

Developing a Leaner Simulation Process

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imagination at work

Premium Partners:



Microsoft

Agenda

- GE at a Glance
- Lean Initiative
- Waste in Simulation Pre-Processing
- Examples of NX4 Reducing Waste
- Further Opportunities for NX
- Questions????

GE at a Glance



- Founded by Thomas Edison in 1878
- Only company still listed in Dow Jones Index from original 18 companies in 1896
- 320,000+ employees worldwide
- 2005 Earnings=\$16B net on \$150B revenues
- Diverse Portfolio of Businesses and Products
 - Infrastructure (aircraft engines, wind turbines, locomotives...)
 - Industrial (plastics, security, appliances, lighting...)
 - Healthcare (diagnostic imaging, IT, clinical systems...)
 - Commercial Finance
 - Consumer Finance
 - NBC Universal



GE Infrastructure

- Aviation
- Energy
- Transportation
- Oil & Gas
- Water & Process Technologies
- Commercial Aviation Services
- Energy Financial Services



Engineering Tools Center of Excellence

Blended IM & Engineering Organization
spanning GE Infrastructure

Initially formed in 2005

Unique synergies to **accelerate the development and advancement** of integrated solutions, resulting in:

- improved product capability
- greater NPI capacity
- standard engineering processes and methods across GE Infrastructure



Benefits of Simulation Tools

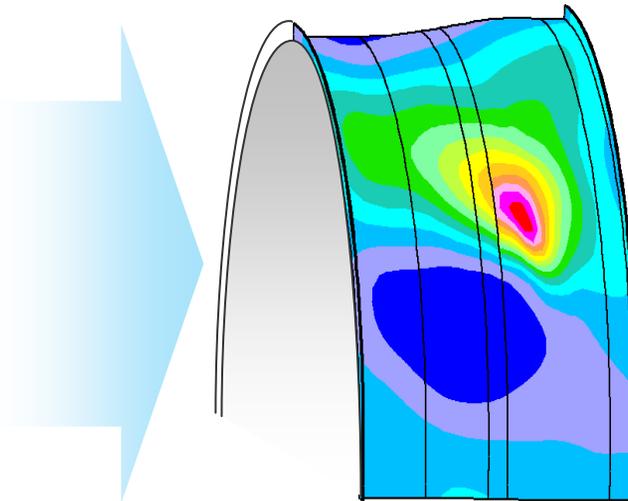
Predictive validation and design space exploration/optimization

- Composites save 700 lbs. per aircraft
- First composite fan **blades** – 1995
- First composite fan **case** – 2005

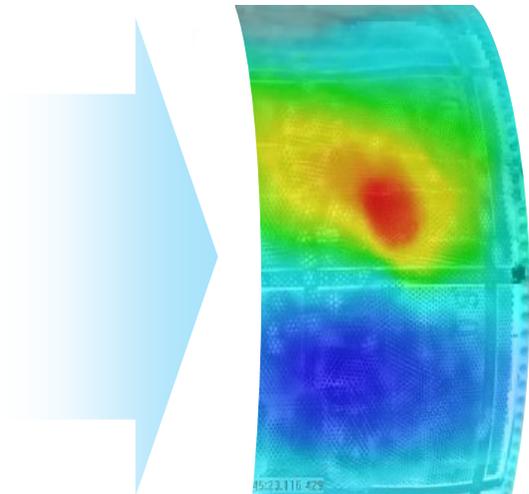
Composite fan case



Predicted containment

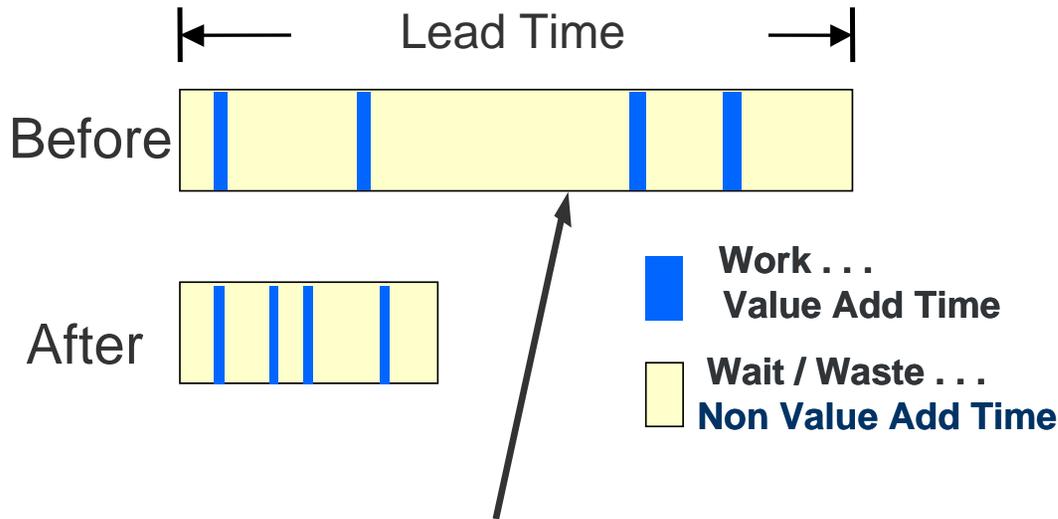


Measured results



Benefits of Lean

See the waste in a process

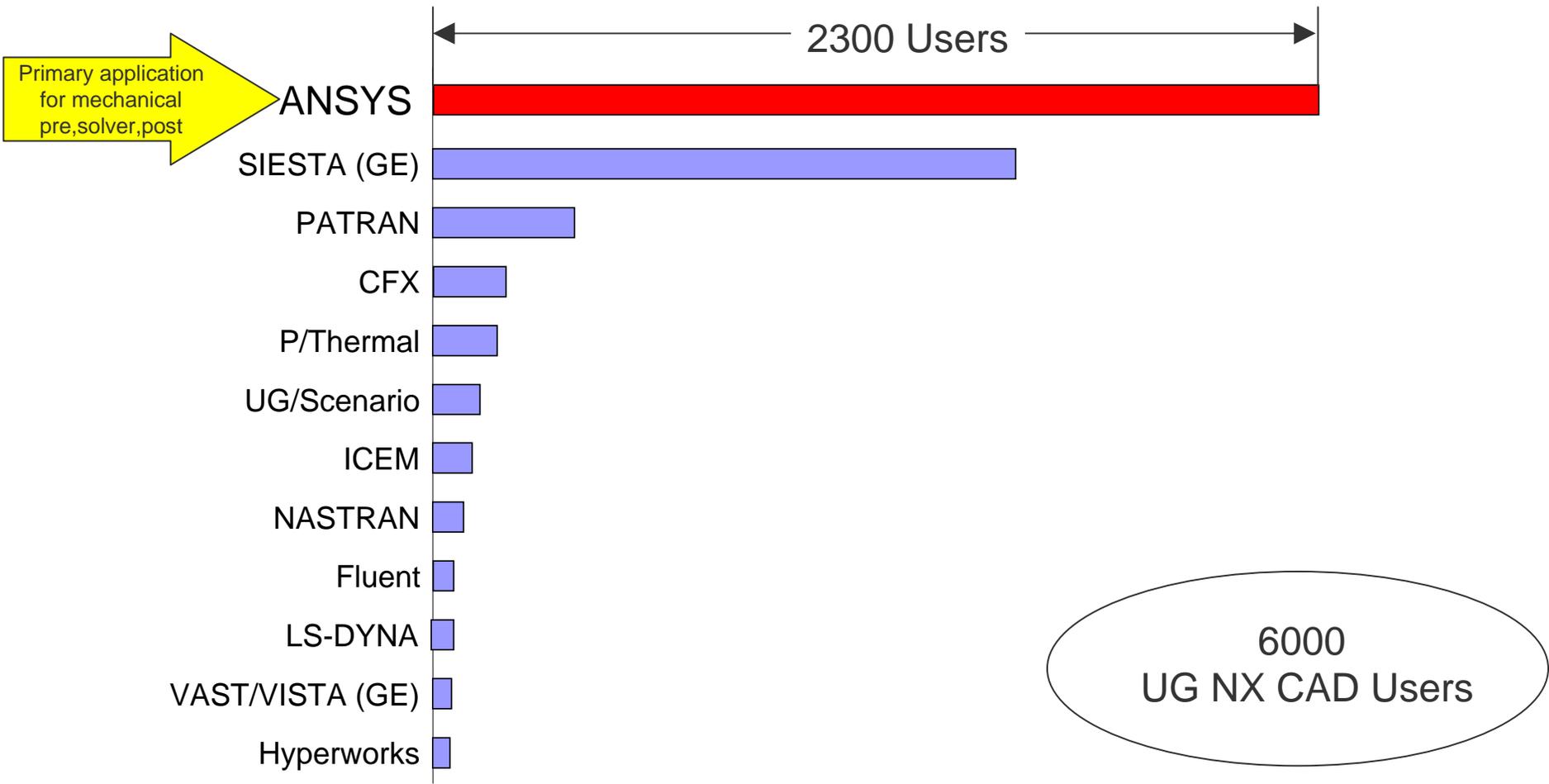


Lean Attacks Waste in the Process

Increased process velocity yields:

