it will be viewed as a "chore" that has to be done

Now All Major MCAD Packages Have Excellent CAE Packages

- CATIA with Abaqus/Simulia
- PTC with Mechanica/ANSYS
- SolidWorks with COSMOSWorks
- UGS with NX.NASTRAN

- And all the FEA and simulation packages can and do use MCAD models for pre- and post-processing. Both are huge steps in shrinking time-of-use and ease-of-use.

- Time consuming Pre and Post Processing is going to be a thing of the past.

- Any engineer that can “do” CAD can now “do” lots of CAE. If you have CAD – you have FEA.

Time / Value of Money Decisions

- **What is the cost for incomplete or incorrect analysis (with downstream failures) vs. getting it right the first time vs. using "cheaper" part time analysts?**

- **When do you "spend" your experienced analyst time and when do you "spend" a novice or part analysts time?**

The easier it gets, the less value it has (FEA responds well to specific questions)

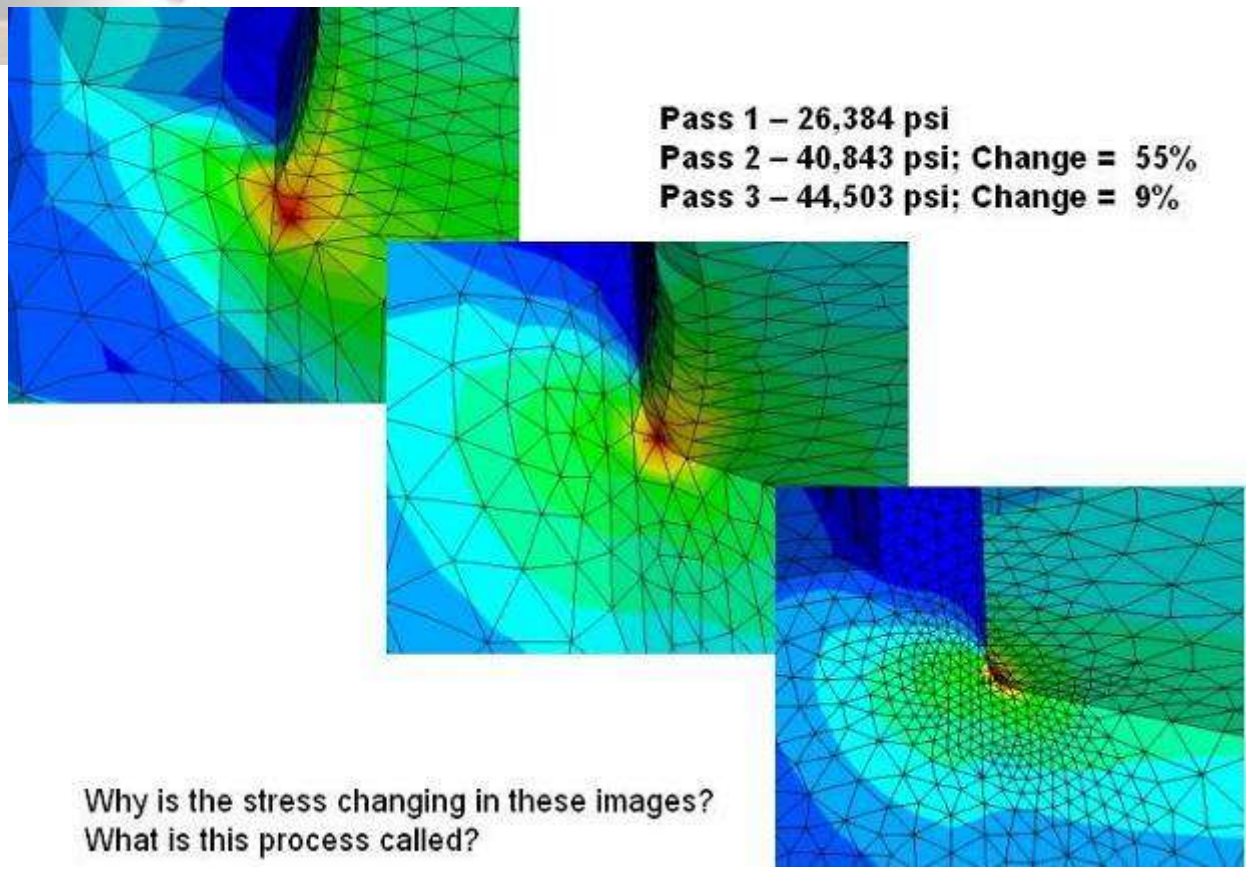
As FEA gets easier and easier, too many users lose track of the "why" in the results they get.

Why are you looking at Von Mises Stress? Maximum Principal Stress Theory? Maximum Shear Stress theory?

