

# Workshop - MSC Nastran Topography Optimization - Bead or Stamp Optimization

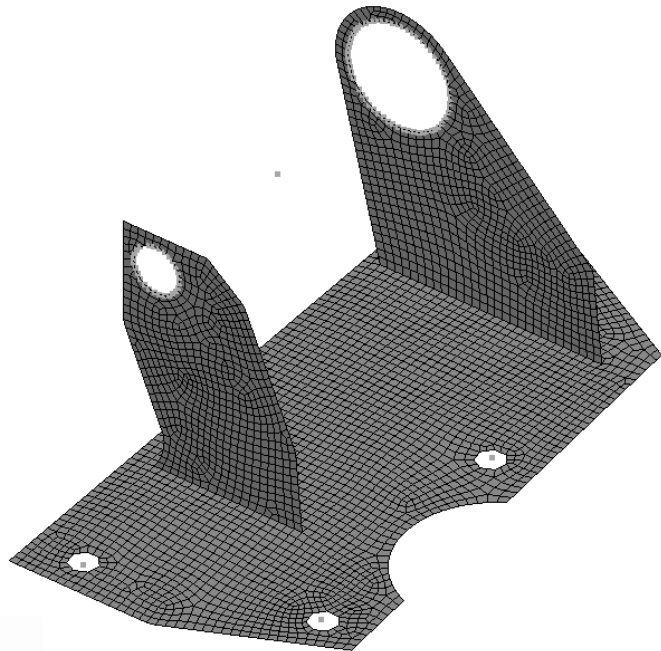
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AN MSC NASTRAN SOL 200 TUTORIAL

# Goal: Use Nastran SOL 200 Optimization

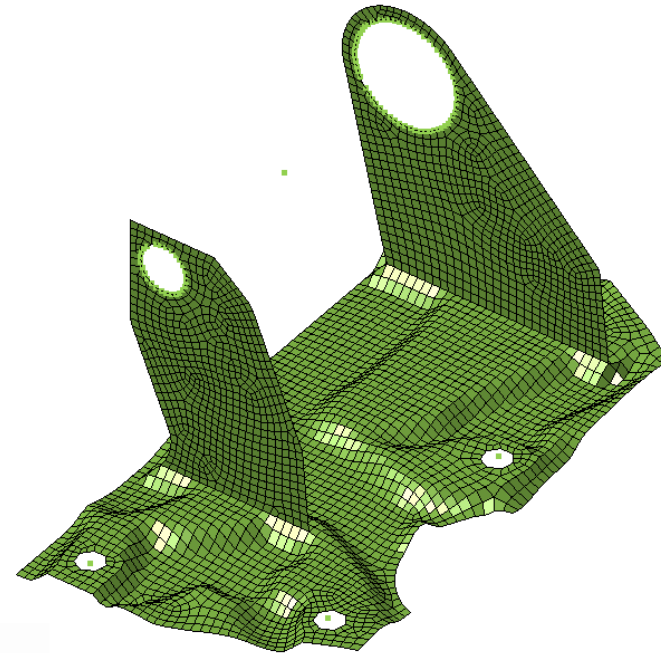
## Before Optimization

- 1<sup>st</sup> Natural Frequency: 581.9 Hz



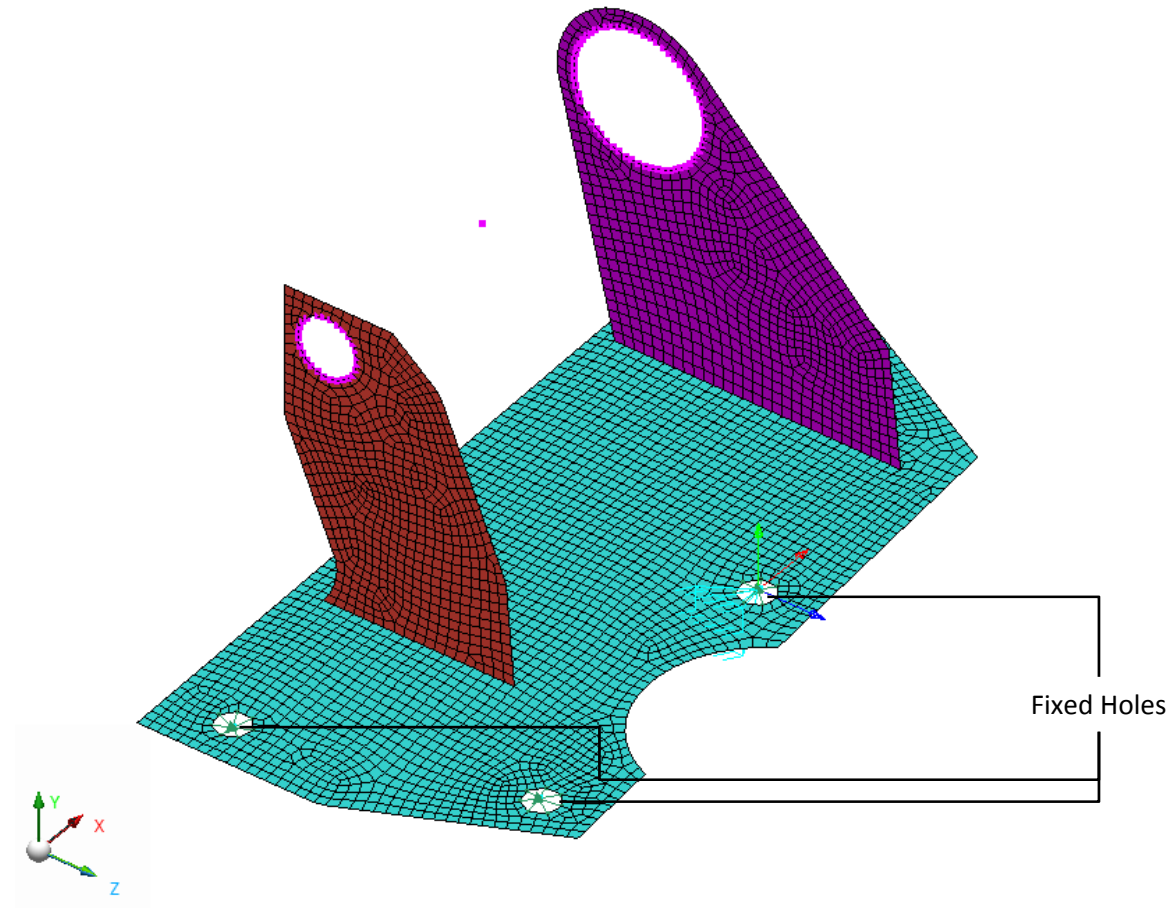
## After Optimization

- 1<sup>st</sup> Natural Frequency: 647.22 Hz



# Details of the structural model

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# Optimization Problem Statement