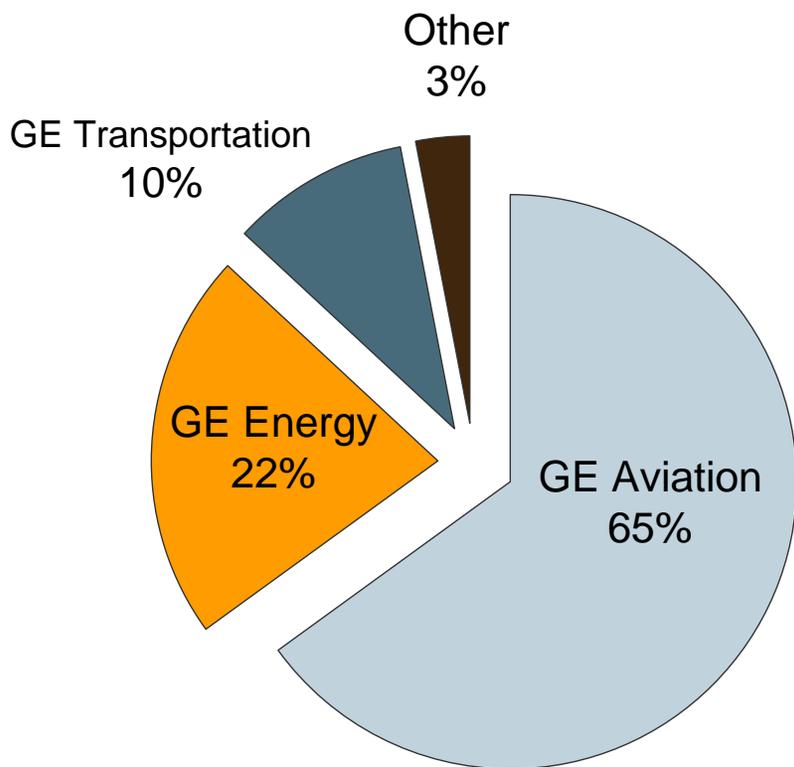
- Reduced cycles
- Better delivery
- More capacity
- Better quality
- Productivity
- Customer satisfaction

