

CETOL 60 **TM**

2011 U2U CONFERENCE
TEXAS MOTOR SPEEDWAY, OCT 25-26

Incorporating FEA Results into a CETOL Analysis

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Leading Edge Engineering

Agenda

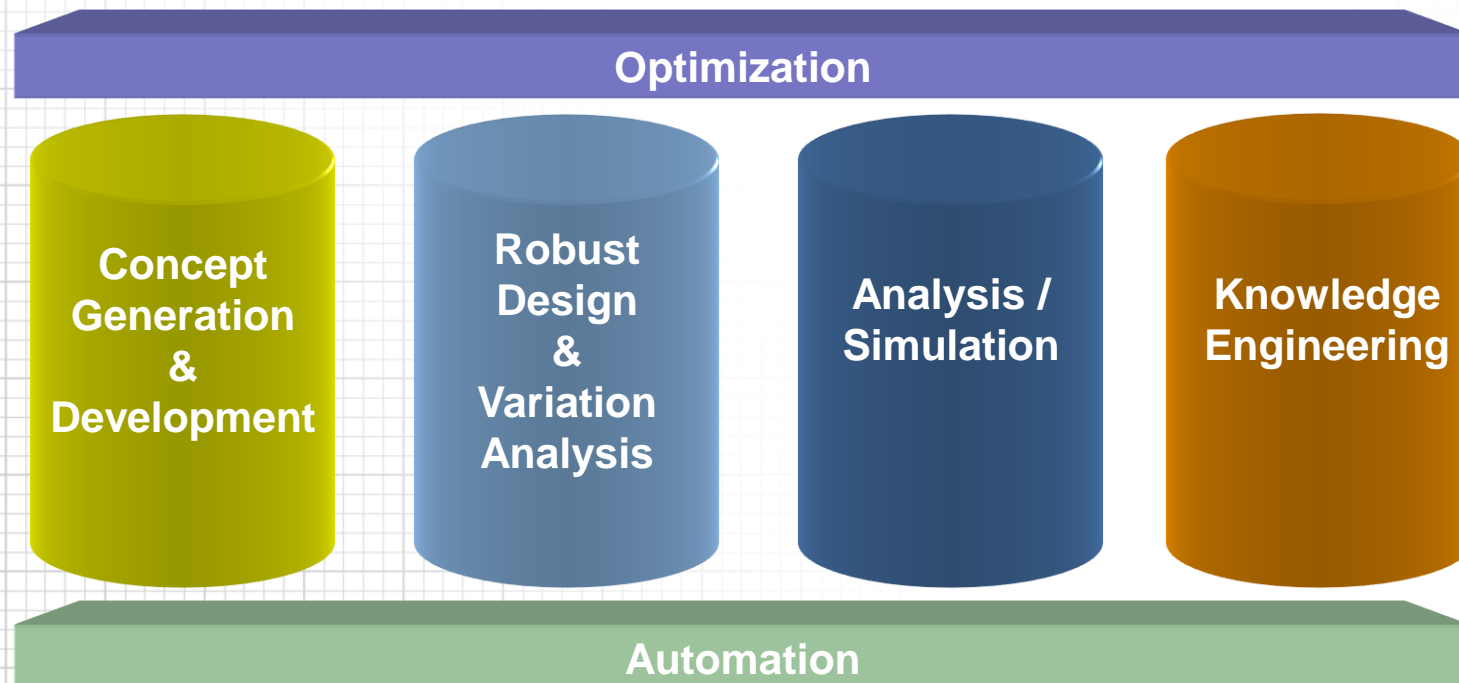


- Problem Setup
- CETOL Model Setup
- Non-Linear FE Analysis Setup
- Response Calculation
- Response Incorporation to CETOL Analyzer

Leading Edge Engineering

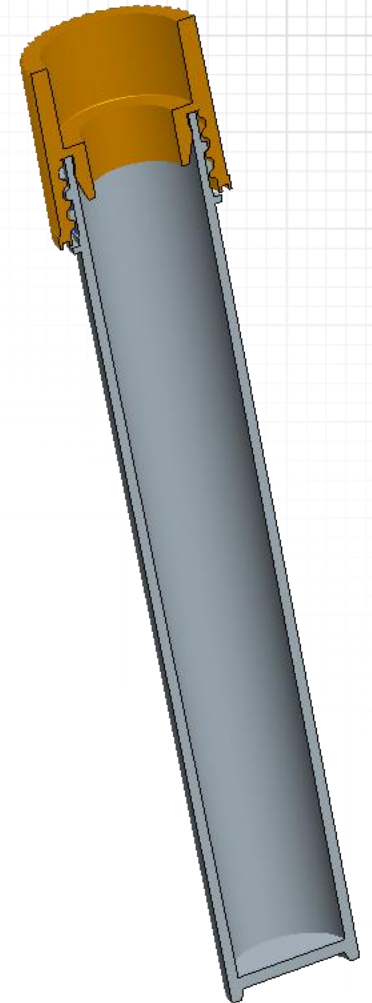


- Use simulation to drive design and development process
- Apply advanced techniques to and knowledge transfer to assist our customers to implement virtual testing and development programs
- Provide software sales and technical support