## Design Region/Variables

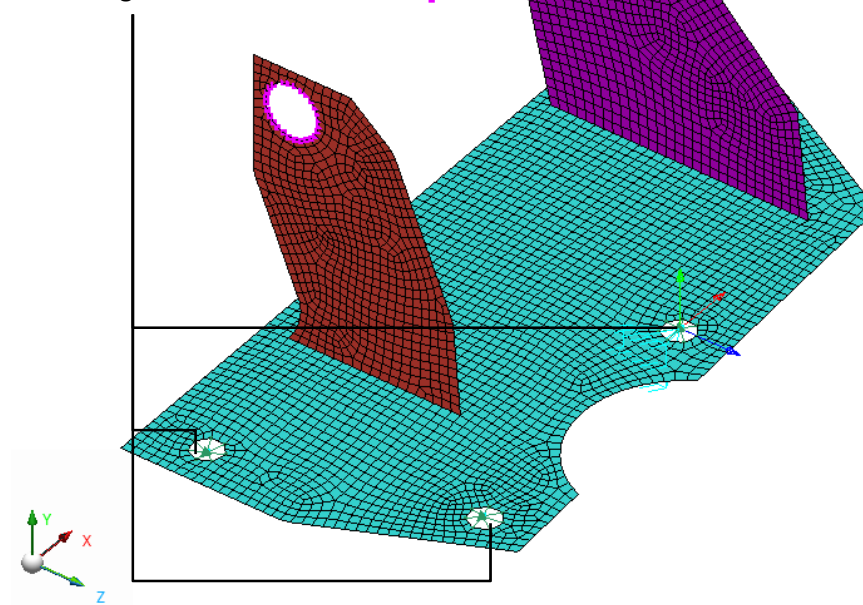
x1: PSHELL 8

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



Regions around the holes are excluded from the design region



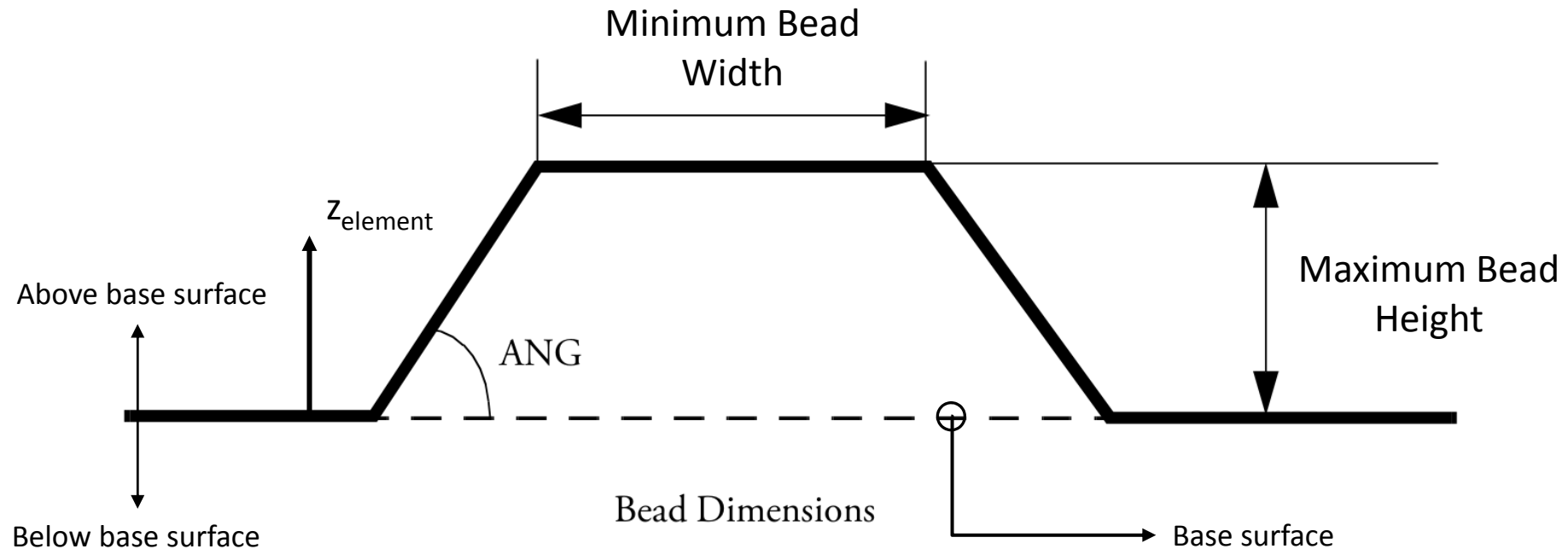
PSHELL 8  
PSHELL 9  
PSHELL 10



## Design Objective

r0: Maximize the 1<sup>st</sup> natural frequency

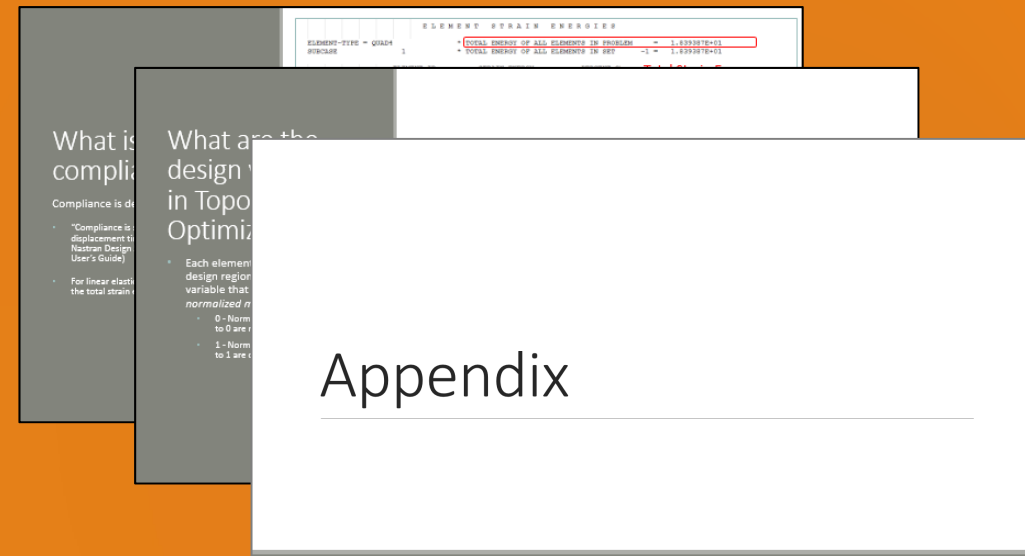
# Options to Configure Topography Design Region



# 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

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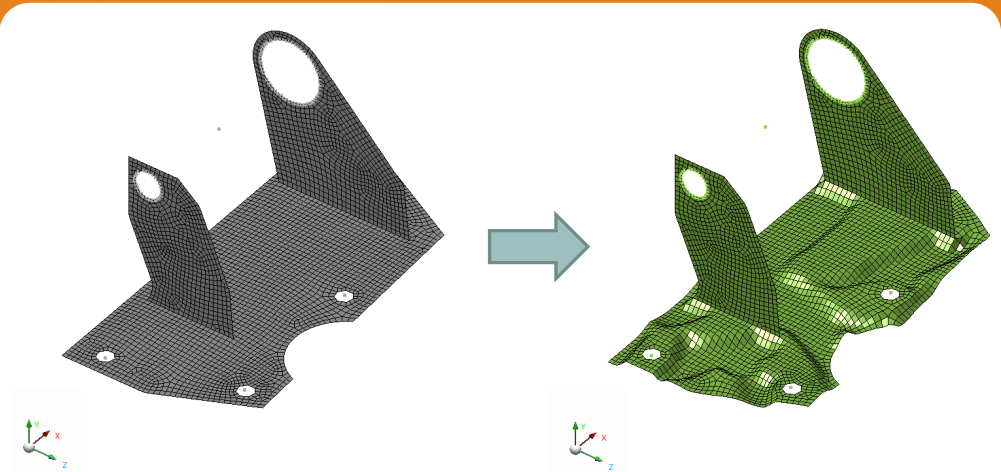


# Tutorial Overview

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.

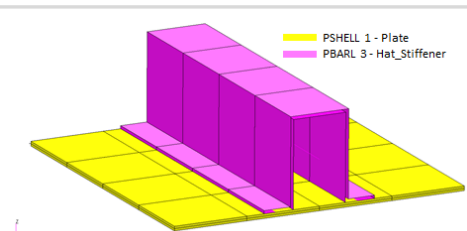
## Compatibility

- 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.

