Workshop - MSC Nastran Topography Optimization - Bead or Stamp Optimization

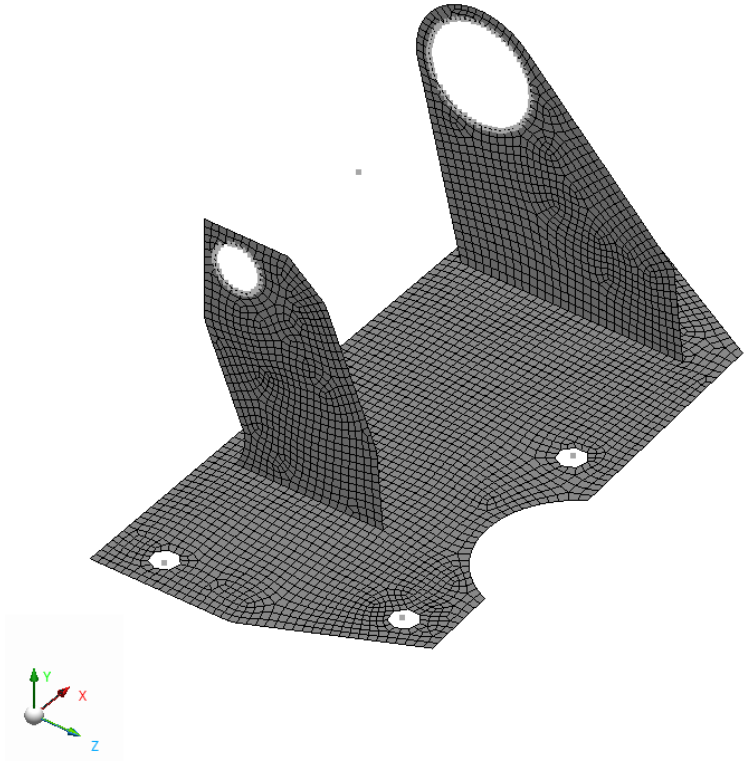
AN MSC NASTRAN SOL 200 TUTORIAL

Questions? Email: christian@ the-engineering-lab.com

Goal: Use Nastran SOL 200 Optimization

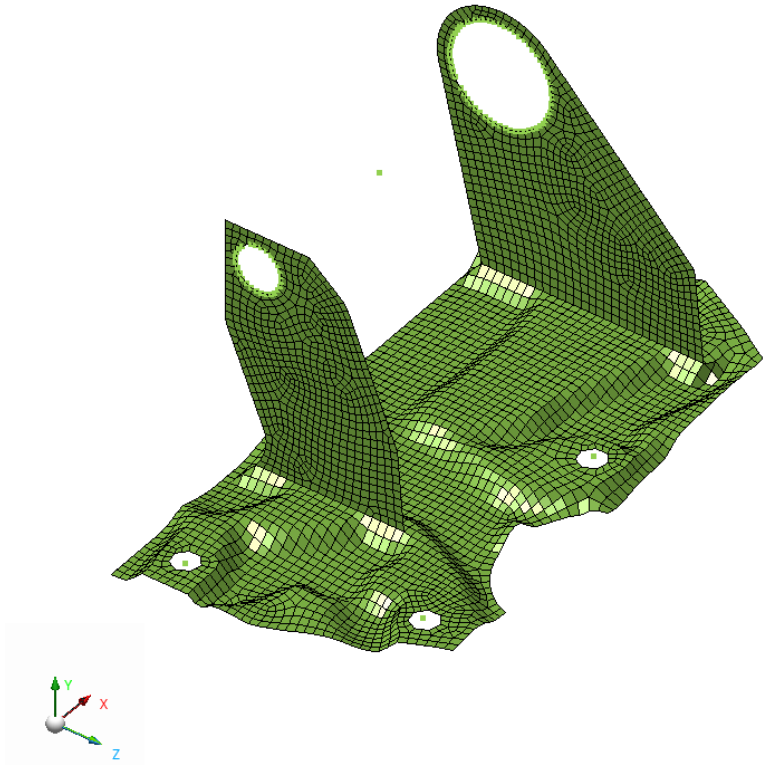
Before Optimization

- 1st Natural Frequency: 581.9 Hz

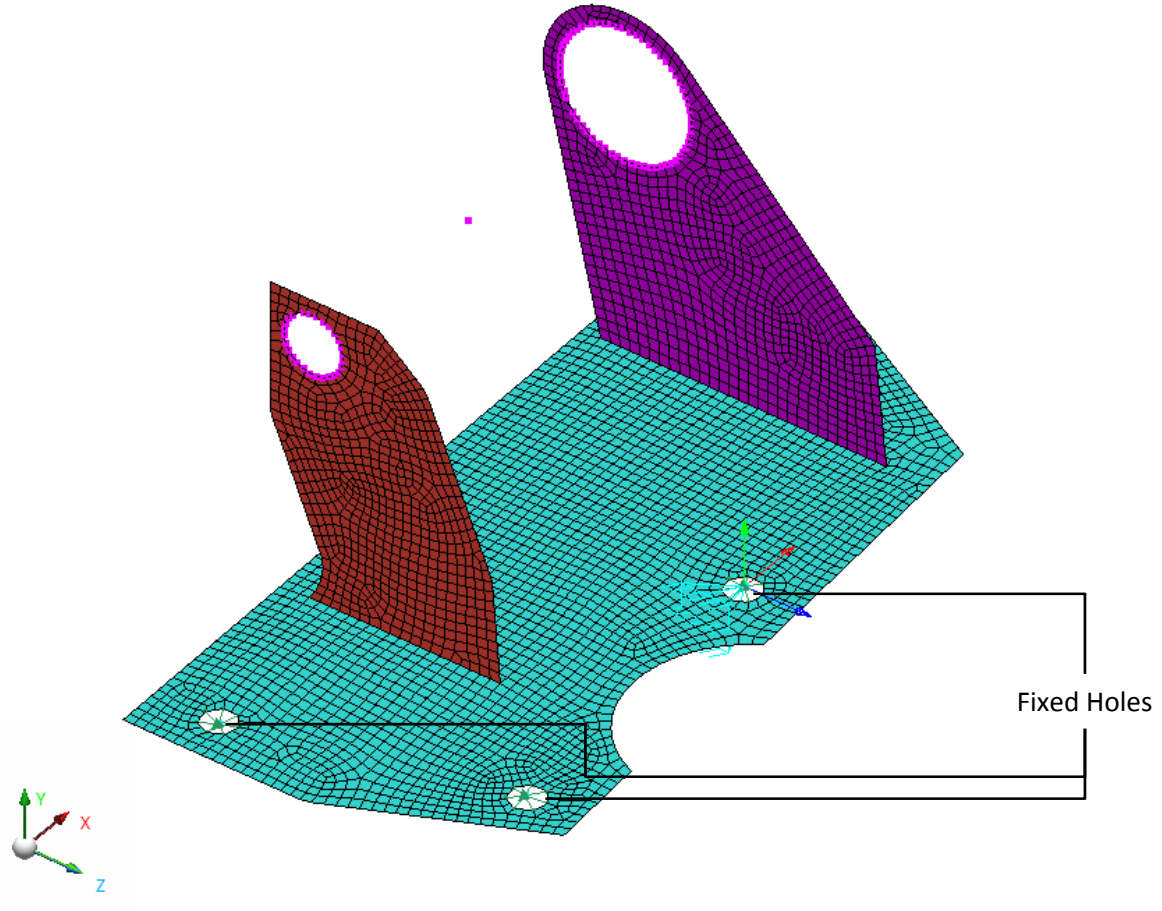


After Optimization

- 1st Natural Frequency: 647.22 Hz



Details of the structural model



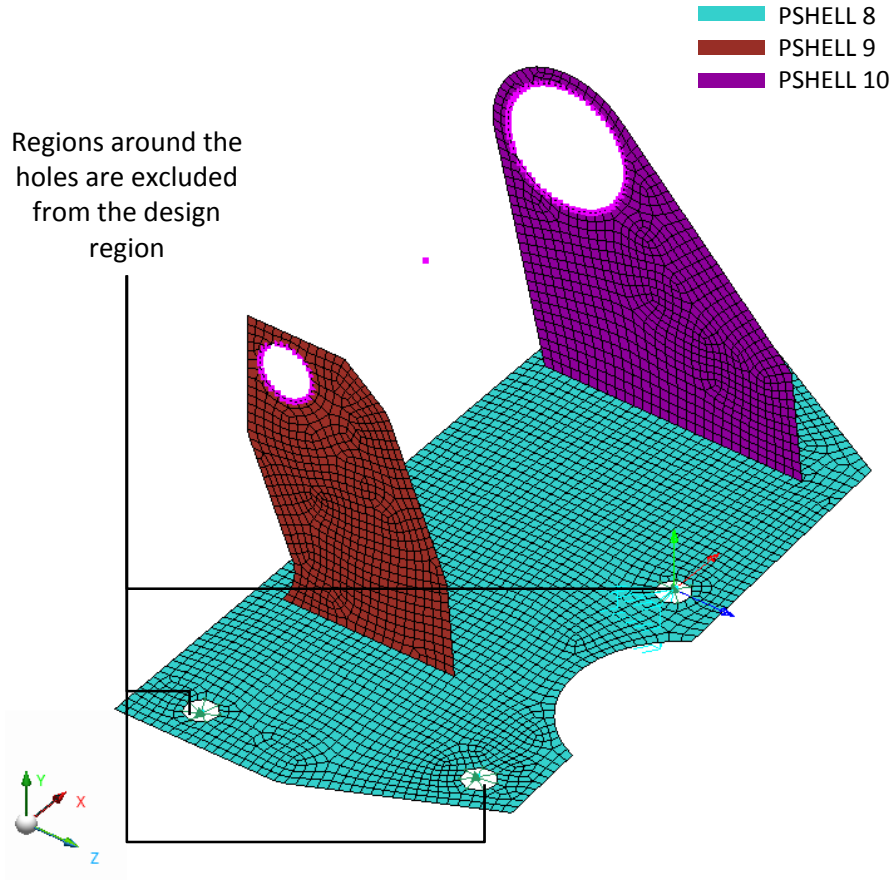
Optimization Problem Statement

Design Region/Variables

x1: PSHELL 8

Configuration:

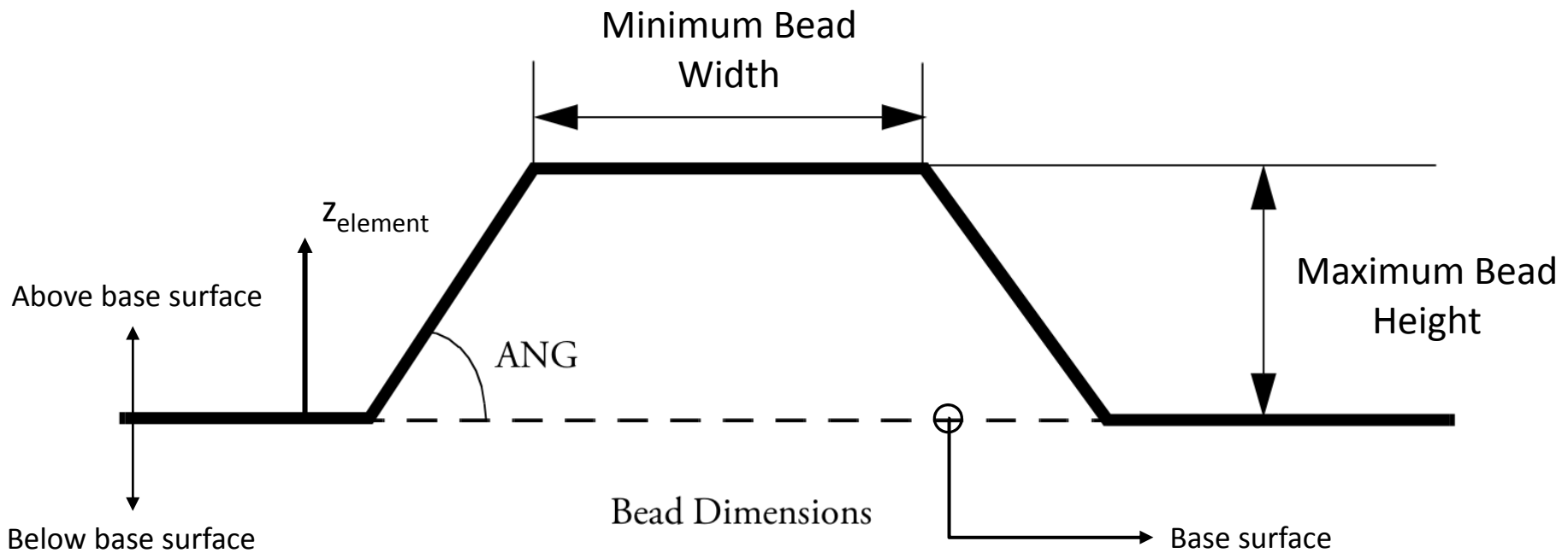
- Minimum Bead Width: 6
- Maximum Bead Height: 6
- Bead Draw Direction: Below base surface
- NGSET: 100
  - The NGSET field points to a SET1 entry that defines a list of nodes to exclude from the design region
  - The regions around the holes are excluded from the design region