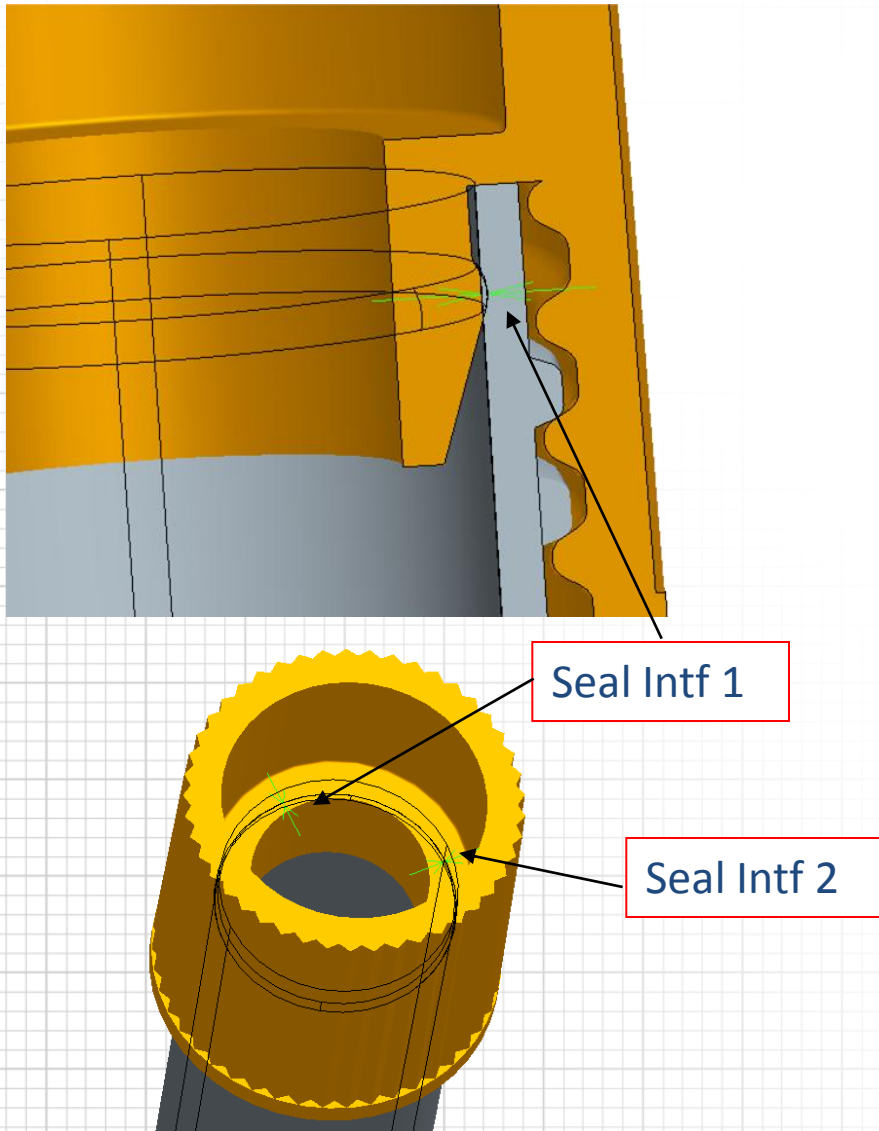


Project Scope

- Biomedical sample tube that may contain genetic samples
- Critical that samples are sealed within the tube, and will not be contaminated.
- Customer requested assistance in performing tolerance study to identify manufacturing and performance effects
- Need to account for non-linear effects of seal geometry, incorporating these results into Analyzer results to have single unique

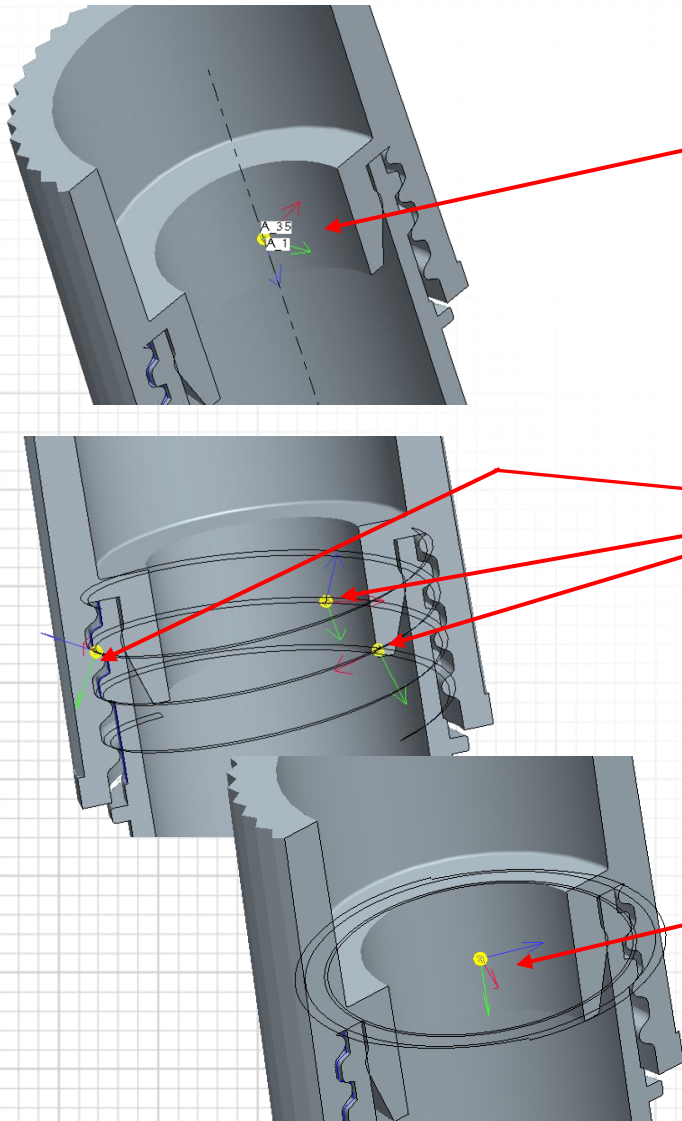


Measurements



- Interference measurement between the sealing surface of the cap and the ID of the tube. Interference is considered a negative value, so this is a one-sided measurement to verify that there isn't a clearance condition
- There are two measurements, at 90 degrees apart. Both measurements should produce very similar results, but this acts as a check to verify the model is built correctly.