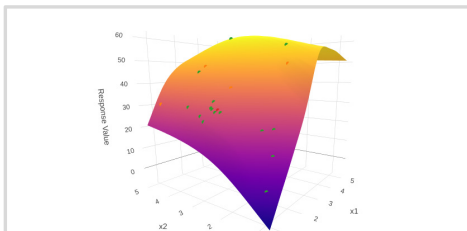
## Web Apps

## Benefits

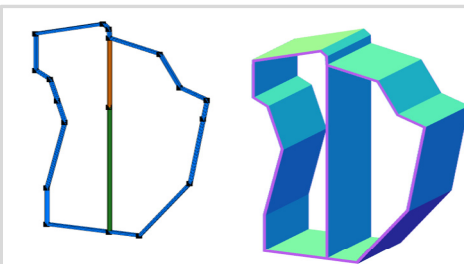
- REAL TIME error detection. 200+ error validations.
- REAL TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials



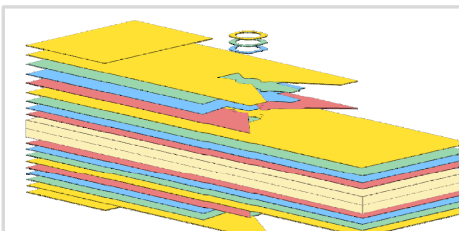
**Web Apps for MSC Nastran SOL 200**  
Pre/post for MSC Nastran SOL 200.  
Support for size, topology, topometry, topography, multi-model optimization.



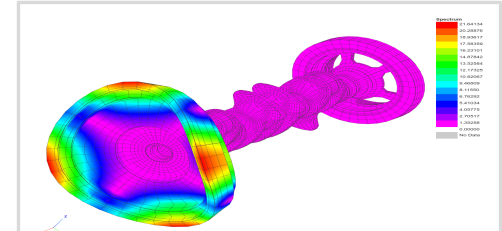
**Machine Learning Web App**  
Bayesian Optimization for nonlinear response optimization (SOL 400)



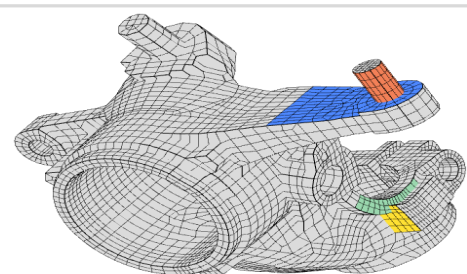
**PBMSECT Web App**  
Generate PBMSECT and PBRSECT entries graphically



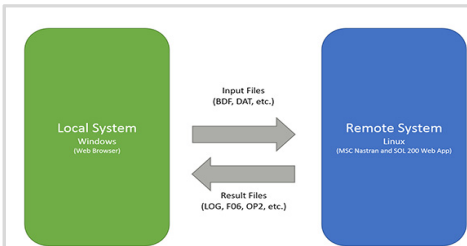
**Ply Shape Optimization Web App**  
Optimize composite ply drop-off locations, and generate new PCOMPG entries



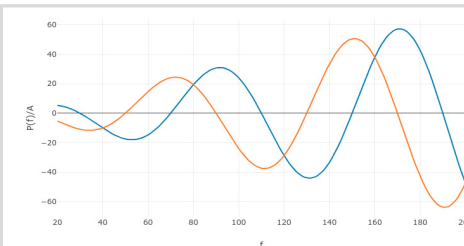
**Post-processor Web App**  
View MSC Nastran results in a web browser on Windows and Linux



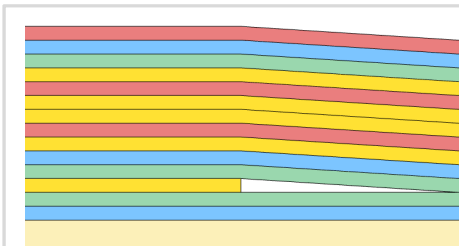
**Shape Optimization Web App**  
Use a web application to configure and perform shape optimization.



**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

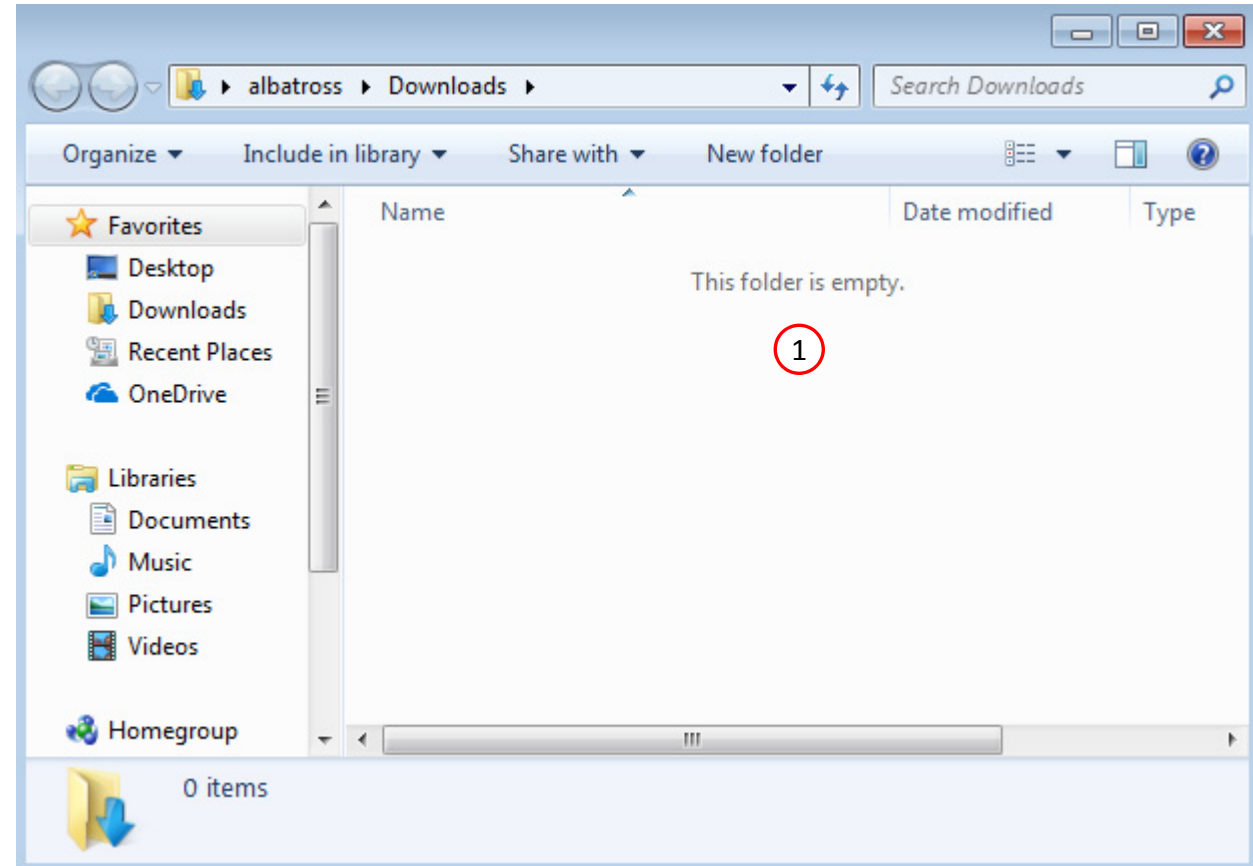


**HDF5 Explorer Web App**  
Create graphs (XY plots) using data from the H5 file

# 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

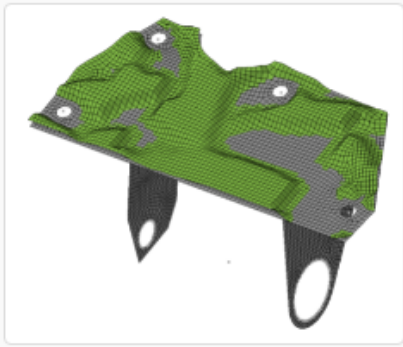
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