Design Objective

r0: Maximize the 1st natural frequency

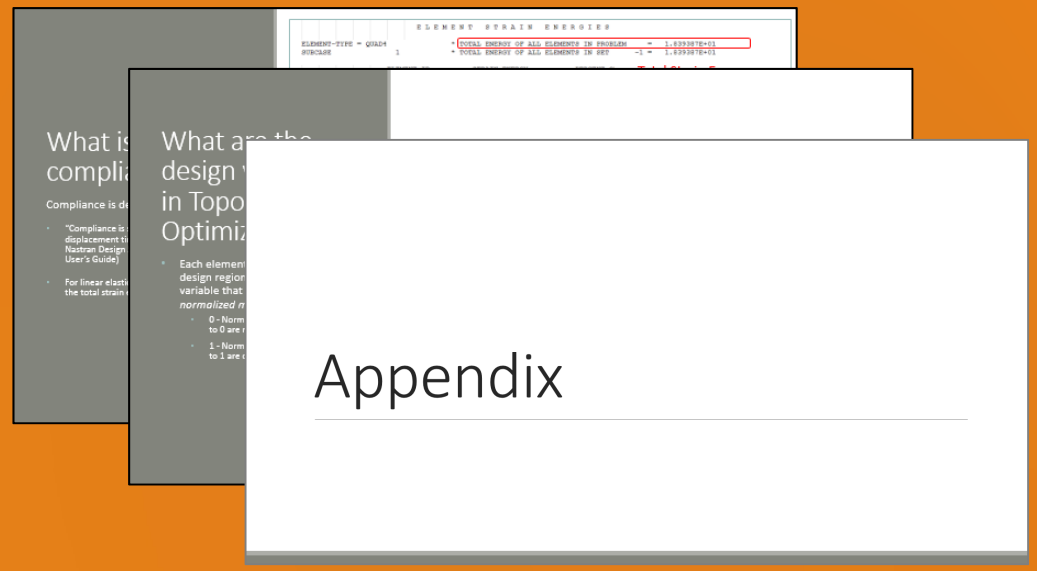
Options to Configure Topography Design Region



More Information Available in the Appendix

The Appendix includes information regarding the following:

- Frequently Asked Questions
  - How do I access more configuration options for Topography optimization?
  - What MSC Apex and MSC Nastran versions are supported?



Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

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Tutorial

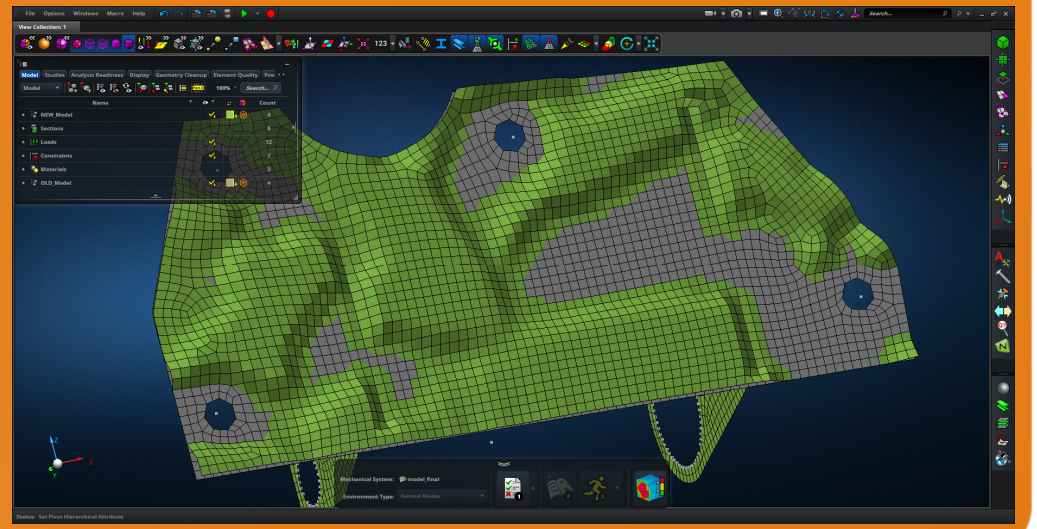
Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
   - Convert the .bdf file to SOL 200
     - Design Regions/Variables
     - Design Objective
     - Design Constraints
   - Perform optimization with Nastran SOL 200
3. Review optimization results
   - .f06
   - Topography Optimization and Structural Results

Special Topics Covered

Topography Optimization – Topography optimization used to determine an optimal reinforcement bead pattern.

MSC Apex – MSC Apex is used to review the optimized shape and new structural responses.

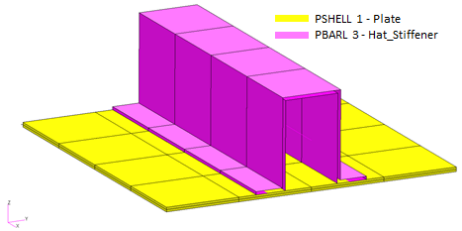


SOL 200 Web App Capabilities

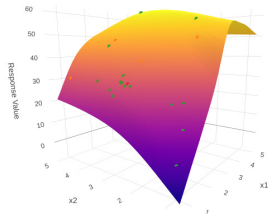
Benefits

- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 76 tutorials

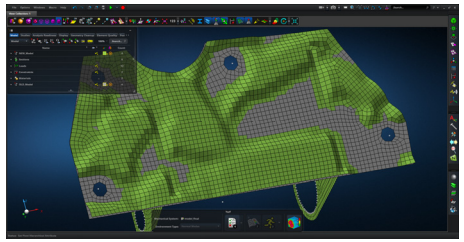
Capabilities



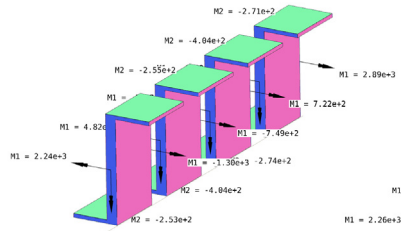
Web Apps for SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography and multi-model.



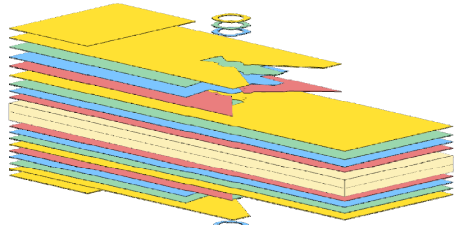
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



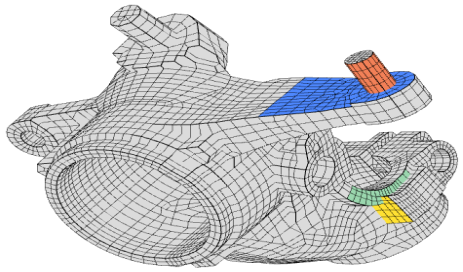
MSC Apex Post Processing Support
View the newly optimized model after an optimization



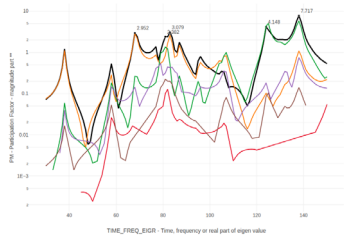
Beams Viewer Web App
Post process 1D element forces, including shear forces, moments, torque and axial forces



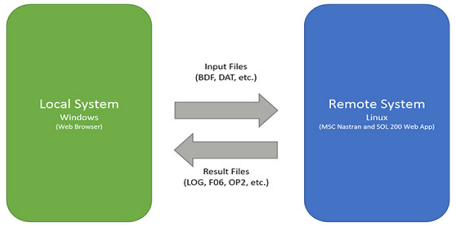
Ply Shape Optimization Web App
Spread plies optimally and generate new PCOMPG entries



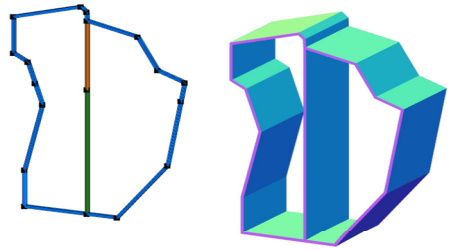
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



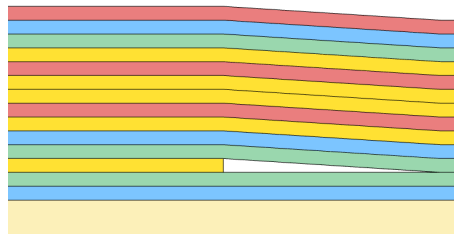
HDF5 Explorer Web App
Create XY plots using data from the H5 file



Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically

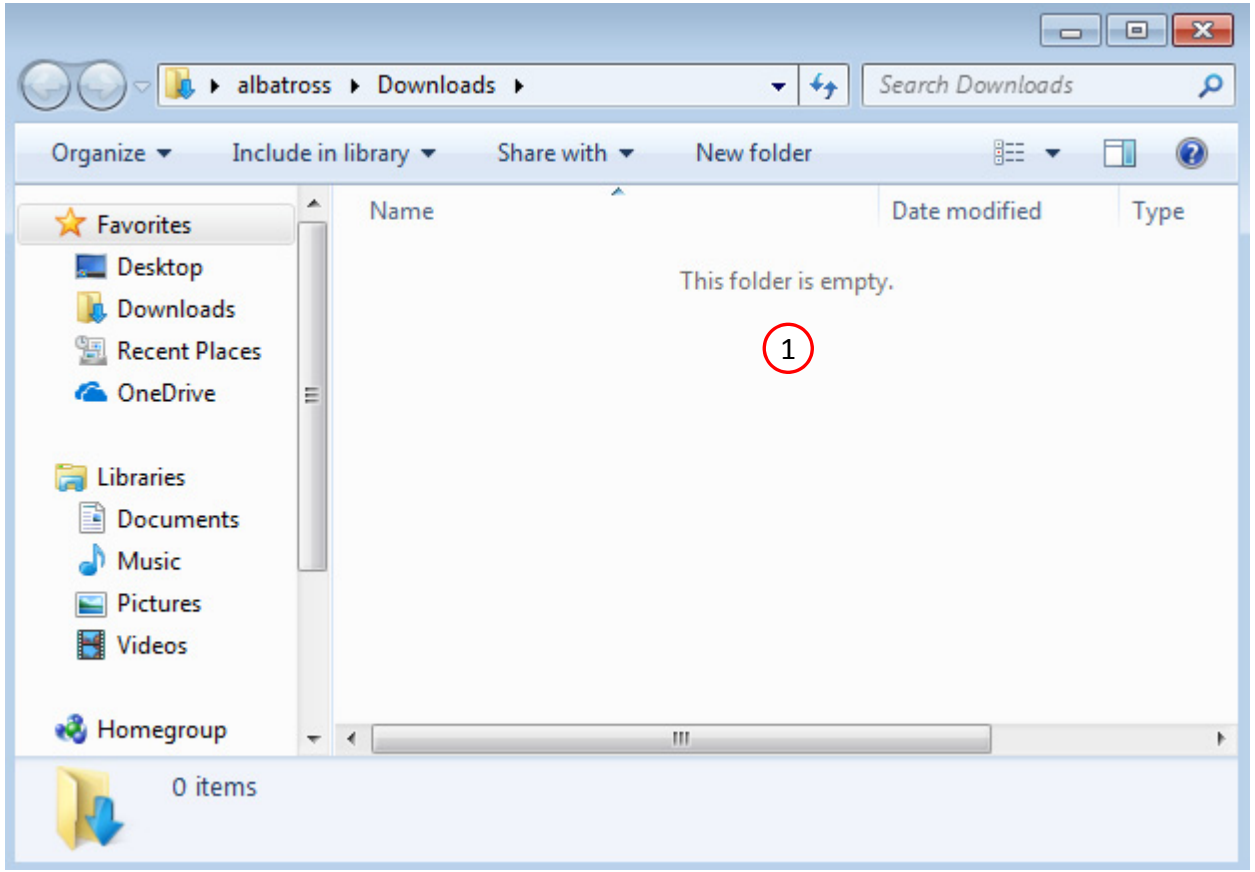


Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies

Before Starting

1. Ensure the Downloads directory is empty in order to prevent confusion with other files

- Throughout this workshop, you will be working with multiple file types and directories such as:
  - .bdf/.dat
  - nastran_working_directory
  - .f06, .log, .pch, .h5, etc.
- To minimize confusion with files and folders, it is encouraged to start with a clean directory.