Primary Simulation Application Usage no. of unique users in 2005

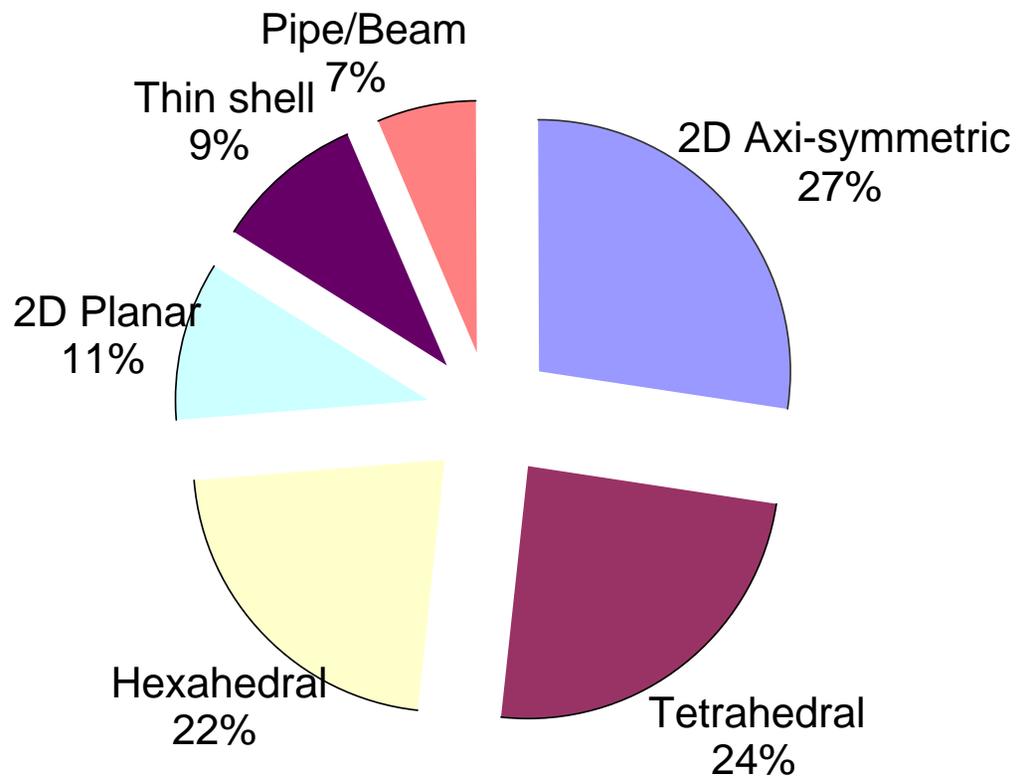


2300 ANSYS User Breakdown

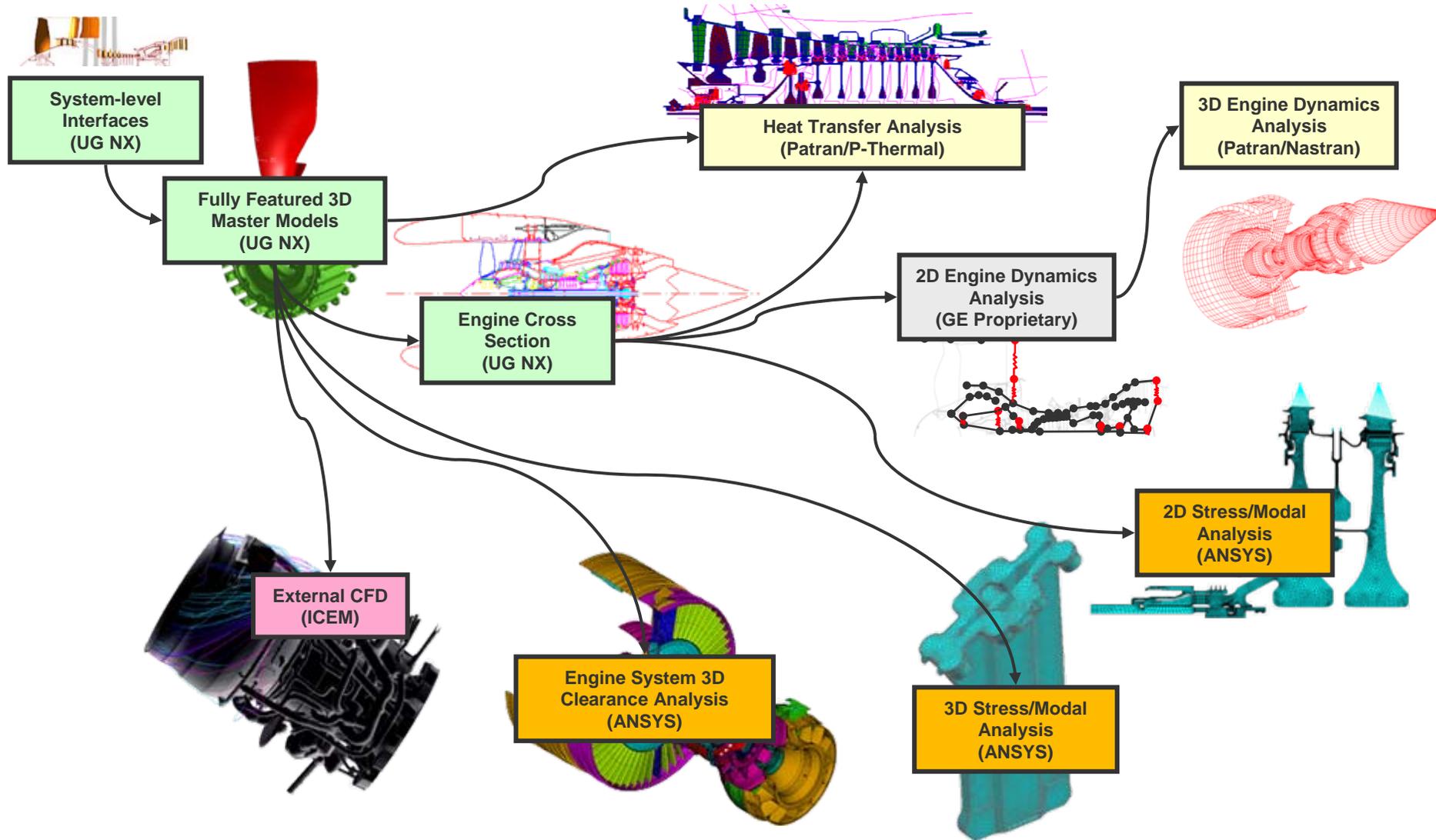
By Business



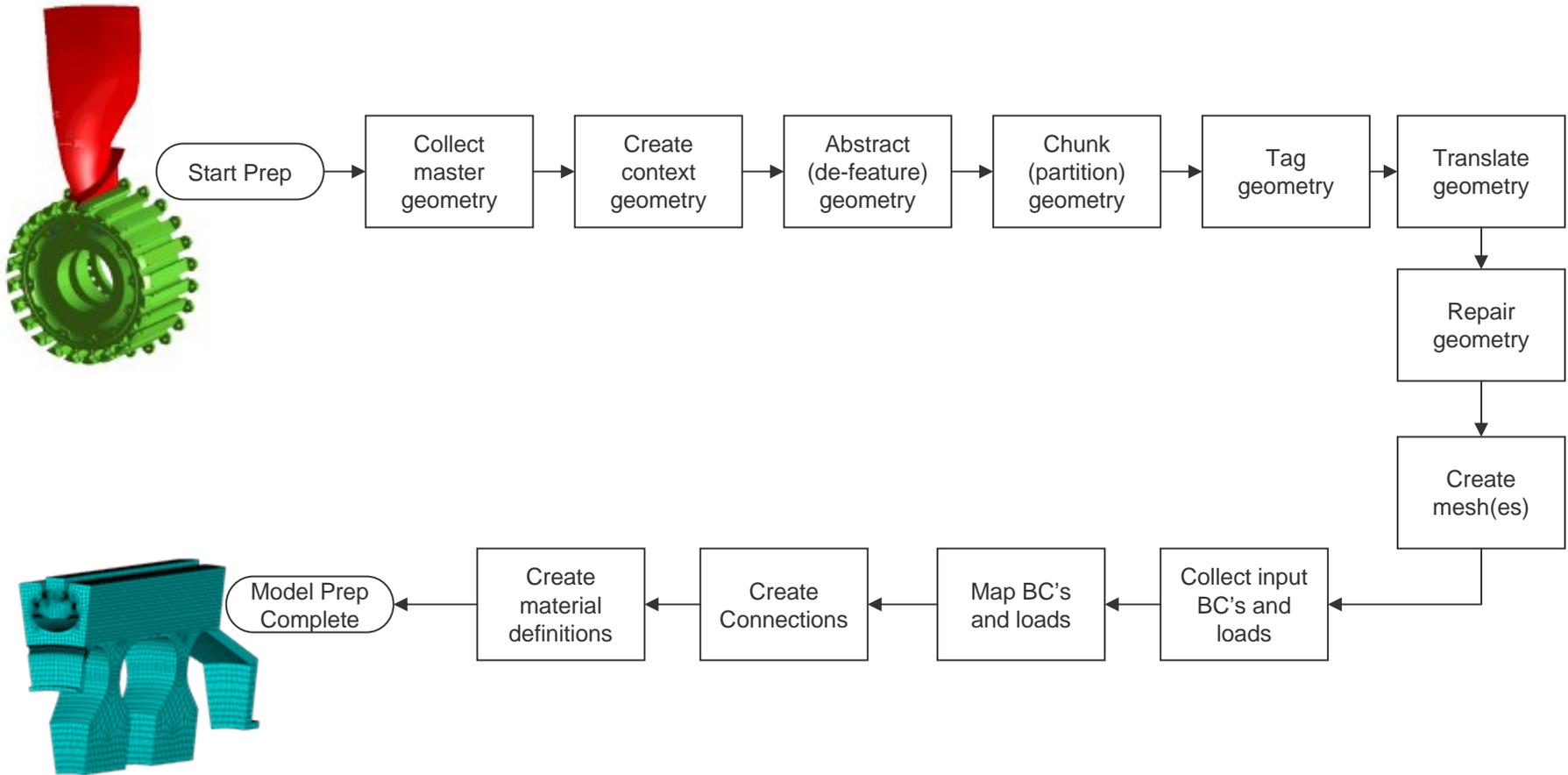
By Dominant Element Geometry



Simulation Geometry Flow @ GE Aviation



Simulation Preparation Process



Seven Types of Waste

7 Wastes	Product Flow	Knowledge Flow
Overproduction	<ul style="list-style-type: none"> • Sub assemblies and components between feeder & main lines 	<ul style="list-style-type: none"> • Processing before next operation is ready • Processing prior to need
Inventory	<ul style="list-style-type: none"> • Material between operations & process steps • Inventory stored in warehouses • Buffer & safety stock inventory 	<ul style="list-style-type: none"> • Multiple credit applications awaiting approval • Unnecessary document / data storage
Extra Processing	<ul style="list-style-type: none"> • Planned re-work • Un planned re-work • Handwork .polishing, deburring 	<ul style="list-style-type: none"> • Navigating multiple screens to input data • Multiple ways to do the same task • Printed material • Duplicate entries
Motion	<ul style="list-style-type: none"> • Operators bending, turning, twisting, reaching, walking • Machines “cutting air” • Robotic motion “getting back to home” 	<ul style="list-style-type: none"> • Navigating multiple screens to input data • Printing Material • Ergo. .walking, bending, twisting • Looking for data / info
Defects	<ul style="list-style-type: none"> • Poor quality of materials • Equipment failures • Missing customer due dates. .internal & external 	<ul style="list-style-type: none"> • Personal data incorrect • Missed customer due dates • Data entry errors • Rework
Waiting	<ul style="list-style-type: none"> • Operators waiting • Machines waiting • Customers waiting 	<ul style="list-style-type: none"> • Credit applications awaiting approval • Info awaiting an overnight “systems batch run” • Manual decisions • System downtime / response time
Transportation	<ul style="list-style-type: none"> • Conveyance of any materials, tooling • Conveyance systems 	<ul style="list-style-type: none"> • Delivering hard-copies • Shipping hard-copies that requiring signature