# 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.



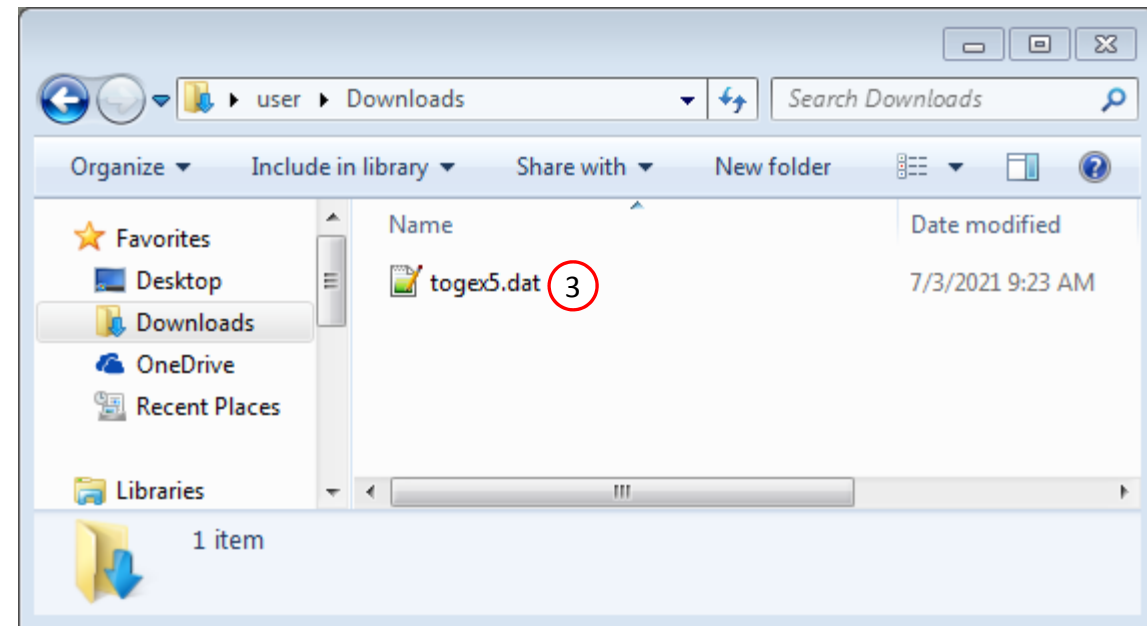
**1**

### MSC Nastran Topography Optimization - Bead or Stamp Optimization

This tutorial covers the use of Topography Optimization to determine optimal bead or stamp patterns. MSC Apex is used afterwards to review the results of the optimization.

Starting BDF Files: [Link](#) **2**

Solution BDF Files: [Link](#)





# 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.

## Step 1 - Upload .BDF Files

The screenshot shows a two-step process for uploading files. Step 1, '1. Select files', is highlighted with a red circle and shows a file named 'togex5.dat' selected. Below it is a green progress bar labeled 'Inspecting: 100%'. Step 2, '2. Upload files', is also highlighted with a red circle and shows a green progress bar labeled 'Uploading: 100 %'. At the bottom, there is a checkbox labeled 'List of Selected Files' which is currently unchecked.

1. Select files togex5.dat

Inspecting: 100%

2. Upload files

Uploading: 100 %

☐ List of Selected Files

# 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

SOL 200 Web App - Optimization    Upload    **Variables**    Objective    Constraints    Subcases    Exporter    Results    Settings    Match    Other    User's Guide    Home

Size    Topology    Topometry    **Topography** 1

---

### Step 1 - Select design regions

+ Options

Create BEADVAR	Entry	Entry ID	Entry Name
	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
<span style="border: 1px solid red; border-radius: 50%; padding: 2px;">2</span> <span style="background-color: #007bff; color: white; padding: 2px 5px;">+</span>	PSHELL	8	
<span style="background-color: #007bff; color: white; padding: 2px 5px;">+</span>	PSHELL	9	pshell.9
<span style="background-color: #007bff; color: white; padding: 2px 5px;">+</span>	PSHELL	10	pshell.10

5   10   20   30   40   50  
Number of Visible Rows 5

---

### Step 2 - Adjust BEADVAR Entries

+ Options

	BEADVAR ID	Status	Entry	Entry ID	Entry Name	Minimum Bead Width	Maximum Bead Height	Bead Draw Direction	NGSET	DGSET
	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>					
<span style="background-color: #dc3545; color: white; padding: 2px 5px;">✖</span>	1	<span style="color: #007bff;">+</span>	PSHELL	8		<span style="border: 1px solid red; padding: 2px 10px;">6.</span>	<span style="border: 1px solid red; padding: 2px 10px;">6.</span>	<span style="border: 1px solid red; padding: 2px 10px;">Below base surface</span>	<span style="border: 1px solid red; padding: 2px 10px;">100</span>	<span style="border: 1px solid red; padding: 2px 10px;">SET1 ID</span>

Minimum Bead Width	Maximum Bead Height	Bead Draw Direction	NGSET	DGSET
<span style="border: 1px solid red; padding: 2px 10px;">6.</span>	<span style="border: 1px solid red; padding: 2px 10px;">6.</span>	<span style="border: 1px solid red; padding: 2px 10px;">Below base surface</span>	<span style="border: 1px solid red; padding: 2px 10px;">100</span>	<span style="border: 1px solid red; padding: 2px 10px;">SET1 ID</span>

3

BDF Output - Design Model

```

$
----- Design Regions for Topography Optimization -----
$
BEADVAR 1    PSHELL 8      6.      6.      70.0  YES  BOTH
DESVAR
GRID 100      -1.0  0.0
          
```

Developed by The Engineering Lab



# 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 1<sup>st</sup> natural frequency.

## Step 1 - Select an objective

Select an analysis type

SOL 103 - Normal Modes

Select a response

	Response Description ▾	Response Type ▾
	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	Weight	WEIGHT
	Volume	VOLUME
	Eigenvalue	EIGN
	Frequency	FREQ
	Displacement	DISP

« 1 2 3 »

5 10 20 30 40 50

## Step 2 - Adjust objective

+ Options

	Label	Status	Response Type	Maximize or Minimize	Property Type	ATTA	ATTB	ATTi
	r0		FREQ	MAX	STRUC	1		

# 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"

SOL 200 Web App - Optimization Upload Variables Objective Constraints Subcases **1** Exporter Results Settings Match Other User's Guide Home

### BDF Output - Model

```
assign userfile = 'optimization_results.csv', status = unknown,
form = formatted, unit = S2
$ UNITS
$ Length: mm
$ Density: t/mm^3 (Also known as tonne/mm^3 or Mg/mm^3)
$ Time: s
$ Force: N
$ Temperature: K
$ Angle: rad (Radians)
$
$ MSC Apex oscilabel(label): mm-t-s-N-K (mm-t-s-N-K)
$
$ NASTRAN input file created by the Patran 2007 rib input file
$ translator on November 30, 2007 at 15:31:01.
$ Direct Text Input for Nastran System Cell Section
$ Direct Text Input for File Management Section
$ Linear Static Analysis, Database
SOL 200
$ Direct Text Input for Executive Control
CEND

ECHO = NONE
DISP(PLOT)=ALL
$ Direct Text Input for Global Case Control Data
DESOBJ(MAX) = 8000000
$ DESOBJ Slot
$ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1
ANALYSIS = MODES
```

