Workshop - MSC Nastran Topography Optimization - Bead or Stamp Optimization

AN MSC NASTRAN SOL 200 TUTORIAL

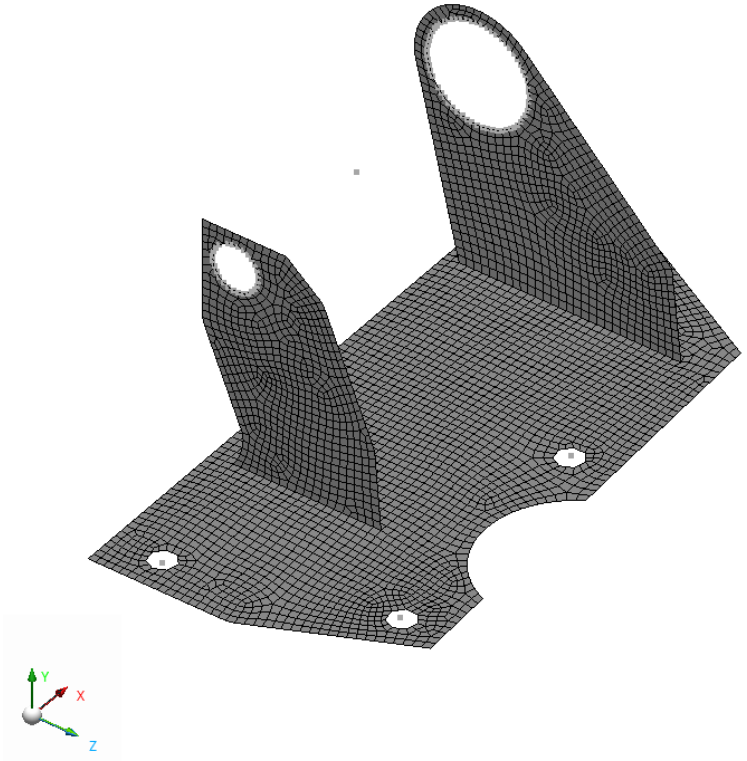
Questions? Email: christian@ the-engineering-lab.com

HEXAGON
Technology Partner

Goal: Use Nastran SOL 200 Optimization

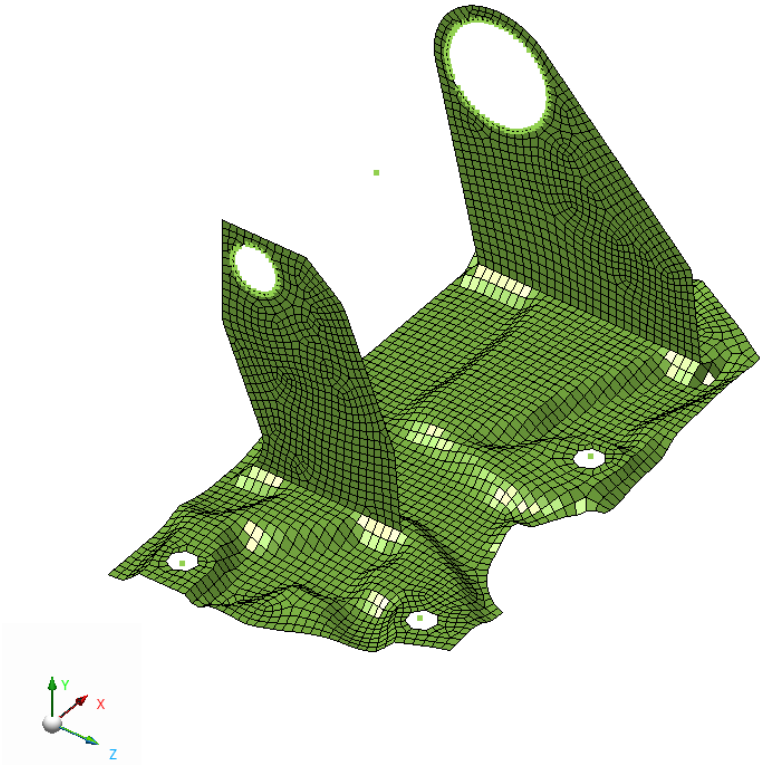
Before Optimization

- 1st Natural Frequency: 581.9 Hz

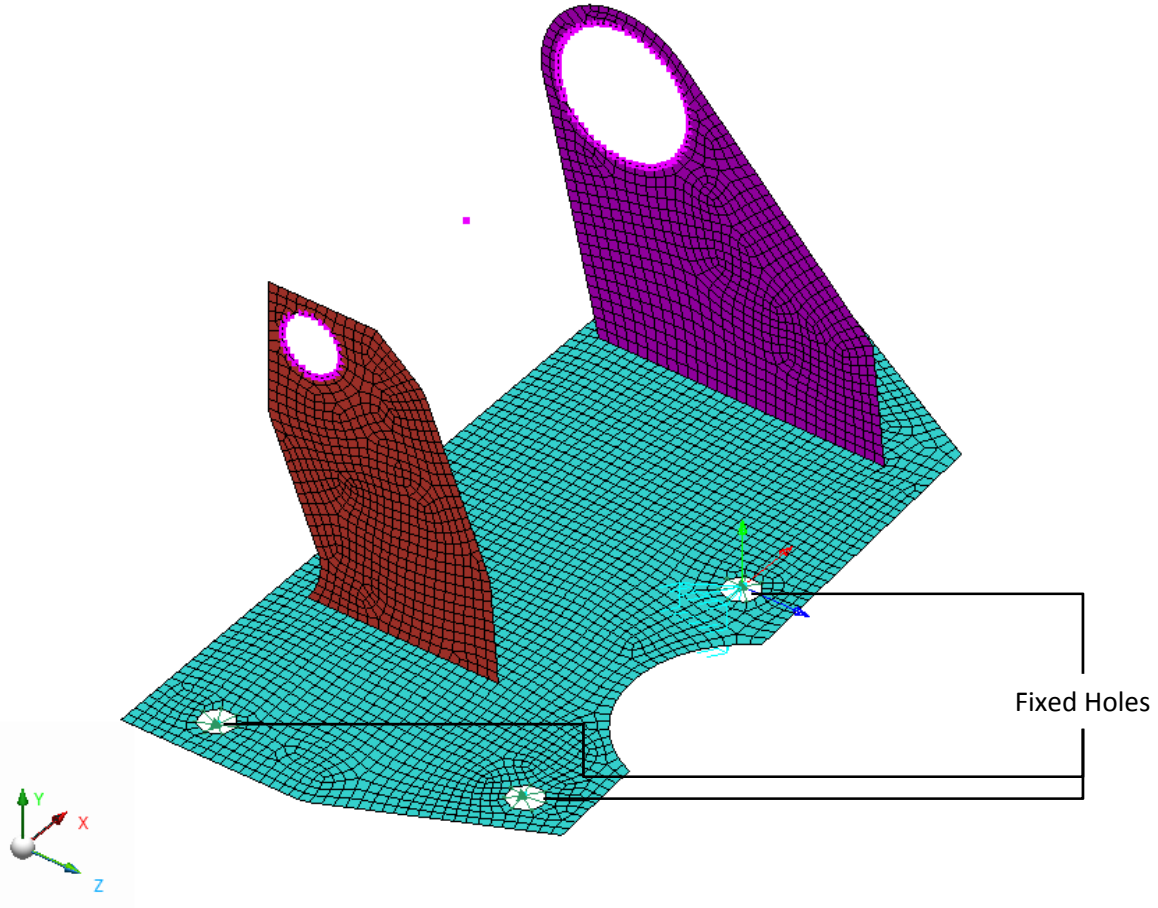


After Optimization

- 1st Natural Frequency: 647.22 Hz



Details of the structural model



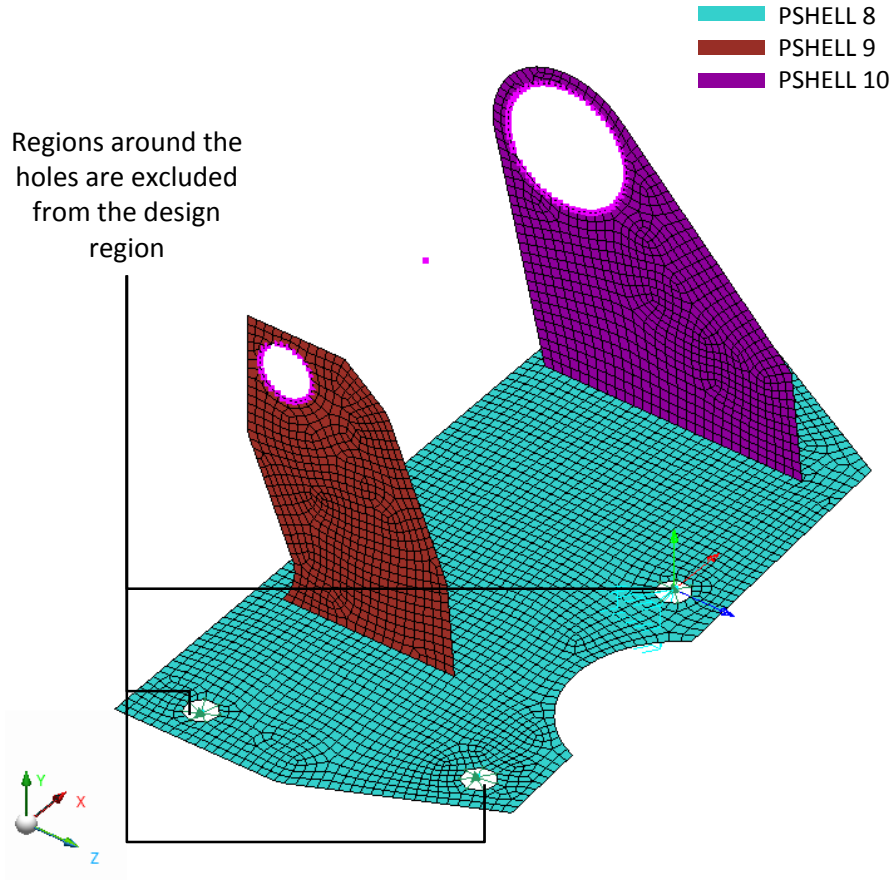
Optimization Problem Statement

Design Region/Variables

x1: PSHELL 8

Configuration:

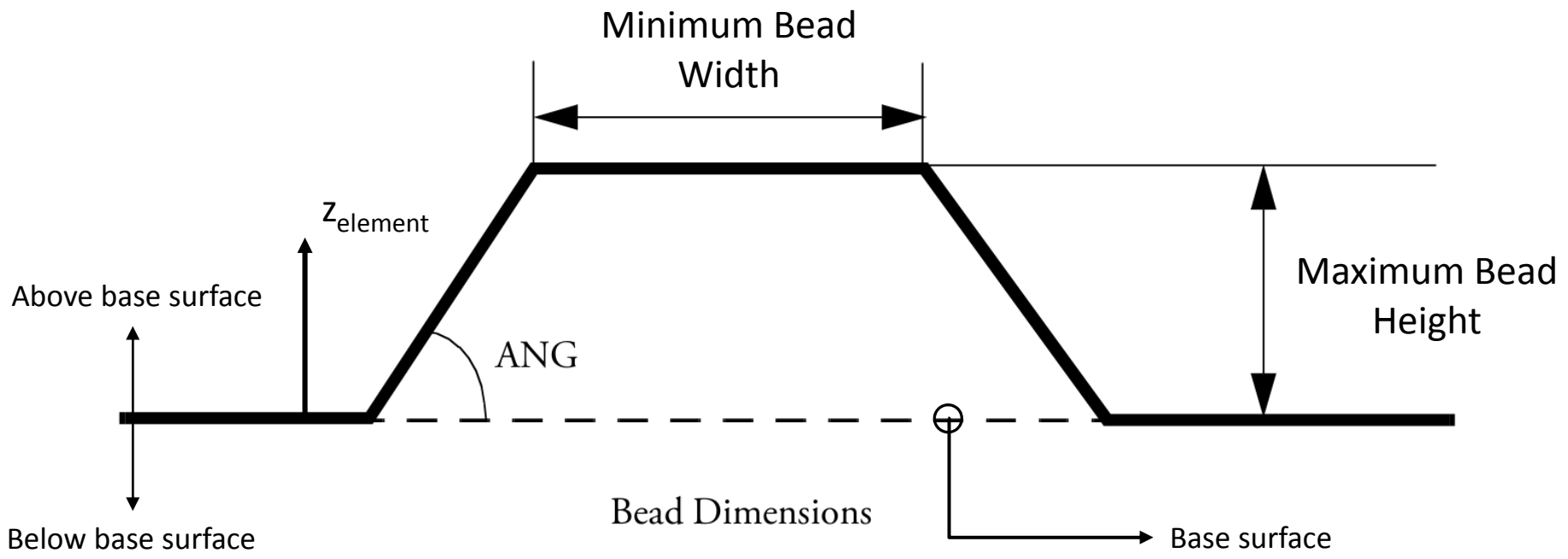
- Minimum Bead Width: 6
- Maximum Bead Height: 6
- Bead Draw Direction: Below base surface
- NGSET: 100
  - The NGSET field points to a SET1 entry that defines a list of nodes to exclude from the design region
  - The regions around the holes are excluded from the design region



Design Objective

r0: Maximize the 1st natural frequency

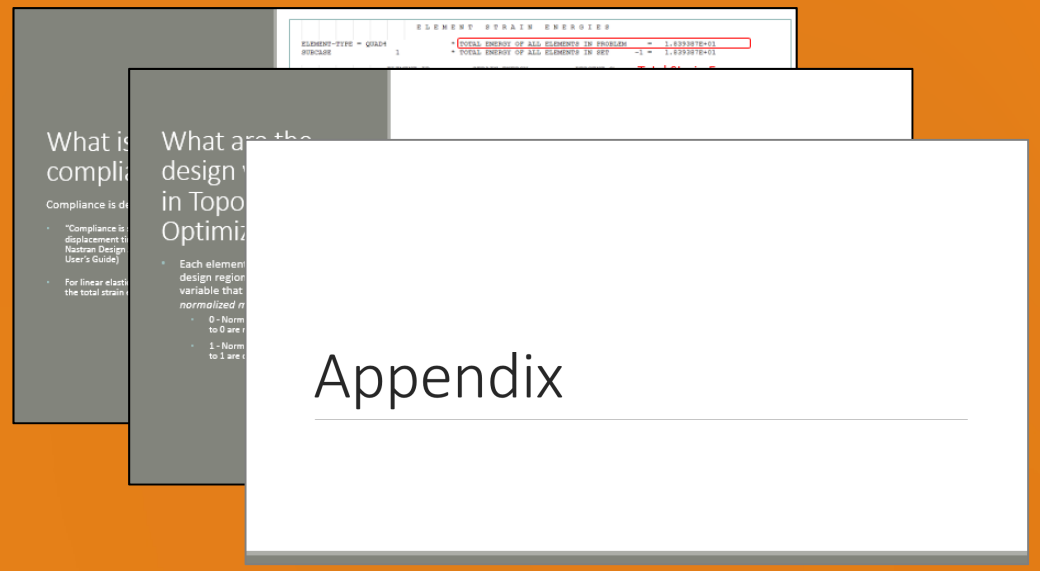
Options to Configure Topography Design Region



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?



Contact me

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

christian@ the-engineering-lab.com

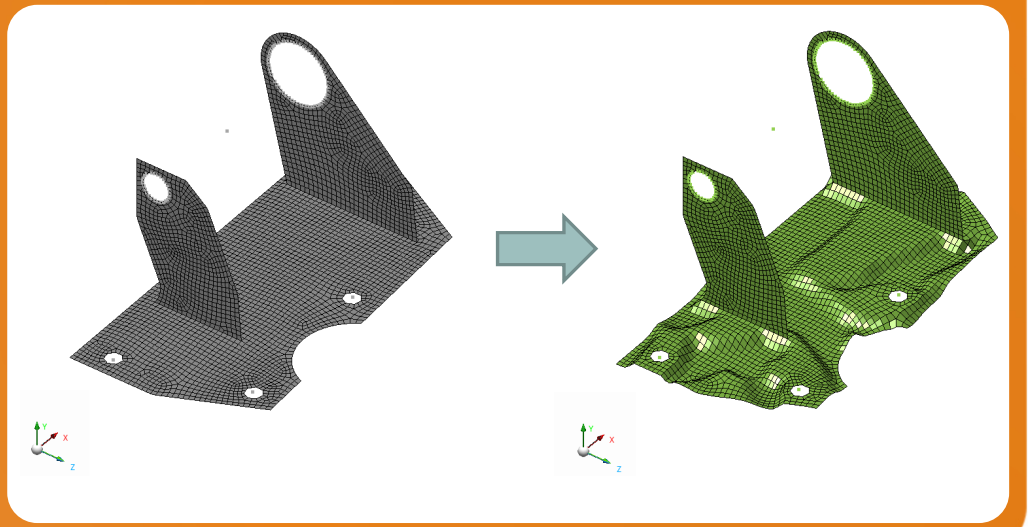
Tutorial

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.



SOL 200 Web App Capabilities

The Post-processor Web App and HDF5 Explorer are free to MSC Nastran users.

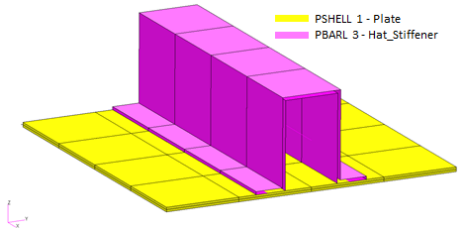
Compatibility

- Google Chrome, Mozilla Firefox or Microsoft Edge
- Windows and Red Hat Linux
- Installable on a company laptop, workstation or server. All data remains within your company.

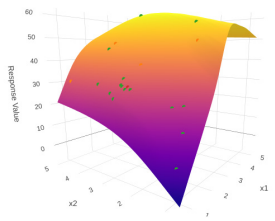
Benefits

- REAL TIME error detection. 200+ error validations.
- REALT TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials

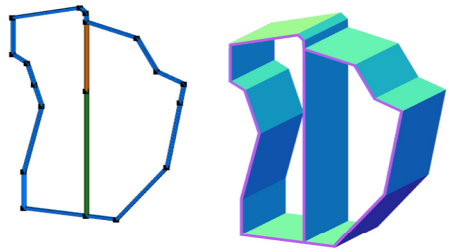
Web Apps



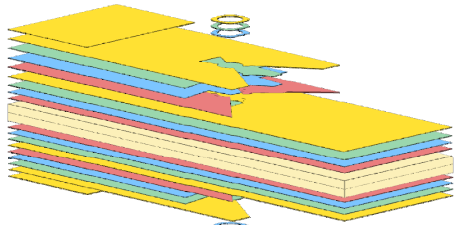
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



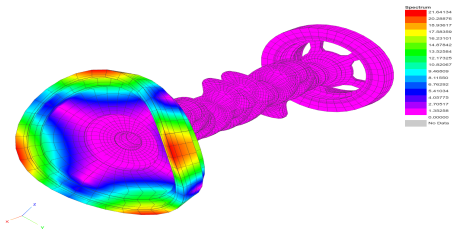
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



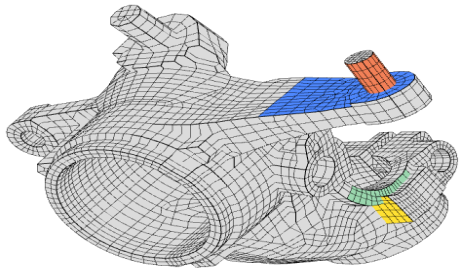
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



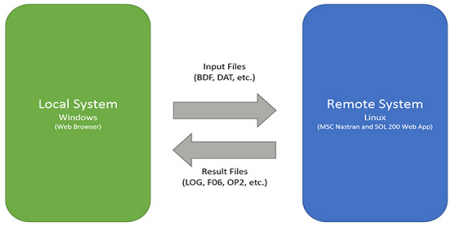
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



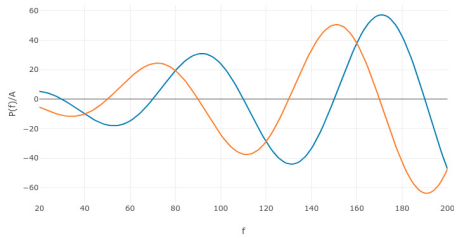
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



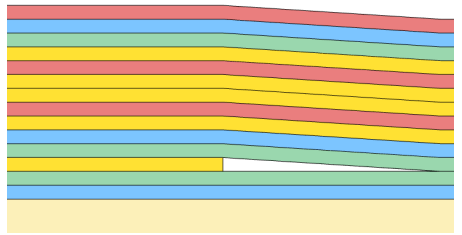
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