Seven Types of Waste

7 Wastes Simulation Model Flow

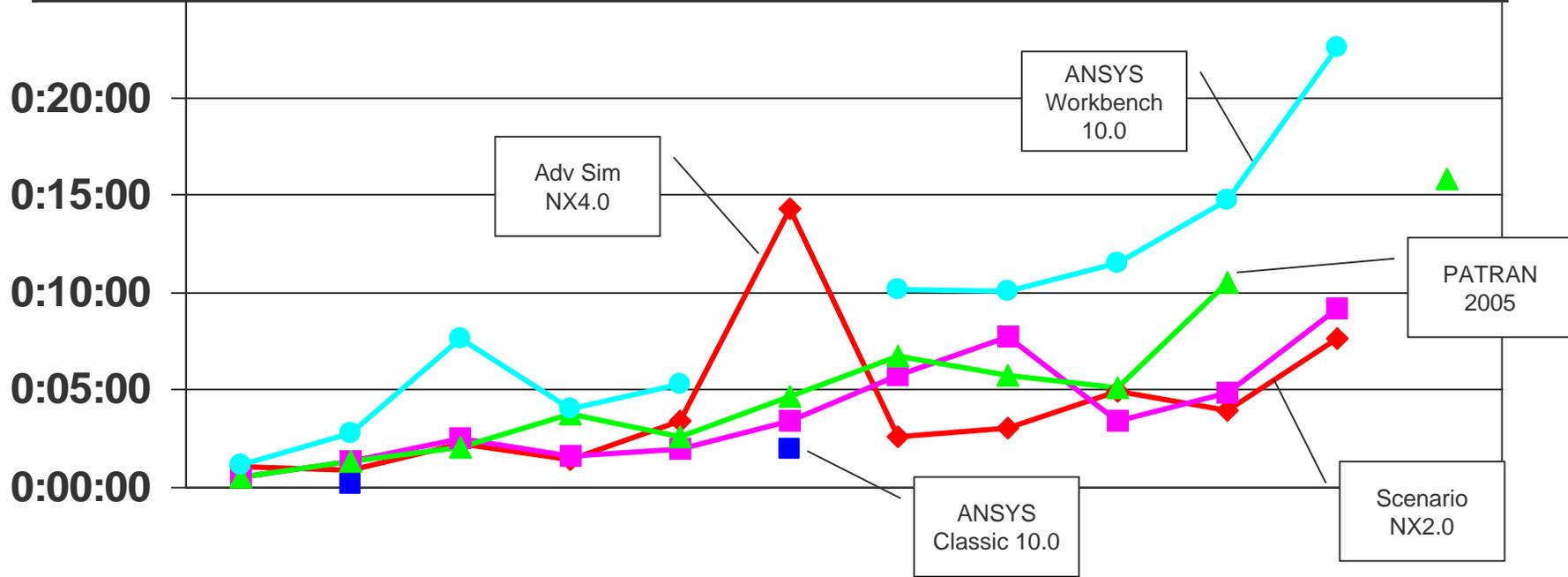
Overproduction	<ul style="list-style-type: none">• Excessive element count generated for target fidelity
Inventory	<ul style="list-style-type: none">• Extra databases stored on local machine• Geometry waiting for processing• Temporary files generated
Extra Processing	<ul style="list-style-type: none">• Planned rework• Un planned re-work• Handwork...polishing,
Motion	<ul style="list-style-type: none">• Searching for input data• Transferring data/files between apps• Transforming
Defects	<ul style="list-style-type: none">• Failed translations• Failure to mesh geometry• Reworking geometry to fix gaps and make meshable
Waiting	<ul style="list-style-type: none">• Analysts waiting• Computers waiting• Customers of results waiting
Transportation	<ul style="list-style-type: none">• Translation of geometry from CAD to CAE• Network transfer of files



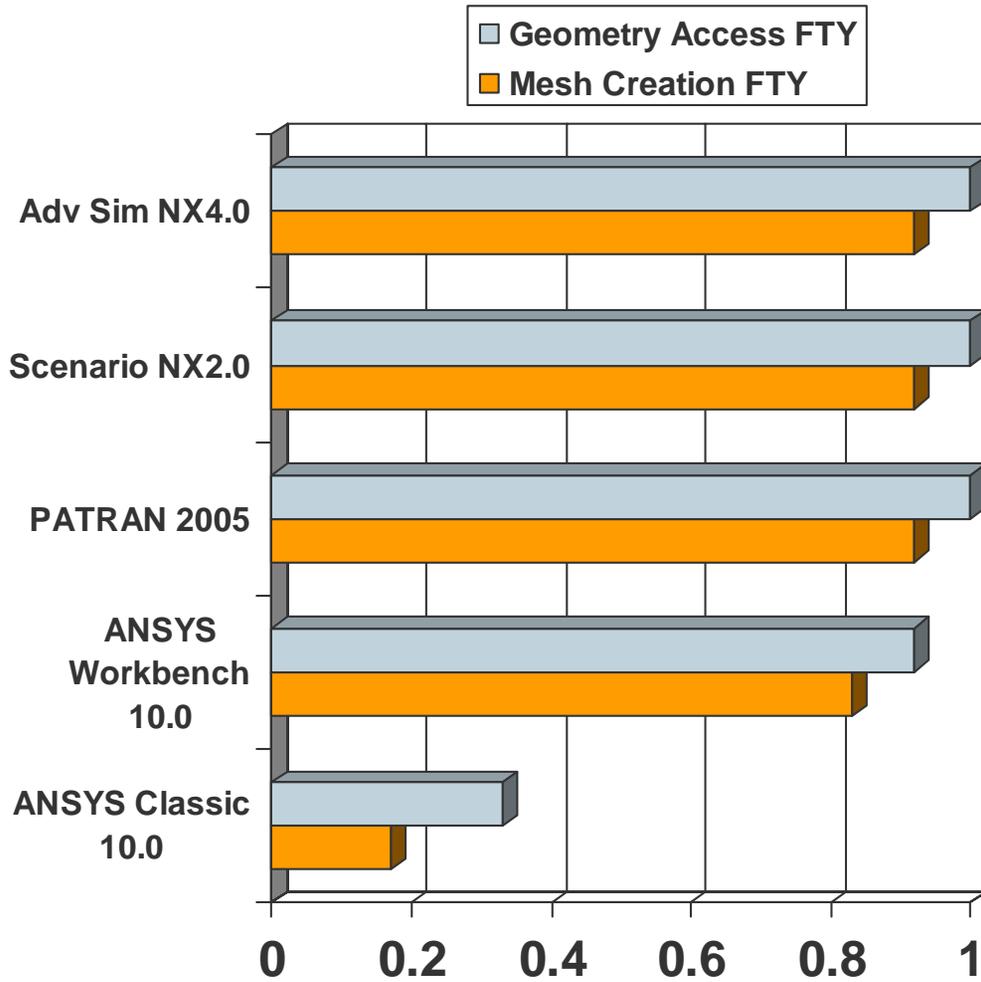
Tetrahedral Meshing Test Parts

												
Description	Impeller Support	Case Sector	TMF Strut	Oil Cooler	Pylon Panel	HPTR Fwd Shaft	Stage 1 HPT Blade	Stage 1 HPT Blade	TMF Case	Stage 1 HPT Nozzle	HPT Disk	Stage 1 HPT Nozzle
# Faces	125	143	420	456	566	803	1597	1807	2322	2646	4019	4401

Mesh Creation Time (minutes)