Go to the User's Guide

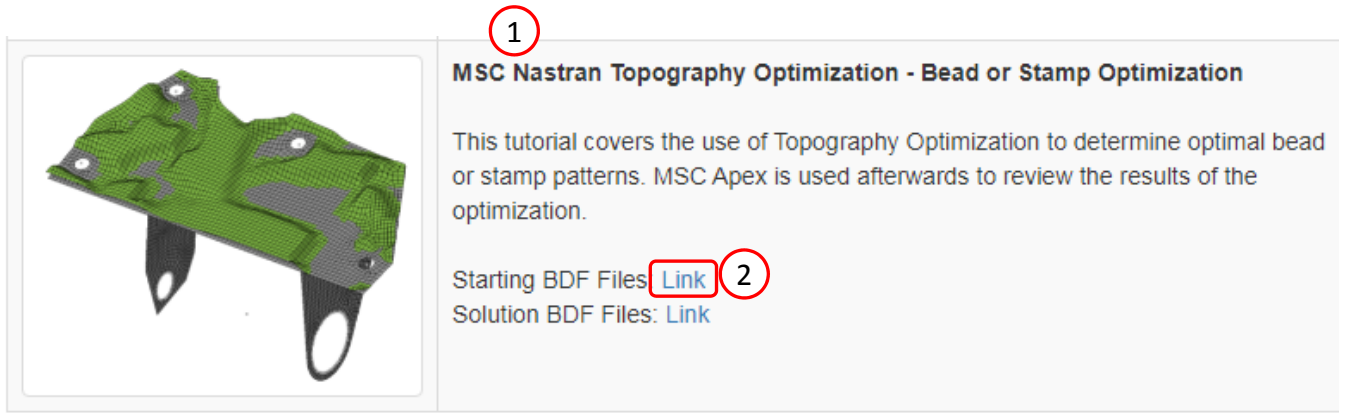
1. Click on the indicated link

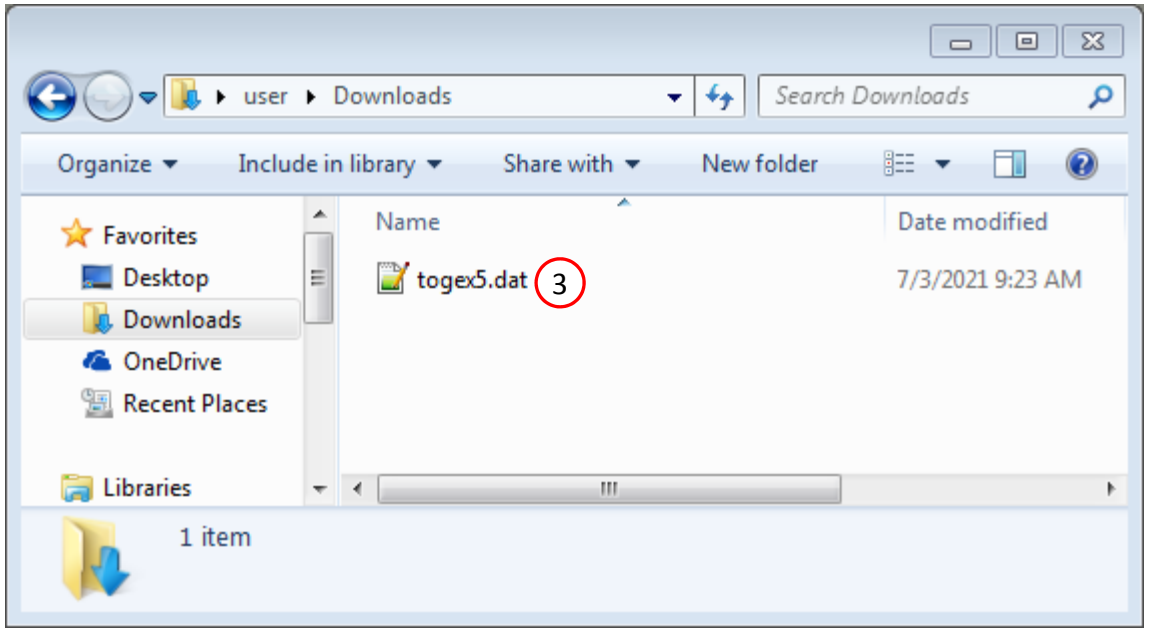
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

Obtain Starting Files

1. Find the indicated example
2. Click Link
3. The starting file has been downloaded

- When starting the procedure, all the necessary BDF files must be collected together.





Open the Correct Page

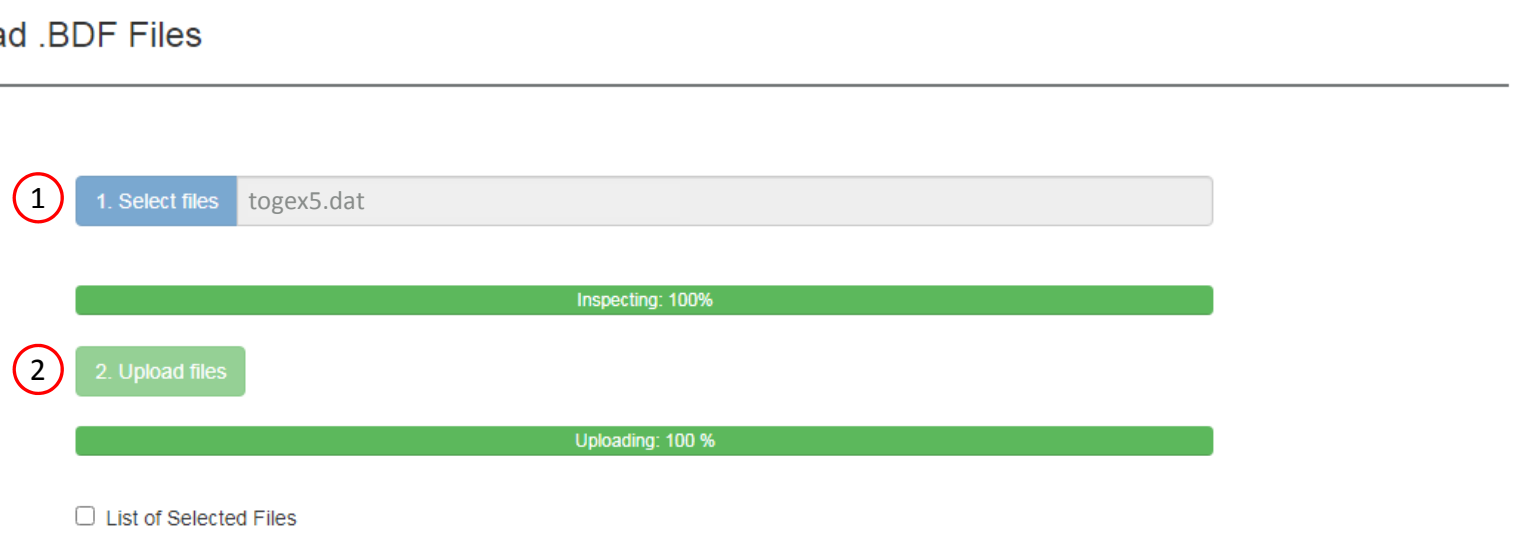
1. Click on the indicated link

- MSC Nastran can perform many optimization types. The SOL 200 Web App includes dedicated web apps for the following:
  - Optimization for SOL 200 (Size, Topology, Topometry, Topography, Local Optimization, Sensitivity Analysis and Global Optimization)
  - Multi Model Optimization
  - Machine Learning
- The web app also features the HDF5 Explorer, a web application to extract results from the H5 file type.

Upload BDF Files

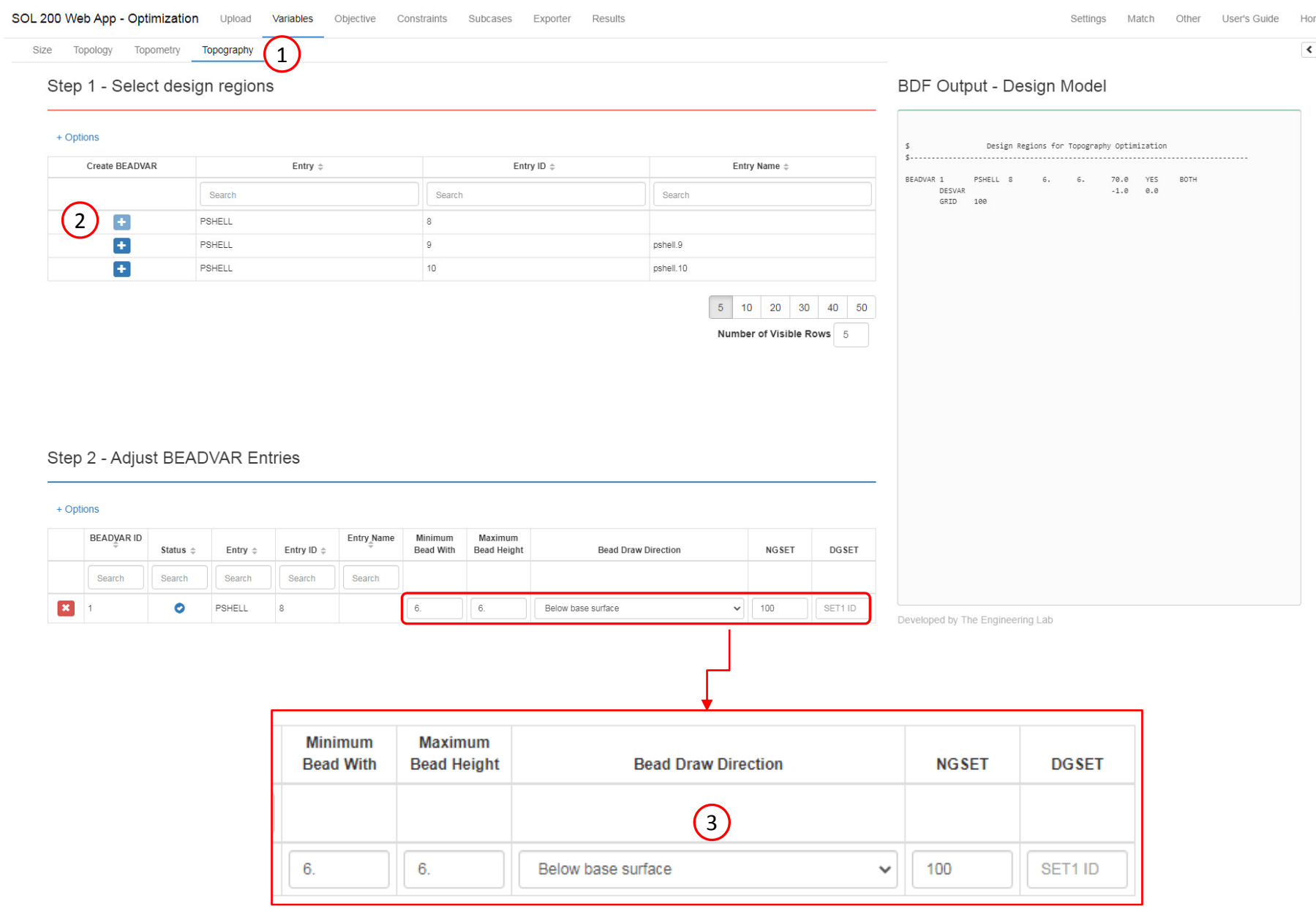
1. Click 1. Select Files and select togex5.dat
2. Click Upload Files

- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.



Create Design Region

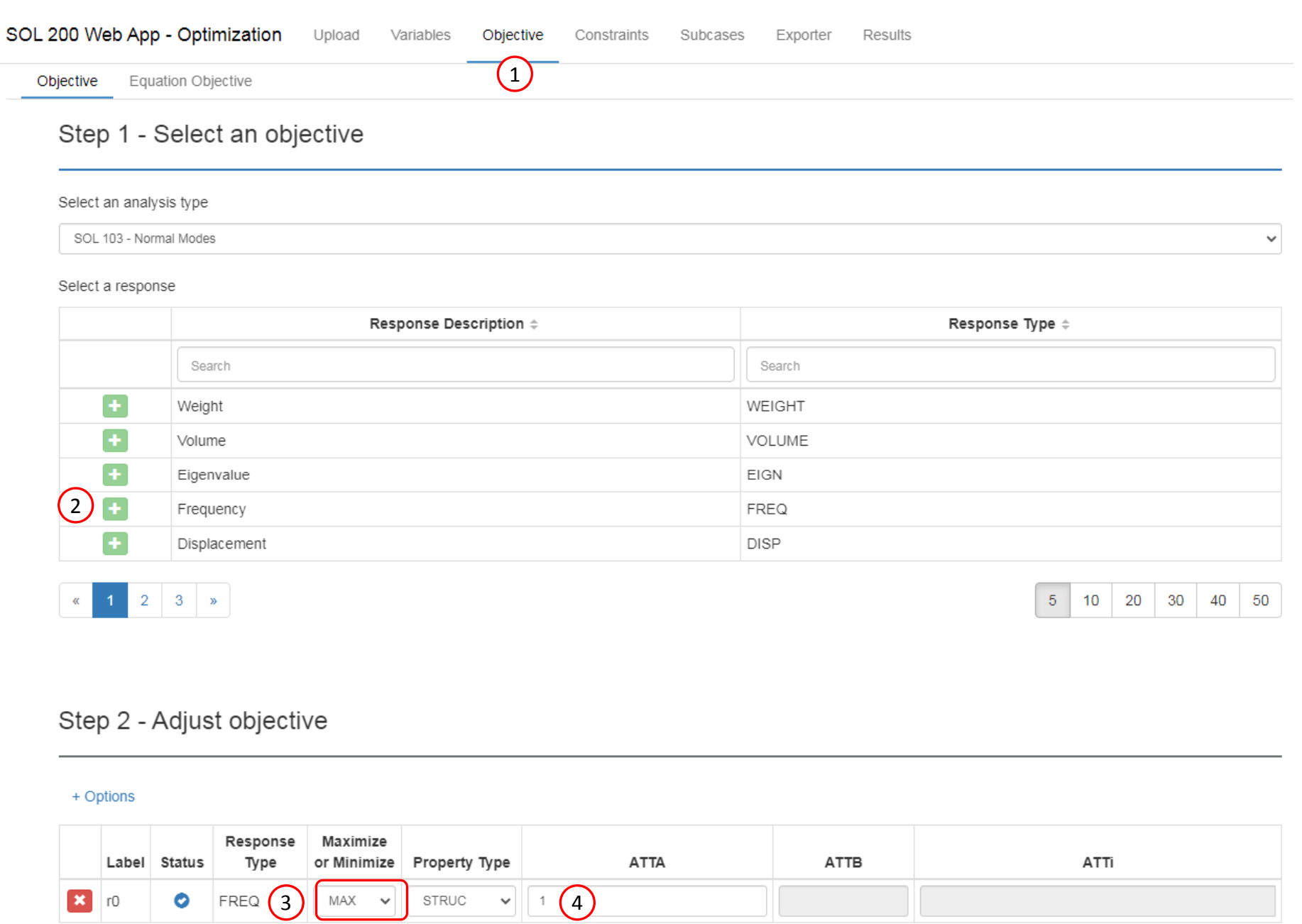
1. Click Topography
2. Click on the plus (+) icons to set PSHELL 8 as a Design Region
3. Set the following for the design region
   - Minimum Bead Width: 6
   - Maximum Bead Height: 6
   - Bead Draw Direction: Below base surface
   - NGSET: 100