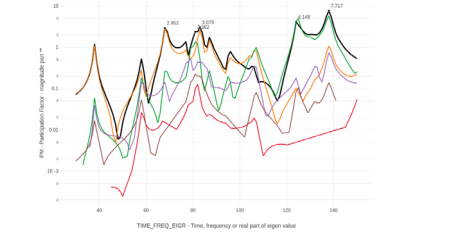
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



Dynamic Loads Web App
Generate RLOAD1, RLOAD2 and DLOAD entries graphically



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

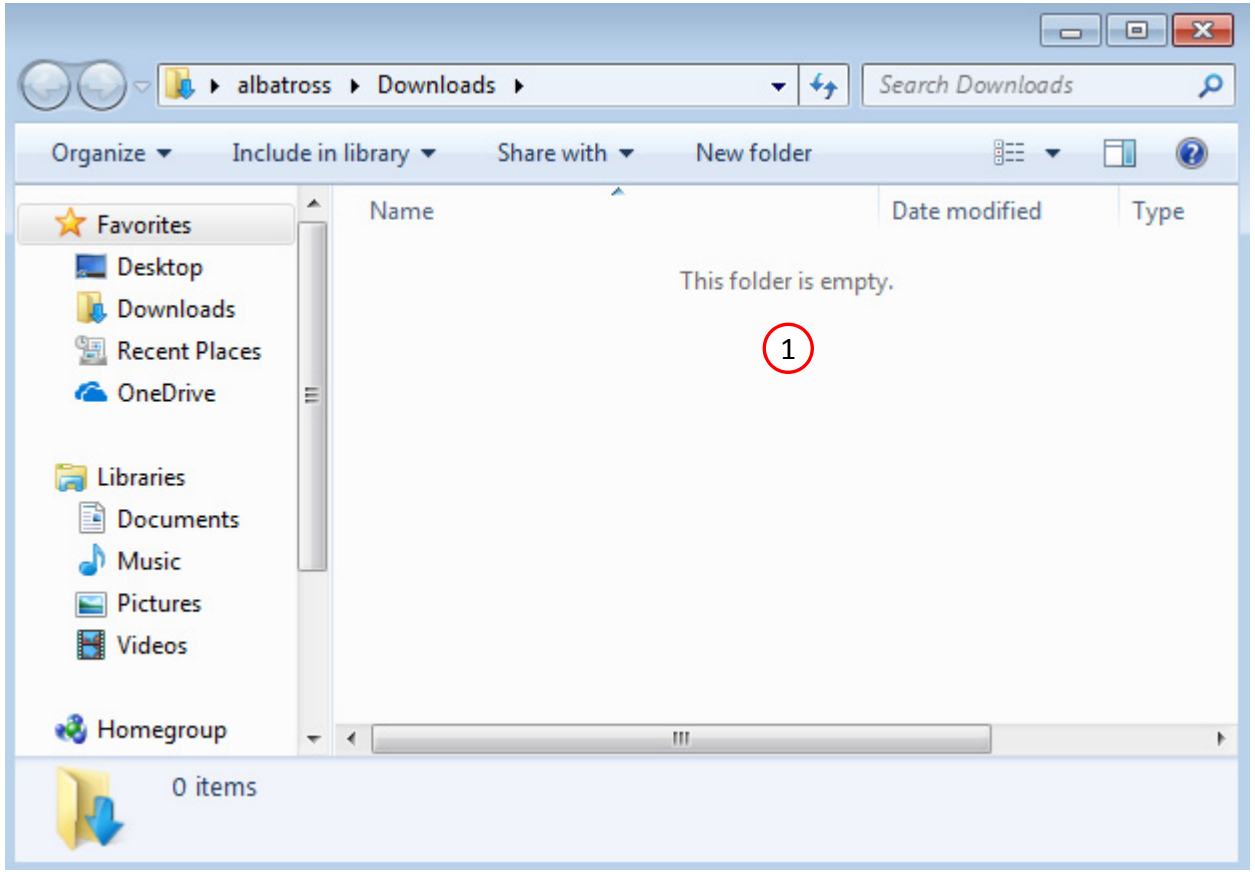


HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

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

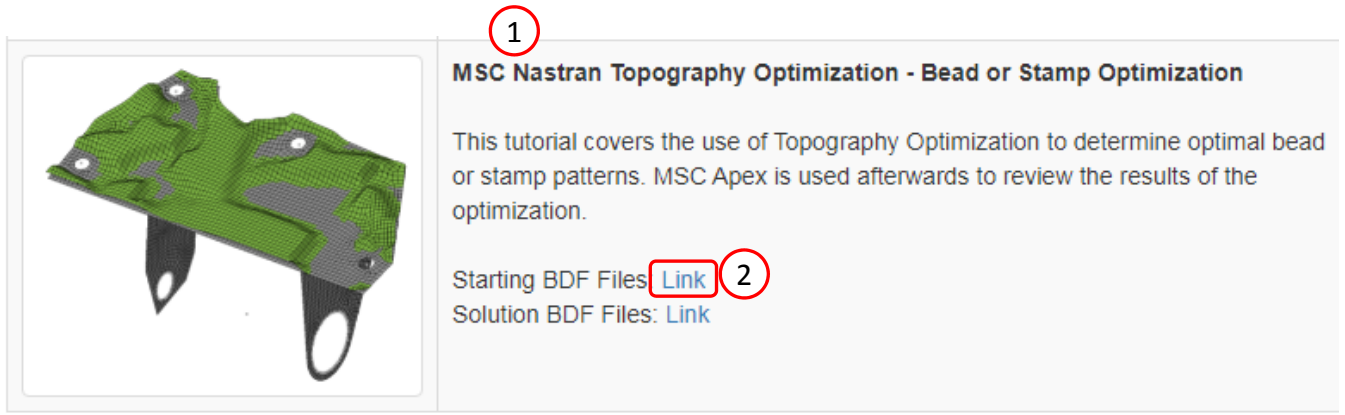
1. Click on the indicated link

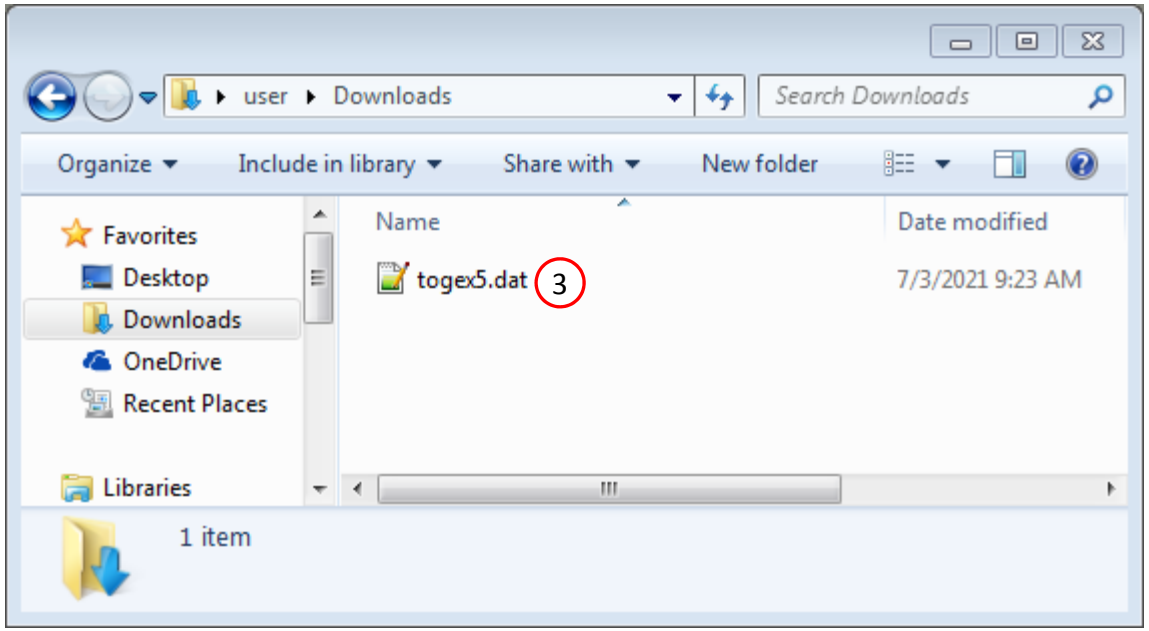
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