### BDF Output - Design Model

```
$*****
$*
$*              Design Model
$*
$*****
$
$----- Design Regions for Topography Optimization
$-----
BEADVAR 1 PSHELL 8 6. 6. 70.0 YES BOTH
DESVAR
GRID 100
$
$----- Design Objective
$-----
$
$ DRCSP1 0000000 r0 rncq STRUC 1
$
$----- Design Constraints
$-----
$
$
$
$
$----- Design Equation Constraints
$-----
$
$
$
$
$
$
$----- Supporting Responses
$-----
$
$
```

Download BDF Files

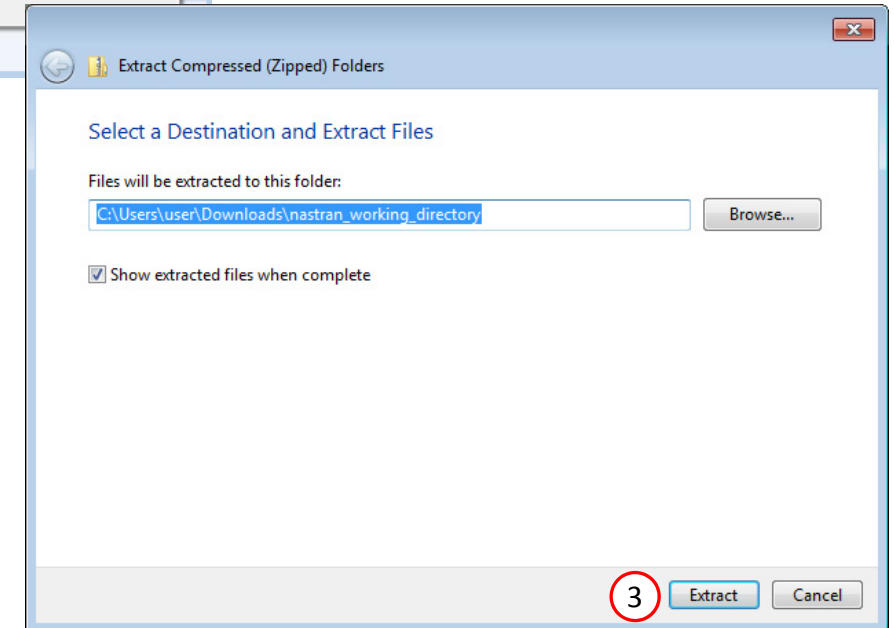
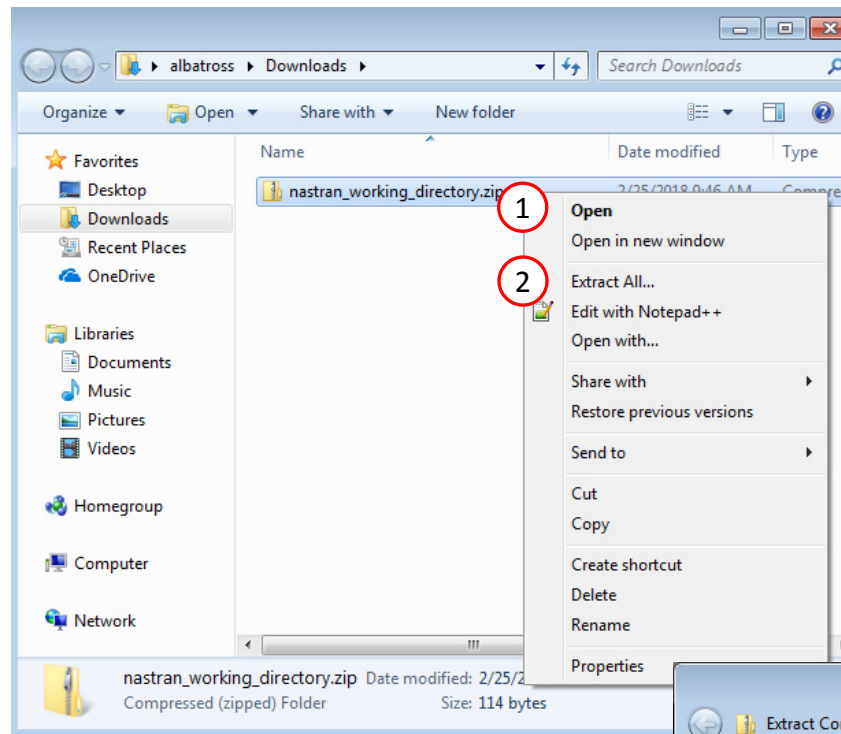
[Download BDF Files](#) **2**

Developed by The Engineering Lab

# 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.

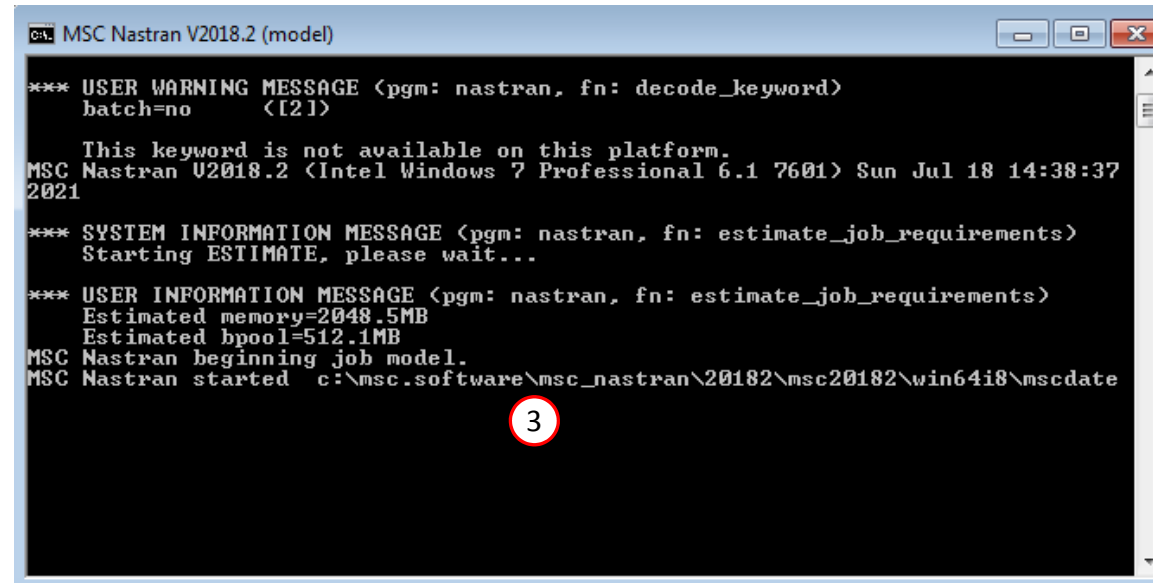
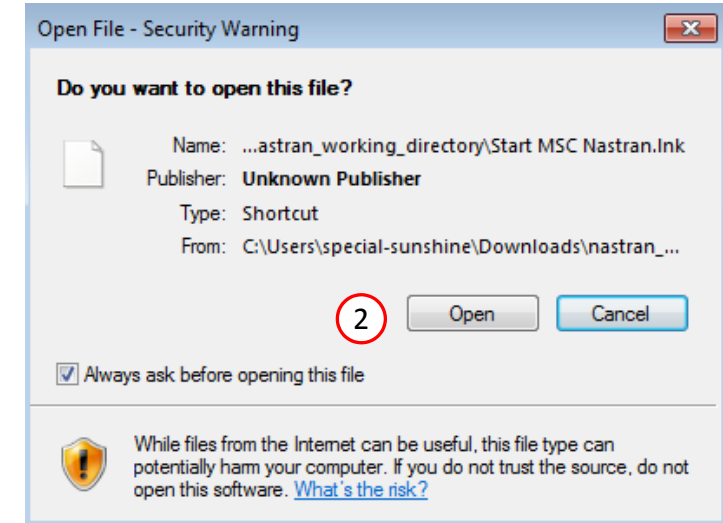
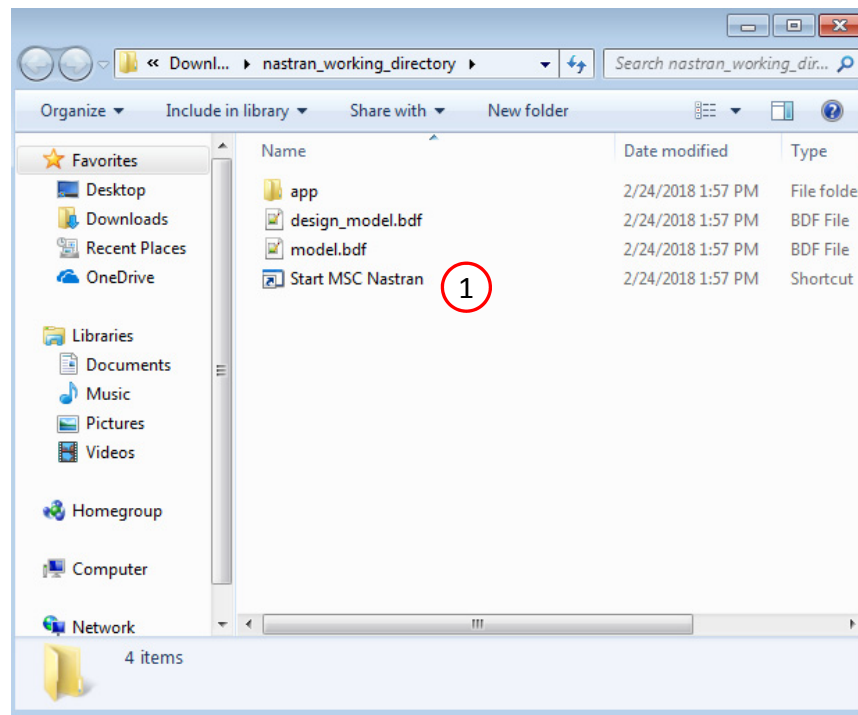
## Using Linux?