Create Design Objective

1. Click on Objective
2. Select the plus (+) icon for frequency
3. To maximize the objective, set Maximize or Minimize option to MAX
4. To specify the mode number, set ATTA to 1

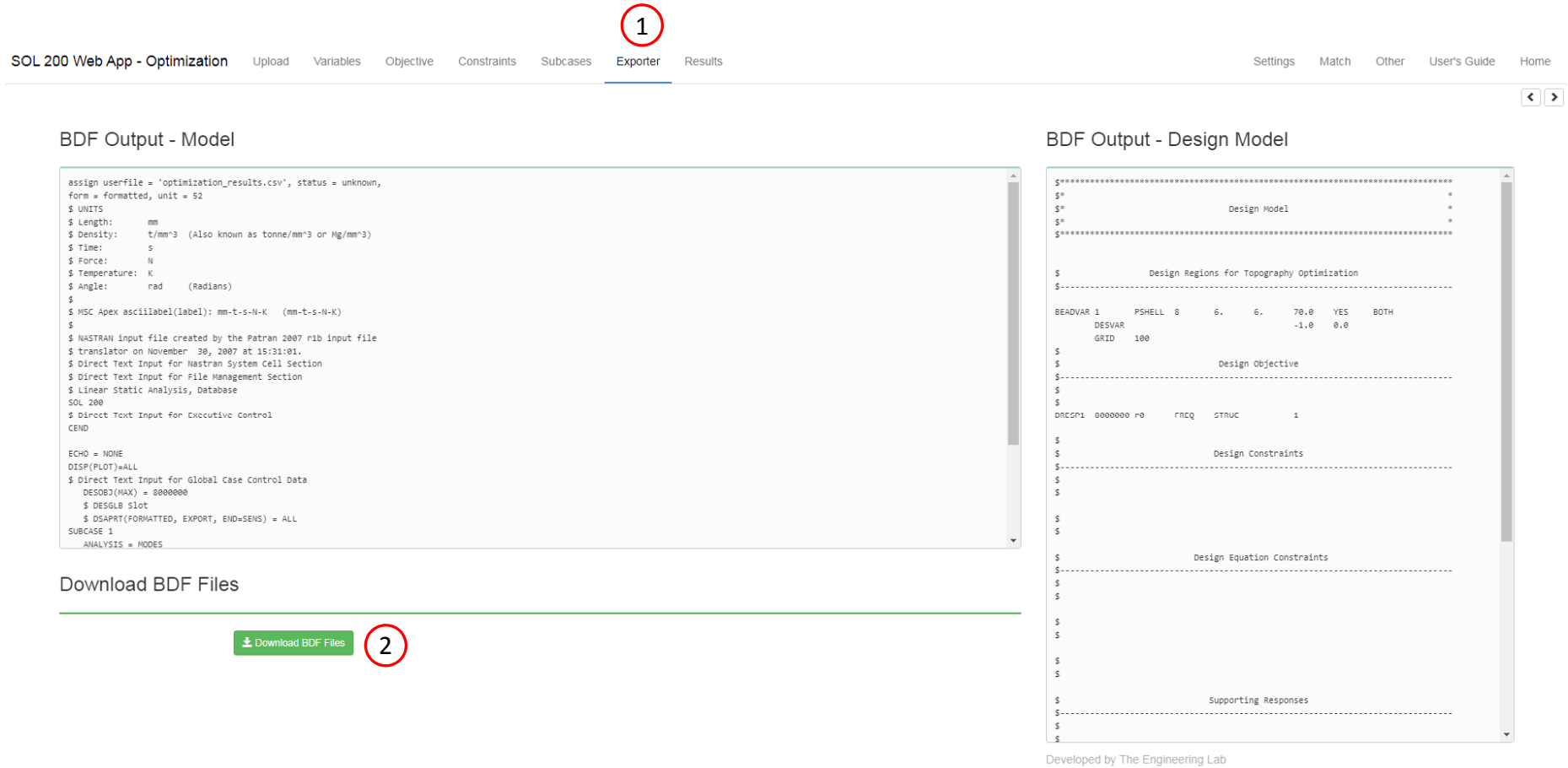
- Topography optimization (bead or stamp optimization) is used to maximize the 1st natural frequency.



Export New BDF Files

1. Click on Exporter
2. Click on Download BDF Files

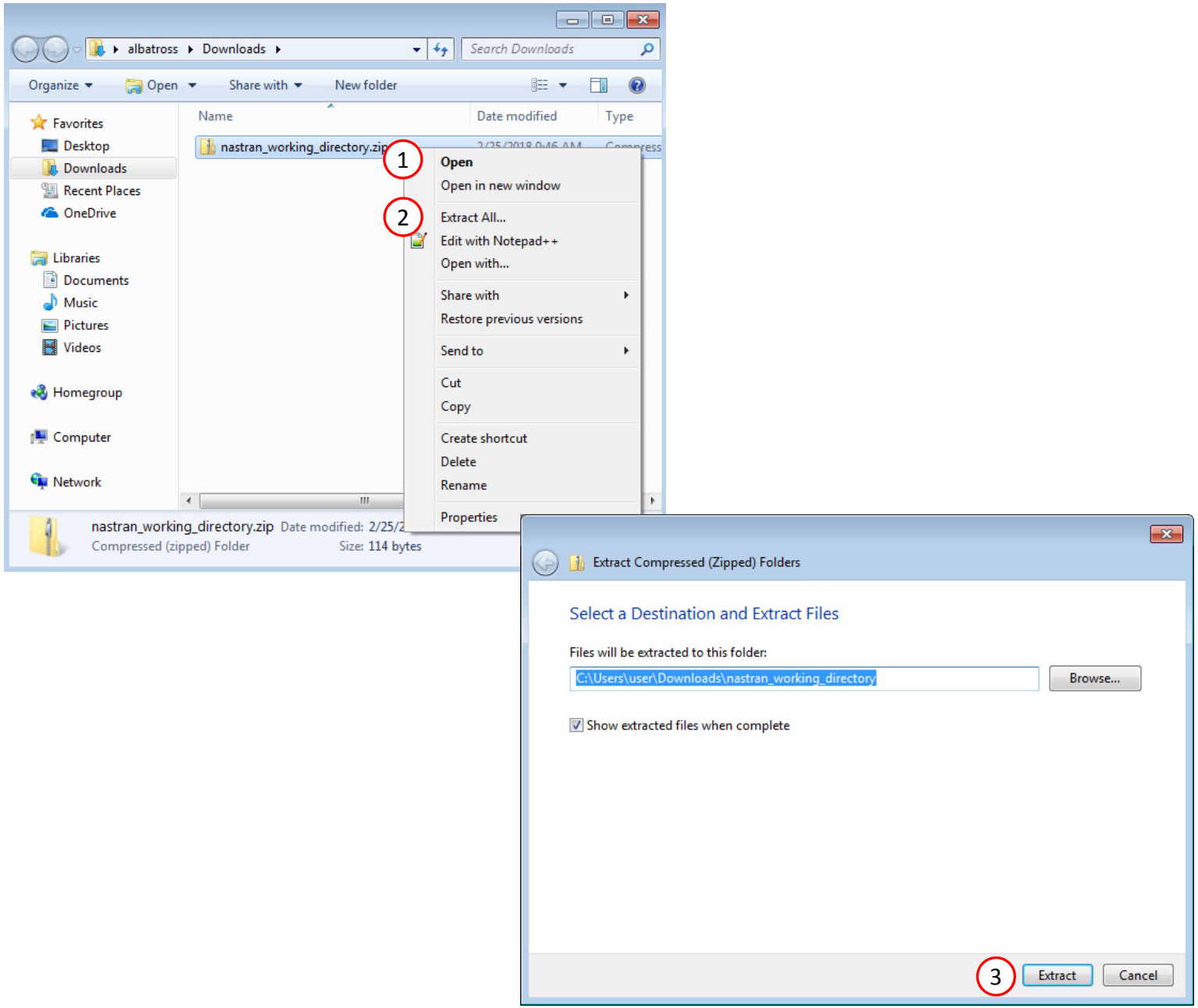
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



Perform the Optimization with Nastran SOL 200

1. A new .zip file has been downloaded
2. Right click on the file
3. Click Extract All
4. Click Extract on the following window

- Always extract the contents of the ZIP file to a new, empty folder.



Perform the Optimization with Nastran SOL 200

1. Inside of the new folder, double click on Start MSC Nastran
2. Click Open, Run or Allow Access on any subsequent windows
3. MSC Nastran will now start

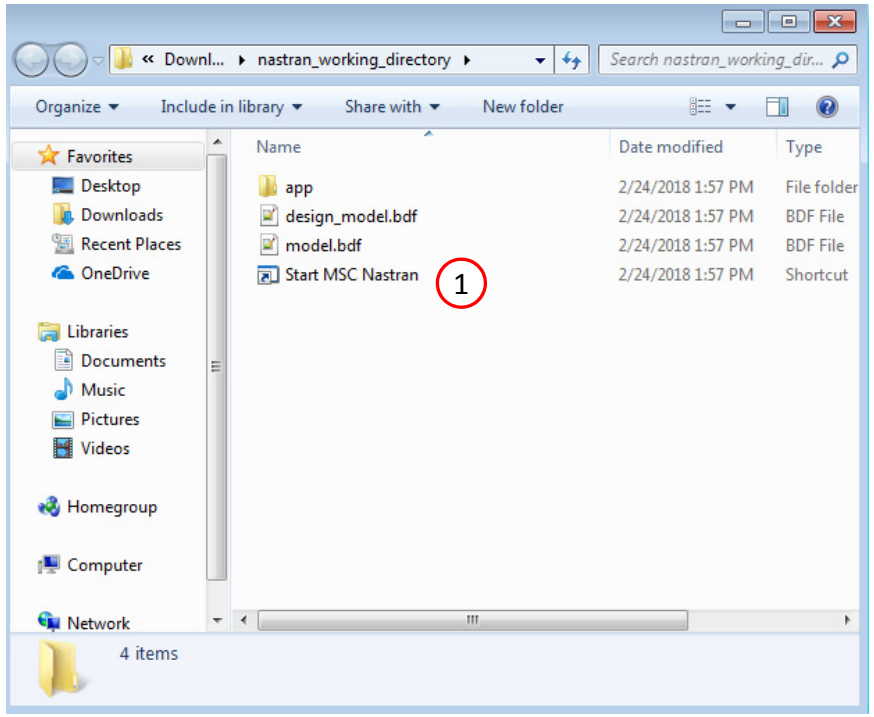
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the remote machine. 3) After completion, copy the BDF, F06, LOG, H5 files to the local machine. 4) Click "Start MSC Nastran" to display the results.

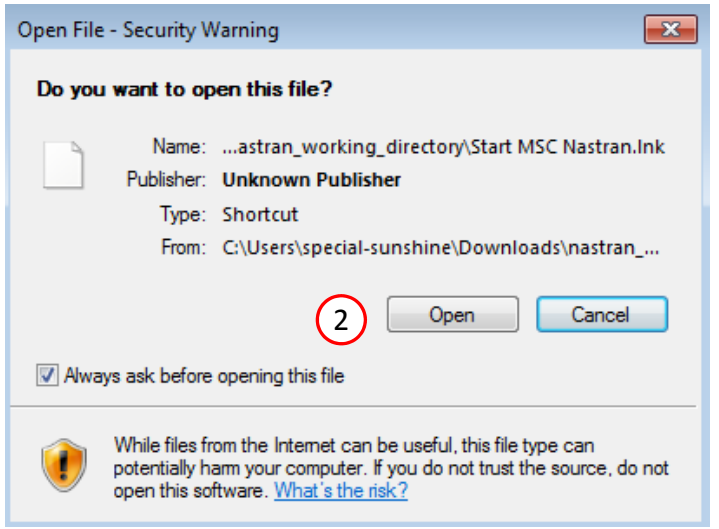
Using Linux?

