

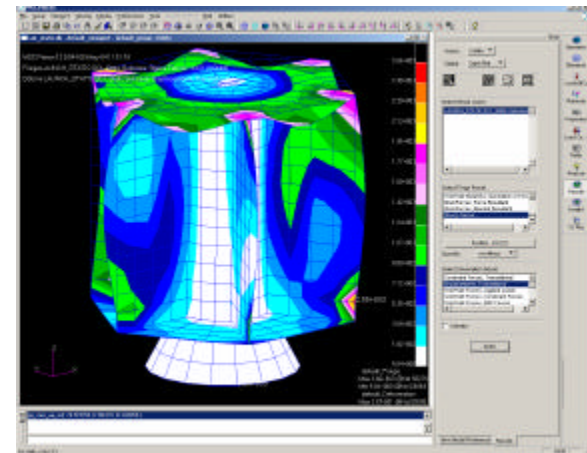
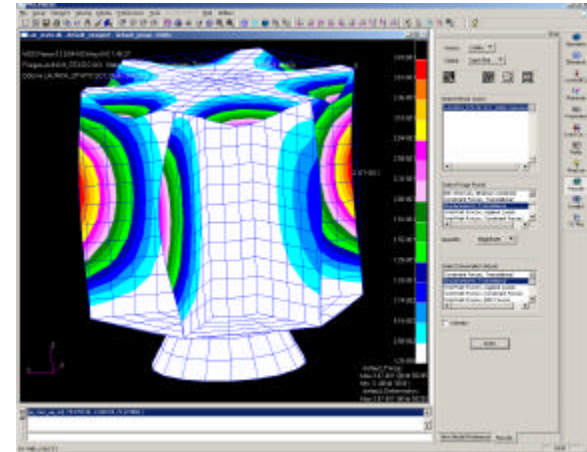
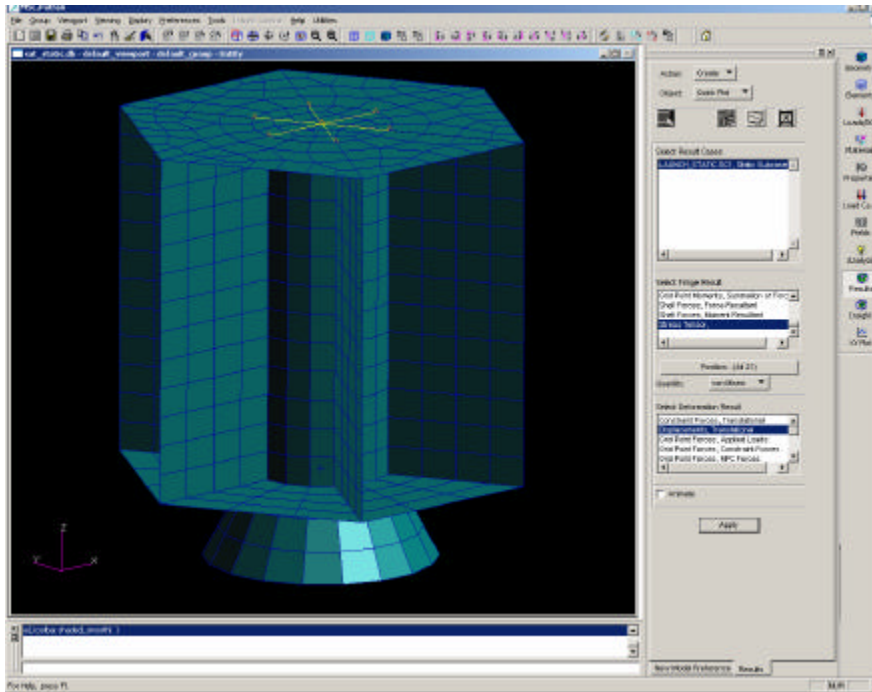
Use of Robust Design™ by MSC Software for Automatic Aerospace Design, Performance Optimization, and Accelerating Engineering Development