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

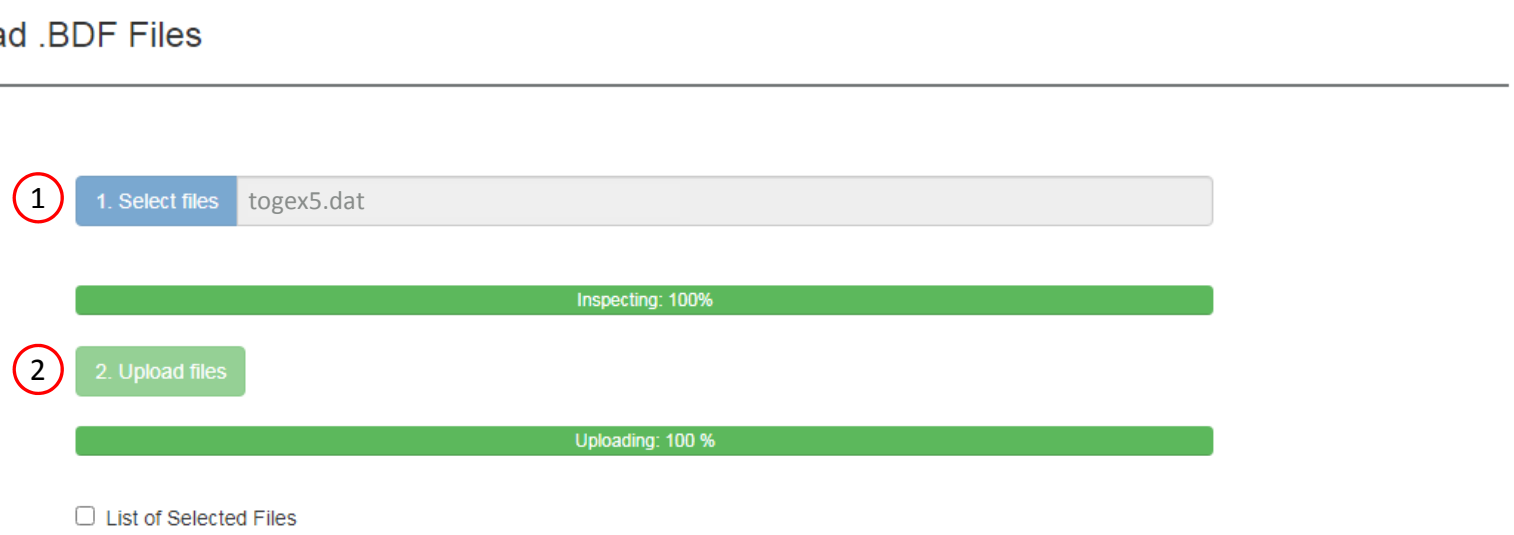
1. Click on the indicated link

- 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

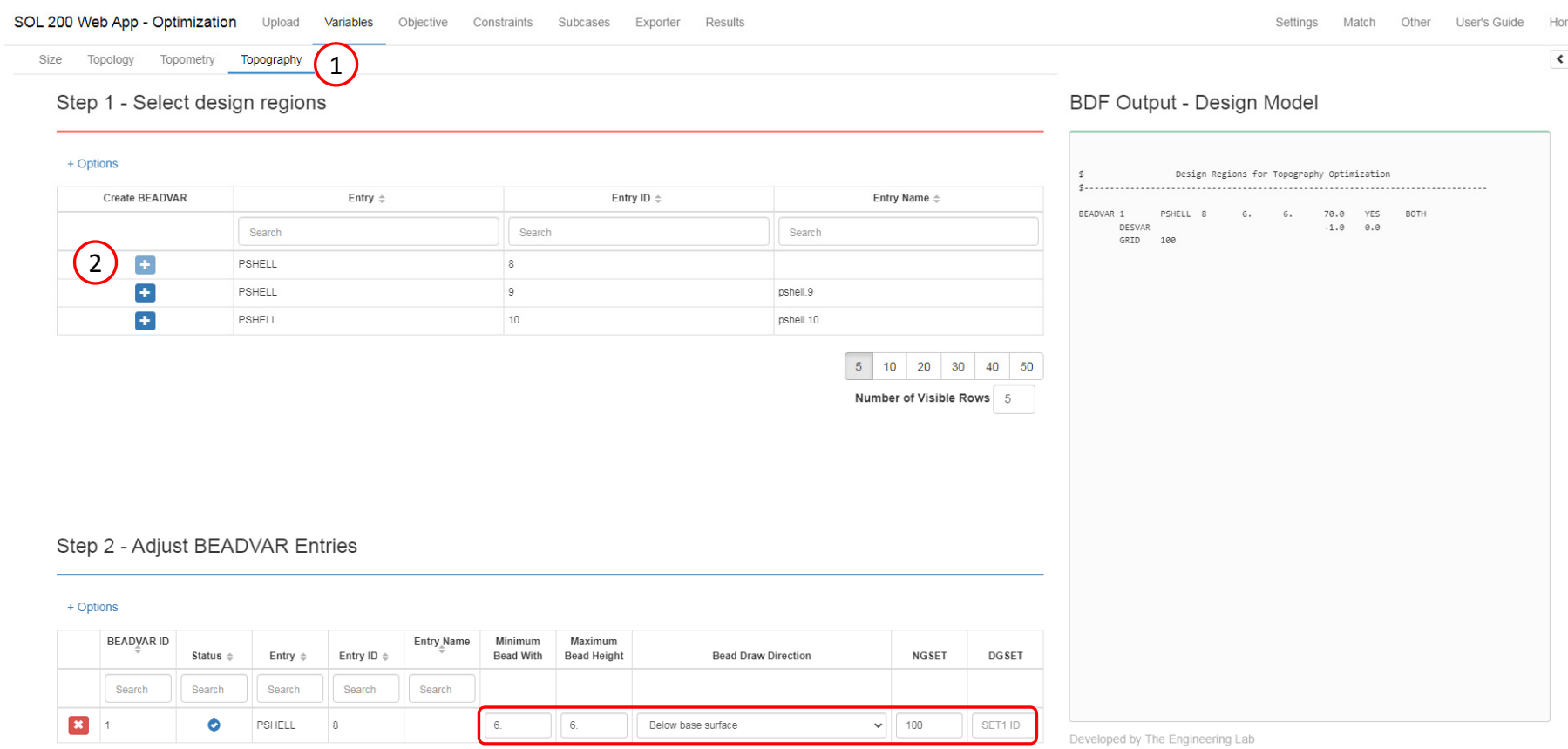
1. Click 1. Select Files and select togex5.dat
2. Click Upload Files

- 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

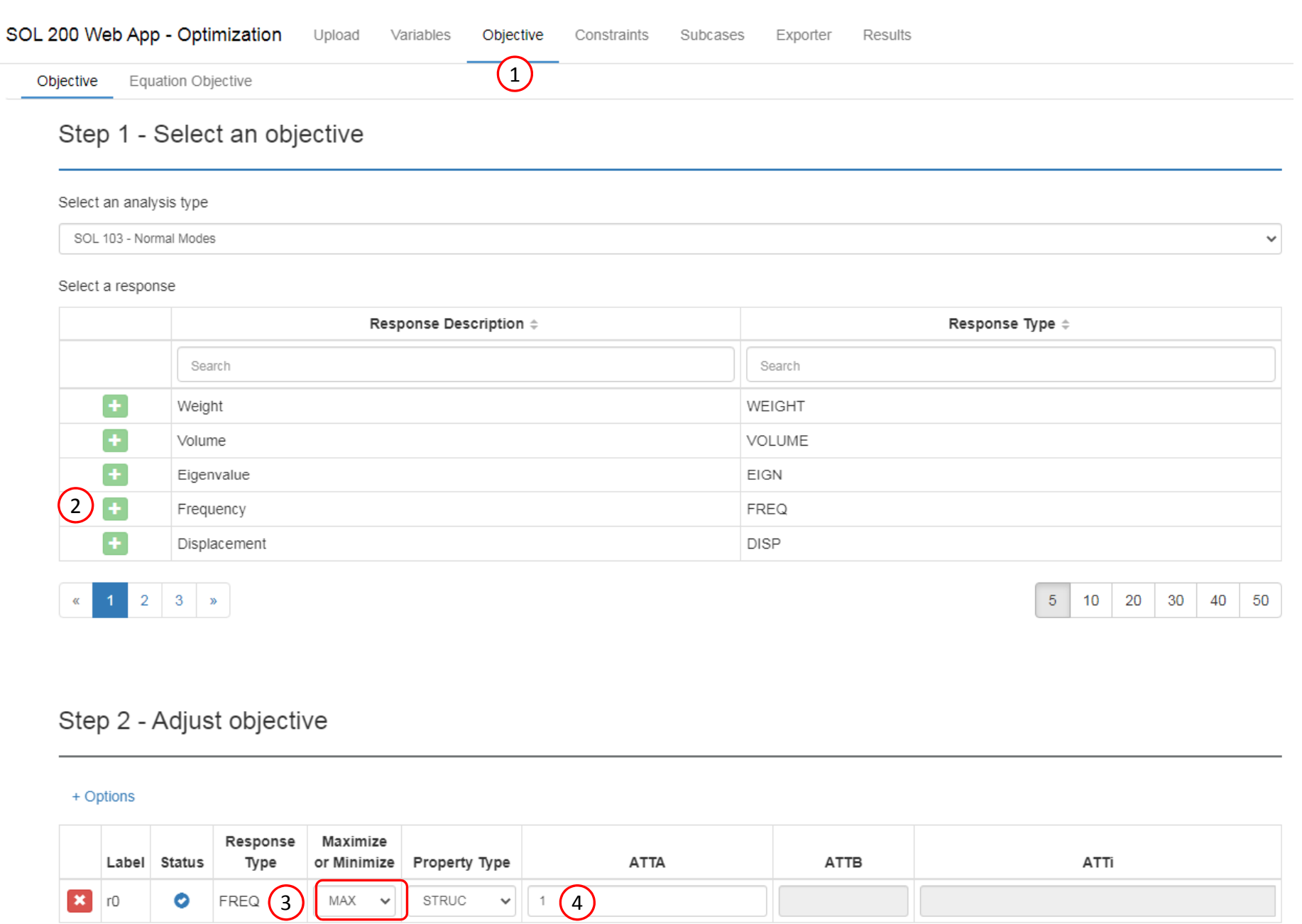
1. Click Topography
2. Click on the plus (+) icons to set PSHELL 8 as a Design Region
3. Set the following for the design region
   - Minimum Bead Width: 6
   - Maximum Bead Height: 6
   - Bead Draw Direction: Below base surface
   - NGSET: 100



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

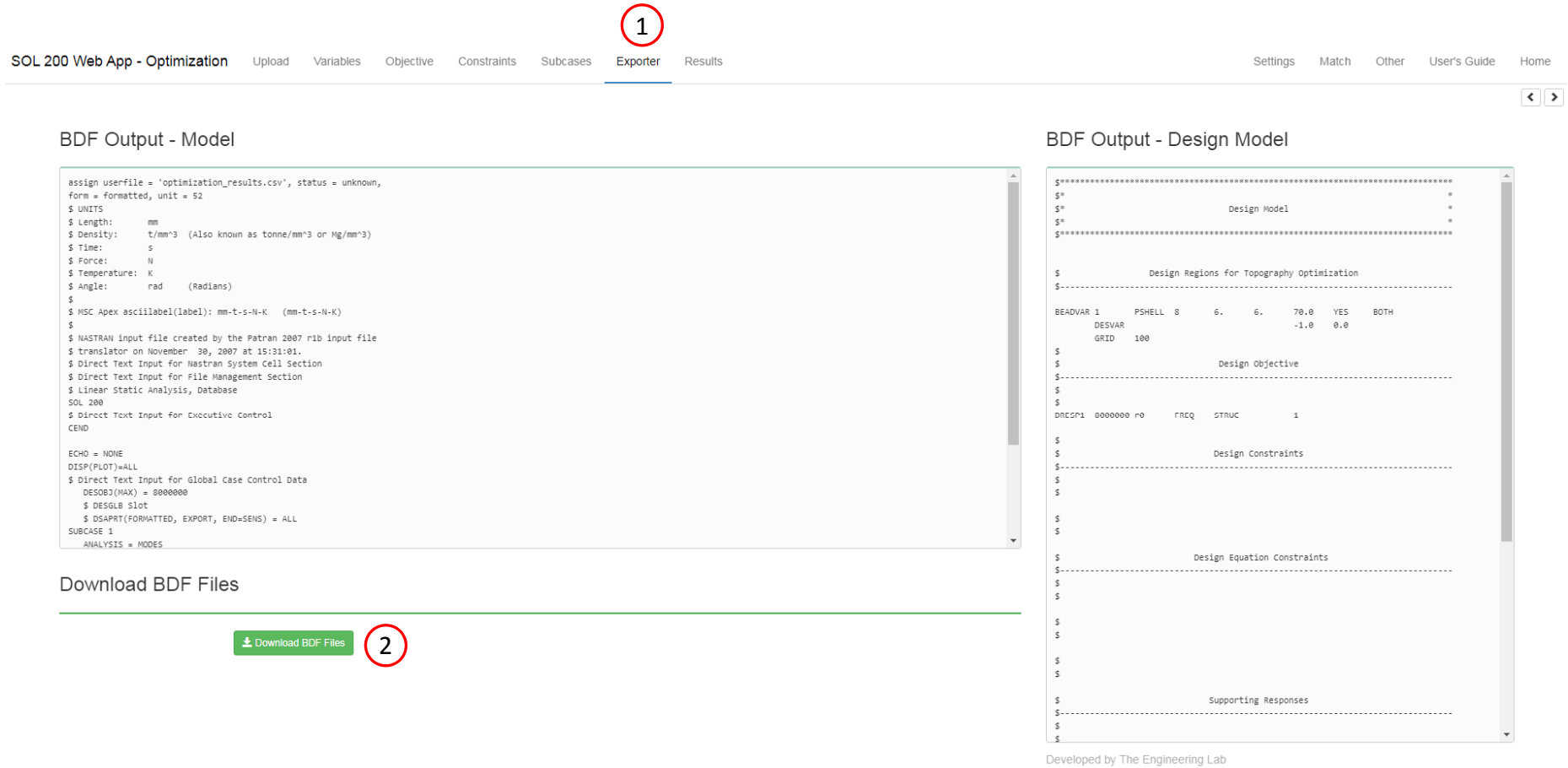
- Topography optimization (bead or stamp optimization) is used to maximize the 1st natural frequency.