Assembly Joints

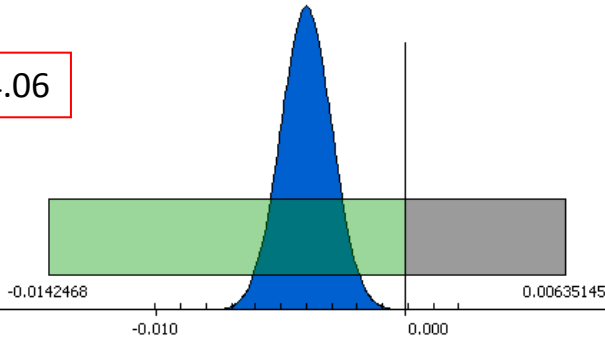


- X(red) & Y(green) translational joint between A datum of cap and tube. This joint makes the assumption that by screwing the cap on, the cap will be centered onto the tube w/ respect to the threads on each component. This is a worst case assumption, and assumes that the seal will be deformed
- 3 point contact joints spaced 120° apart, at thread contact interface. These three joints ultimately control rotation of the cap about the X & Y axis, and translation along the Z axis – but allows the cap to rotate along the thread surfaces, which allows the cap to translate in Z as it rotates
- Translational joint on Y(green) axis, stops cap when a point on cap face comes into contact with tube

Gap Measurements

Sigma = 4.0673
CpK = 1.3008
DPMU = 47.7734

Normal(-0.0039; 0.0010)



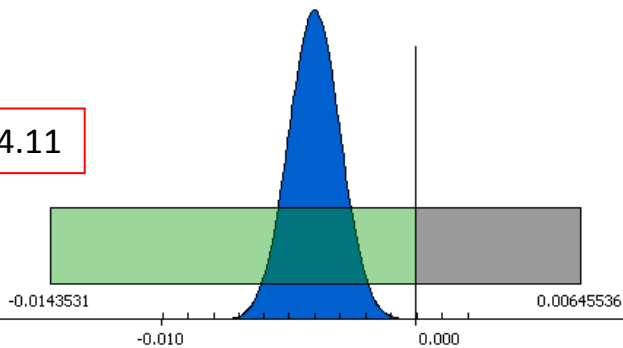
Seal Inf 1: $\sigma = 4.06$

'Seal Intf - 1' Statistical % Contributions

Name	Contribution	
GP-0621-GCD;1 / Top Edge to A B	36.71 %	1
GP0619GCD;1 / Cap Seal Surf to A B-Surf	28.79 %	2
GP0619GCD;1 / Cap Seal Surf Major Size	13.81 %	3
GP-0621-GCD;1 / Top Edge Size	13.81 %	4
GP-0621-GCD;1 / Thread Radius 2 to A B	1.96 %	
GP0619GCD;1 / Thread_Surf 2 to A B-Surf	1.81 %	
GP-0621-GCD;1 / Thread Radius 1 to A B	1.63 %	
GP0619GCD;1 / Thread_Surf 1 to A B-Surf	1.45 %	

Sigma = 4.1119
CpK = 1.3161
DPMU = 39.4585

Normal(-0.0039; 0.0010)

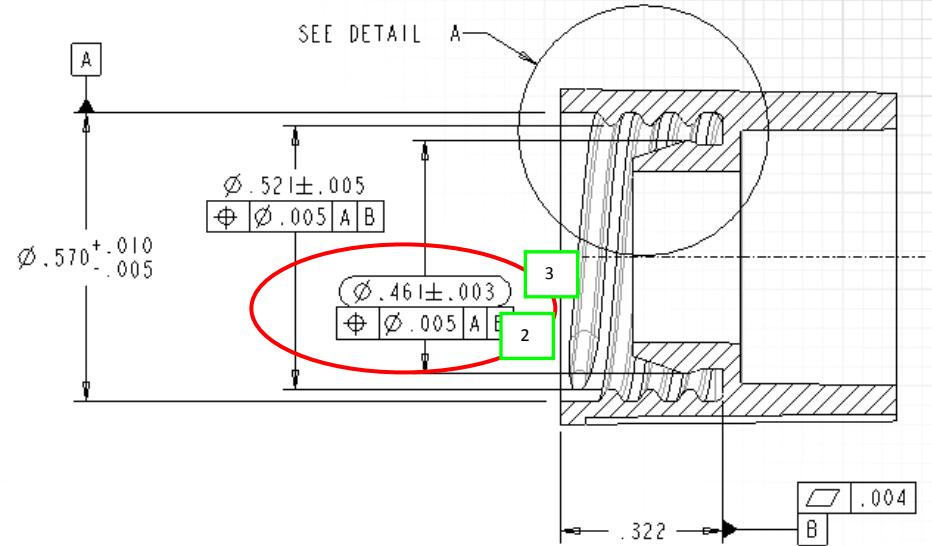
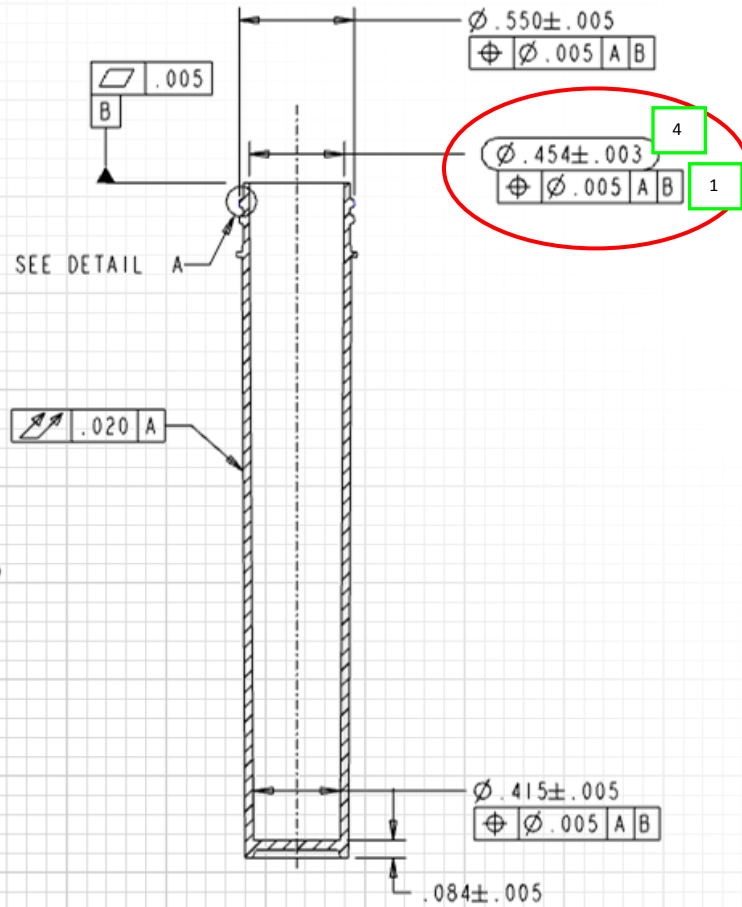