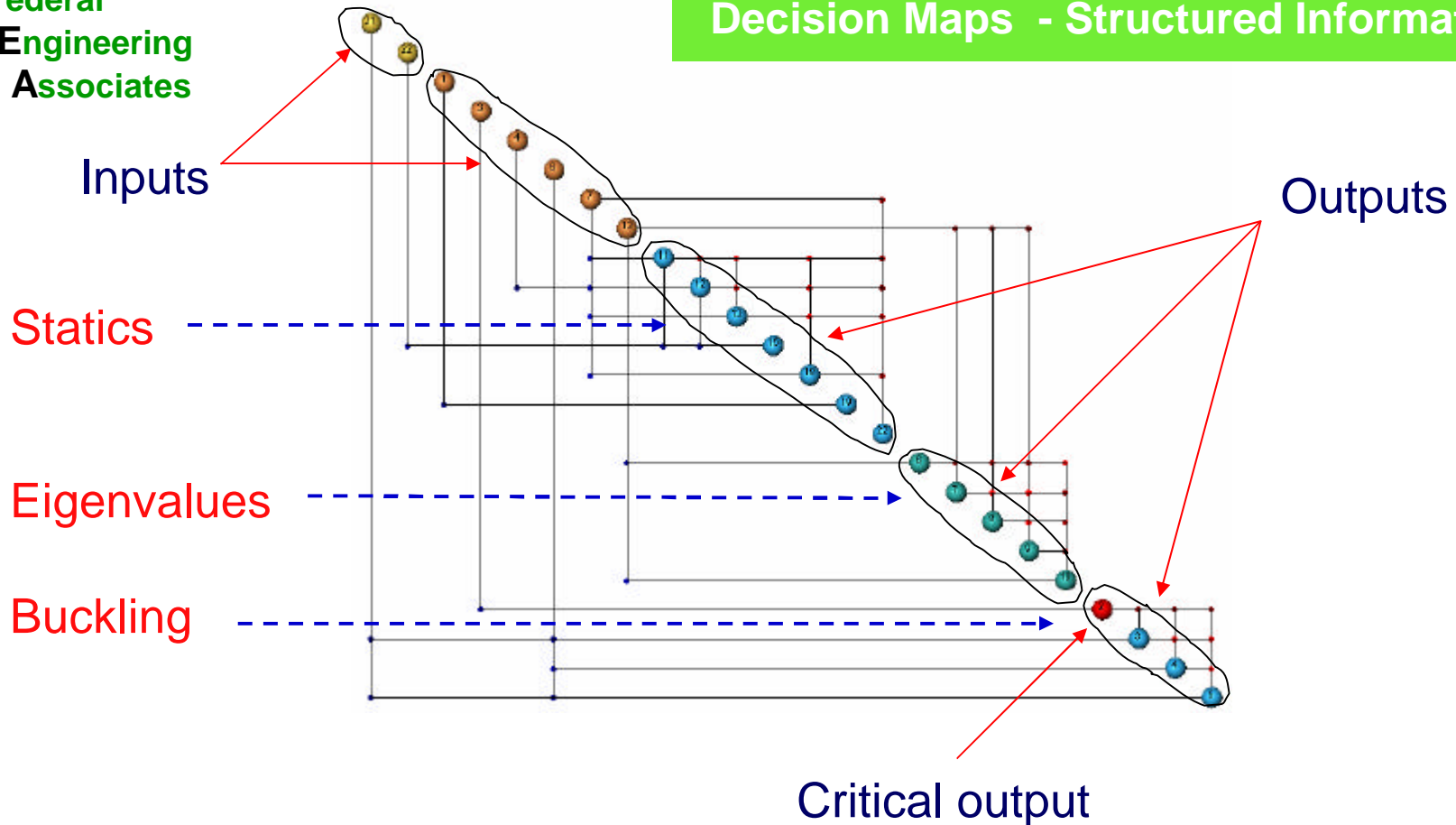
Fred Perkins

Federal Engineering Associates

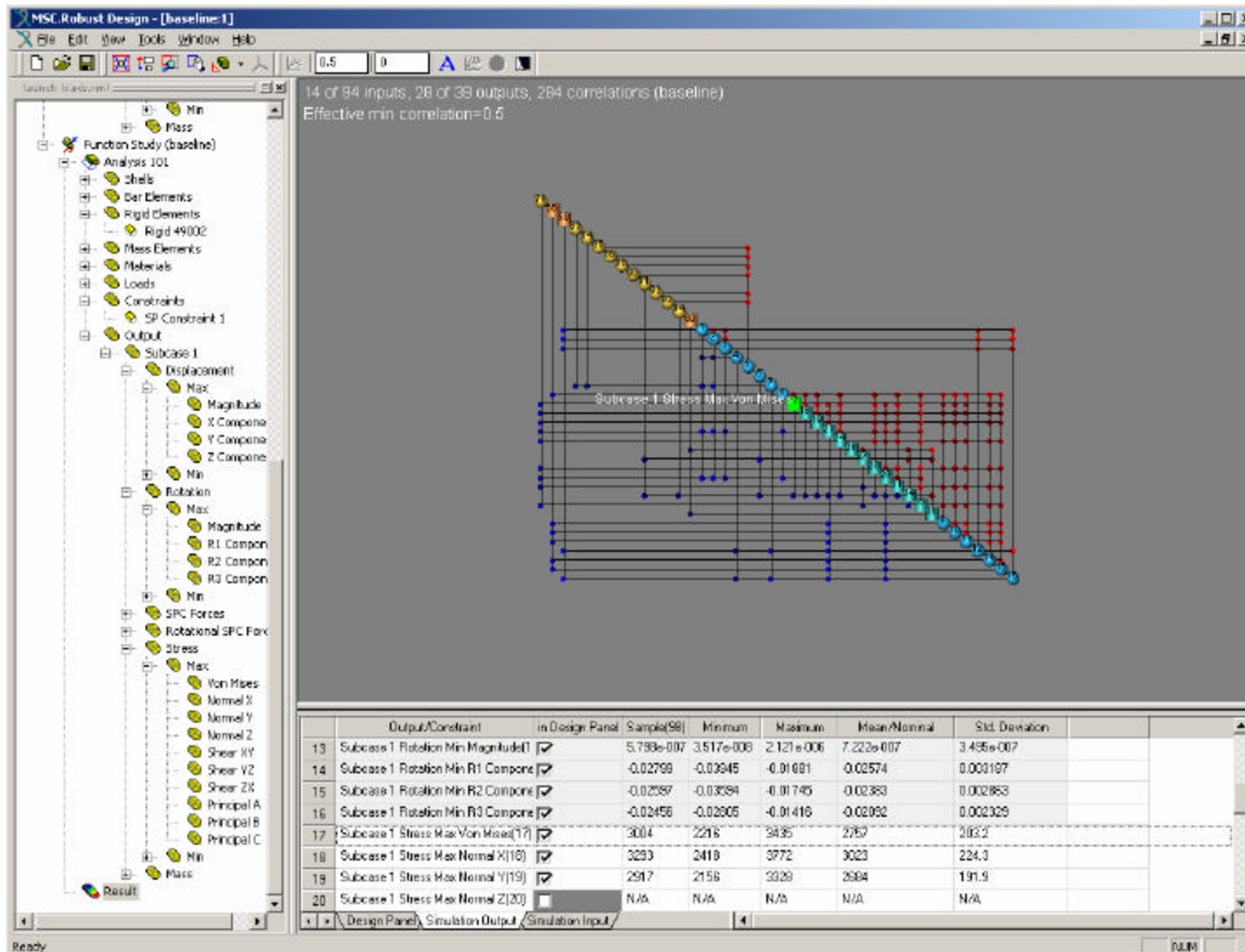
McLean, Virginia

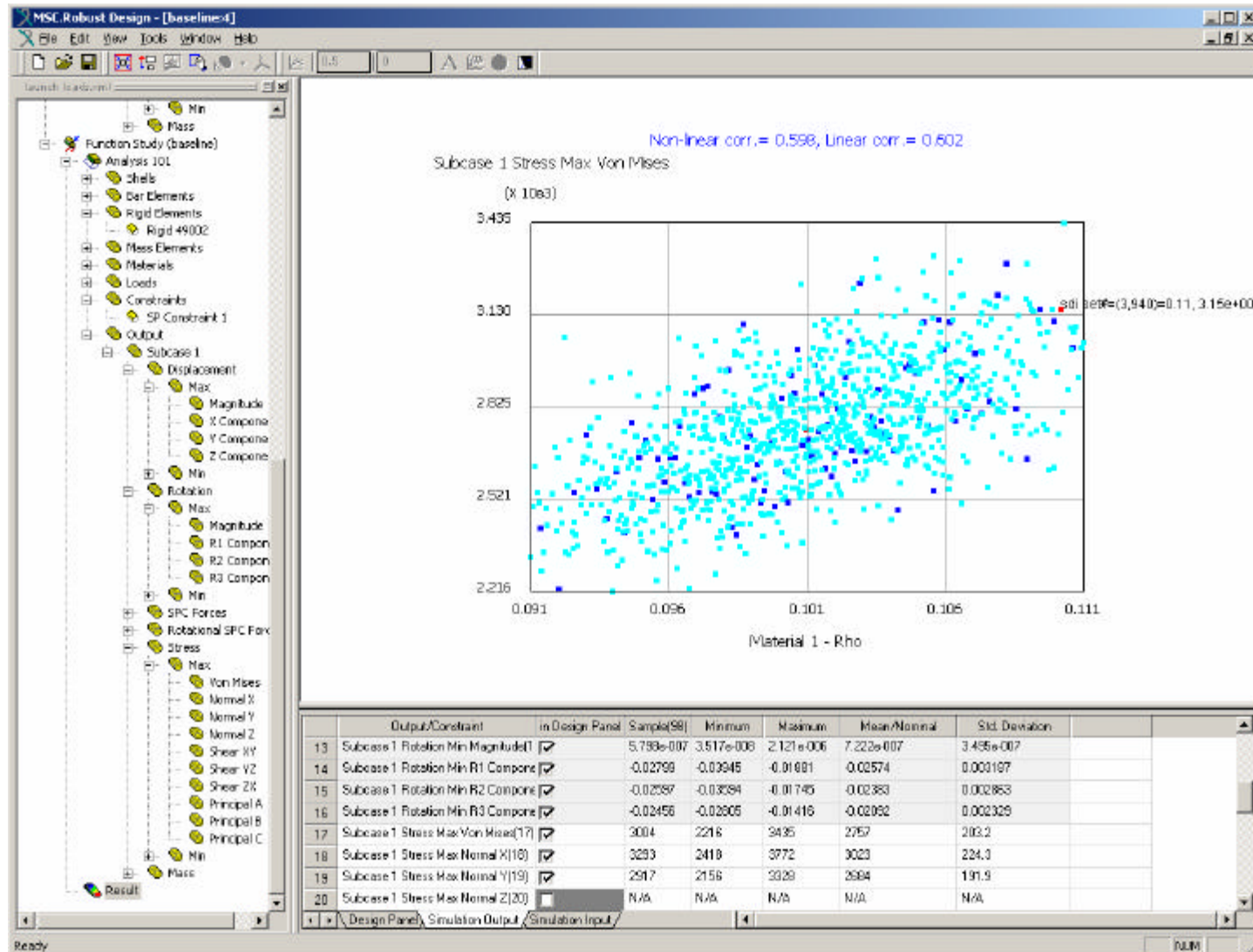
- **Helps reveal real high performance design drivers – even to rocket scientists**
- **Improves the focus of FEM, reducing analysis time and accelerating engineering development, reducing cost and time to achieve superior results**
- **Helps eliminate unknown unknowns**
- **Improves FEA validation while enhancing the value of test data**