Export New BDF Files

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

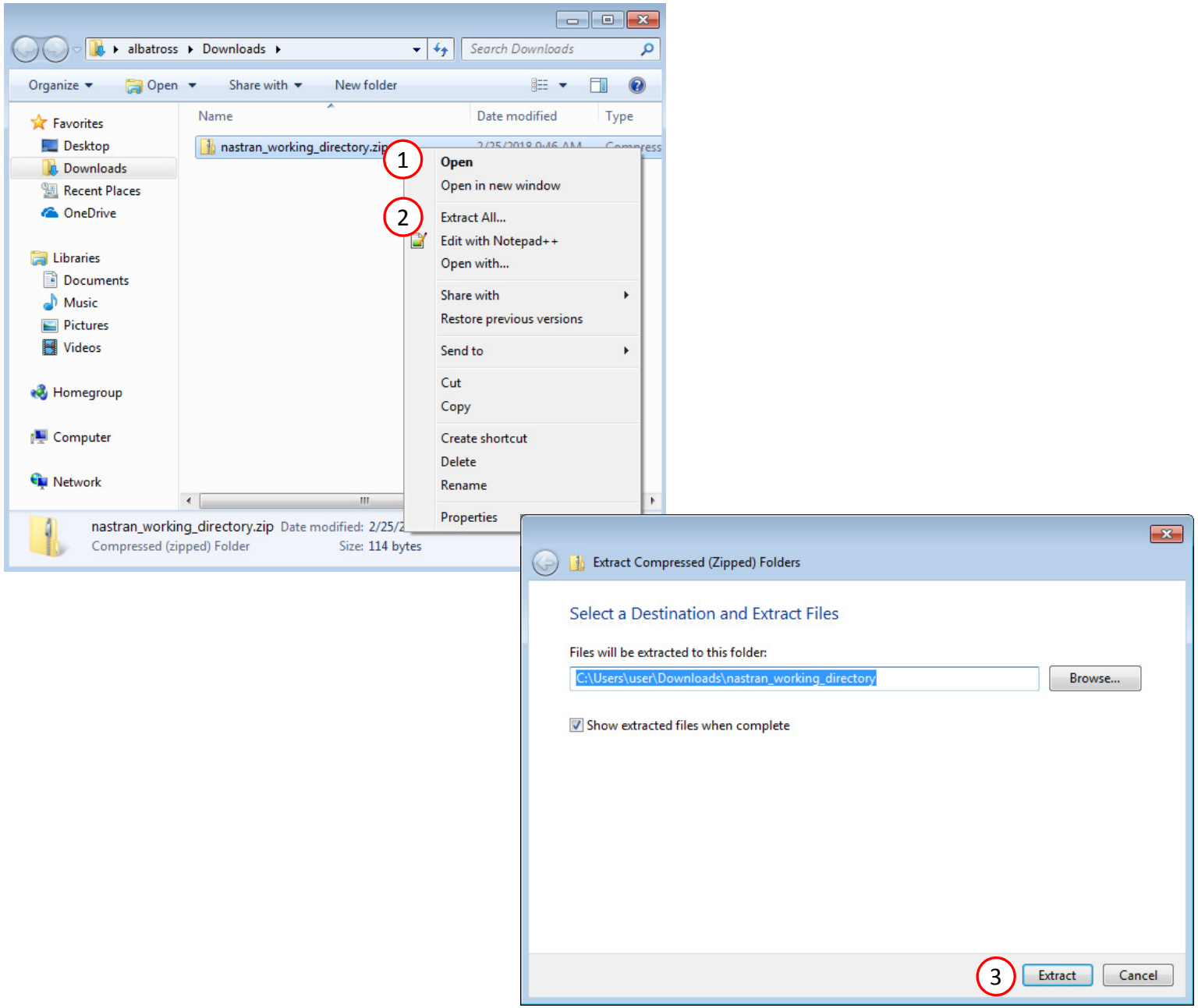
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



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

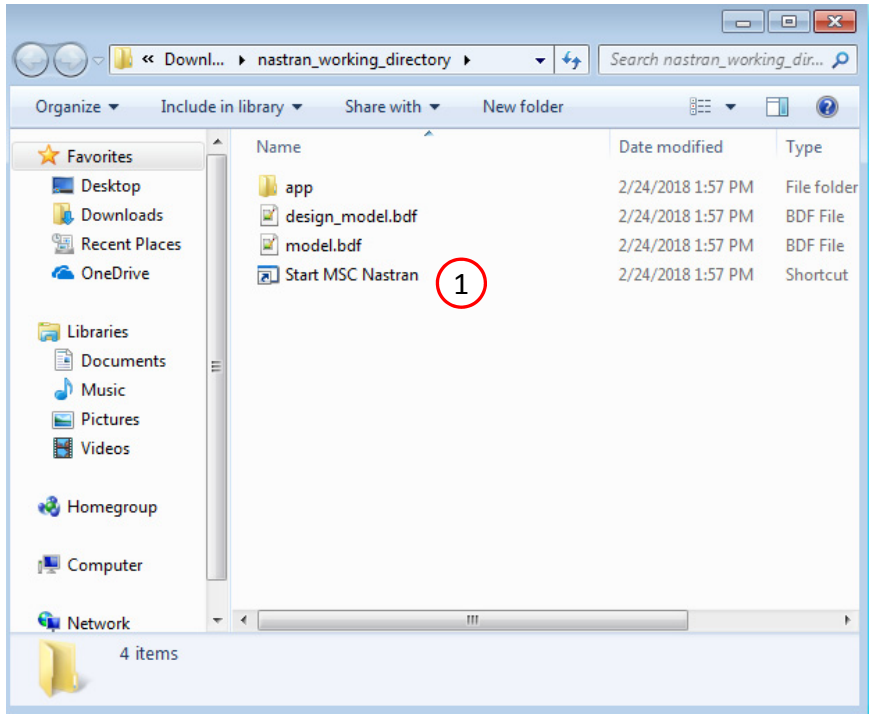
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the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

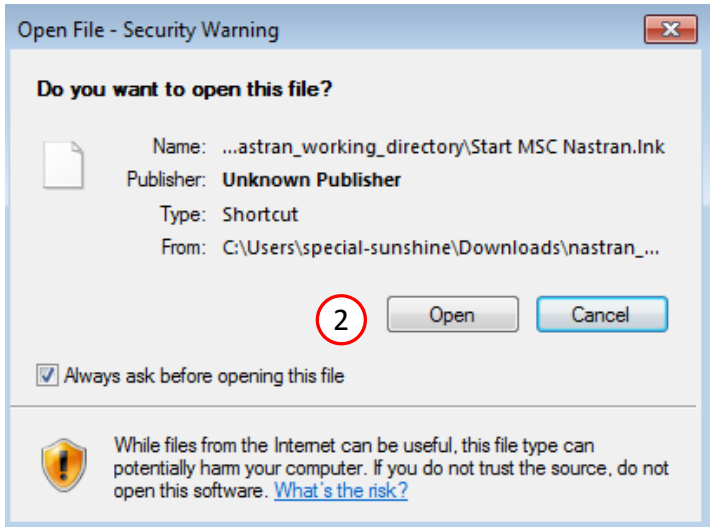
Using Linux?

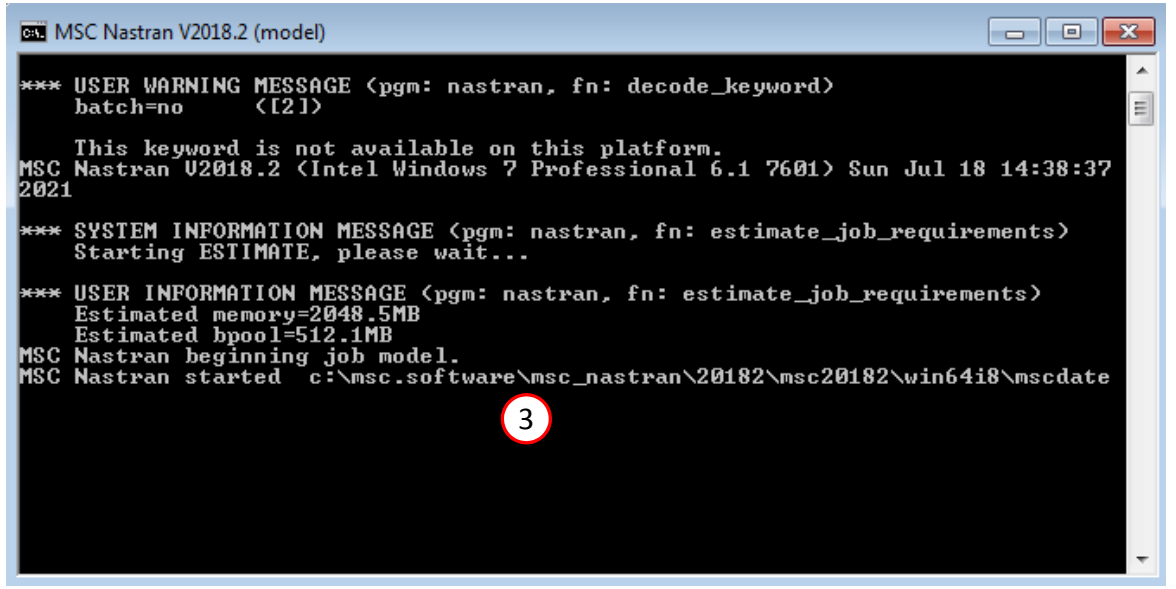
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
   cd ./nastran_working_directory
3) Use this command to start the process
   ./Start_MSC_Nastran.sh