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.

## SOL 200 Web App - Status

 Python

 MSC Nastran

### Status

Name	Status of Job	Design Cycle	RUN TERMINATED DUE TO
model.bdf	Running	None	

# 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).

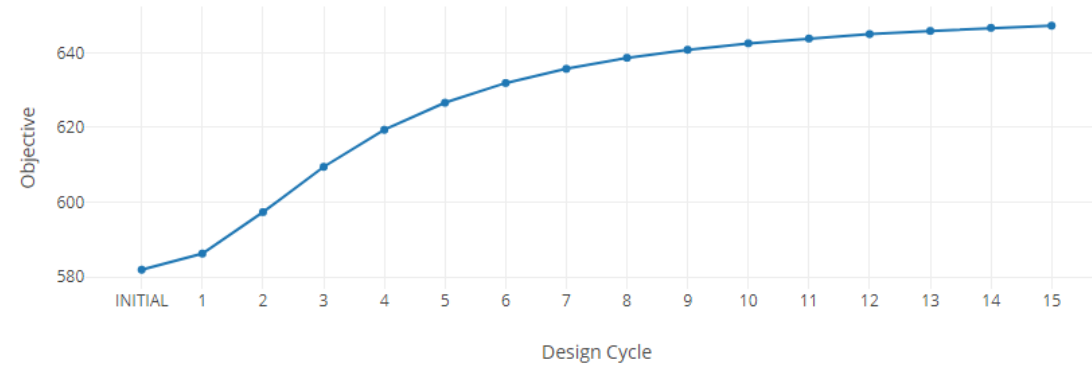
## Final Message in .f06

1



RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 15.