Applicable failure mechanisms for their parts and/or materials?

Many ways to fail - Ductile, brittle failure theories, buckling, fatigue, & creep.*

For Example: The more I refine the mesh, the higher the stress. Why?*



*** From Assessing FEA Skills by Vince Adams**
Product Manager – Analysis Products
SolidWorks Corporation

Answer - Convergence

- The steps shown here reflect a 3 step relative convergence study using the h-adaptivity method.

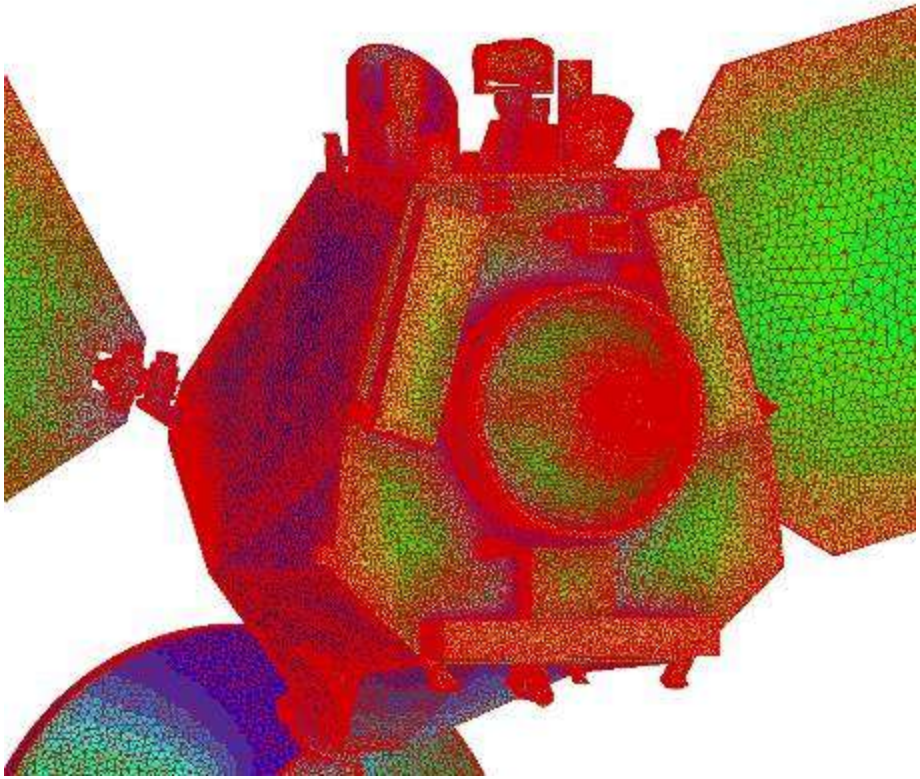
- This entails systematically increasing the number of nodes (reducing the nominal element size) local to a stress riser and tracking the relative increase in stress. In this case, the stress nearly doubled from Pass 1 to Pass 3, possibly taking the region from acceptable to unacceptable.

- Being aware of the large potential increase in stress due to convergence is one of the biggest areas newer and part-time users miss the mark.

Some Anonymous Lockheed Martin Examples

Rubber Metal Example:

“As a beginner I misplaced the decimal on a material modulus for a 12' diameter, cast iron trunnion for a grinding mill. It was supported by a plain journal bearing. The stresses looked great and the normalizing of the deformed shape view made the part appear to respond as expected. It wasn't until the boss looked at the deflection numbers that he realized I'd made the part out of rubber.”