Seal Inf 2: $\sigma = 4.11$

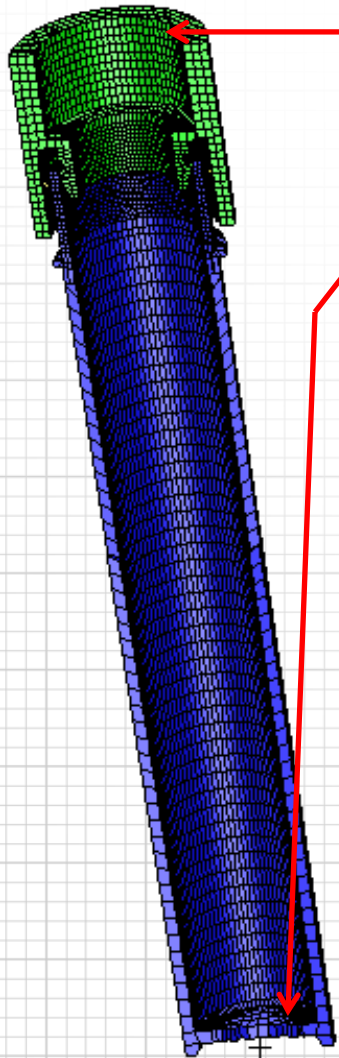
'Seal Intf - 2' Statistical % Contributions

Name	Contribution	
GP-0621-GCD;1 / Top Edge to A B	37.56 %	1
GP0619GCD;1 / Cap Seal Surf to A B-Surf	29.45 %	2
GP0619GCD;1 / Cap Seal Surf Major Size	14.13 %	3
GP-0621-GCD;1 / Top Edge Size	14.13 %	4
GP0619GCD;1 / Thread_Surf 1 to A B-Surf	2.99 %	

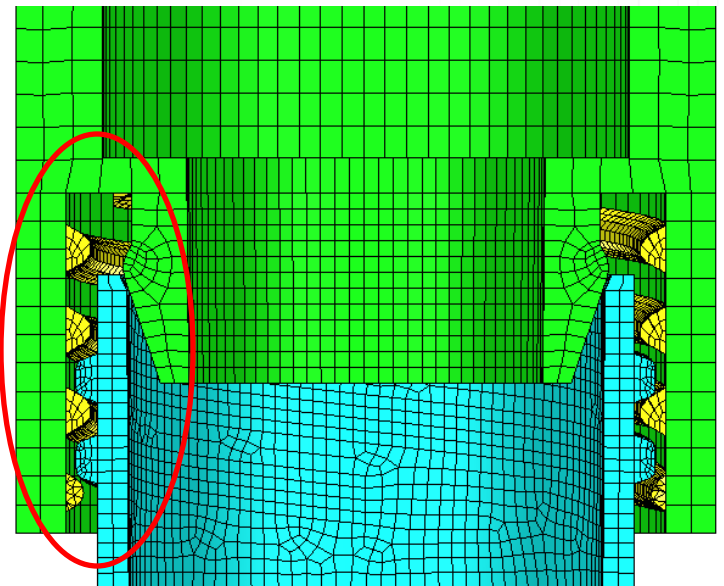
GD&T Callouts



FE Model Setup

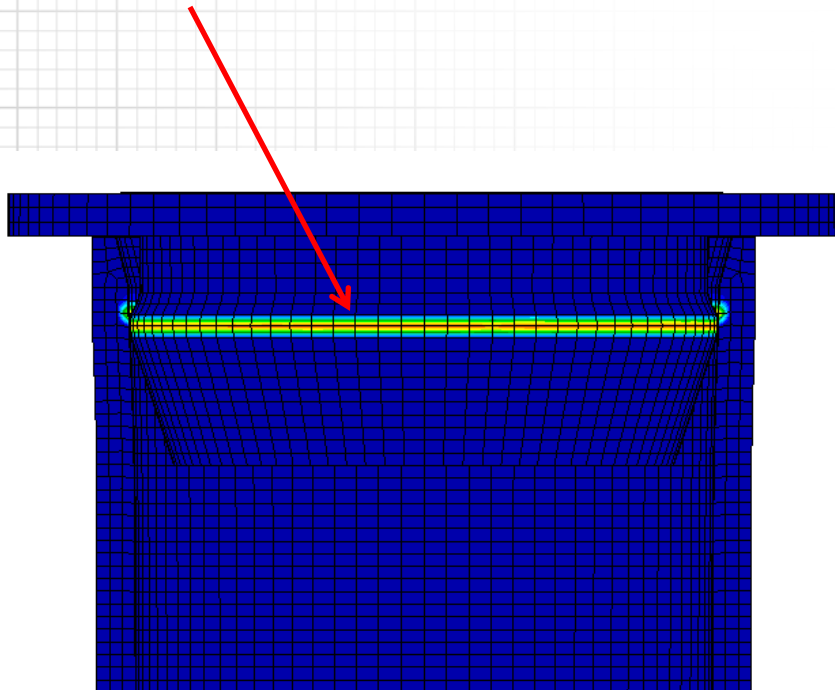


- Apply Torque at Cap
- Restrain bottom of tube
- Only restraints on cap are contact between threads and seal with inner tube diameter