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



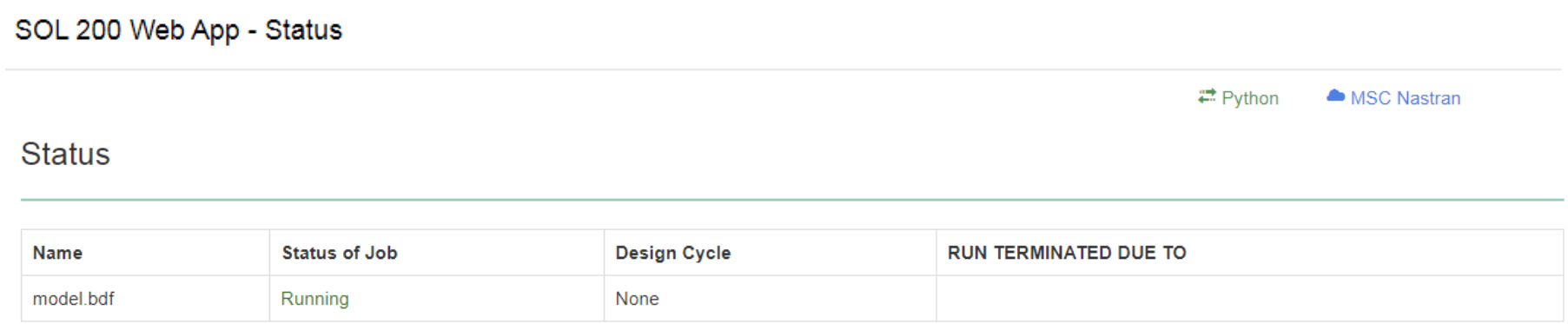




Status

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.

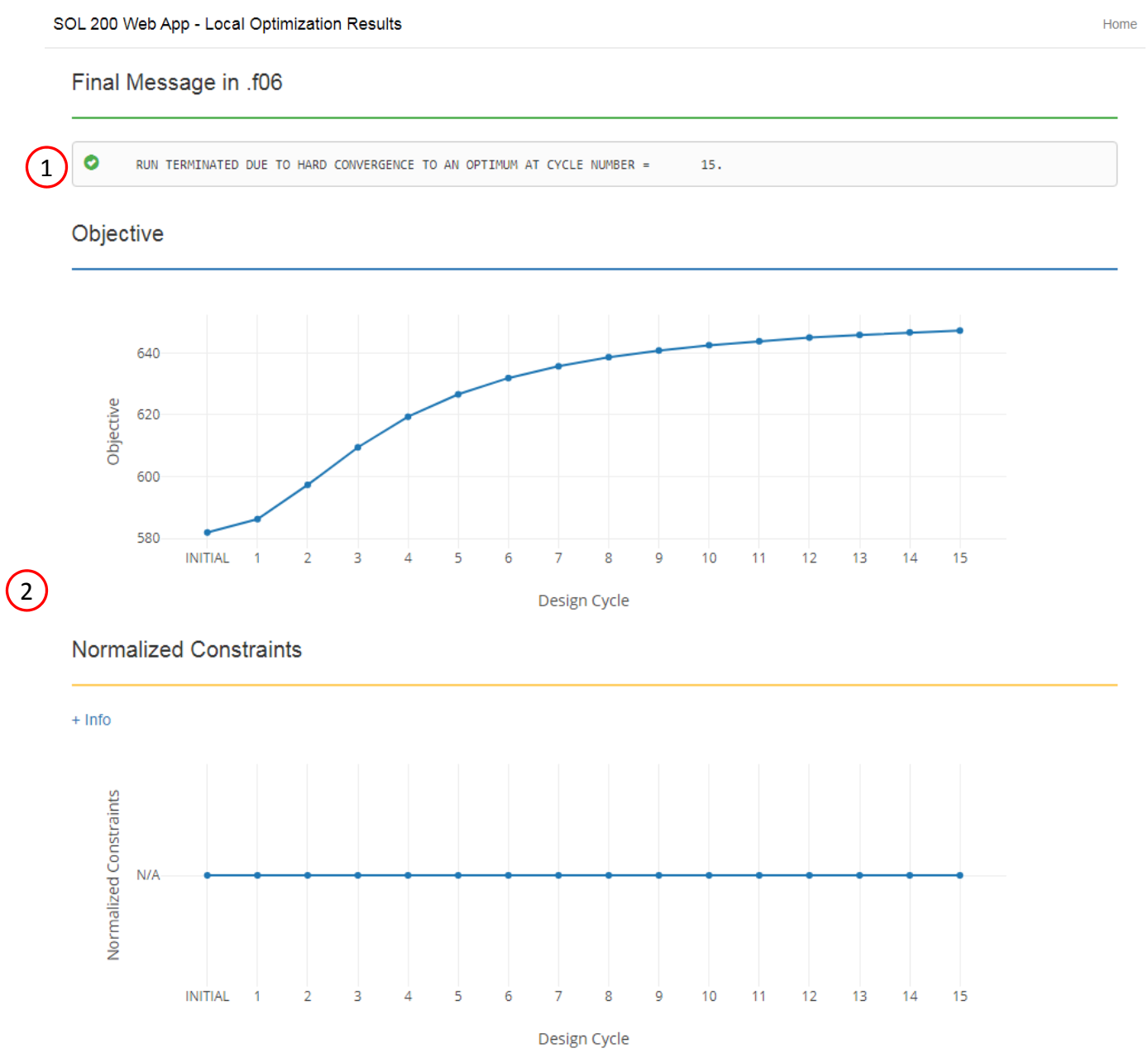


Review Optimization Results

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.

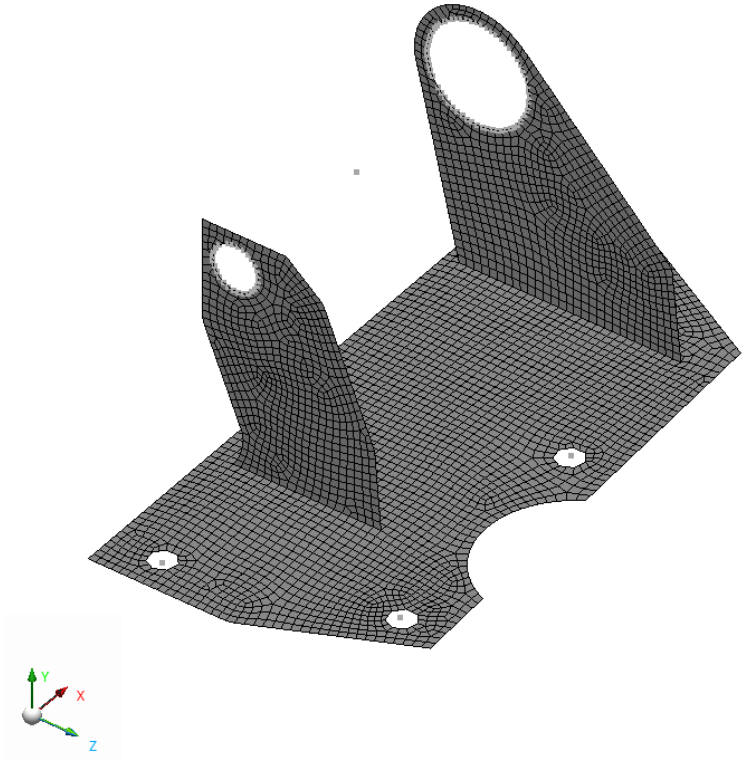
- This optimization did not include any design constraints and is why the Normalized Constraints plot shows N/A (Not Available).