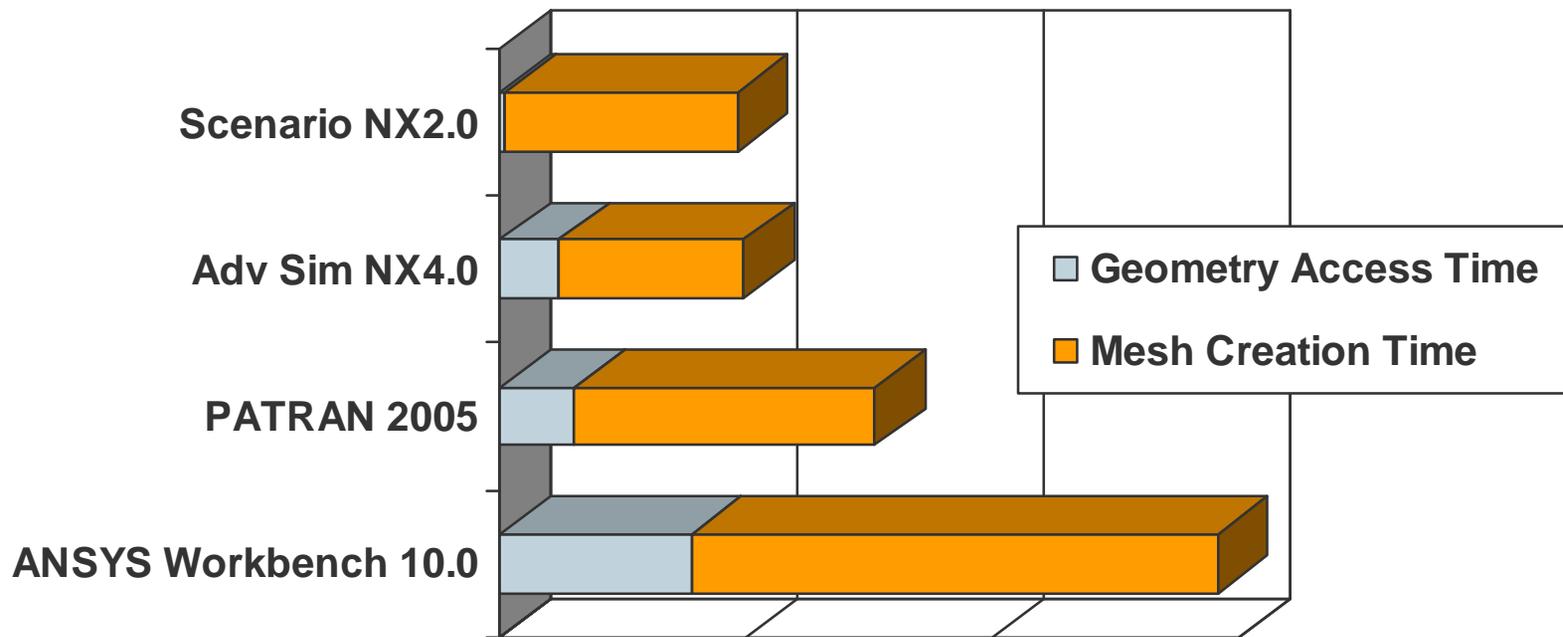
First Time Yield



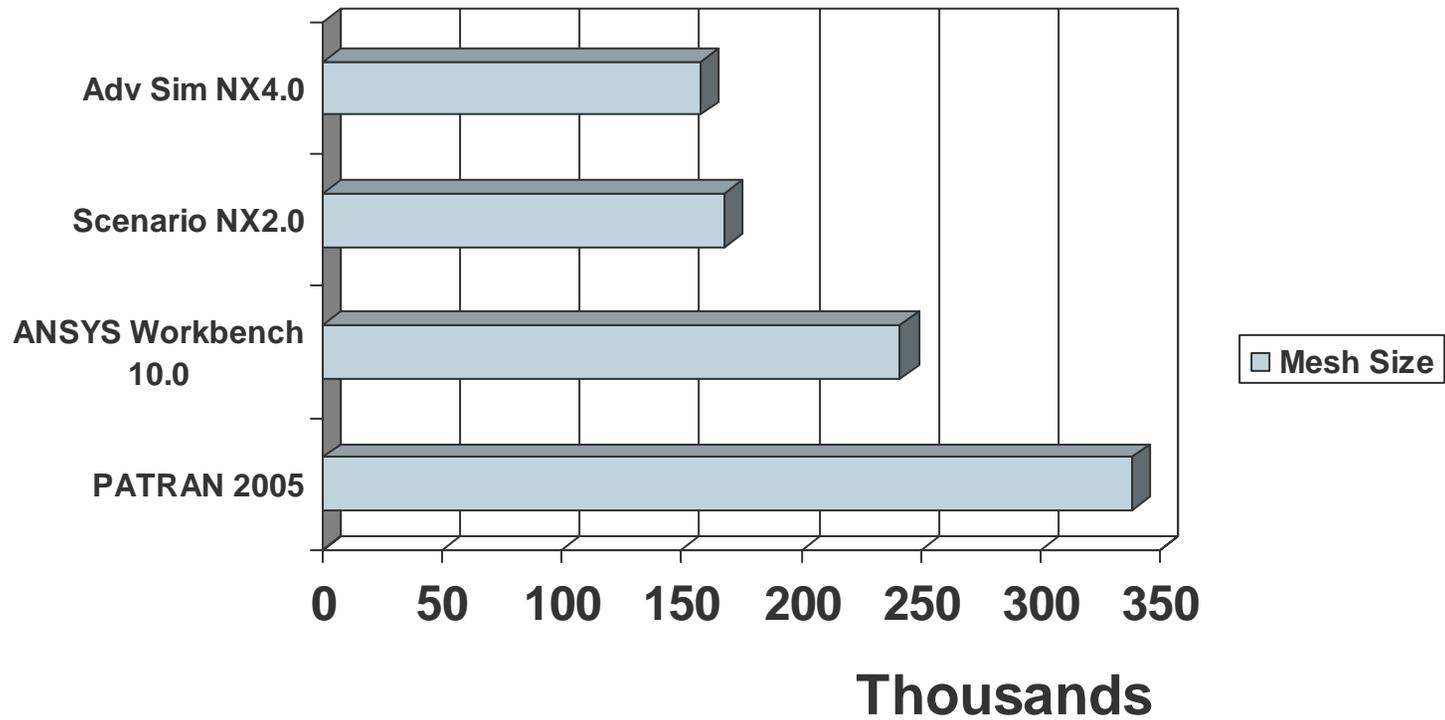
Failed Parts



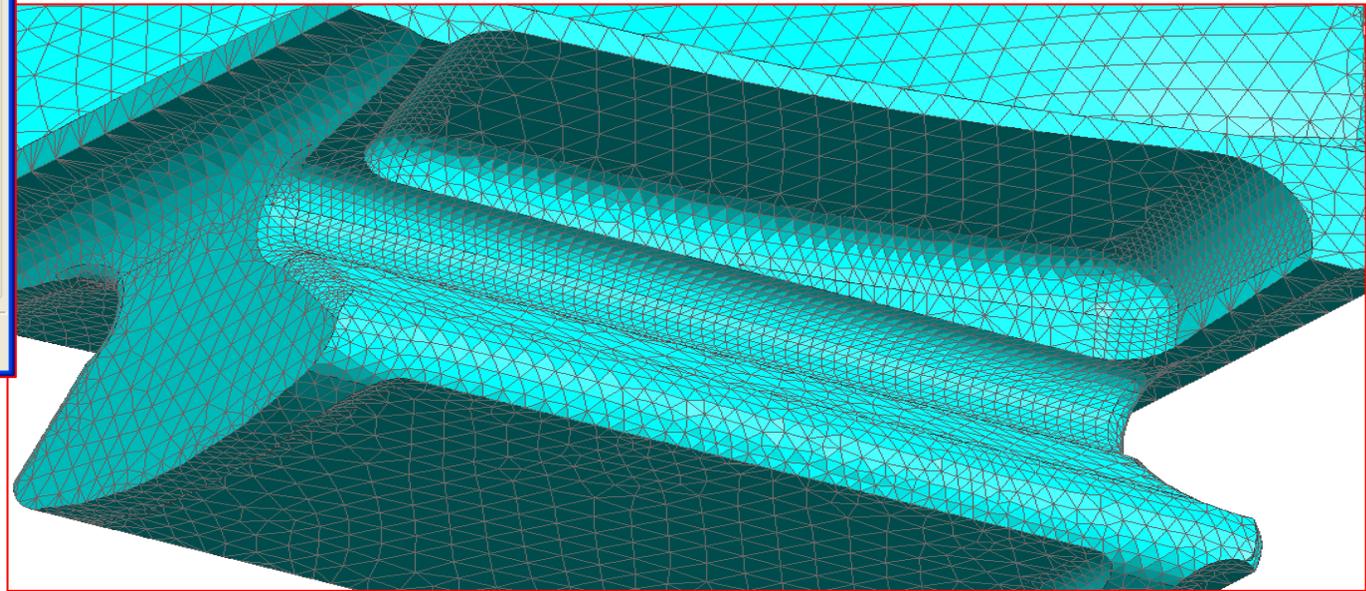
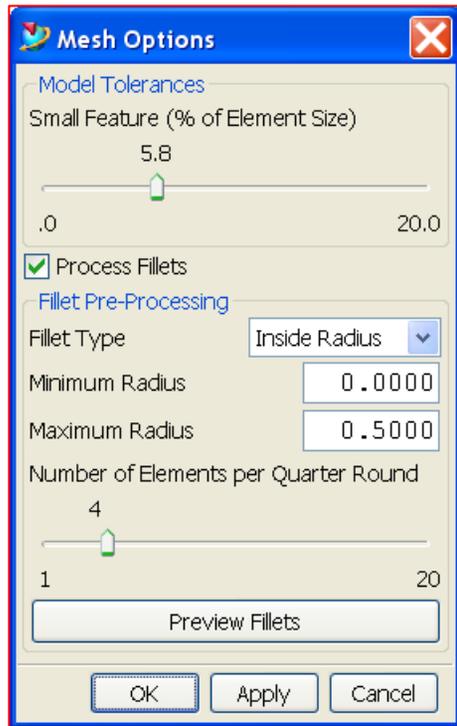
Tetrahedral Meshing Comparison