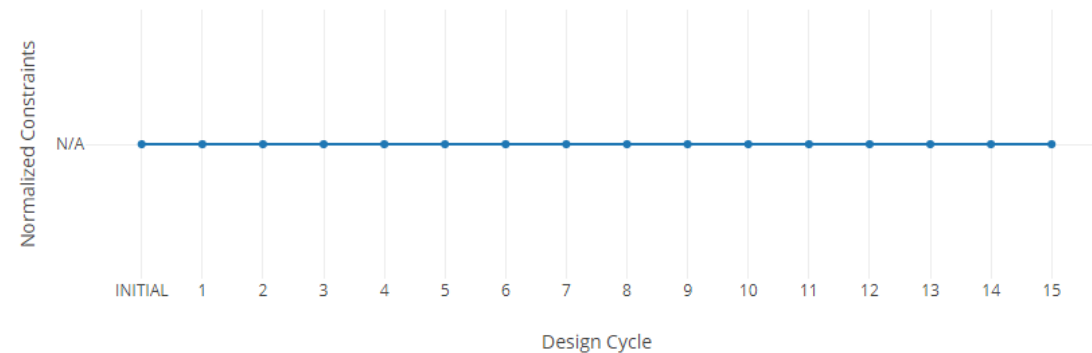
## Objective



2

## Normalized Constraints

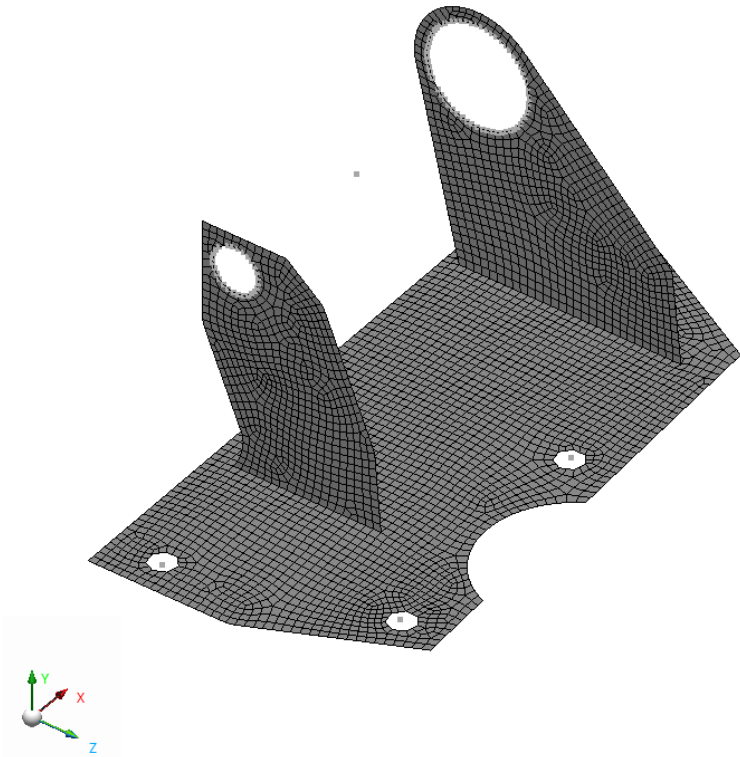
+ Info



# Results

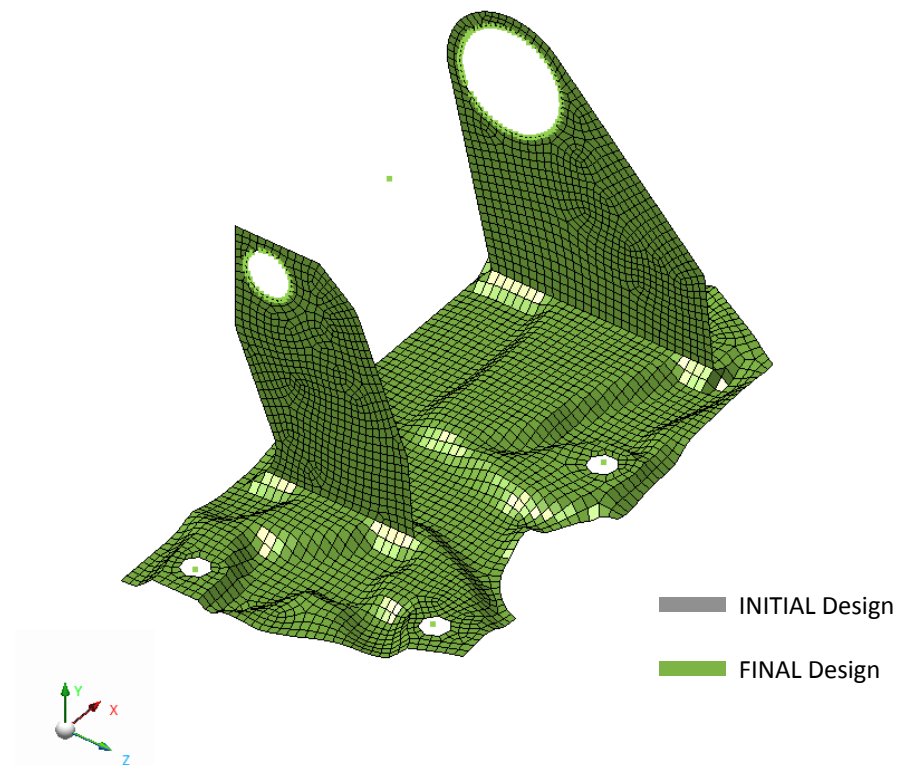
## Before Optimization

- 1<sup>st</sup> Natural Frequency: 581.9 Hz



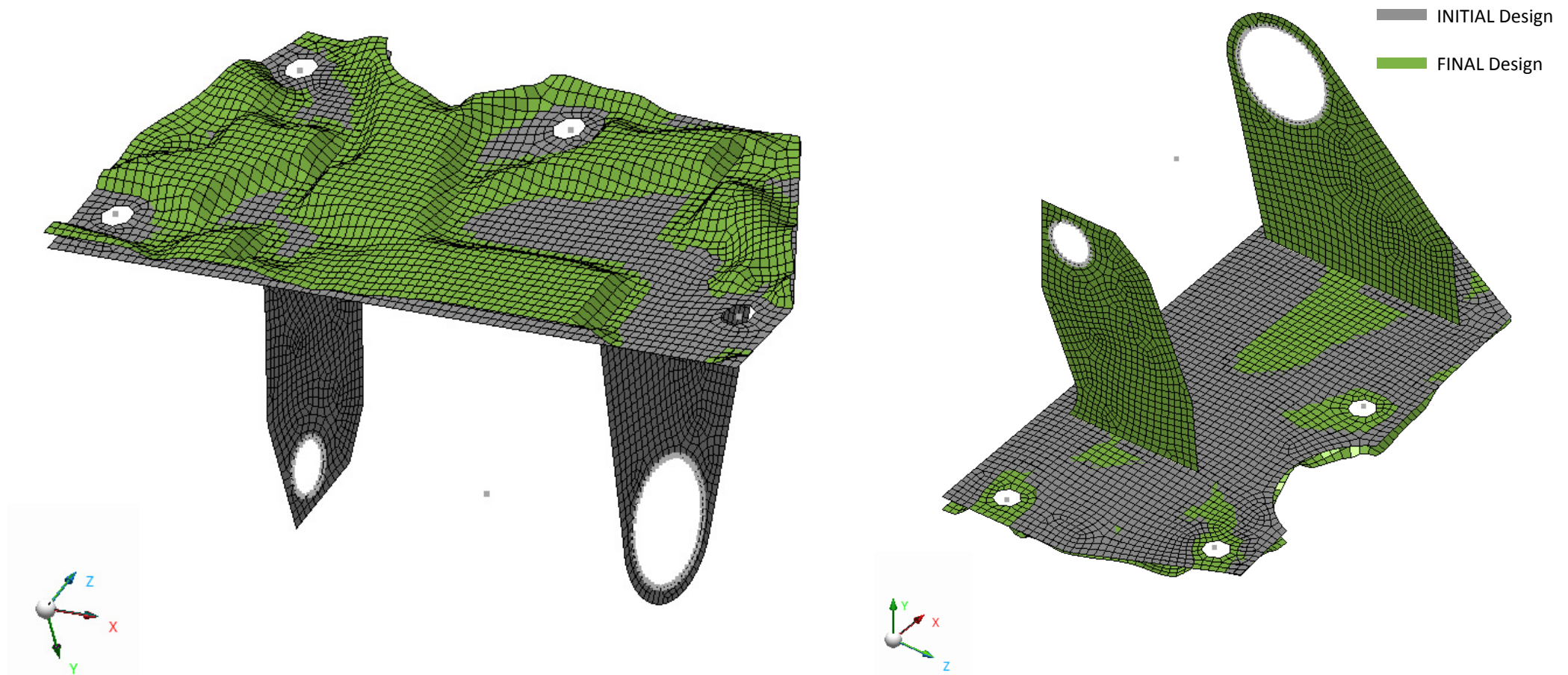
## After Optimization

- 1<sup>st</sup> Natural Frequency: 647.22 Hz





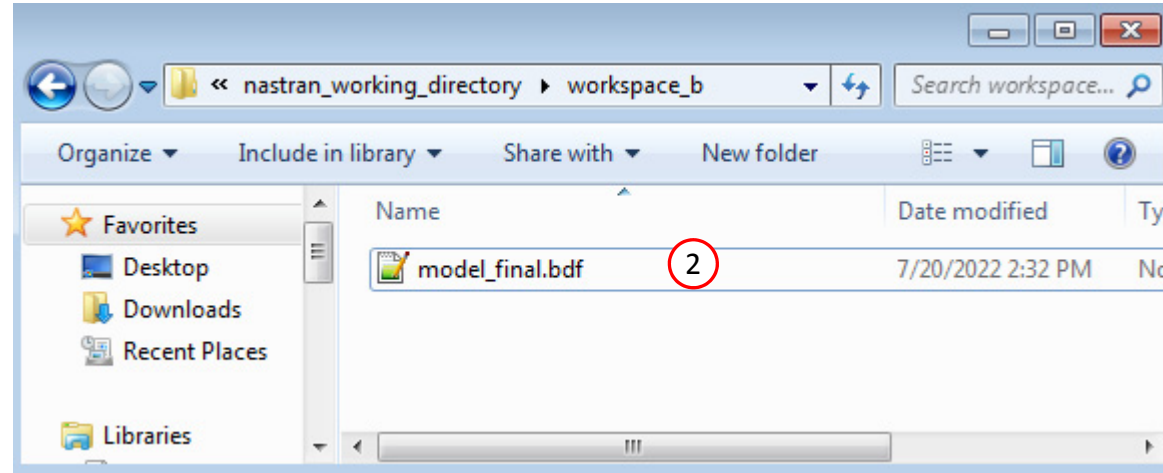
# Results





# 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.



Original Input Files

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

- 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.