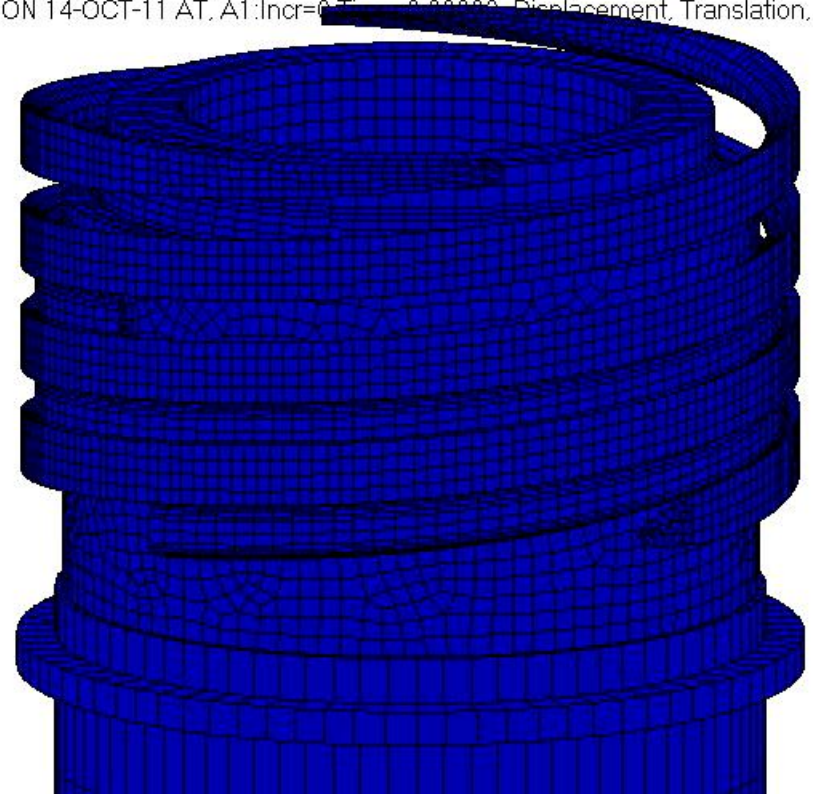
FEA Output

- Seal contact force is measured along seal diameter



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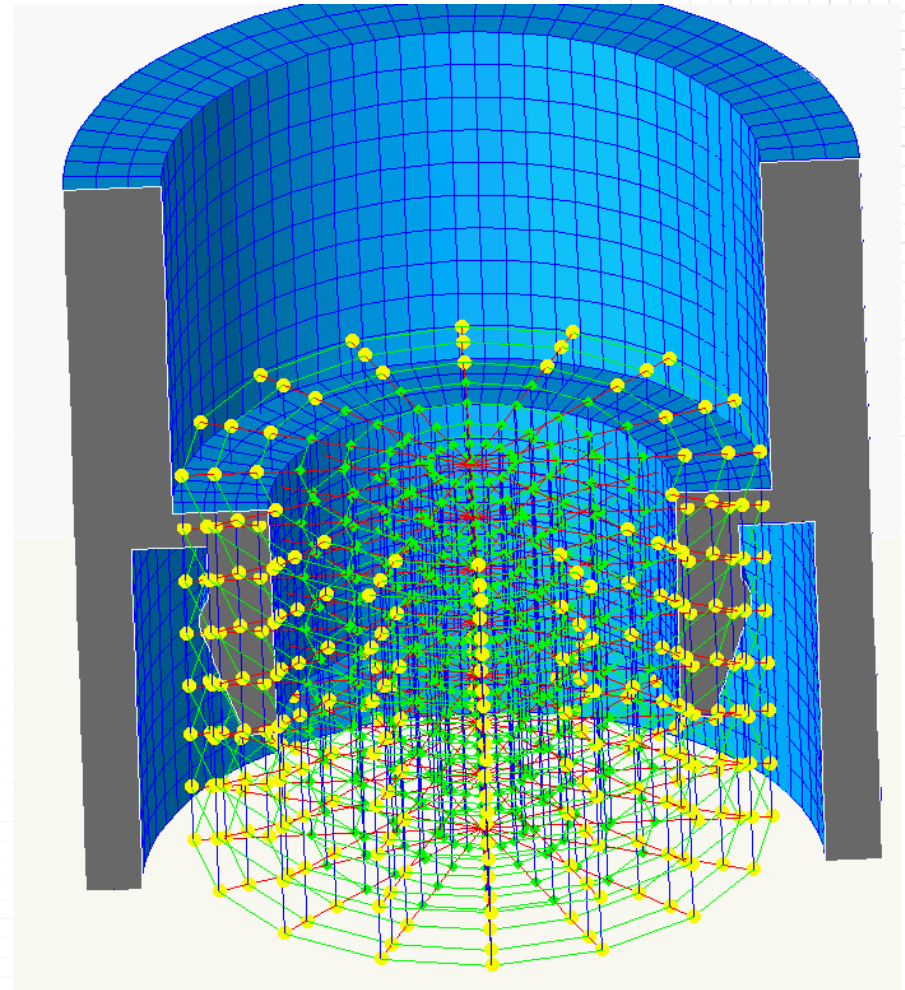
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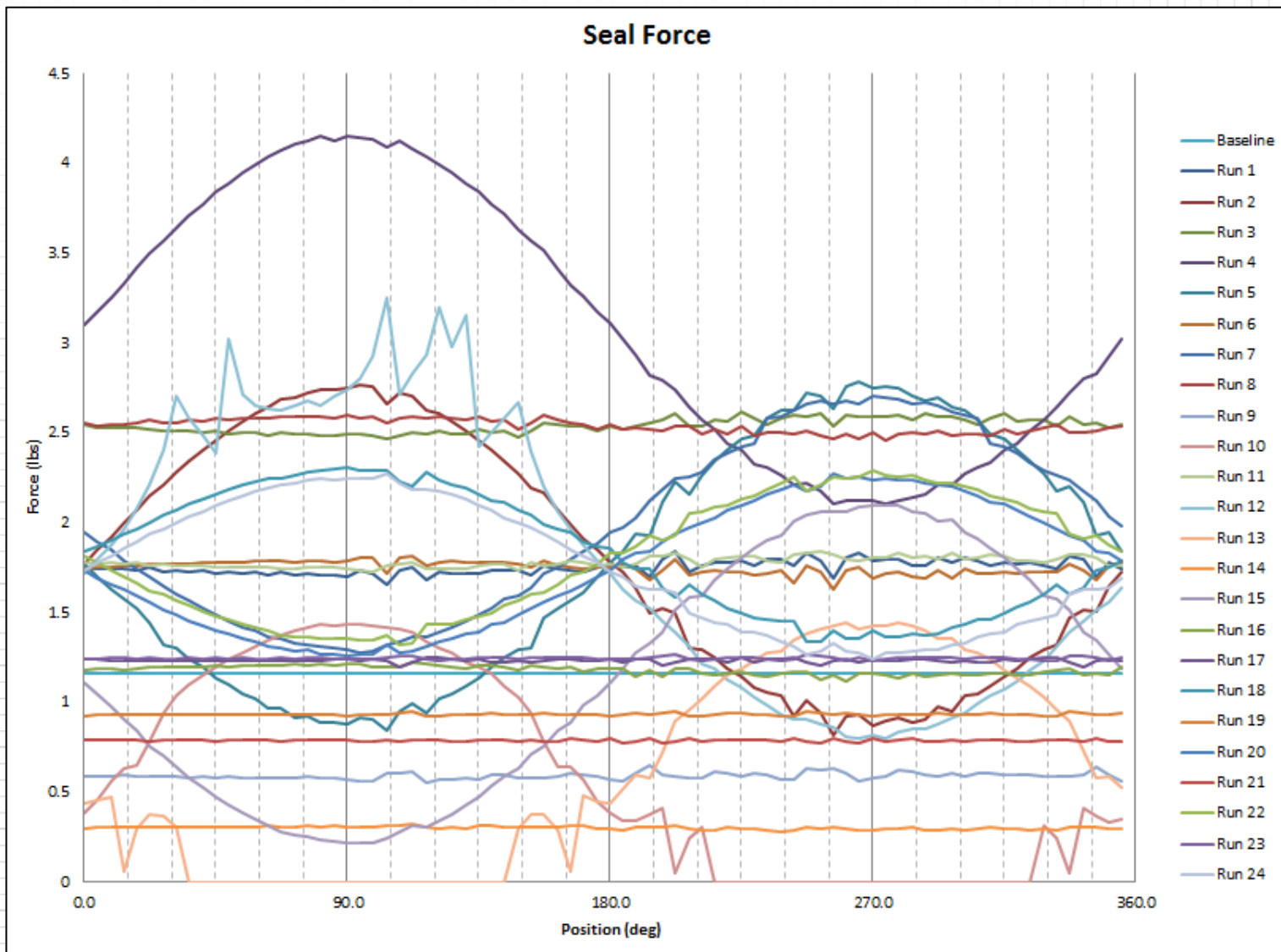
Sensitivity Calculation