Results

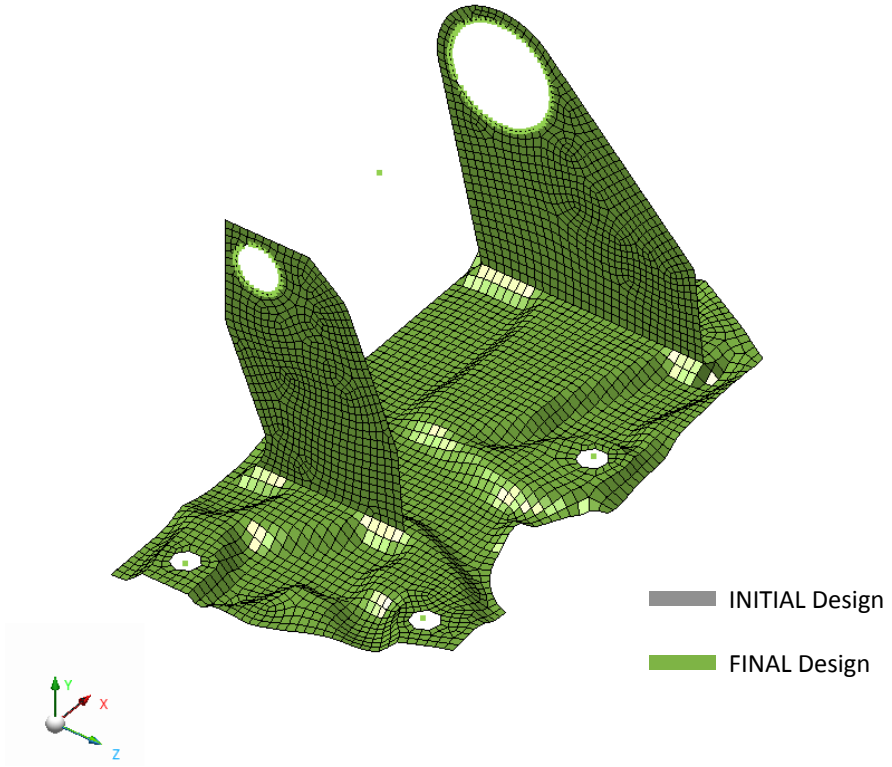
Before Optimization

- 1st Natural Frequency: 581.9 Hz

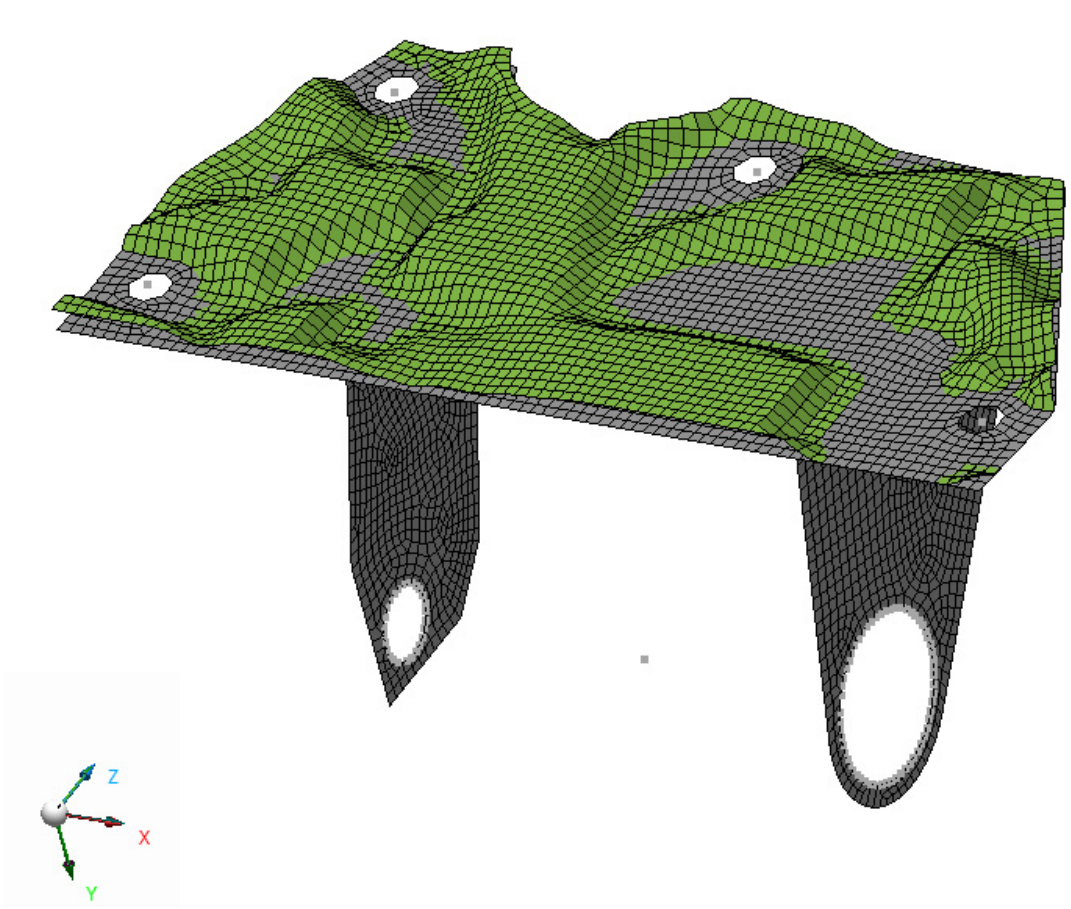


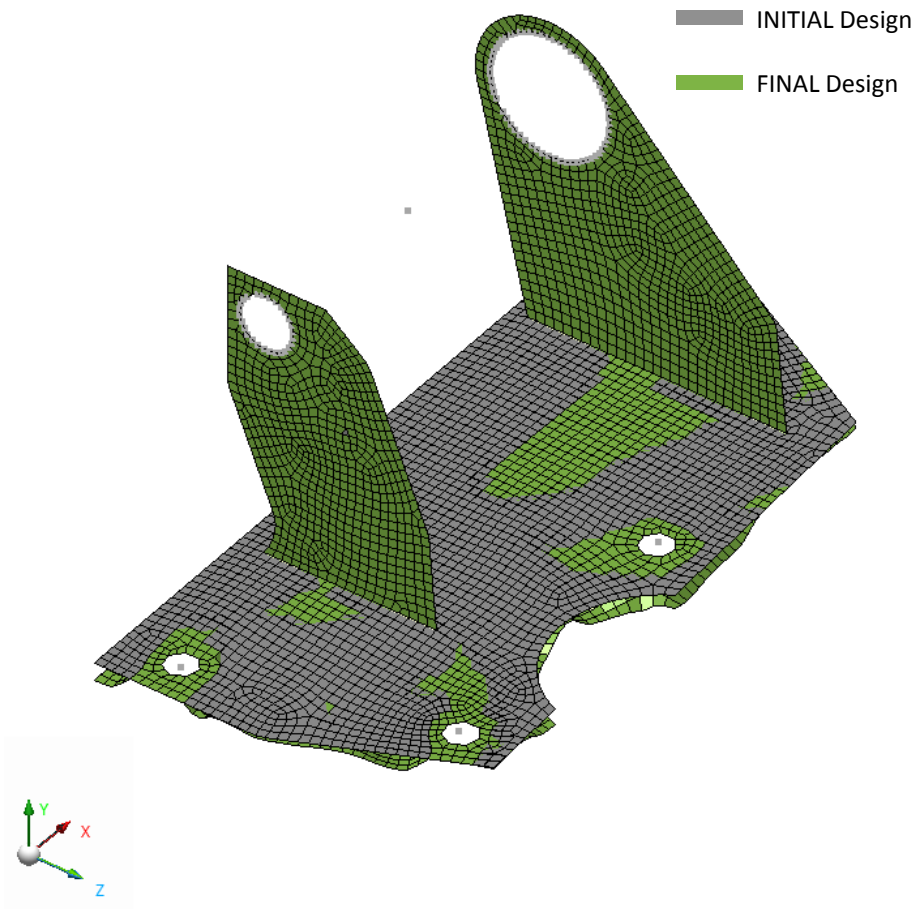
After Optimization

- 1st Natural Frequency: 647.22 Hz



Results

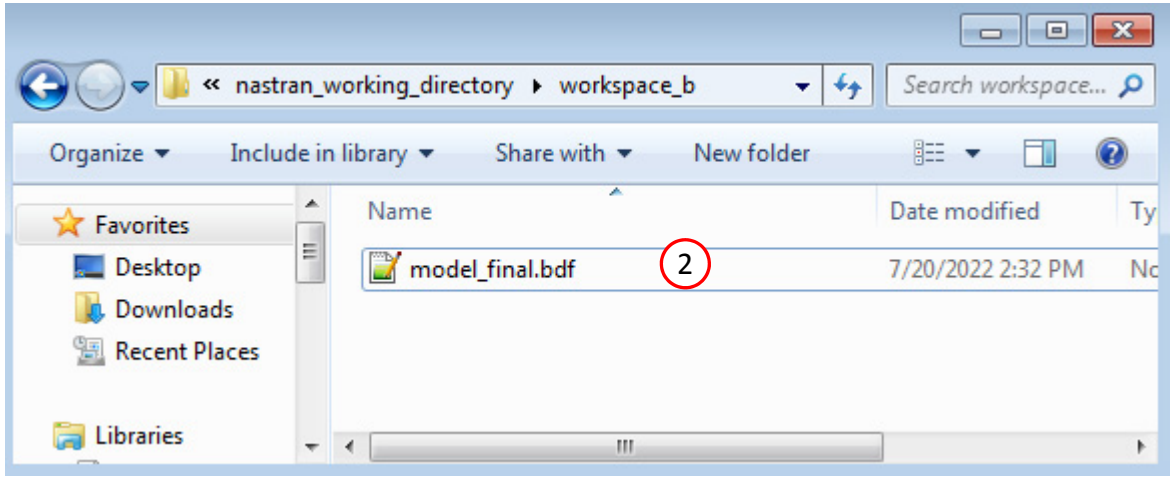




Update the Original Model

1. The original input files, e.g. DAT, BDF, etc., contains the original values for the designed properties. These original values must be updated to use the new and optimized values.
2. A new BDF file has been created in nastran_working_directory/workspace_b/model_final.bdf.
3. The file model_final.bdf is a copy of the original input files but the original values for the designed properties have been updated to use the optimized values.

- If you were using multiple INCLUDE files, model_final.bdf is a combination of all INCLUDE files. The next few slides discuss an alternative method of using the PCH to BDF web app to update the values for the designed properties while preserving separate INCLUDE files.



Original Input Files

1

```
GRID     57200          1692.31  192.7   768.031
GRID     57201          1692.26  192.7   771.2
GRID     57202          1692.14  192.7   774.486
GRID     57203          1691.9   192.7   777.919
GRID     57204          1691.55  192.7   781.502
GRID     57205          1691.12  192.7   785.243
GRID     57206          1693.94  192.7   788.325
GRID     57207          1692.44  192.7   796.15
GRID     57208          1637.68  192.7   747.522
GRID     57209          1640.69  192.7   747.381
GRID     57210          1643.7   192.7   747.246
```

Updated BDF File (model_final.bdf)

```
GRID     57200        0 1692.31  191.06  768.031       0
GRID     57201        0 1692.26  189.374 771.2         0
GRID     57202        0 1692.14  188.597 774.486       0
GRID     57203        0 1691.9   189.644 777.919       0
GRID     57204        0 1691.55  191.444 781.502       0
GRID     57205        0 1691.12  192.563 785.243       0
GRID     57206        0 1693.94  192.7   788.325       0
GRID     57207        0 1692.44  192.7   796.15        0
GRID     57208        0 1637.68  189.844 747.522       0
GRID     57209        0 1640.69  189.711 747.381       0
GRID     57210        0 1643.7   188.931 747.246       0
```