Mesh Size Comparison



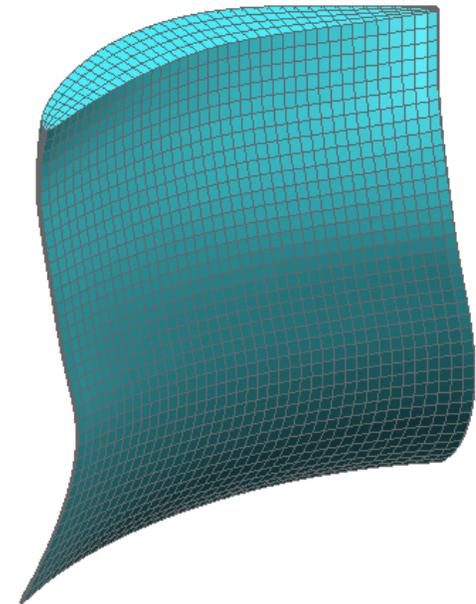
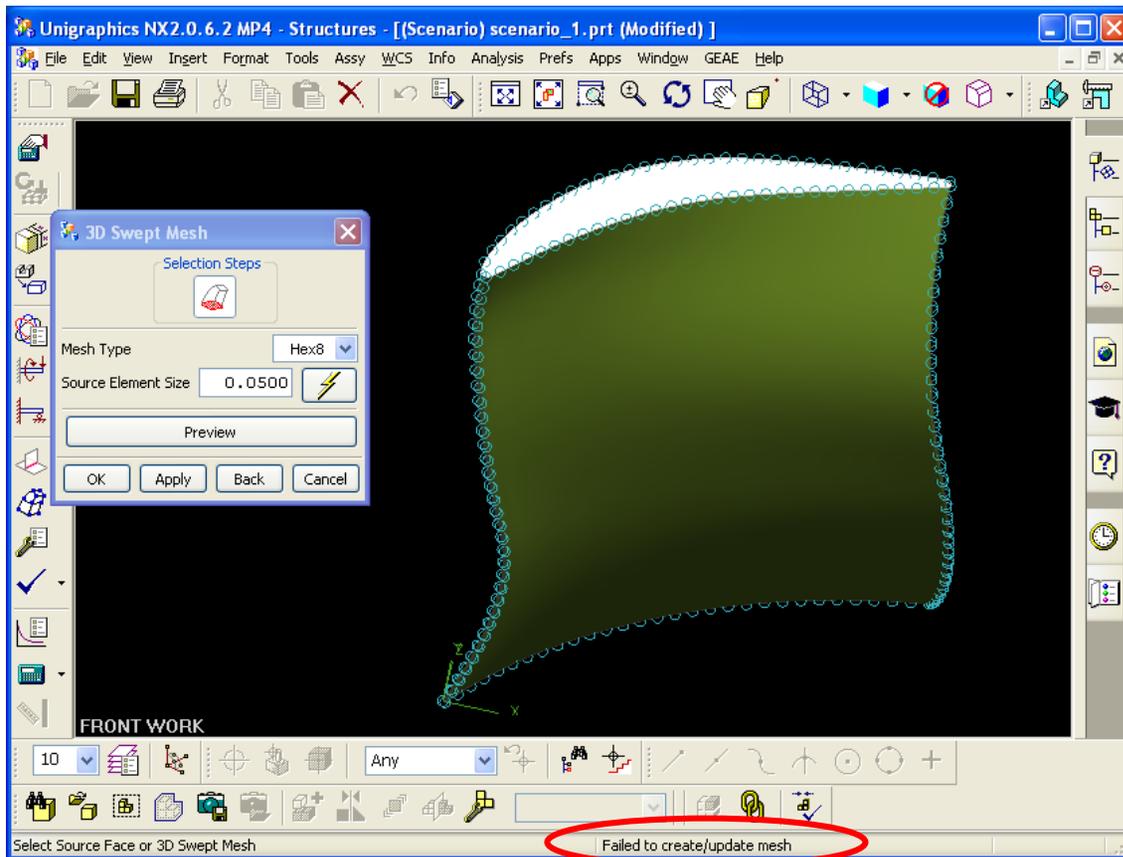
Tetrahedral Meshing: Fillet Pre-Processing