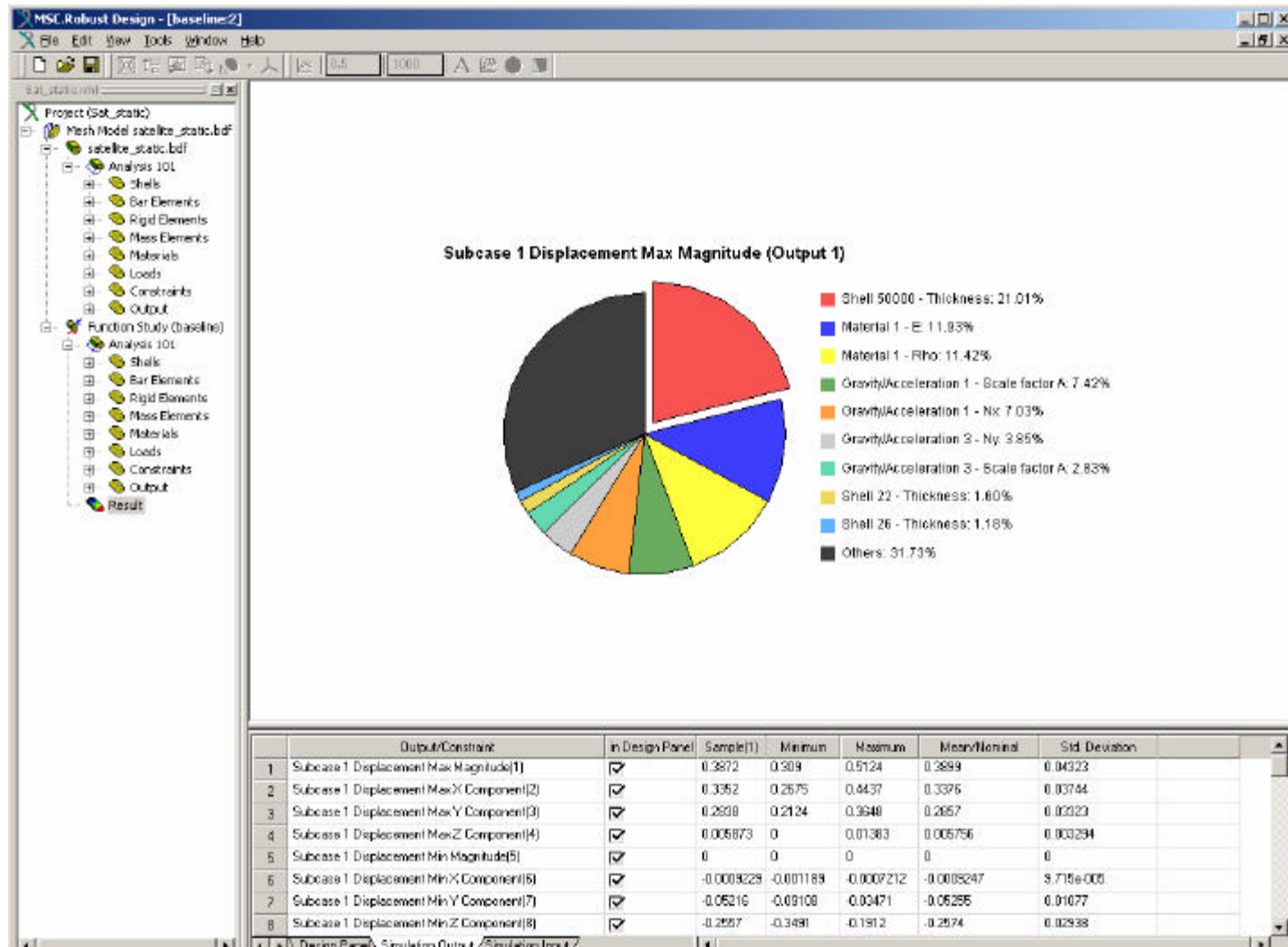




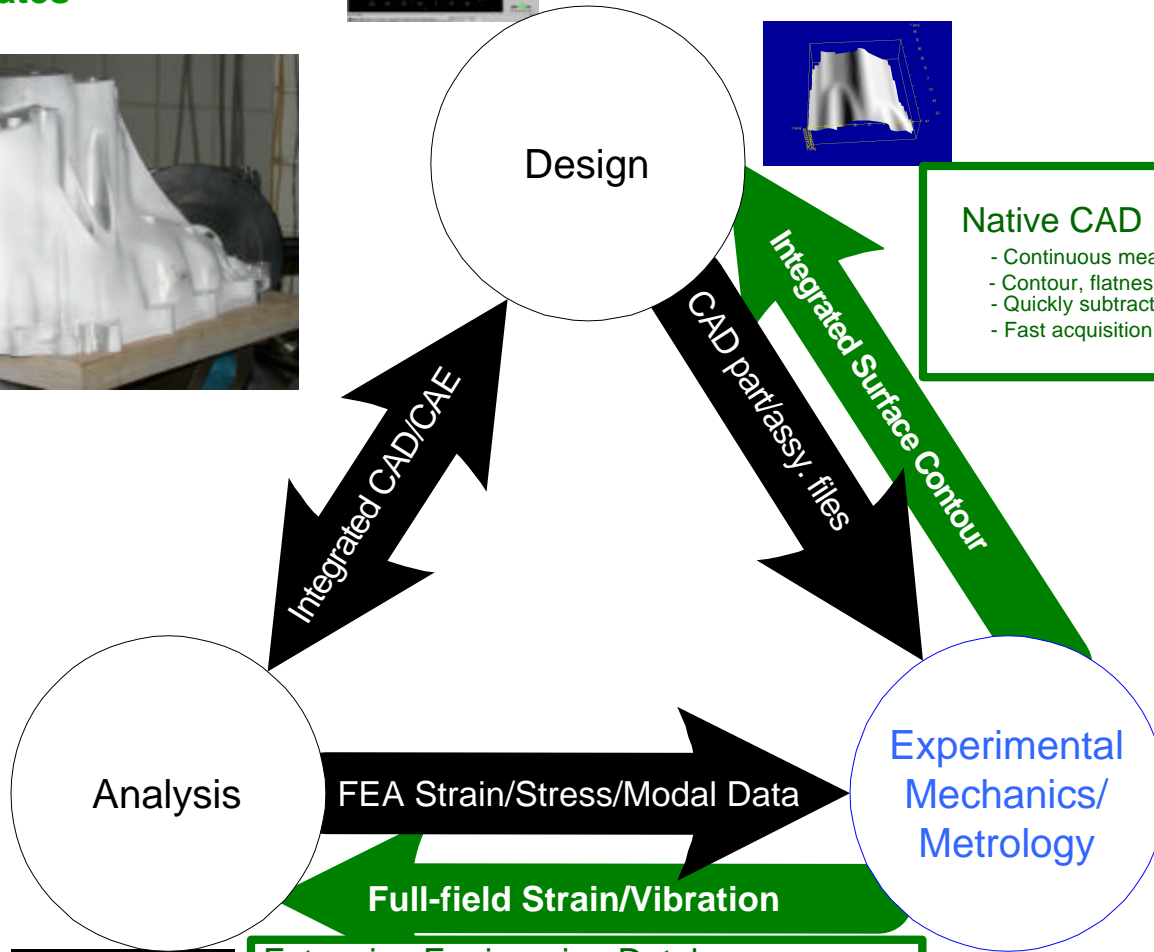
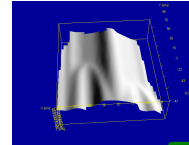
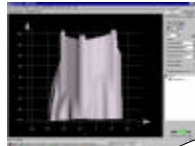
- Unlimited Model Sophistication
- Unlimited Coupled Outputs (for supported solvers)