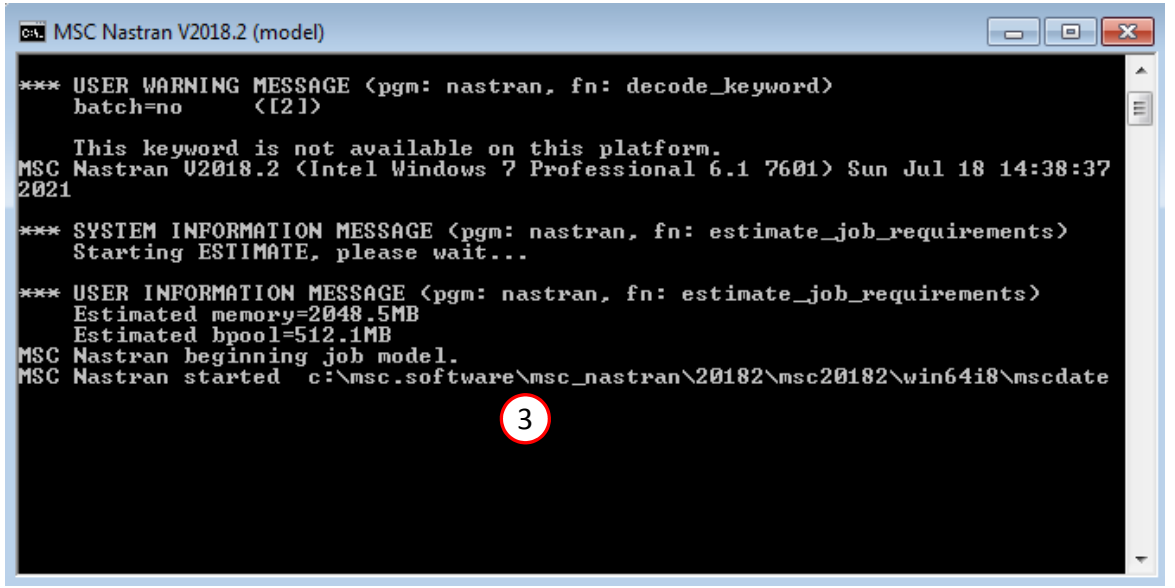
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
cd ./nastran_working_directory
3) Use this command to start the process
./Start_MSC_Nastran.sh

In some instances, execute permission must be granted to the directory. Use this command. This command assumes you are one folder level up.

sudo chmod -R u+x ./nastran_working_directory



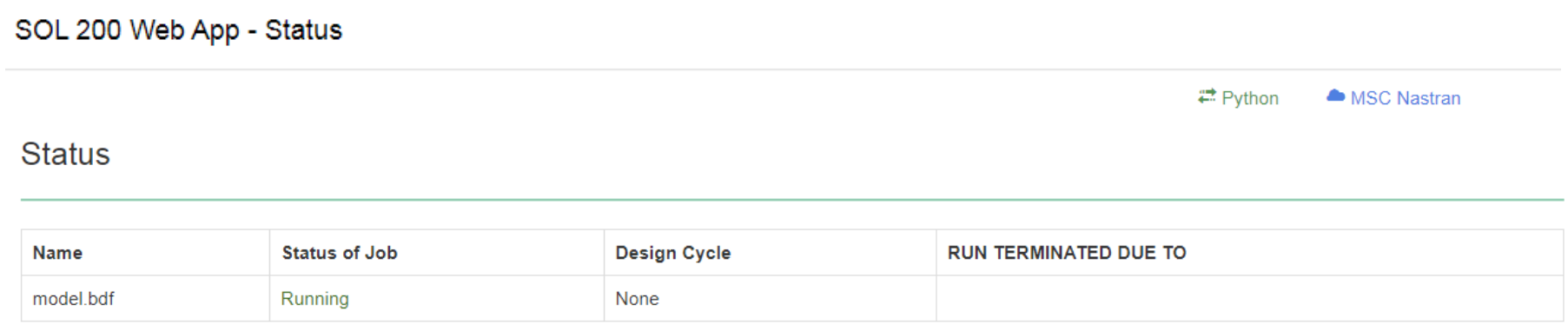




Status

1. While MSC Nastran is running, a status page will show the current state of MSC Nastran

- The status of the MSC Nastran job is reported on the Status page. Note that Windows 7 users will experience a delay in the status updates. All other users of Windows 10 and Red Hat Linux will see immediate status updates.

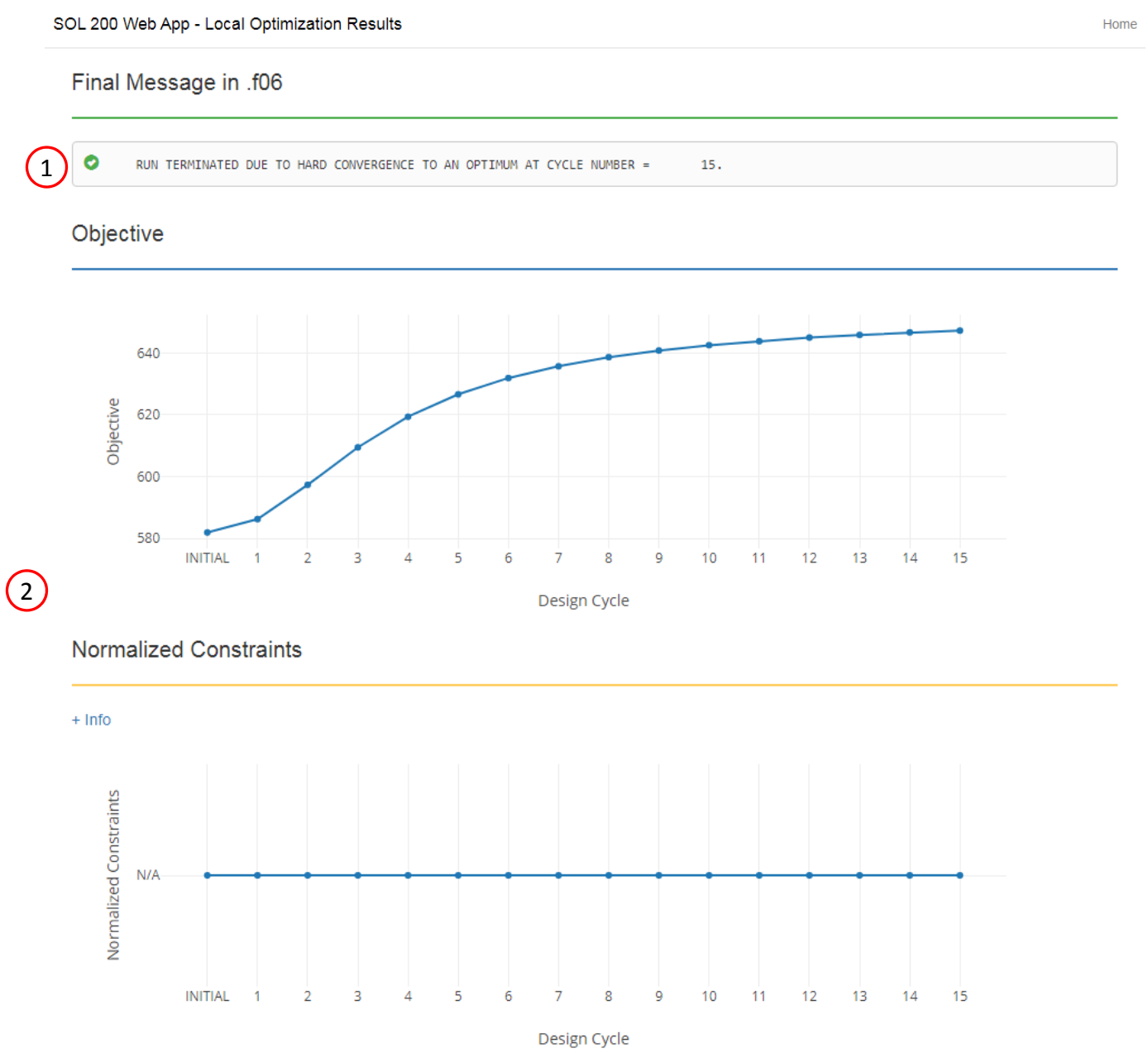


Review Optimization Results

After MSC Nastran is finished, the results will be automatically uploaded.

1. Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
2. The final value of objective and normalized constraints can be reviewed.

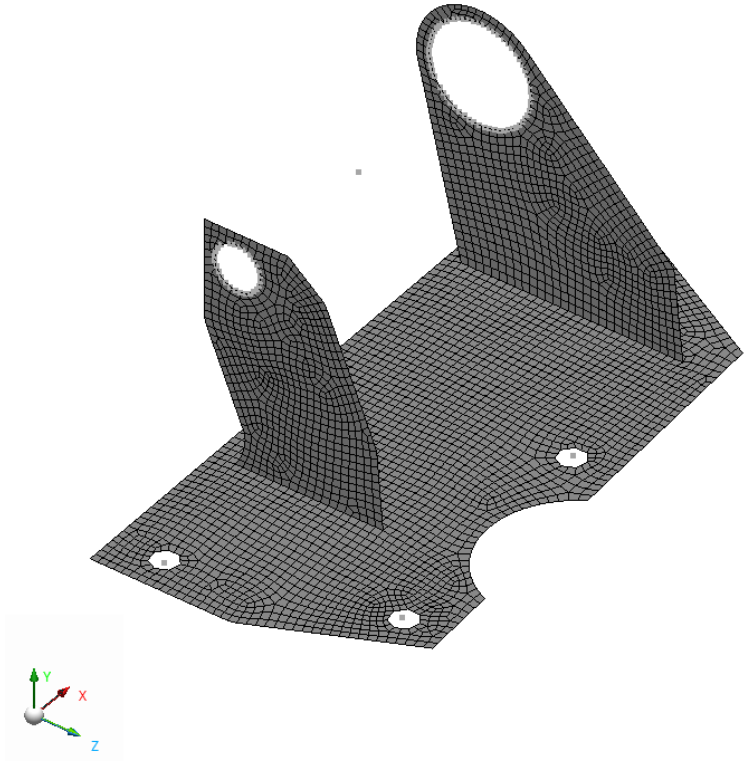
- This optimization did not include any design constraints and is why the Normalized Constraints plot shows N/A (Not Available).