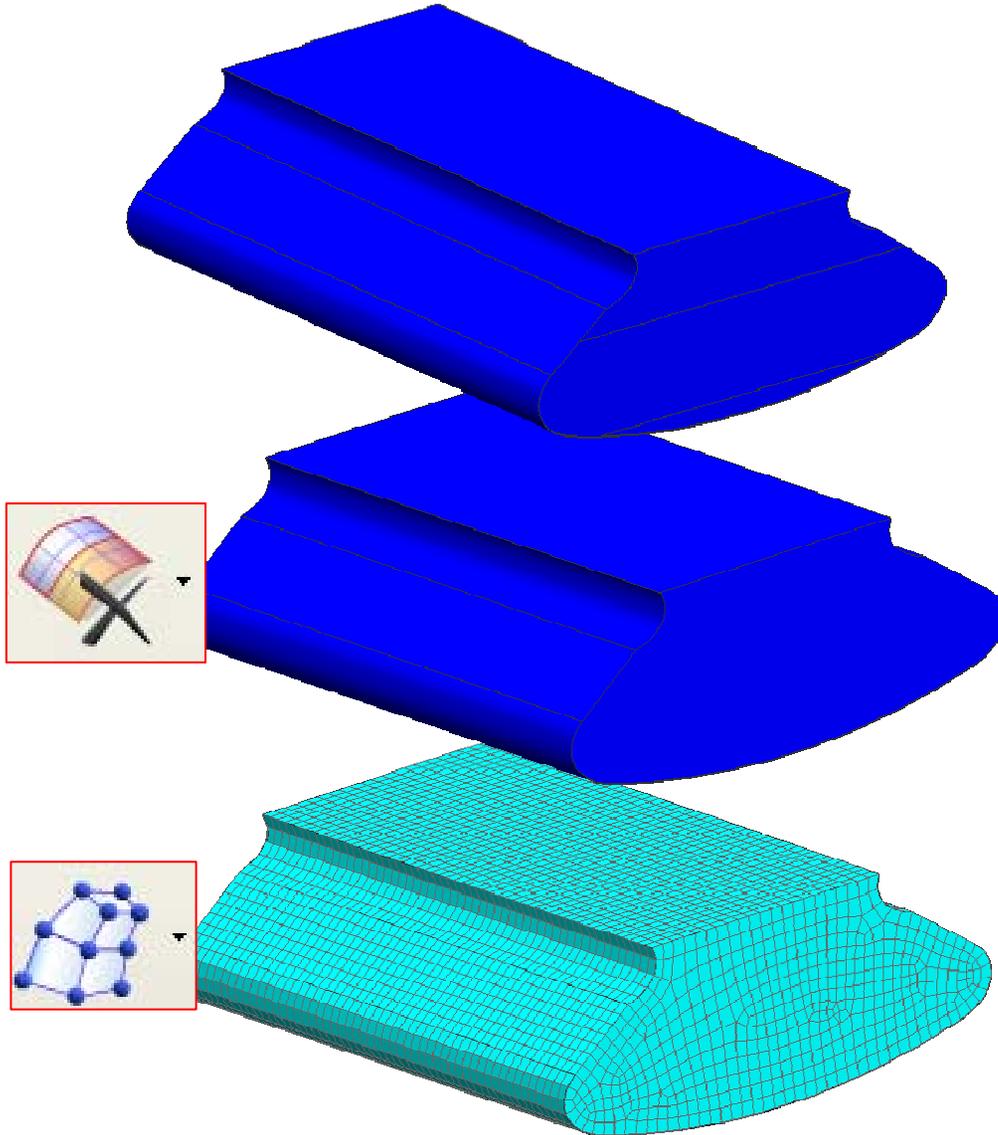
Hexahedral Meshing

NX2 Fails to Mesh

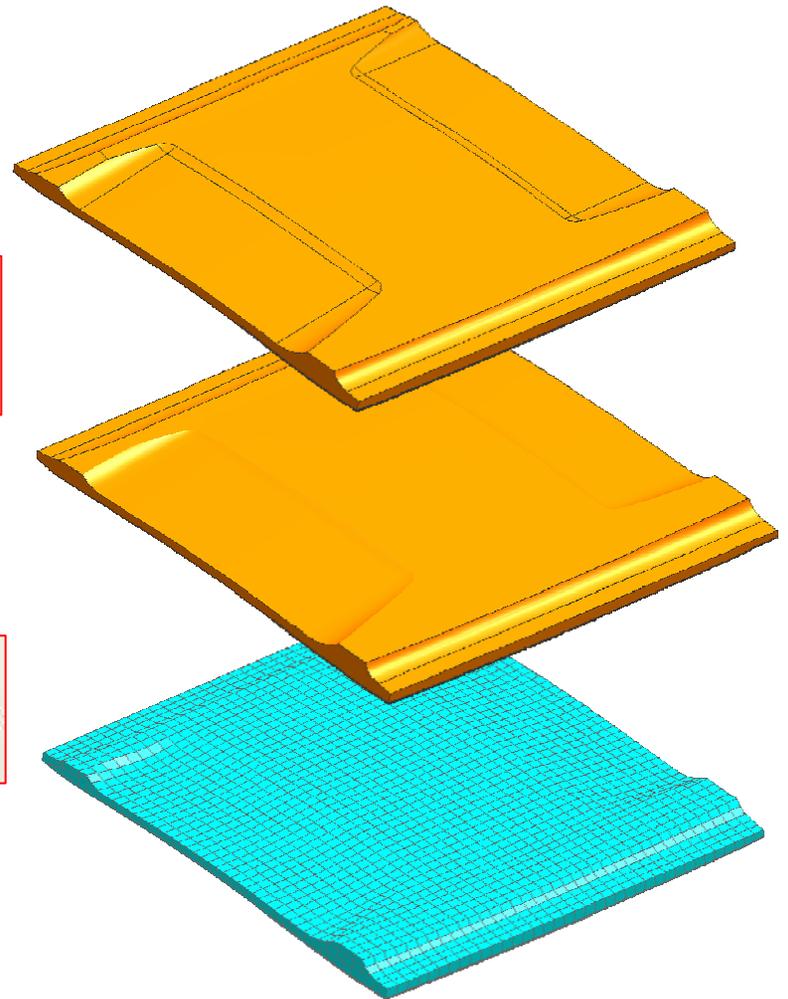
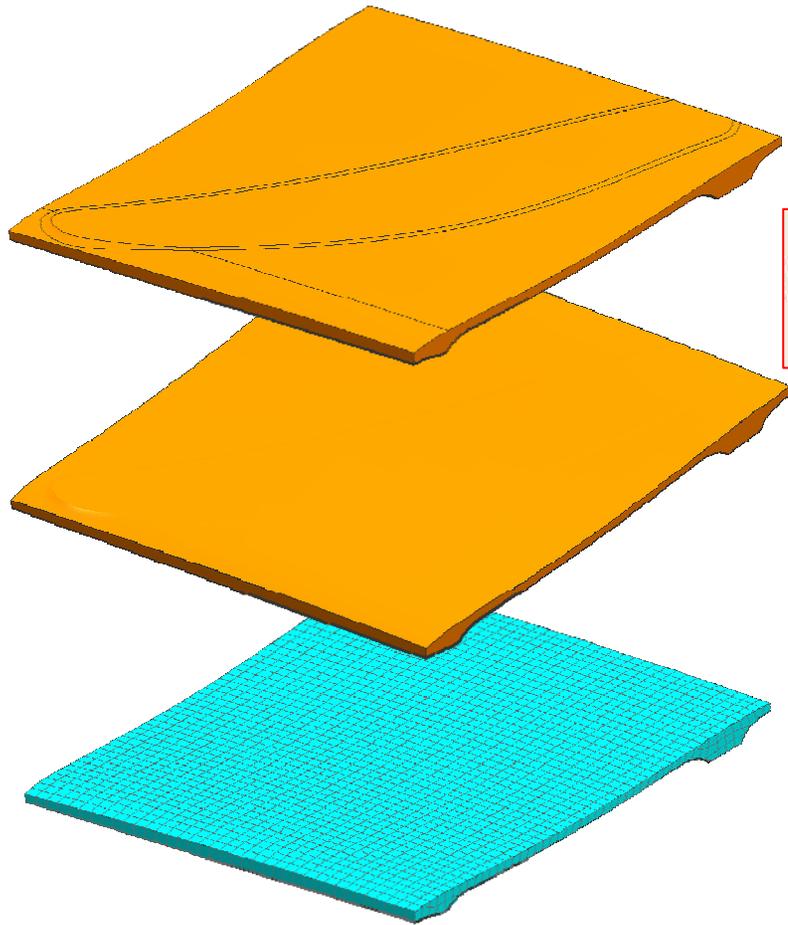
NX4 Mesh
FTY=1