- **Modern optical and other experimental mechanics measurement systems produce large datasets of high precision static and dynamic data**
- **Robust Design™ promises a path to automation of many FEA validation and optimization tasks, leading to better models and faster results.**



Native CAD External Shape Data

- Continuous measurement points
- Contour, flatness, curvature measurement
- Quickly subtract as-built from as-modeled part
- Fast acquisition, fully integrated

Analysis

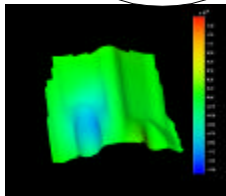
FEA Strain/Stress/Modal Data

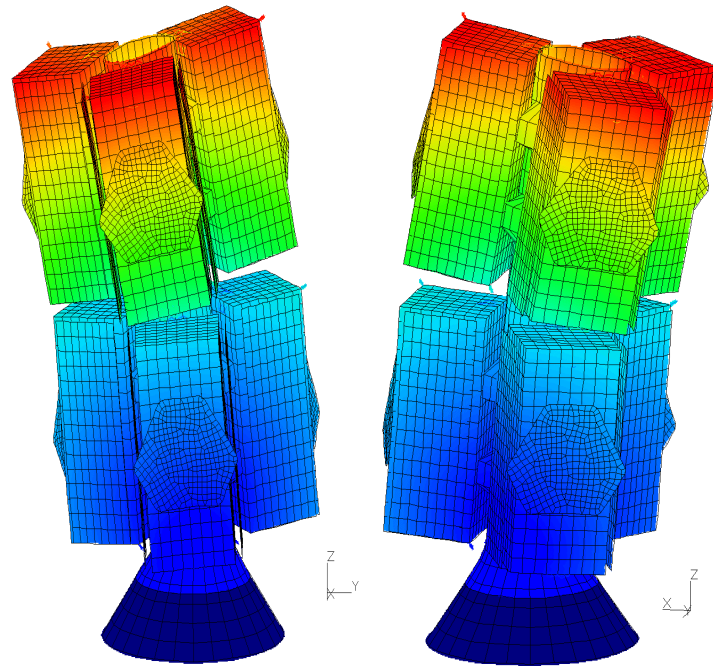
Experimental
Mechanics/
Metrology

Full-field Strain/Vibration

Extensive Engineering Database

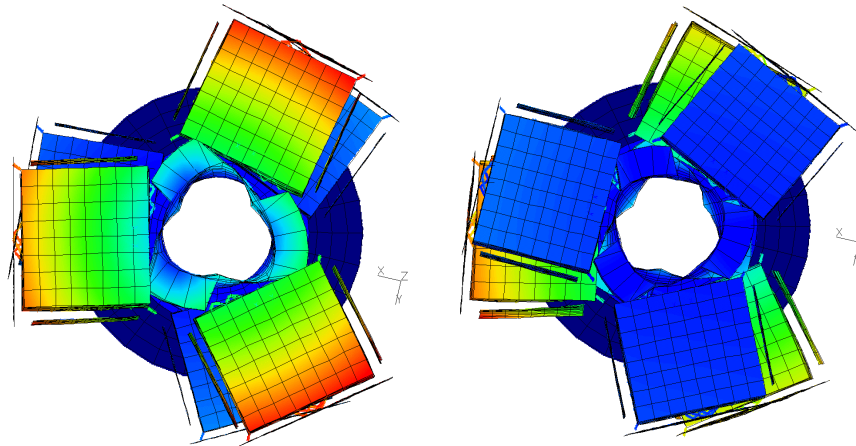
- 10's thousands of strain/vibration measurements
- Data overlaid on picture of objects
- Section between features for point-to-point comparisons
- No gaps between sensors
- Fast and easy data acquisition
- No confusion about results