3

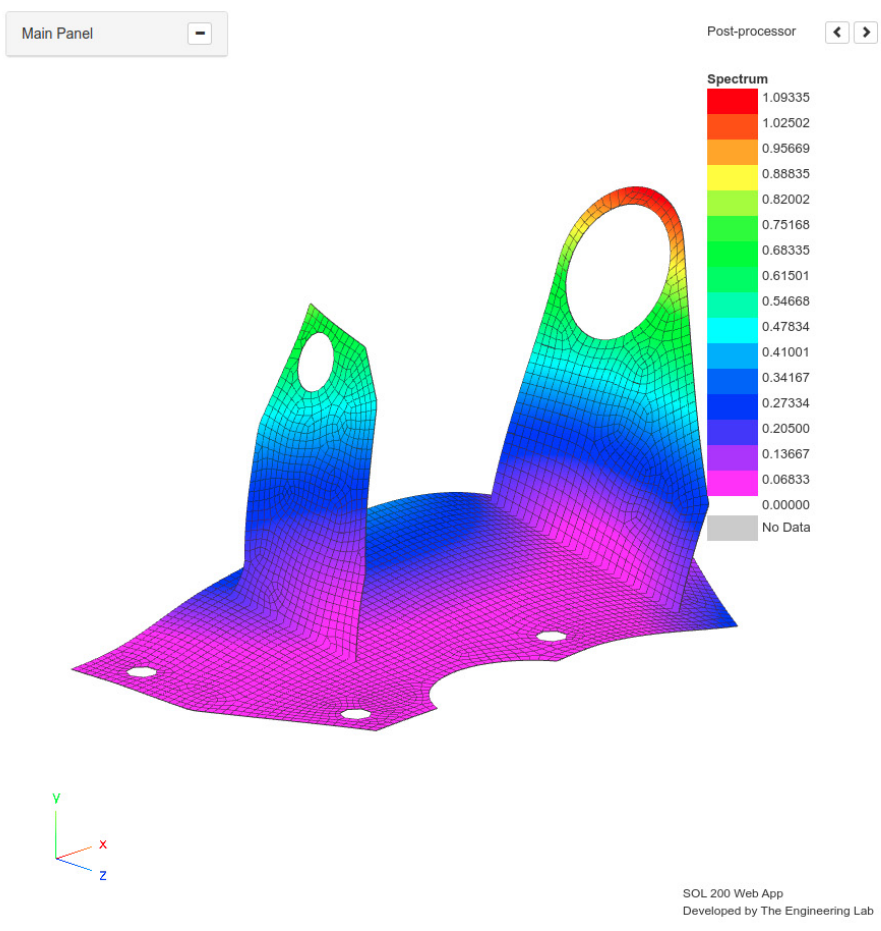
Inspection of MSC Nastran Results with the Post-processor Web App

Post-processor Web App

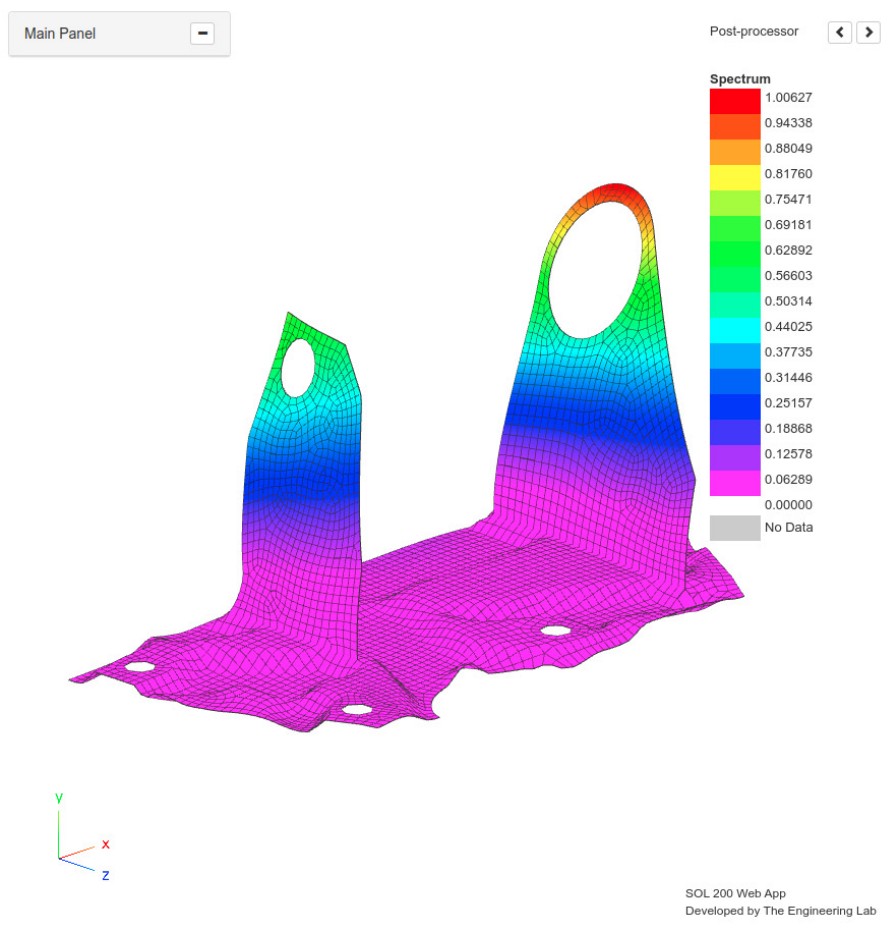
- The Post-processor web app is used to inspect the MSC Nastran results.
- Consider the mode shape and natural frequency for mode 1.
  - For the initial design, the natural frequency is 581.89 Hz.
  - For the final design, the natural frequency is 647.22 Hz.

- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

Mode Shape 1



Initial Design

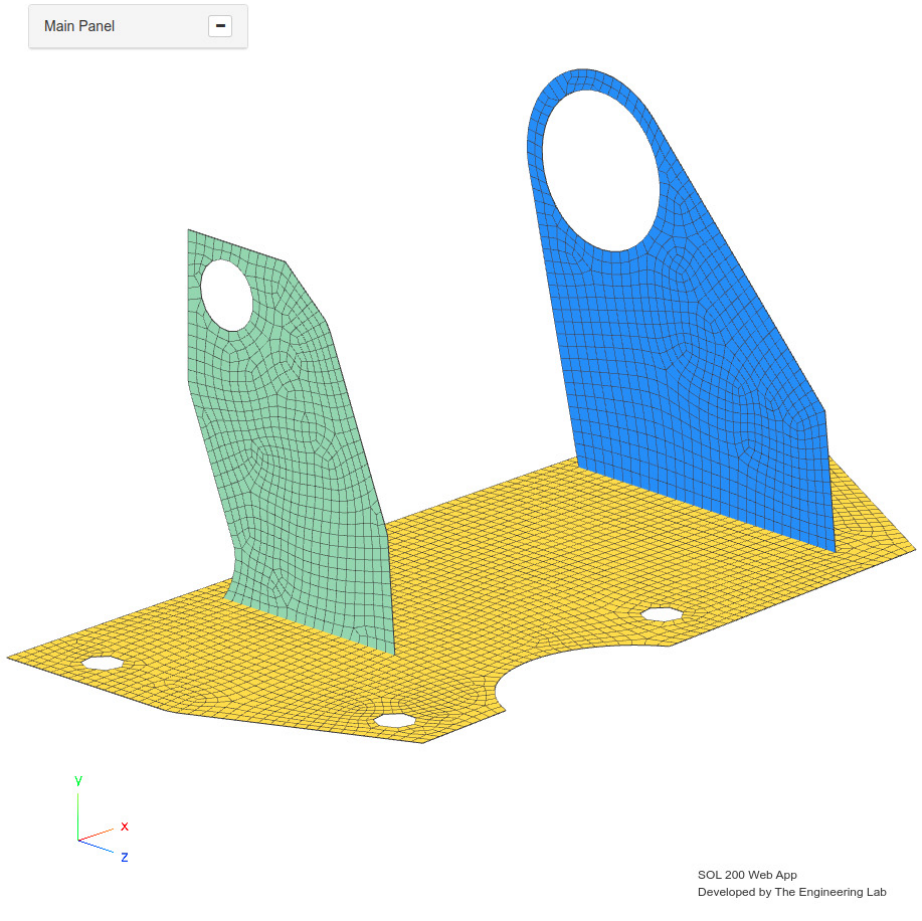


Final Design

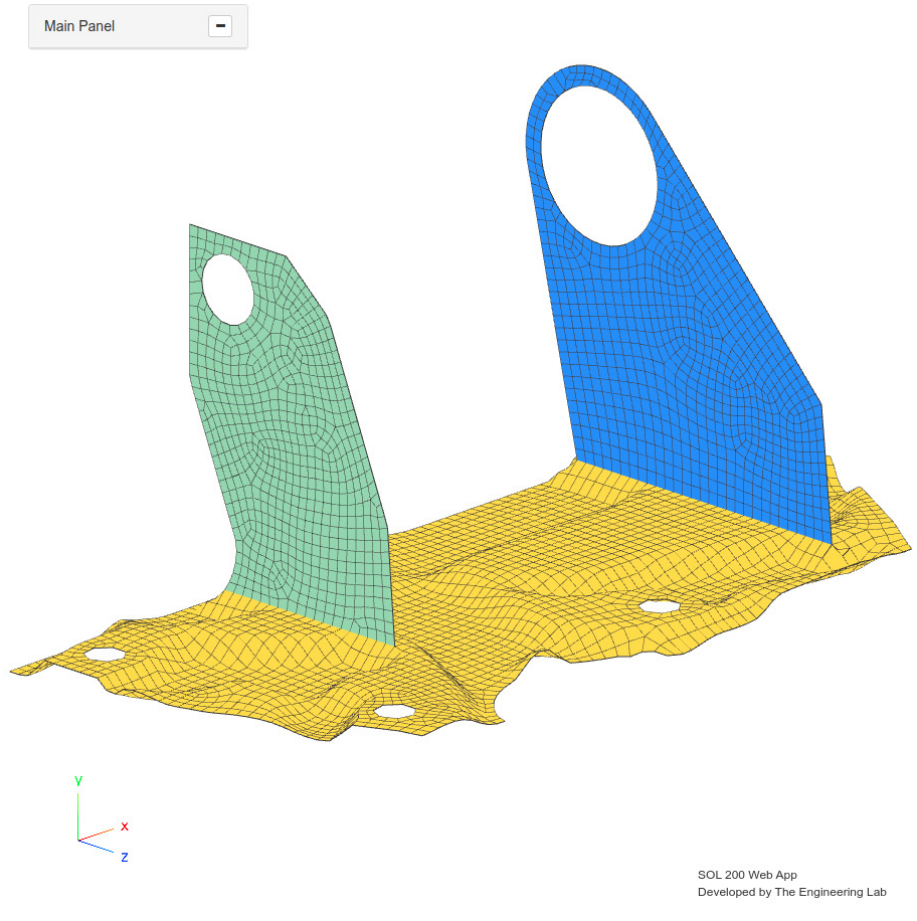
Post-processor Web App

- The grids (nodes) of the initial and final design are compared.

- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.



Initial Design



Final Design

End of Tutorial

Appendix

Appendix Contents

- Frequently Asked Questions
  - How do I access more configuration options for Topography optimization?

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