Full Factorial DOE Setup

Run #	Seal Rad	Seal Z Shift	Tube Rad	Tube Z Shift
1	+	+	+	+
2	+	+	+	-
3	+	+	-	+
4	+	+	-	-
5	+	-	+	+
6	+	-	+	-
7	+	-	-	+
8	+	-	-	-
9	-	+	+	+
10	-	+	+	-
11	-	+	-	+
12	-	+	-	-
13	-	-	+	+
14	-	-	+	-
15	-	-	-	+
16	-	-	-	-
17	+	0	0	0
18	0	+	0	0
19	0	0	+	0
20	0	0	0	+
21	-	0	0	0
22	0	-	0	0
23	0	0	-	0
24	0	0	0	-

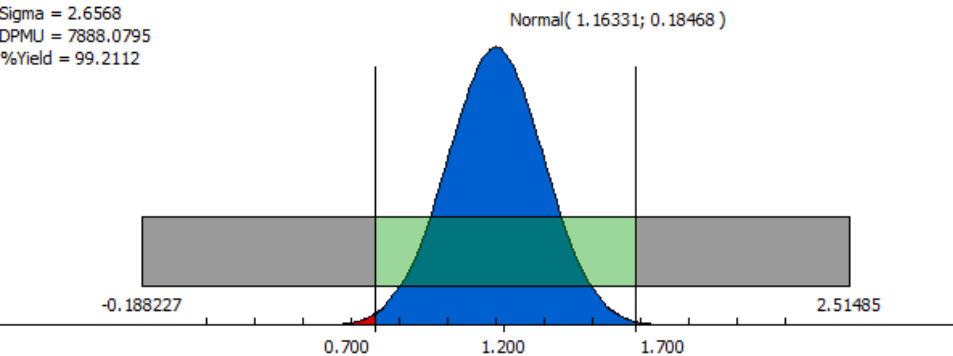


Force Output Results



Force Measurements

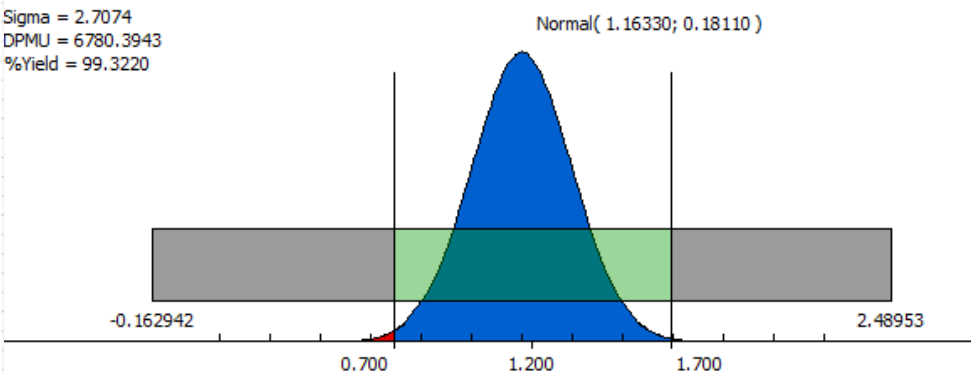
90 deg: $\sigma = 2.65$



'Seal Compression Force @ -90deg' Statistical % Contributions

Name	Contribution
GP-0621-GCD;1 / Top Edge to A B / TY	47.83 %
GP0619GCD;1 / Cap Seal Surf to A B-Surf / TX	37.98 %
GP0619GCD;1 / Cap Seal Surf Major Size / Diameter:Outside	9.48 %
GP-0621-GCD;1 / Top Edge Size / Diameter	4.71 %