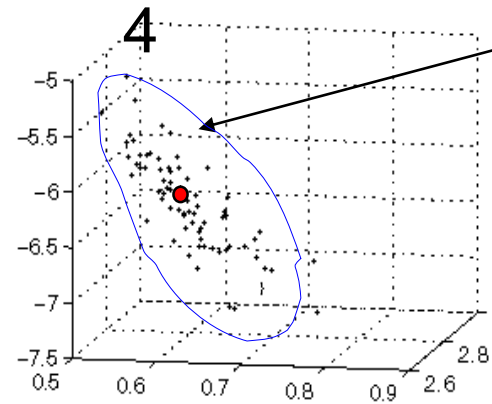
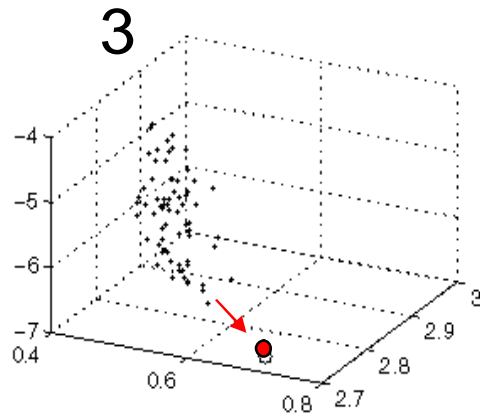
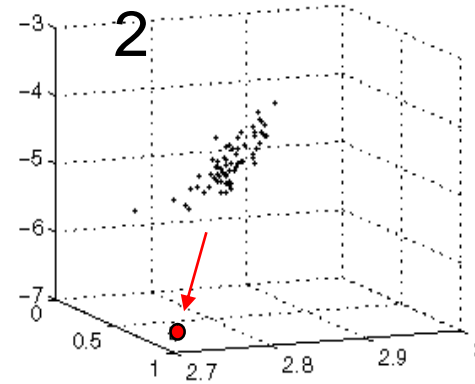
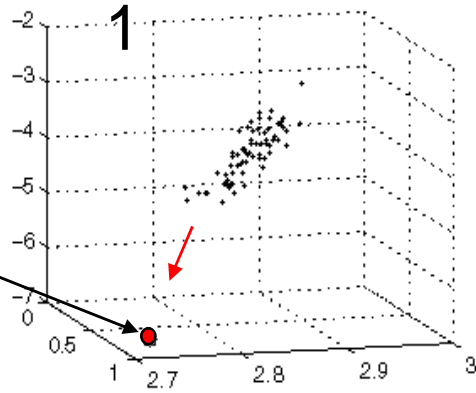
MODE 1 (9.7Hz)

MODE 2 (9.74Hz)



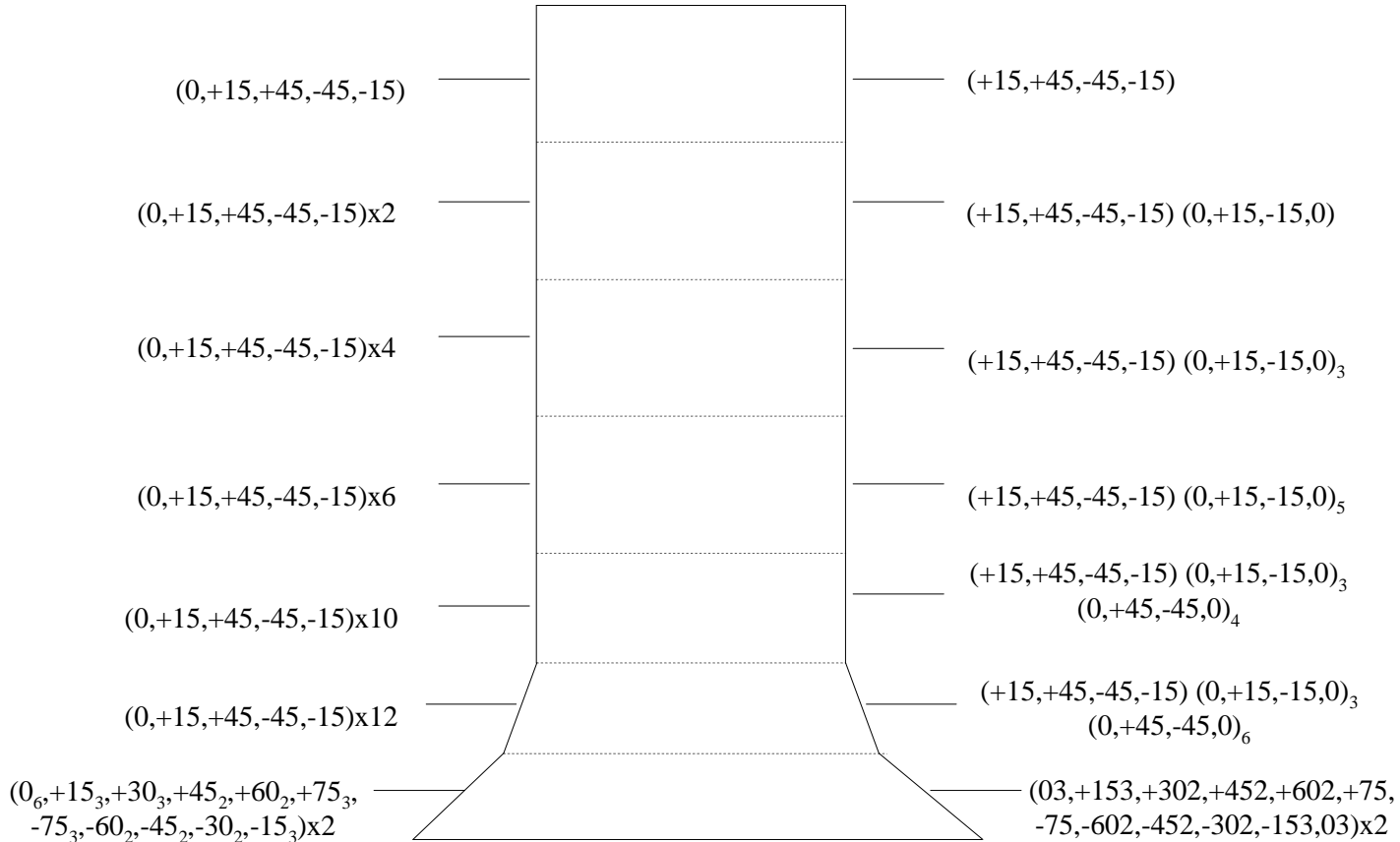
Courtesy EADS-CASA

Target location
of meta-model
(mean of tests)