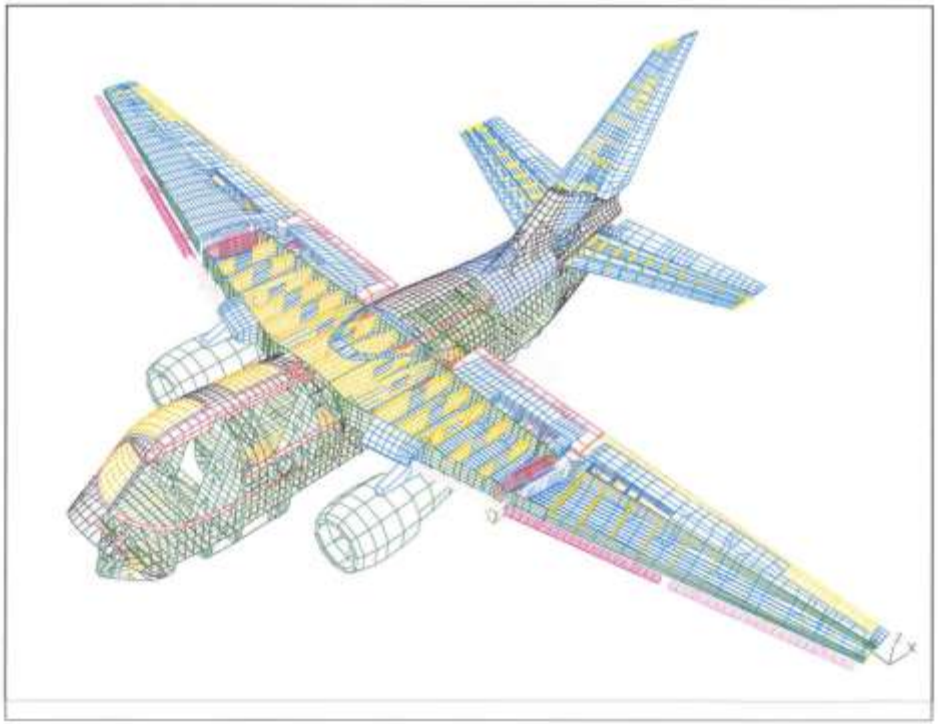


Some Anonymous Lockheed Martin Examples

Superman Materials Example:

"One should always ask if the results you are presenting make sense. I once had an associate, who will remain nameless, measure residual stress in metals using x-ray stress analysis."

"Well he got results alright, 2-3 million ksi in fact which were reported. One would only have to ask the question, what has a strength of million ksi to know that these results were totally in error."

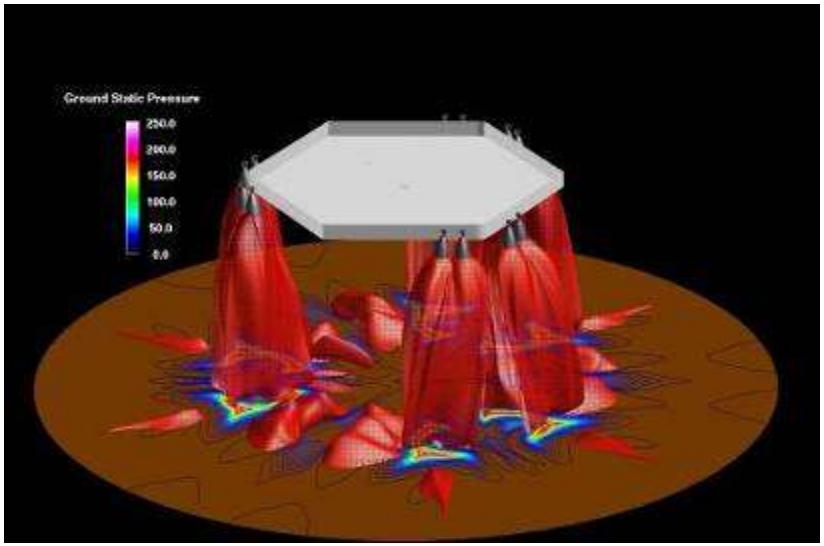


Biggest Problems for the Non Experienced

- Boundary conditions is #1 - fixing too many surfaces and not paying attention to the deformations at the BCs is rampant
- Lack of Convergence is #2 - Too many people simply throw a default tet mesh into the most inappropriate geometry
- Failure to understand requisite engineering principals is #3 – Have a designer explain Von Mises and Principal Stress when they feel they've been successful with FEA for years

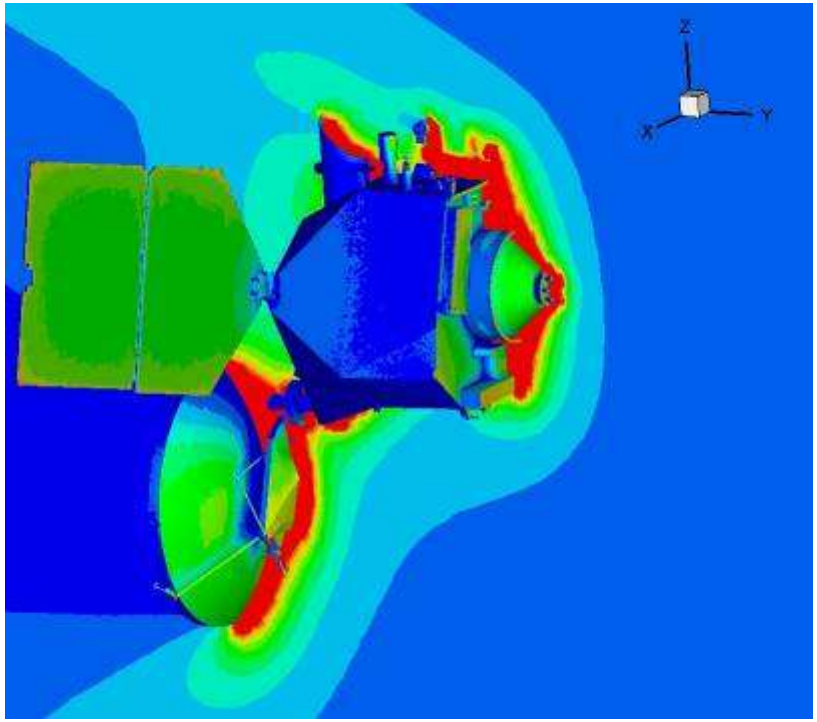
Who Me?