Results

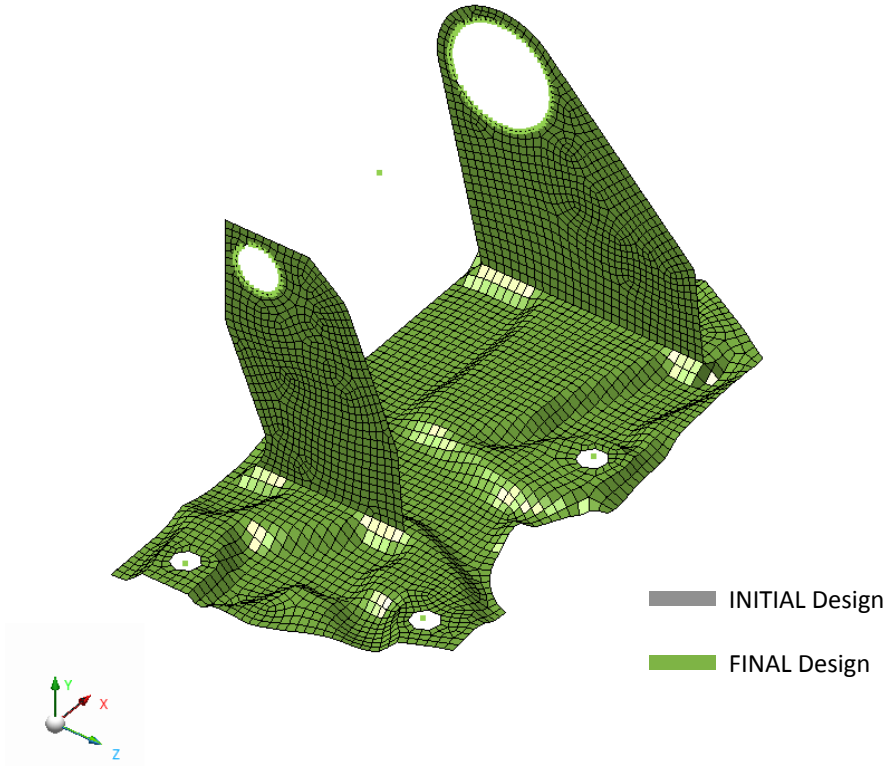
Before Optimization

- 1st Natural Frequency: 581.9 Hz

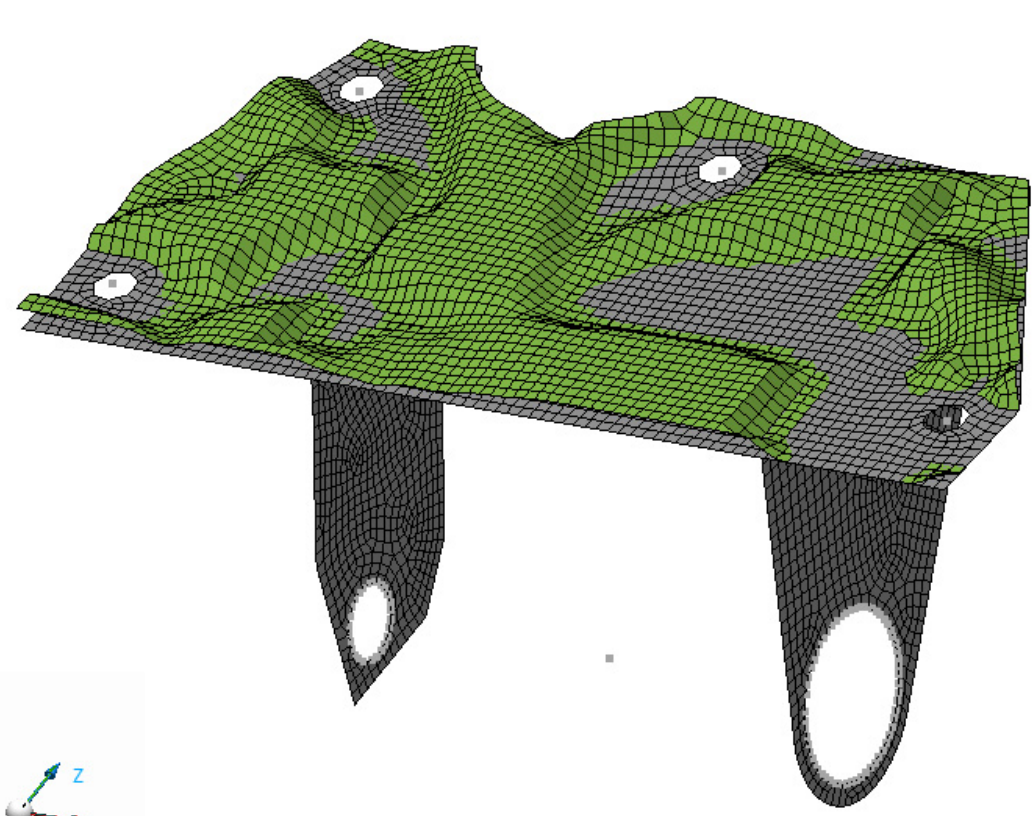


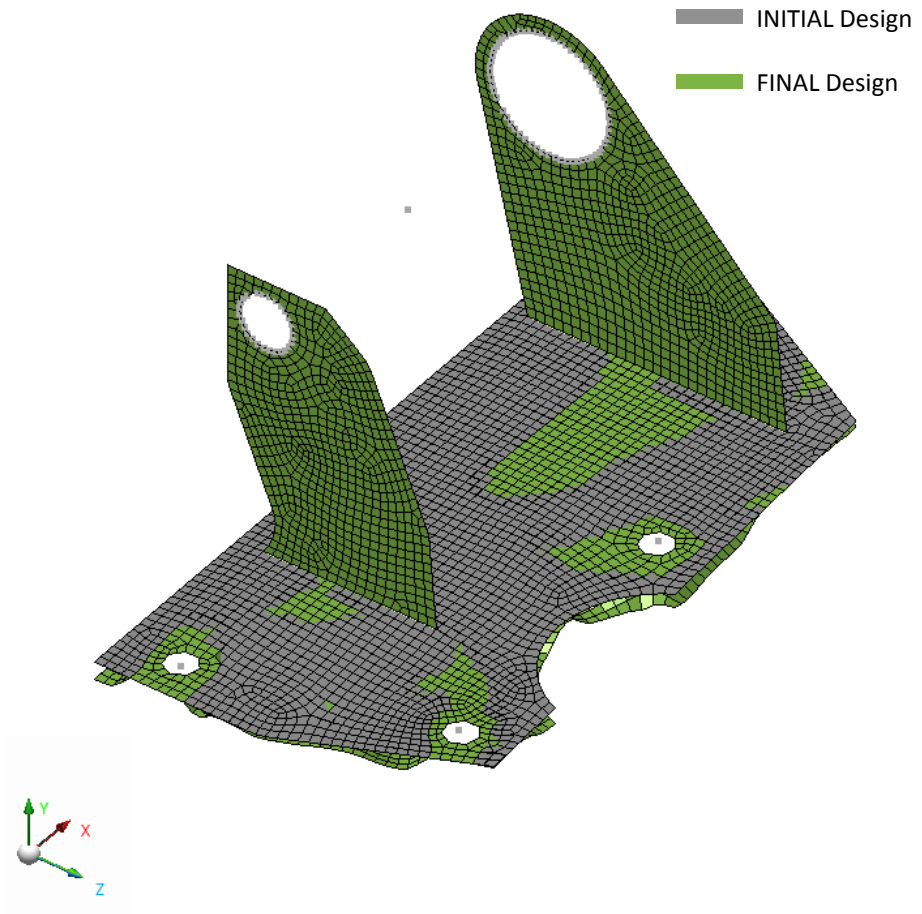
After Optimization

- 1st Natural Frequency: 647.22 Hz



Results



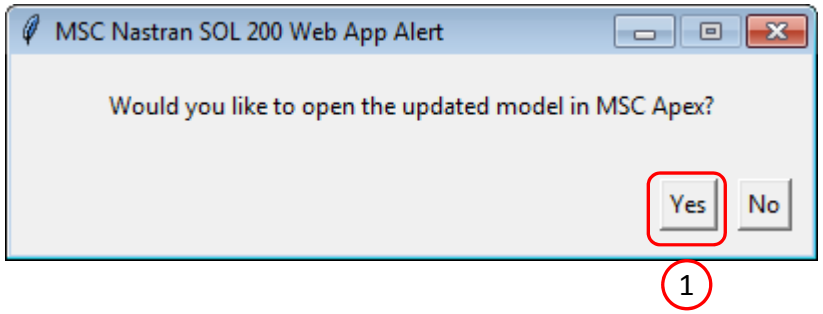


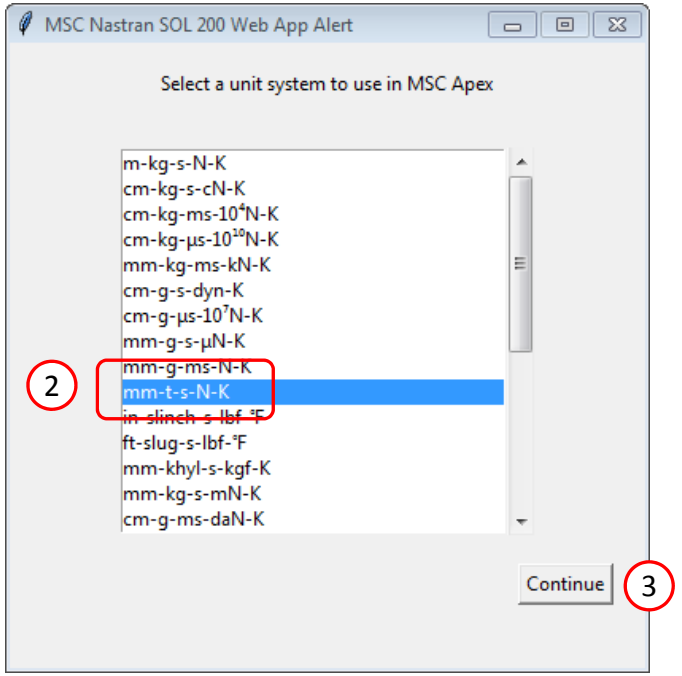
The following requires MSC Apex 2021 (CLR 782254) or newer. Only official releases of MSC Apex are supported. Development, Alpha and Beta versions are not supported.

Review the optimization results MSC Apex

1. When asked to open MSC Apex, click Yes
2. Select this unit system: mm-t-s-N-K
3. Click Continue

MSC Apex will now be opened

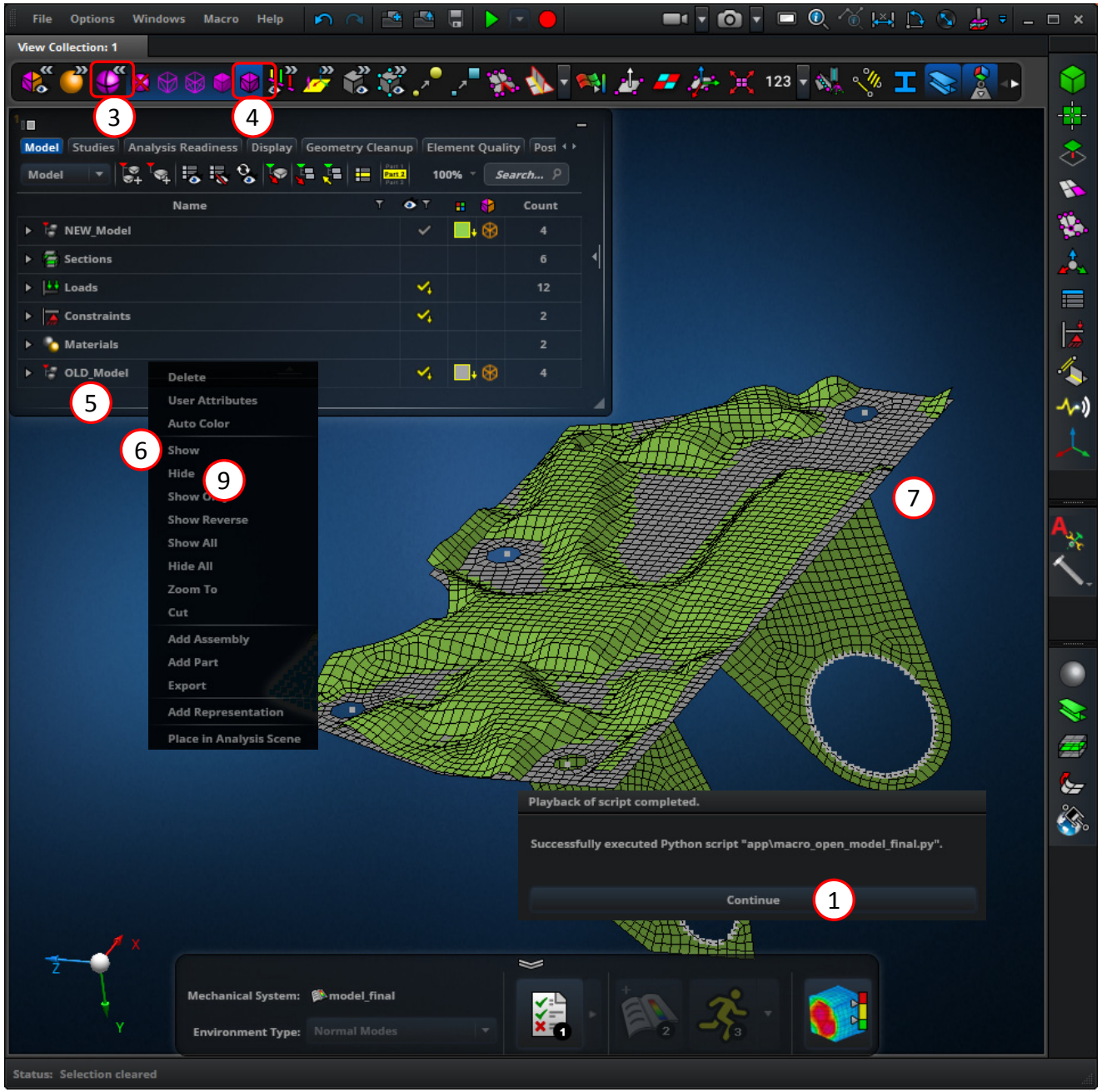




Review the optimization results MSC Apex

After 2 MSC Apex windows are opened, do the following for the MSC Apex window displaying the green model (final design):