INITIAL CONFIGURATION

TUNED CONFIGURATION

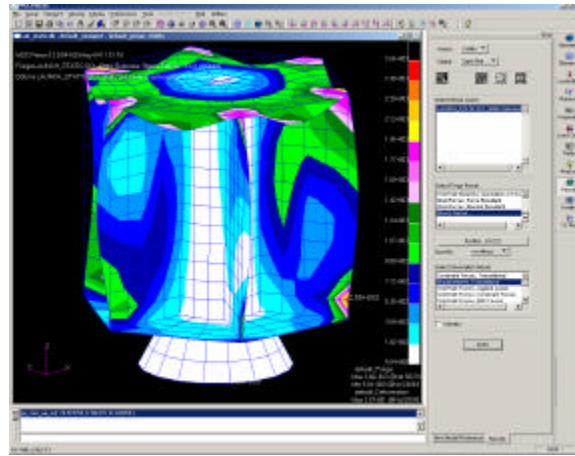


Mass= 436 kg
f1= 9.7 Hz

Courtesy EADS-CASA

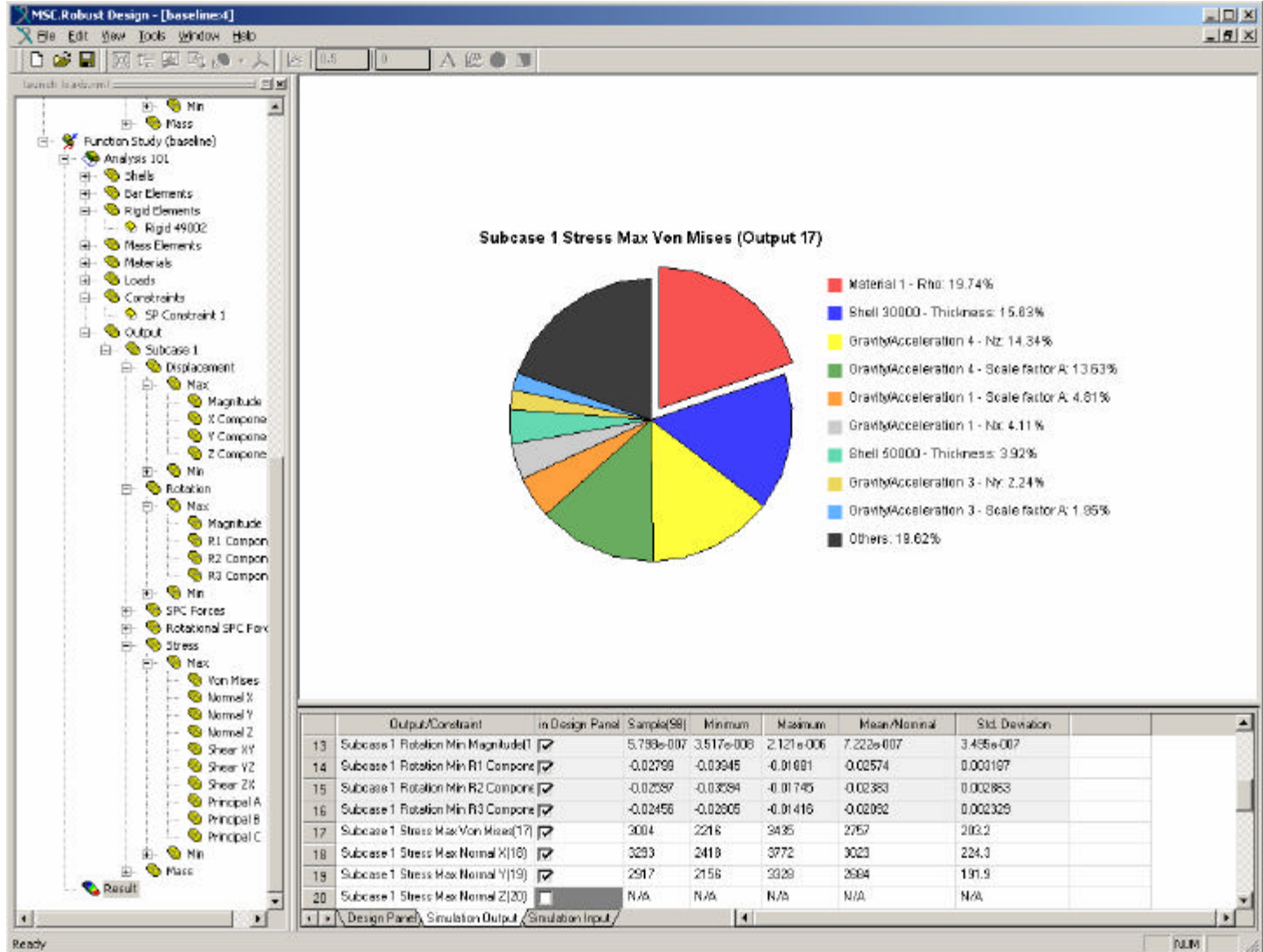
Mass= 362 kg
f1= 9.47 Hz
Reliability > 0.999

We're all rocket scientists here!