- **Which analysis experts need to be looking over the shoulders of others? And when?**
- **“Why can’t the software compensate for the lack of engineering knowledge?”**



The New Role of Analysis in Design…

- Analysis will always have a place
  - Always have value – but where?
- Can't improve the design process if nothing changes
- Integration of design/analysis
  - It has already happening
  - What is the cost if it does not happen?



What Value Do You (Analyst) Bring to the Table?

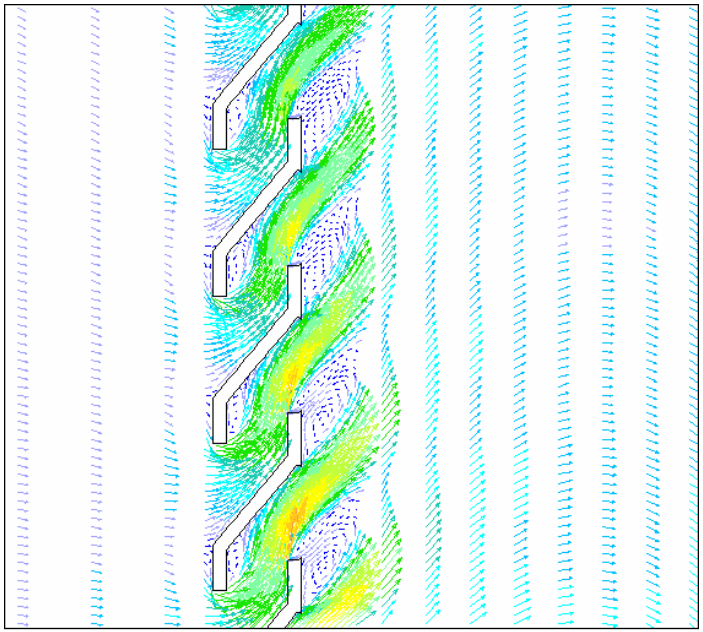
- Bandwidth
  - How to handle ideas (lots of them), how to sort them, discard them.
  - The computer is not “always” right.
  - How can managers tell before it is too late?
  - Do you have expert analysts or “buttonology” experts?

- Automation Tools
  - Take out the tedium/drudgery.
  - Free up creative juices.

- Maximizing Value
  - Keeps Engineering jobs in your country.
  - Maximizes the skills of both design and analysis engineers.
  - Have your new college hires ever done analysis?
  - Was it required for their design projects?

India and China

- What CAN be outsourced, will be outsourced
- FEA is becoming a commodity
- Commodities are outsourced to the LOWEST producers
- Differentiate yourself
- AVOID being a commodity
- Innovation is hard to outsource



Building an Innovative FEA Environment

Lessons from growing Design/Analysis Organizations

- Hit the Streets
  - Observe your customers, don't just ask them what they want
- Develop T-Shaped People
  - Top off their core skills with complementary yet diverse skills that allows them to think in alternate perspectives
  - Promote cross-pollination
- Build to Think
  - Design thinking is inherently a prototyping process. Be the Best
- Design Is Never Done
  - The world is changing, evolving. Your products and strategies need to evolve with it

Closing Remarks…

- In today's market, we all must find way to reinvent ourselves and increase our personal value
  - Corporations don't build sustainable competitive advantage by outsourcing to the lowest bidder
  - However, sustainable competitive advantage isn't gained by paying more to do things the same way their competitors are doing them
  - Embracing state-of-the-art techniques and promoting innovation at all levels of product development **can**, both at a personal and corporate level
- Strive to find opportunities to innovate
  - It's OK to be a little "nuts"
- Start simple & think like a *Designer* - Avoid **CIA**!
  - **C**omplex **I**rrelevant **A**nalysis is the enemy of innovation
- Make the analysis tasks mainstream by integrating tools
- Have fun!

Conclusion (from 3 years ago)

- “The analysis and design worlds are going to shrink and merge. CAD and analysis software (including test software) are going to shrink and merge. Designers are going to do plenty of analysis (including simulation) and analysts are going to do plenty of designing (especially rework and upgrading).”

Questions?