Merge faces eases prep for sweeping

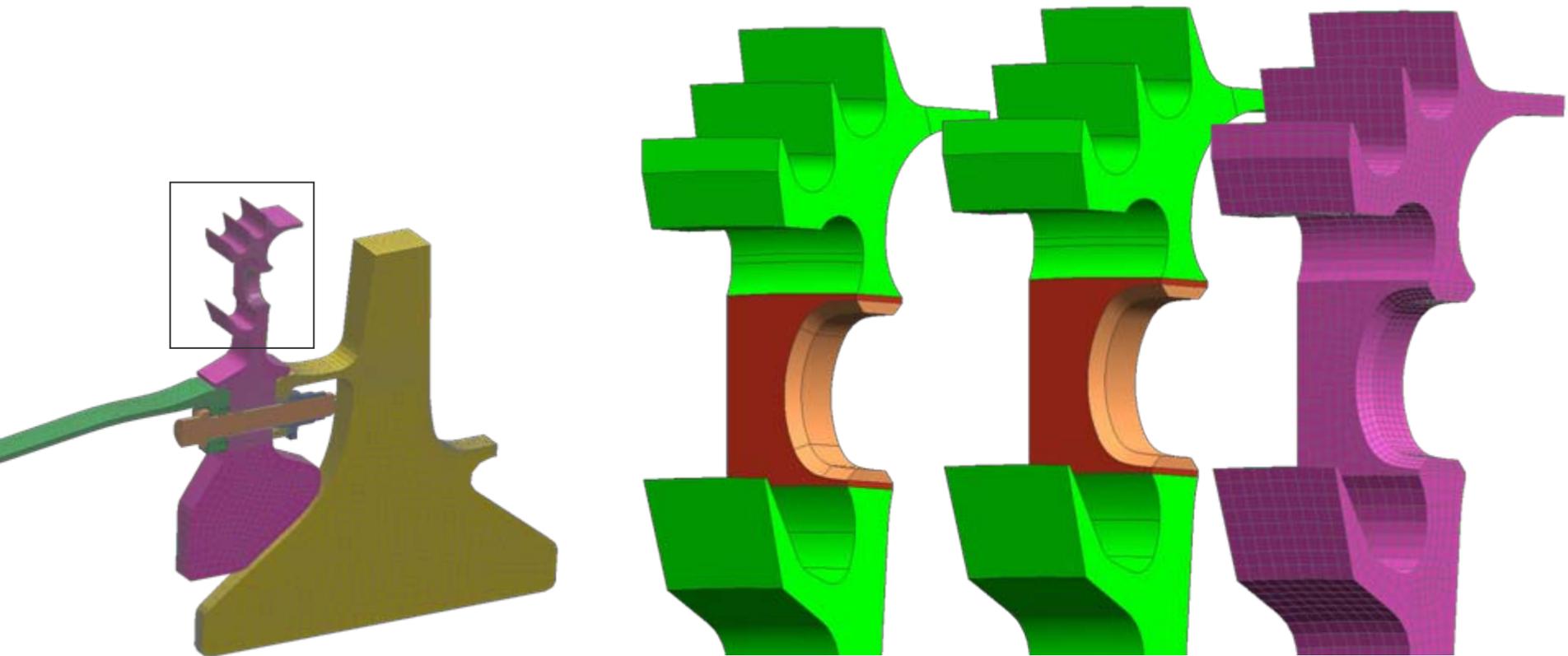


Merge faces eases prep for sweeping



Hex Meshing

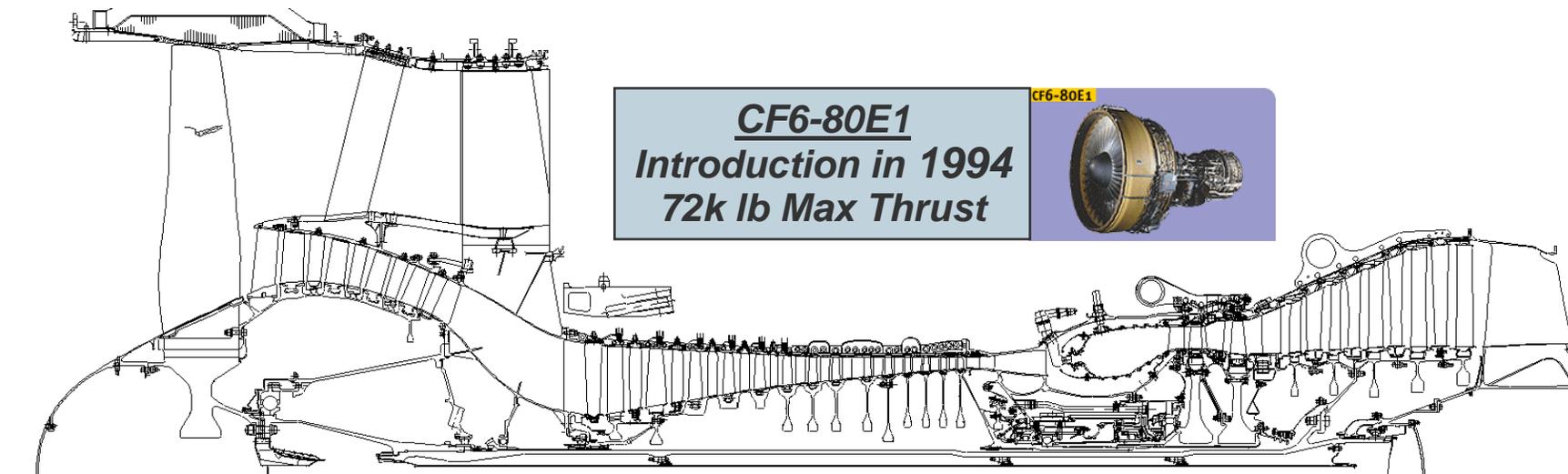
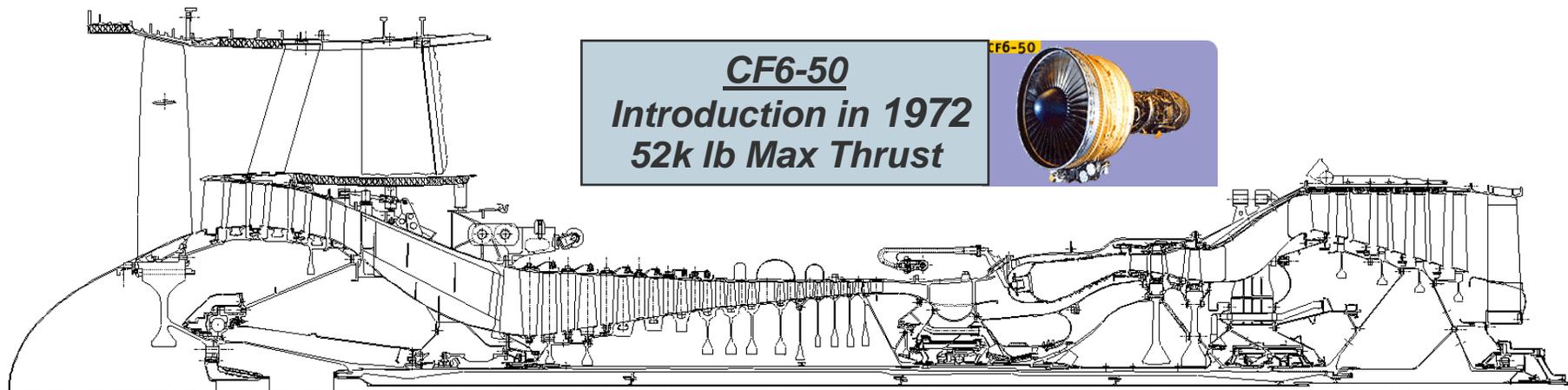
- 30~80% reduction in volume chunking due to merge face capability in NX4



NX Opportunities

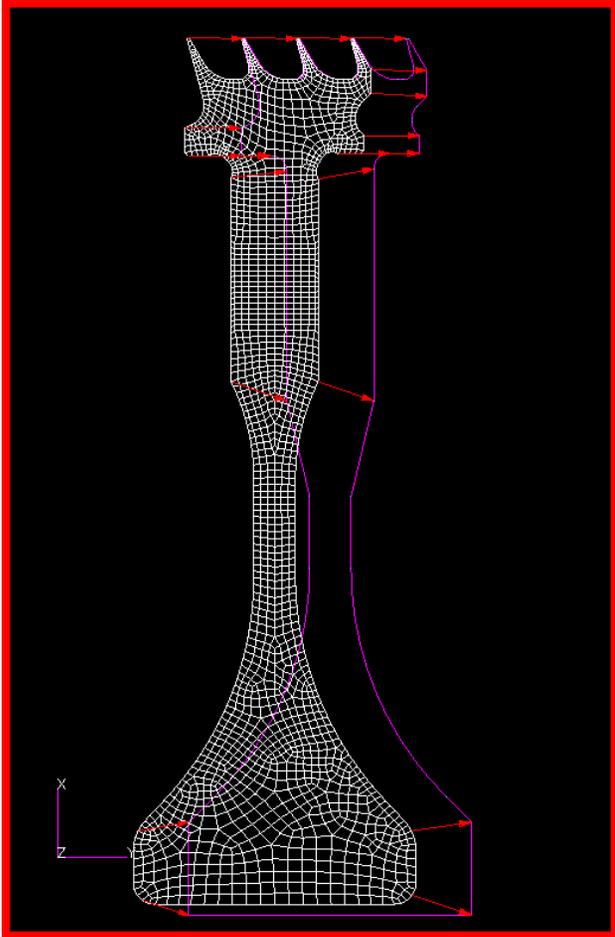
- Mesh Morphing
- CAE Topology edit updates with CAD
- Mesh copy from face to face
- Pyramid element transitions
- BC Transfer between .sim models
- Partitioning on CAE Topology vs CAD topology

Derivative Approach Dominates Evolution of New Products



Morphed Geometry, Significant Improvement in Performance... Typical

NX Opportunity: Mesh Morphing



Leverages Initial Time Spent:
Mesh generation
Assembly of mating components
Load and boundary condition maps
Application of materials
Model validation/correlation

Enables:

Re-use of legacy FE models
Rapid update of analysis
Sensitivity studies

Summary

- Good show of functionality progress in NX4
- Expecting increased user demand and significant engineering productivity across GE Infrastructure
- Opportunities exist to reduce waste in the overall simulation process
- Development focus should be on maximizing reuse and completing advanced functionality

Thanks

Questions????