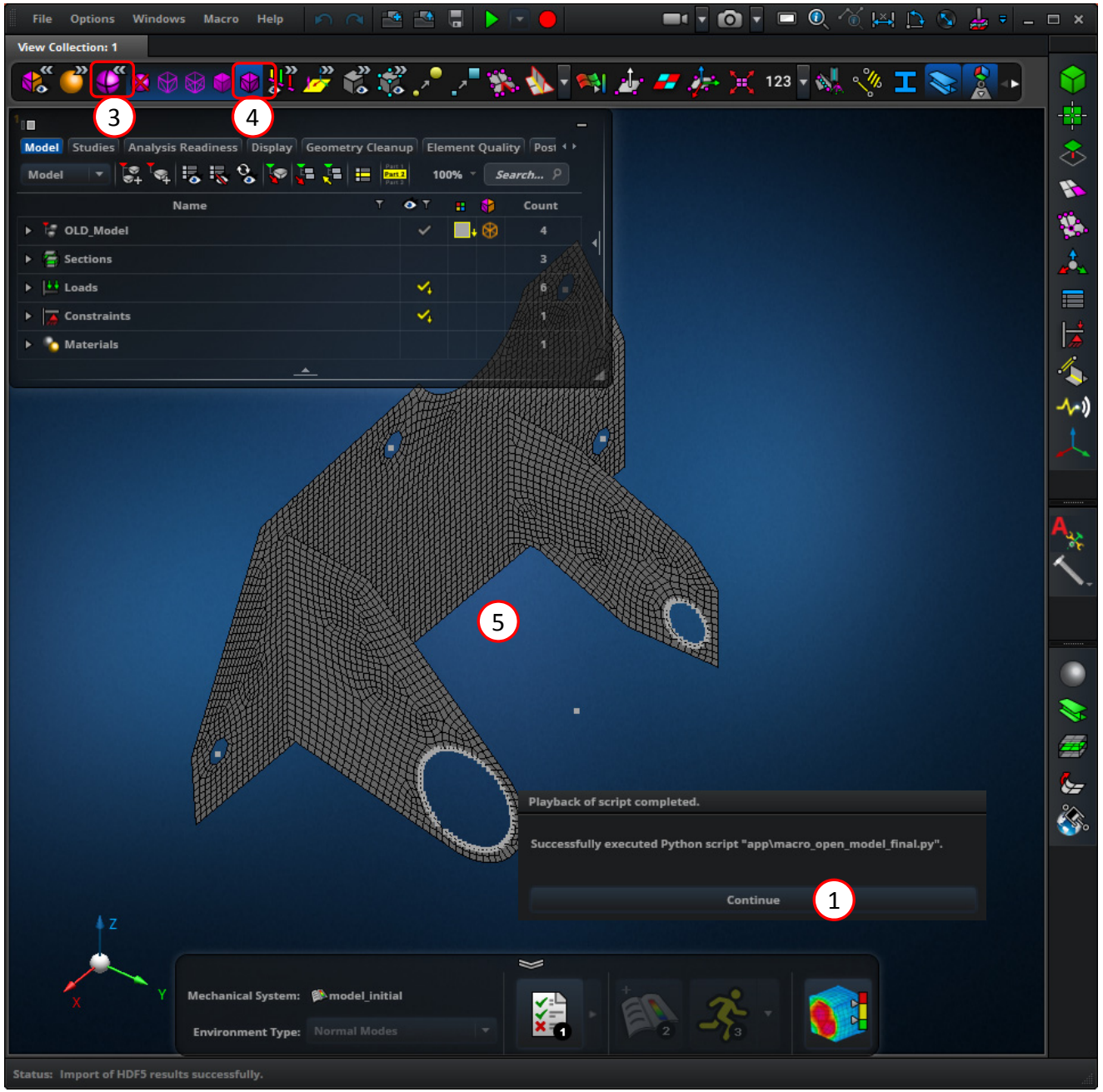
1. Click Continue
2. Press the following keys on the keyboard (Windows Logo + Right Arrow) and the window will be positioned on the right side of the screen
3. Click FEM Render Styles
4. Click Shaded with Edges
5. Right click on OLD_Model
6. Click Show
7. Now the original model is superimposed with the new model (Hold down the middle mouse button and move the mouse to rotate the model)
8. Right click on OLD_Model
9. Click Hide, the original mode is hidden and only the new model should be displayed



Review the optimization results MSC Apex

For the MSC Apex window displaying the gray model (initial design):

1. Click Continue
2. Press the following keys on the keyboard (Windows Logo + Left Arrow) and the window will be positioned on the left side of the screen
3. Click FEM Render Styles
4. Click Shaded with Edges
5. The initial design is now visible



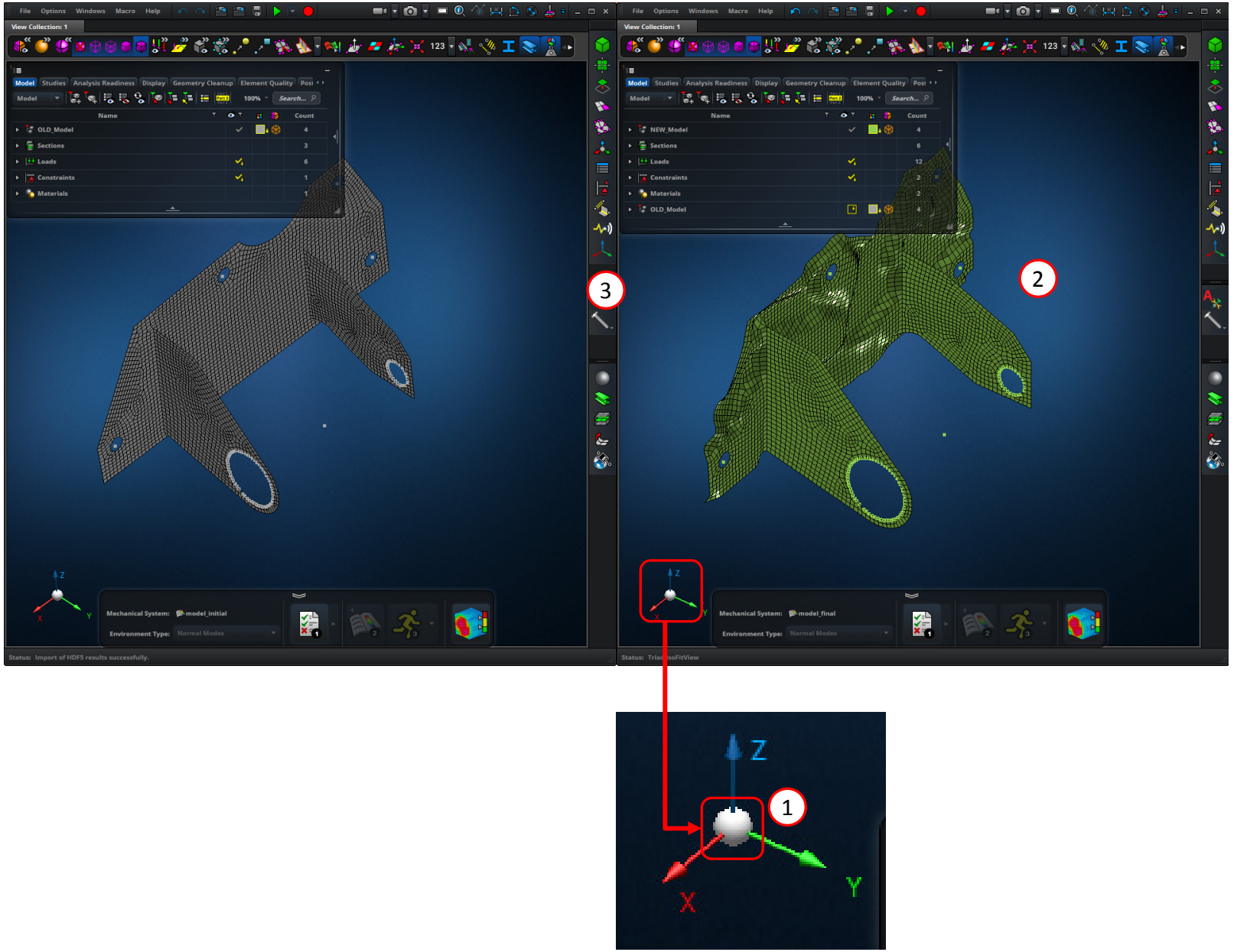
Review the optimization results MSC Apex

1. For the MSC Apex window containing the green model (final design), click on the white sphere of the triad and the model will be restored to its original orientation
2. Click both the left and right mouse keys to fit the model in the window
3. The initial and final designs should be displayed side by side

- The Post Process functionality is available if an H5 file type was generated by MSC Nastran. MSC Nastran 2016 or newer generates the H5 file type.

Initial Design

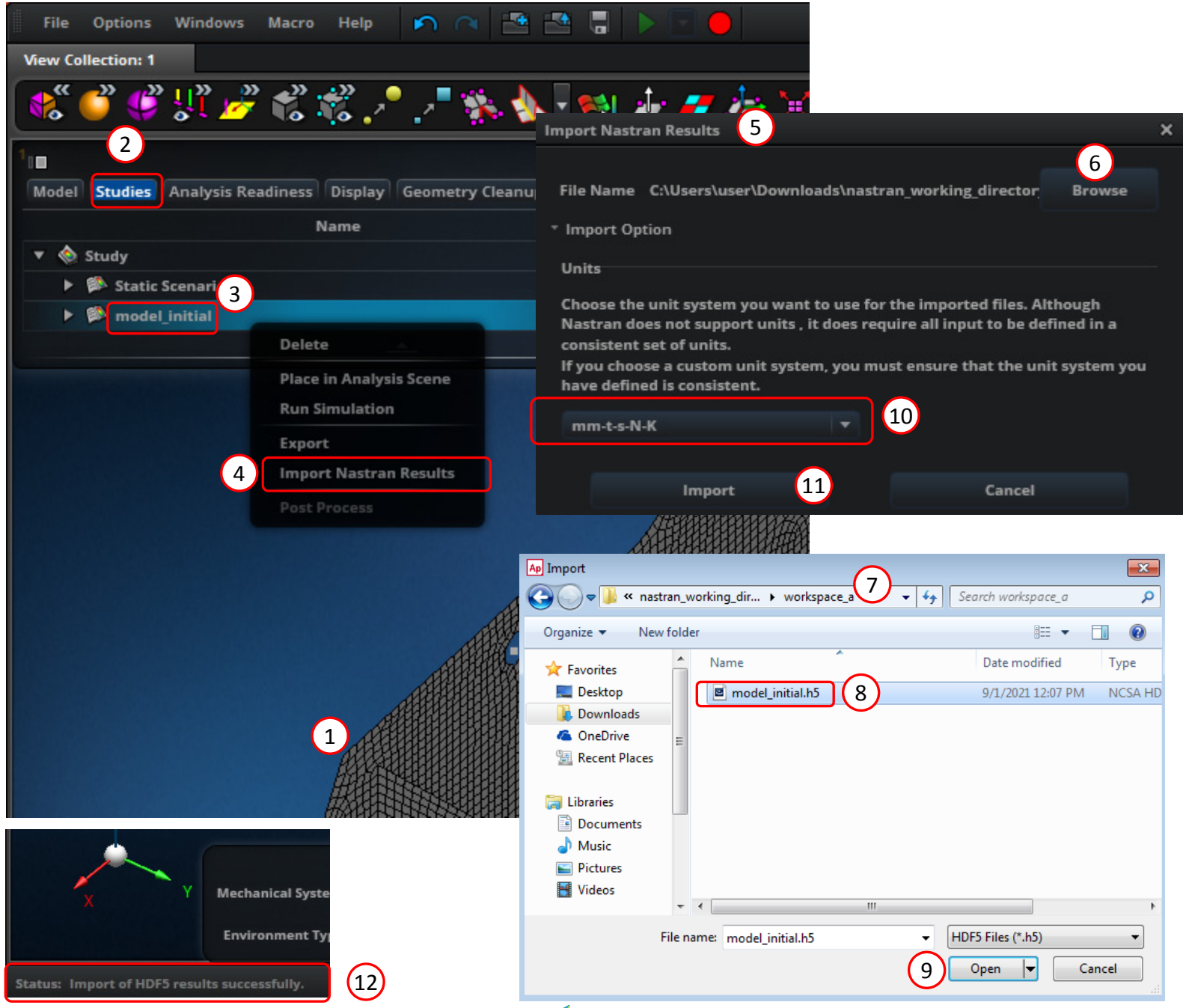
Final Design



Review the optimization results MSC Apex

To view the responses in MSC Apex, the H5 file must be manually imported as follows.

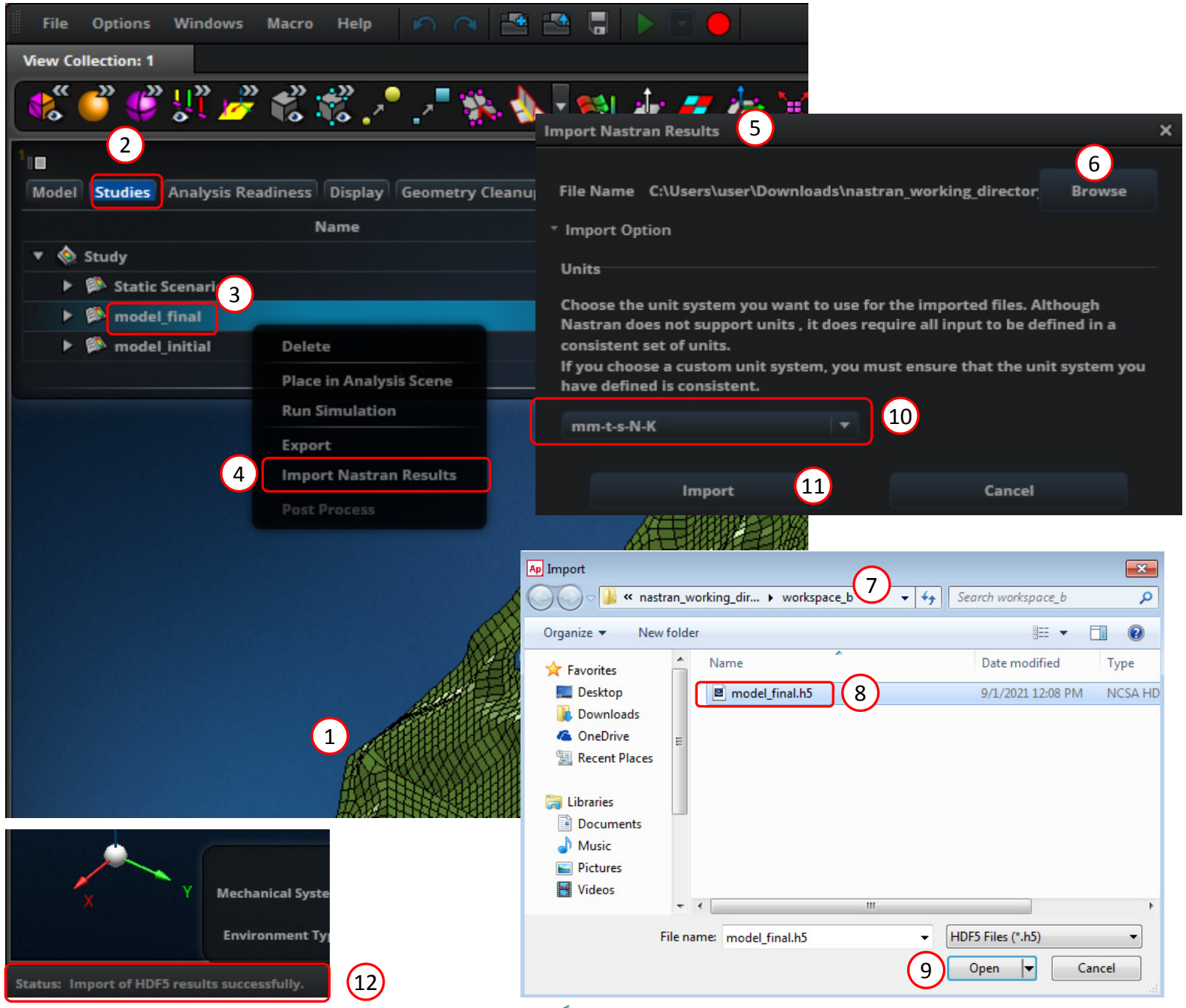
1. Ensure the MSC Apex window contains the INITIAL design (grey model)
2. In the model browser, select the tab titled Studies
3. Right click on the branch named model_initial
4. Click Import Nastran Results
5. A new window is opened and is named Import Nastran Results
6. Click Browse
7. Navigate to the directory named workspace_a
8. Select model_initial.h5
9. Click Open
10. Select the appropriate units
11. Click Import
12. Refer to the bottom left corner of the MSC Apex window. The responses have been successfully imported if the message reads “Import of HDF5 results successfully.”