A quick test! – What is the principal source of Von Mises stress in our candidate satellite design during launch?

Model Complexity Can Obscure Drivers



Isotropic Material (MAT1)

Name	Value	Randomize
E	1.05e+7	<input type="checkbox"/>
G		
Nu	0.33	<input type="checkbox"/>
Rho	0.101	<input checked="" type="checkbox"/>
A		

OK Cancel

Random Variables

Type: Design Variable

Cutoff: (%of Nominal) 2

Coeff. of Variation (%) 10

Weibull/Lognormal Coefficient: 1

SDI

Upper Cutoff (% Nmn.) 20

Lower Cutoff (%Nmn) 20

Step Size Ratio 0.25

Show in DMView

Add if Zero

OK Cancel

Gravity or Acceleration (GRAV)

Name	Value	Randomize
Scale factor A	386.4	<input type="checkbox"/>
Nx	0	<input type="checkbox"/>
Ny	0	<input type="checkbox"/>
Nz	1	<input checked="" type="checkbox"/>

OK Cancel

Random Variables

Type: Design Variable

Cutoff: (%of Nominal) 2

Coeff. of Variation (%) 5

Weibull/Lognormal Coefficient: 1

SDI

Upper Cutoff (% Nmn.) 20

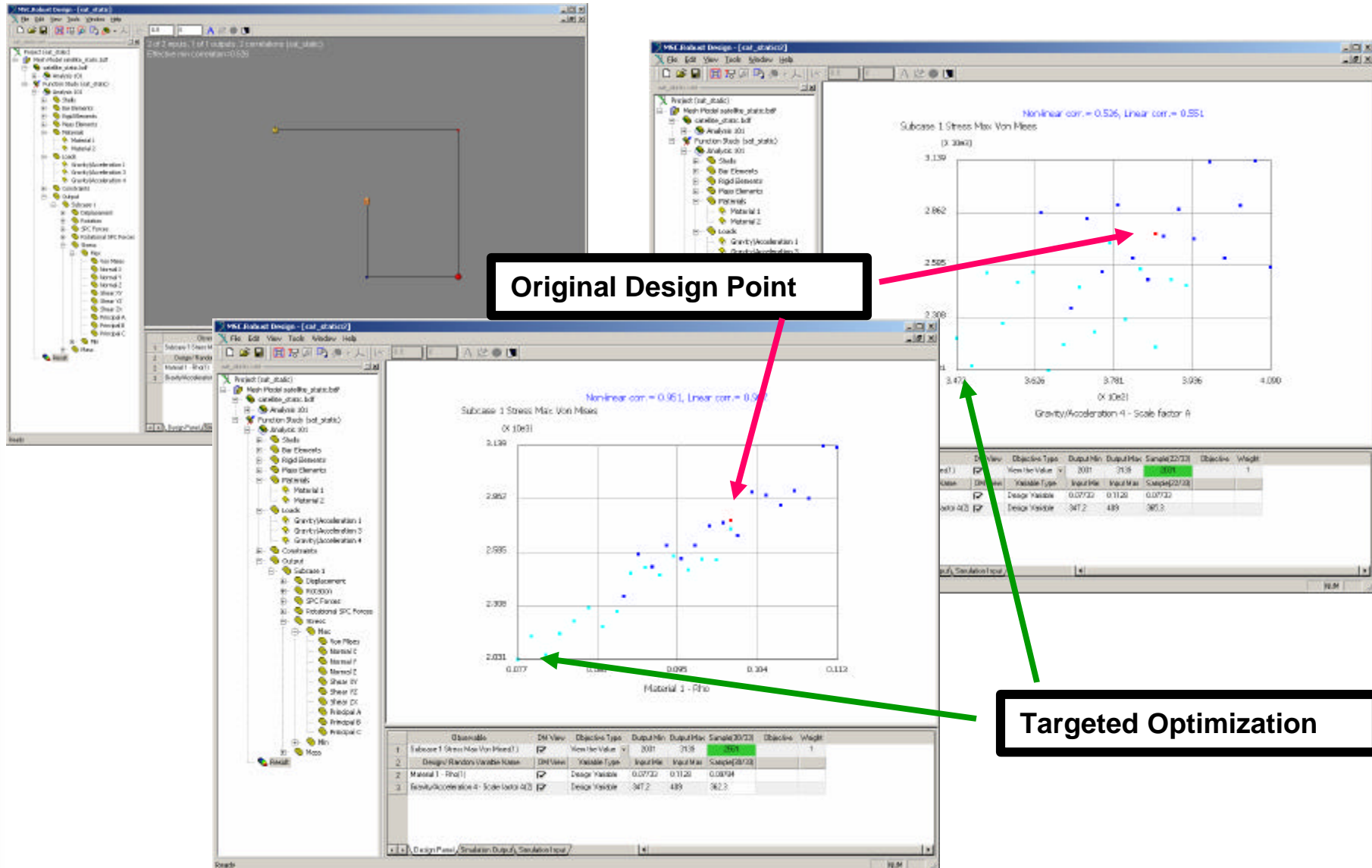
Lower Cutoff (%Nmn) 20

Step Size Ratio 0.25

Show in DMView

Add if Zero

OK Cancel



- **Robust Design™ enhances the value of your MSC NASTRAN FEM - spend less time and money achieving superior results**
- **Verify stability and robustness of high performance design solutions**
- **Reveal unknown unknowns, especially when modifying designs**
- **Increase value of experimental data for FEA validation and optimization**