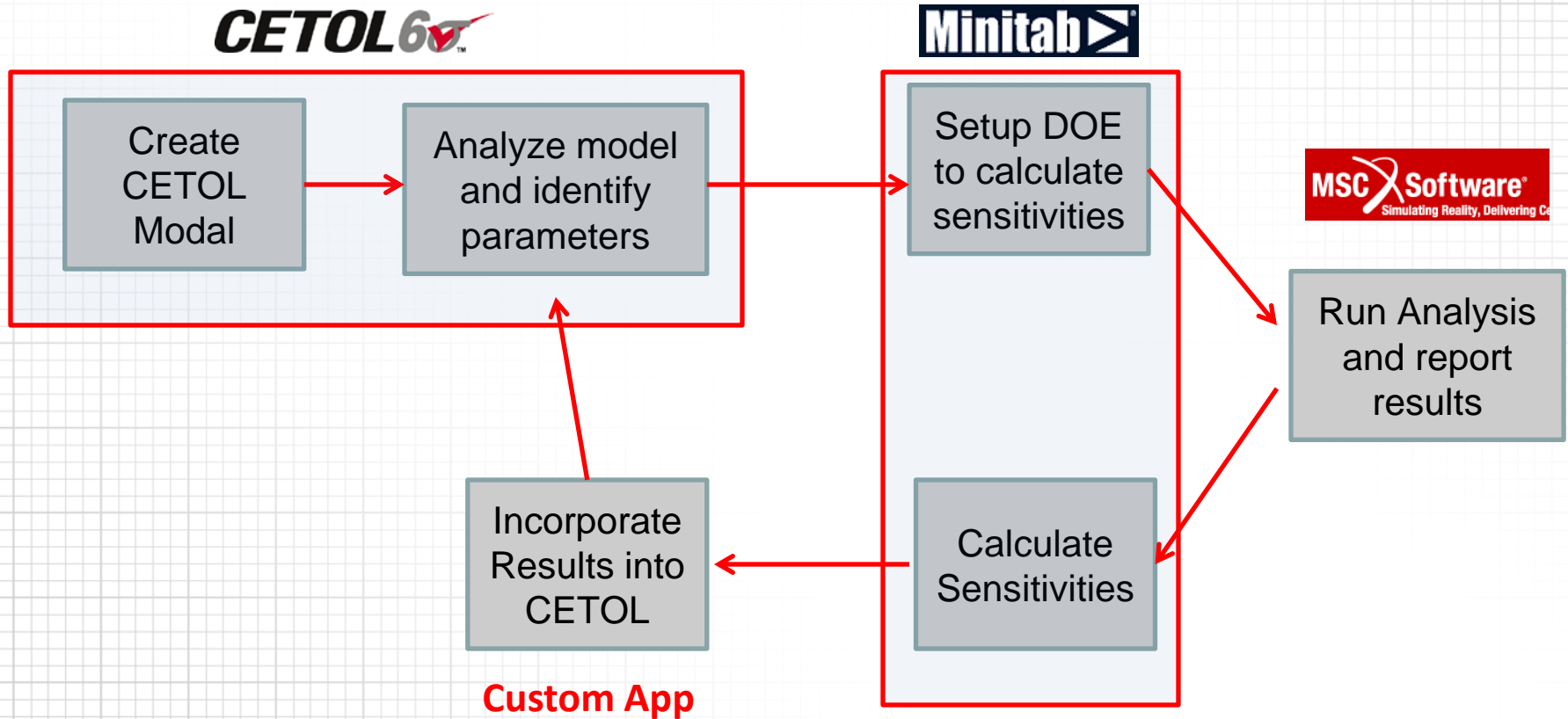
-90 deg: $\sigma = 2.70$



'Seal Compression Force @ -90deg' Statistical % Contributions

Name	Contribution
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GP0619GCD;1 / Cap Seal Surf Major Size / Diameter:Outside	9.48 %
GP-0621-GCD;1 / Top Edge Size / Diameter	4.71 %

Incorporation Process



- Create a CETOL model with accommodations for external data
 - Additional measurements are inserted to store externally-calculated measurements
 - Notes and user-defined fields are used to identify import measurements and variables to be excluded from external design study.

Build and analyze CETOL model

Generate variable screening test

Identify significant variables

Generate RSM runs

Import calculated sensitivities

- A user-run utility reads model data from a saved CXM file to generate the design study
 - 2-level screening test allows a computationally-inexpensive review of the model to determine variables with significant effects

Build and analyze CETOL model

Generate variable screening test

Identify significant variables

Generate RSM runs

Import calculated sensitivities

- Screening test results are incorporated into the CETOL model by flagging variables
 - User-defined fields can be used to store variable status for each imported measurement
 - This process is analogous to Datum Flow Chain calculation for tolerance stack-up measurements.

Build and analyze CETOL model

Generate variable screening test

Identify significant variables

Generate RSM runs

Import calculated sensitivities

- Variables that are identified as significant are included in an RSM run set.
 - Response surface method allows approximation of 1st- or 2nd-order sensitivities
 - Utility generates variables values for run set based on user-selected DOE or RSM-optimized design

Build and analyze CETOL model

Generate variable screening test

Identify significant variables

Generate RSM runs

Import calculated sensitivities

- Once the Response Surface polynomial is calculated, sensitivities are written to the data file.
 - Measurement values and sensitivities can be imported into the CXM file
 - The CETOL Analyzer allows the user to compare externally-calculated performance simulation sensitivities with dimensional variation stack-up sensitivities.