Review the optimization results MSC Apex

To view the responses in MSC Apex, the H5 file must be manually imported as follows.

1. Ensure the MSC Apex window contains the FINAL design (green model)
2. In the model browser, select the tab titled Studies
3. Right click on the branch named model_final
4. Click Import Nastran Results
5. A new window is opened and is named Import Nastran Results
6. Click Browse
7. Navigate to the directory named workspace_b
8. Select model_final.h5
9. Click Open
10. Select the appropriate units
11. Click Import
12. Refer to the bottom left corner of the MSC Apex window. The responses have been successfully imported if the message reads “Import of HDF5 results successfully.”

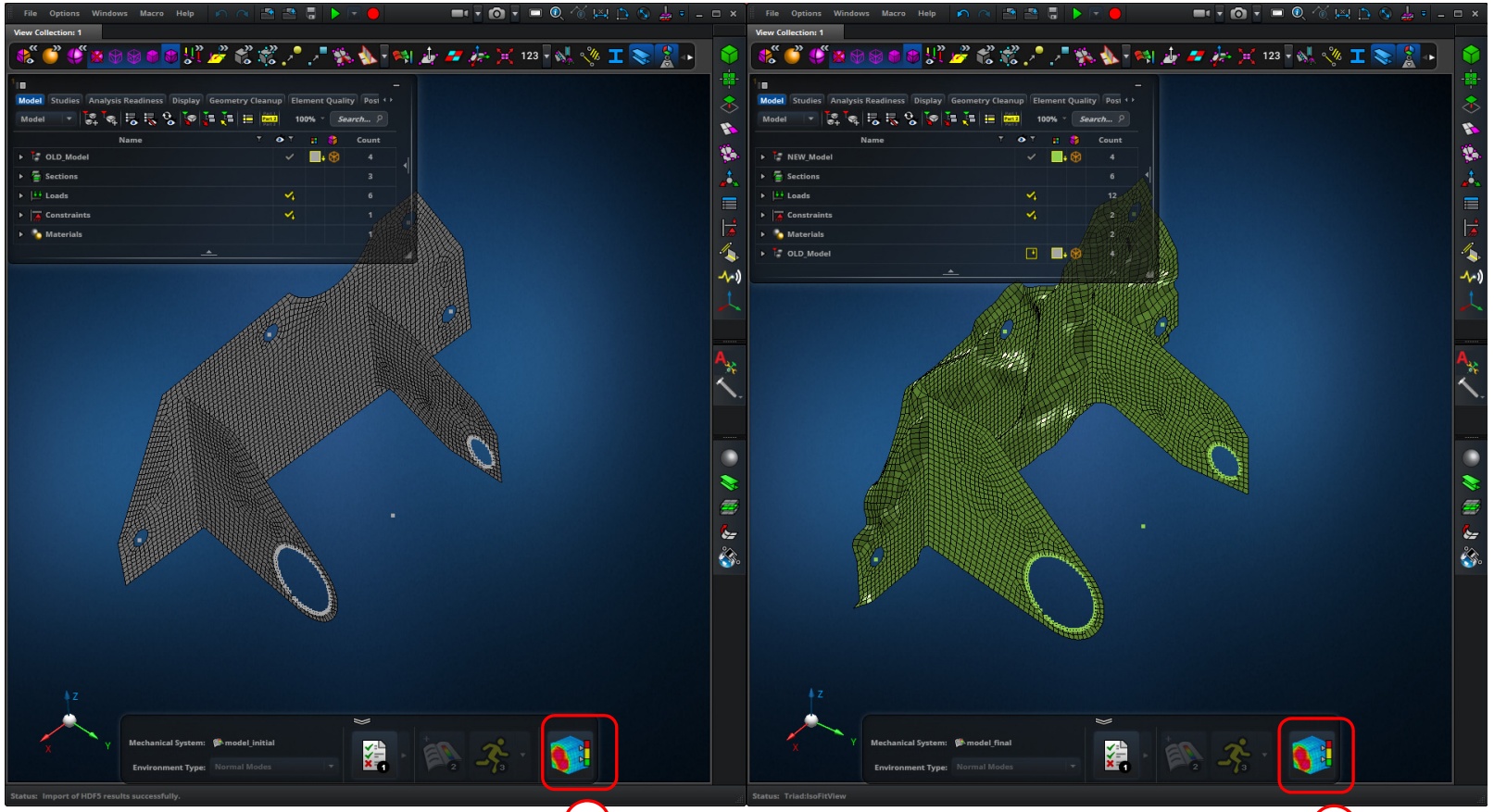


Review the optimization results MSC Apex

1. Click the Post Process button
2. Click the Post Process button

Initial Design

Final Design



Review the optimization results MSC Apex

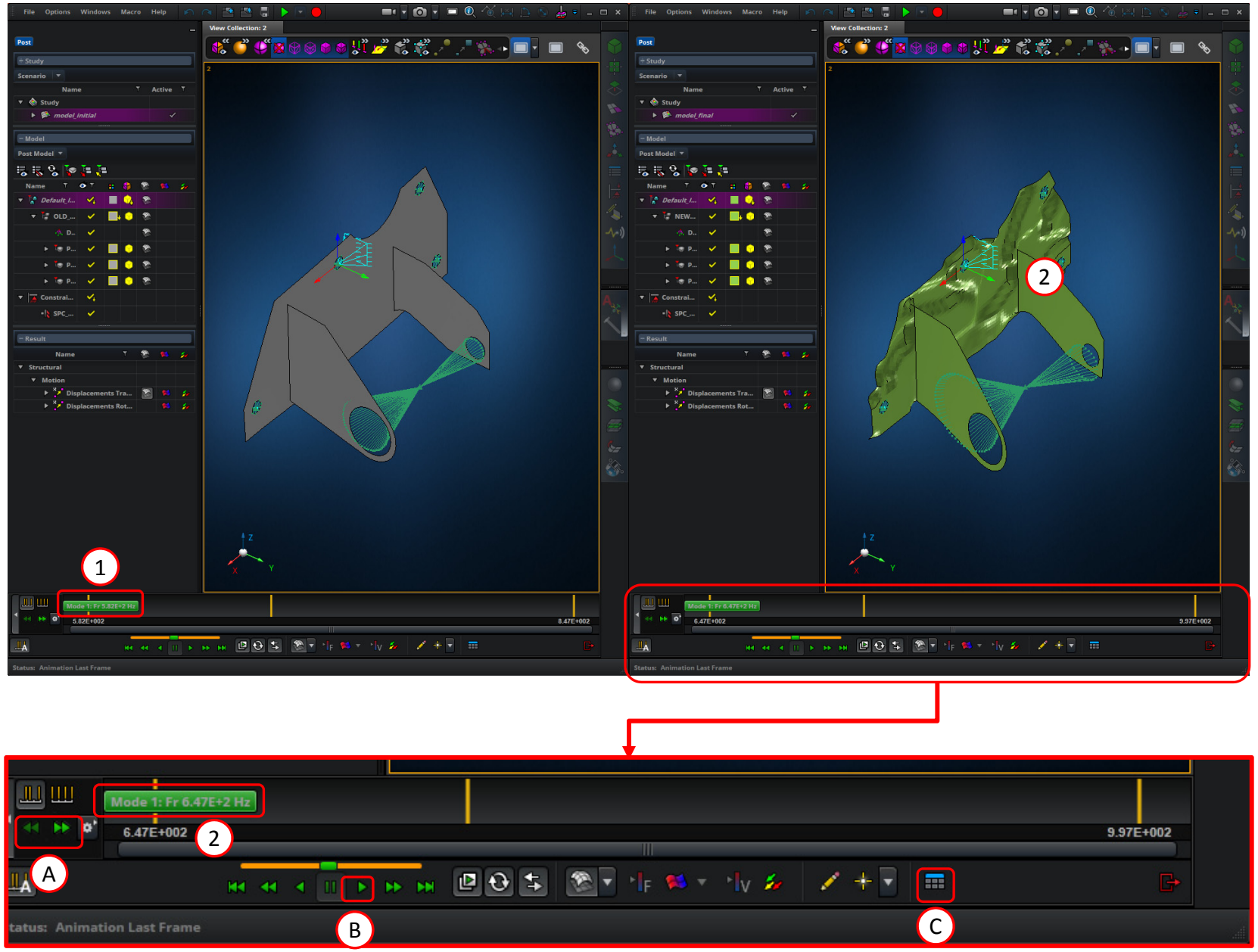
The objective of this optimization was to maximize the 1st natural frequency. MSC Apex is used to confirm the 1st natural frequency has been increased.

1. For the initial design, the indicated frequency of mode 1 is approximately 582 Hz
2. For the final design, the indicated frequency of mode 1 is approximately 647 Hz

The 1st natural frequency has been increased successfully.

The following are noteworthy tools to further review the results in MSC Apex

A. Switch modes
B. Animate the mode shape
C. Display a table containing more information about the modes



End of Tutorial

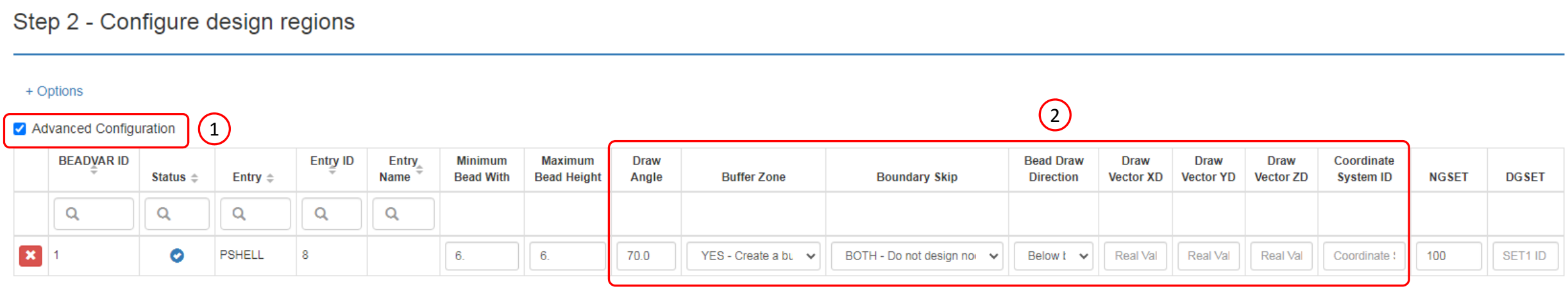
Appendix

Appendix Contents

- Frequently Asked Questions
  - How do I access more configuration options for Topography optimization?
  - What MSC Apex and MSC Nastran versions are supported?
- Topology Optimization Workflows
- Topology Viewer

How do I access more configuration options for Topography optimization?

1. Mark the checkbox titled Advanced Configuration
2. This will display additional options to configure a topography design region



What MSC Apex and MSC Nastran versions are supported?

- MSC Nastran 2008 or newer is required to perform Topography Optimization.
- MSC Apex 2021 (CLR 782254) or newer is required to display the updated mesh in MSC Apex. Only official releases of MSC Apex are supported. Development, Alpha and Beta versions are not supported.
- MSC Nastran 2016 or newer is required to generate an H5 file. The H5 file is used by MSC Apex to display the results.