Build and analyze CETOL model

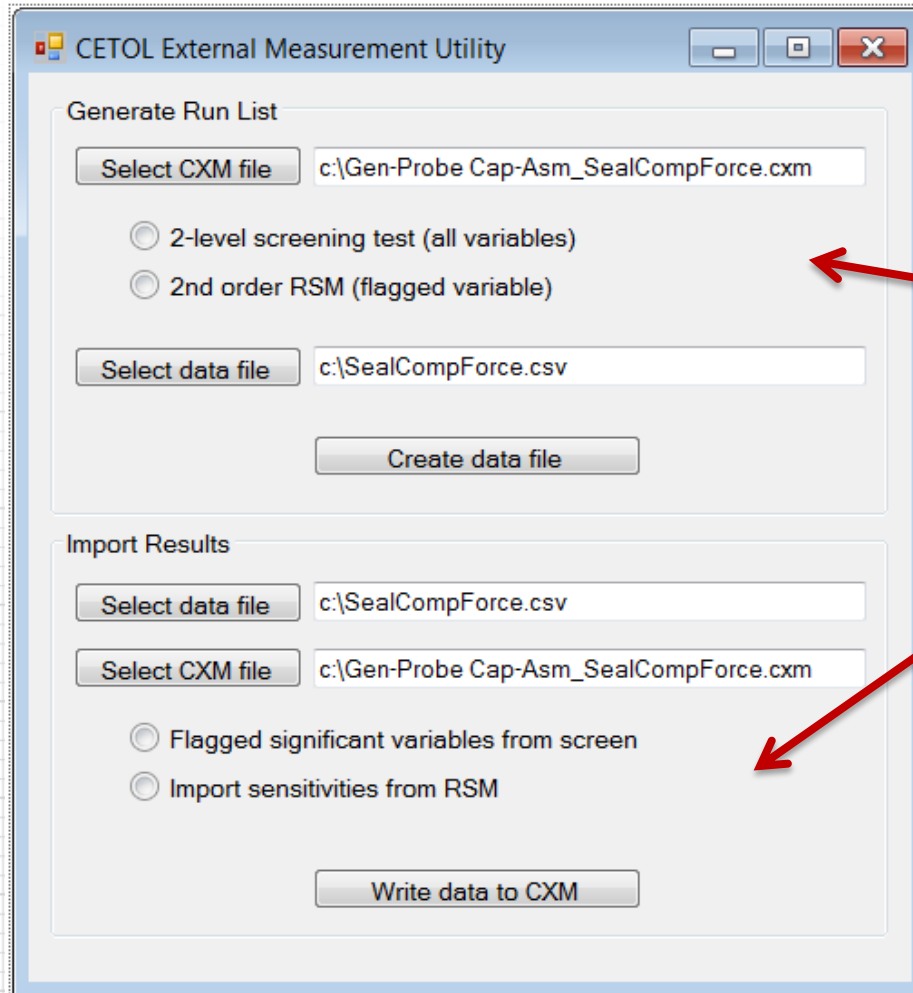
Generate variable screening test

Identify significant variables

Generate RSM runs

Import calculated sensitivities

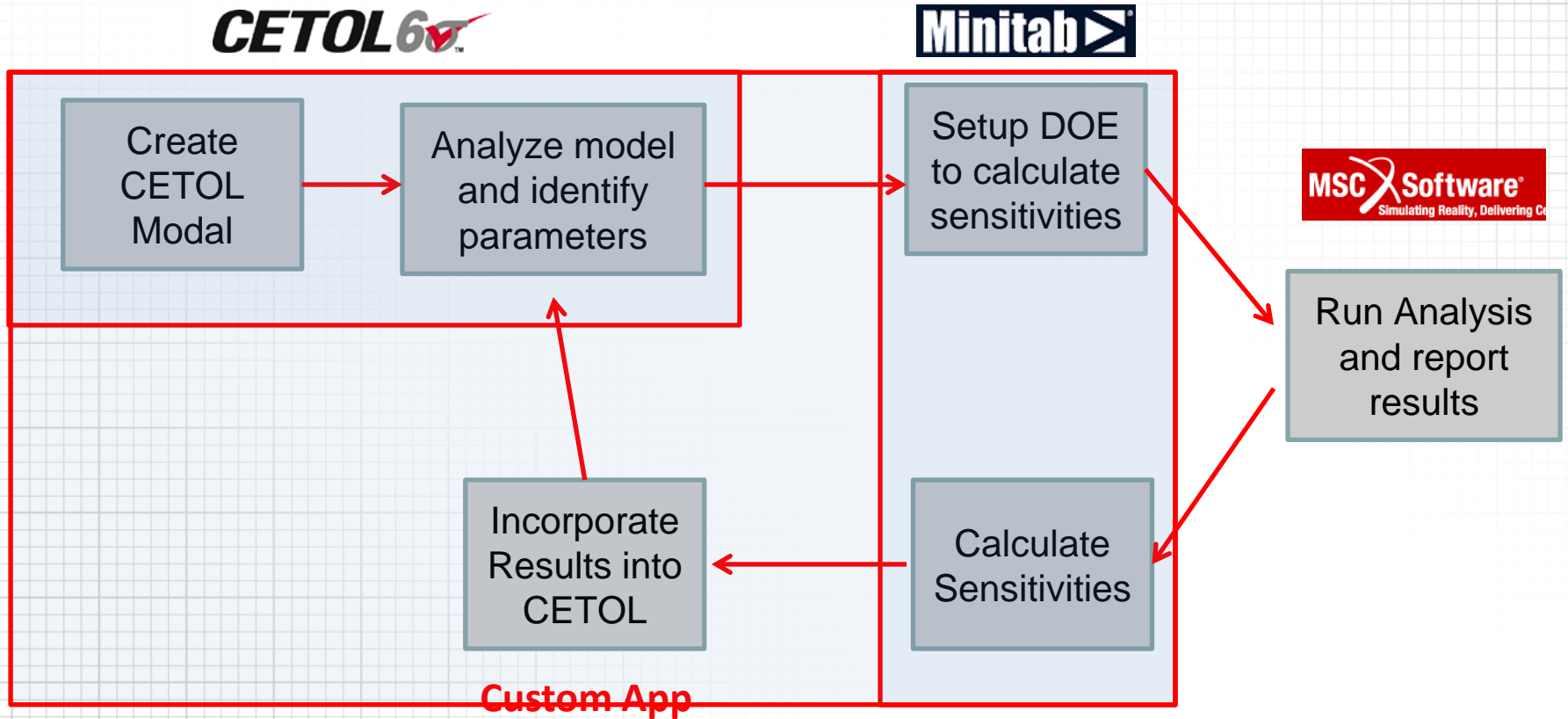
Utility concept



Create a data template that sets variable values for each run. Levels are based on tolerance limits or variable distribution parameters. The external analysis process writes measurement results for each run.

Read the externally-computed data (measurement values, sensitivities, and/or variable significance) from the results-populated data file and write information to the CXM file

Incorporation Process



Software Tools Used



Tolerance Analysis and Optimization



Shape Morphing for FE Models



MSC Marc – Non-Linear FEA Solution

Questions?

Thank You!