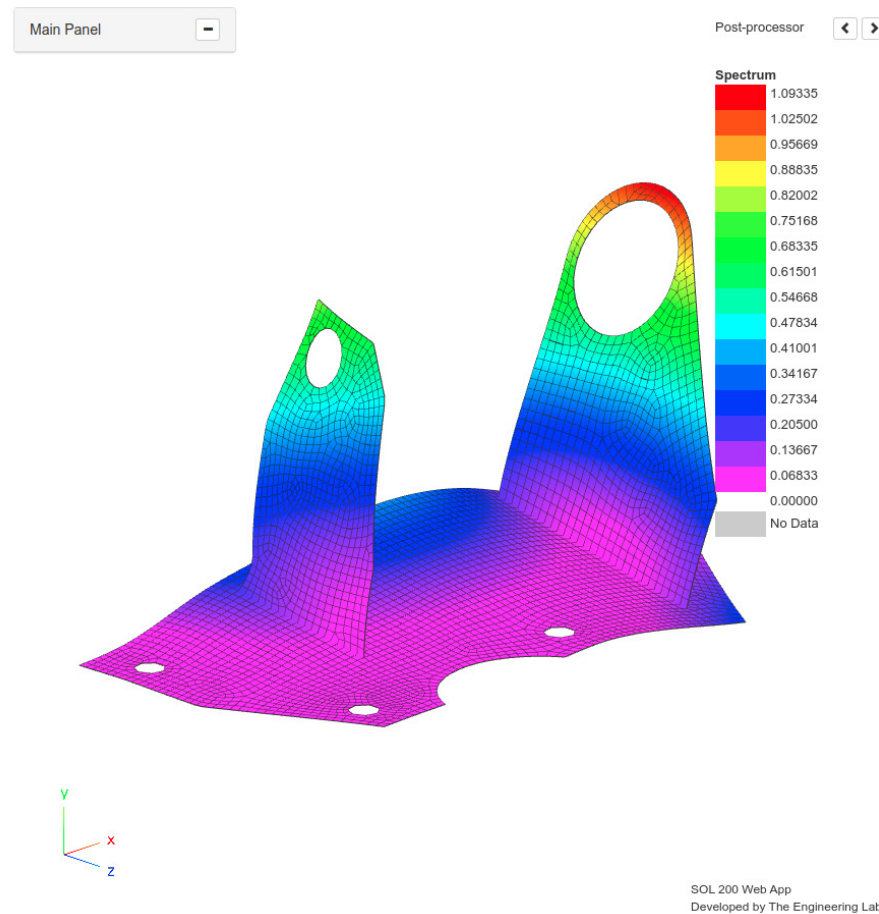
# Inspection of MSC Nastran Results with the Post-processor Web App

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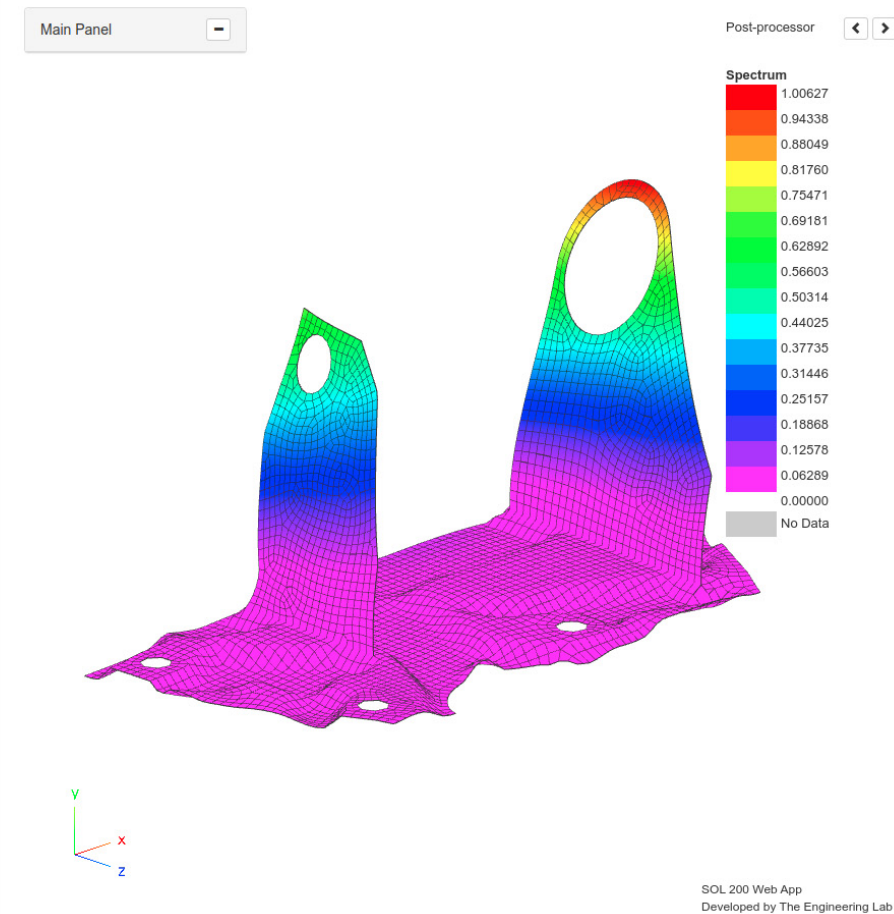
# Post-processor Web App

- 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

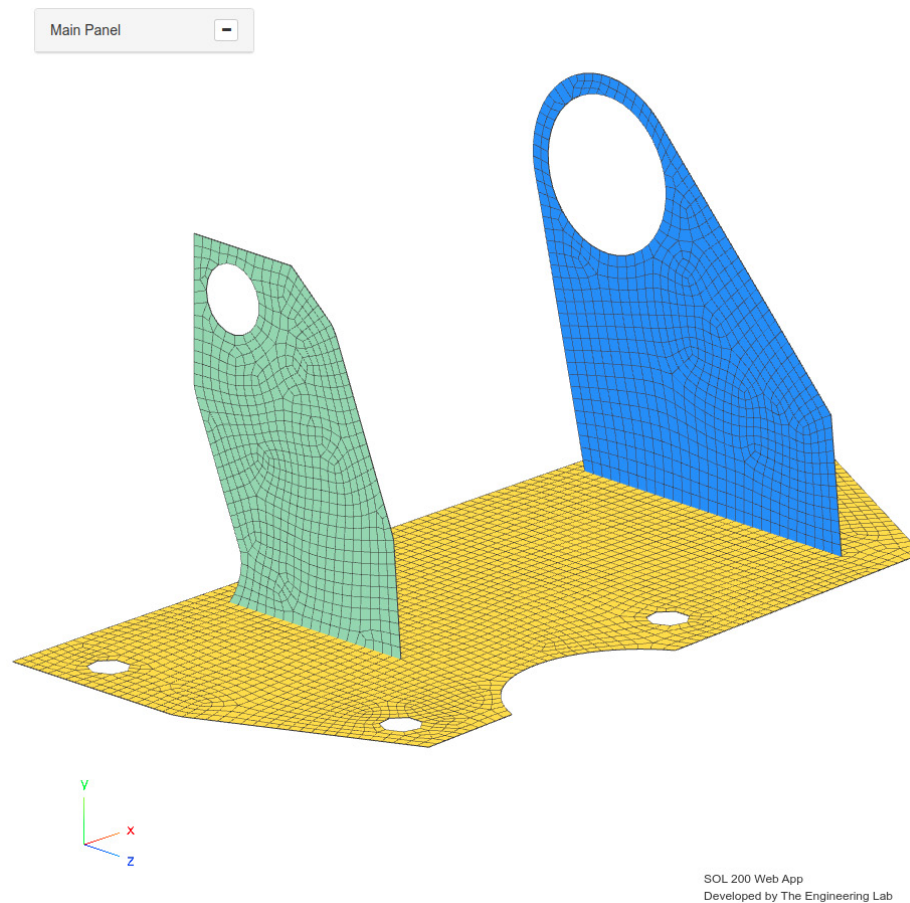


Final Design

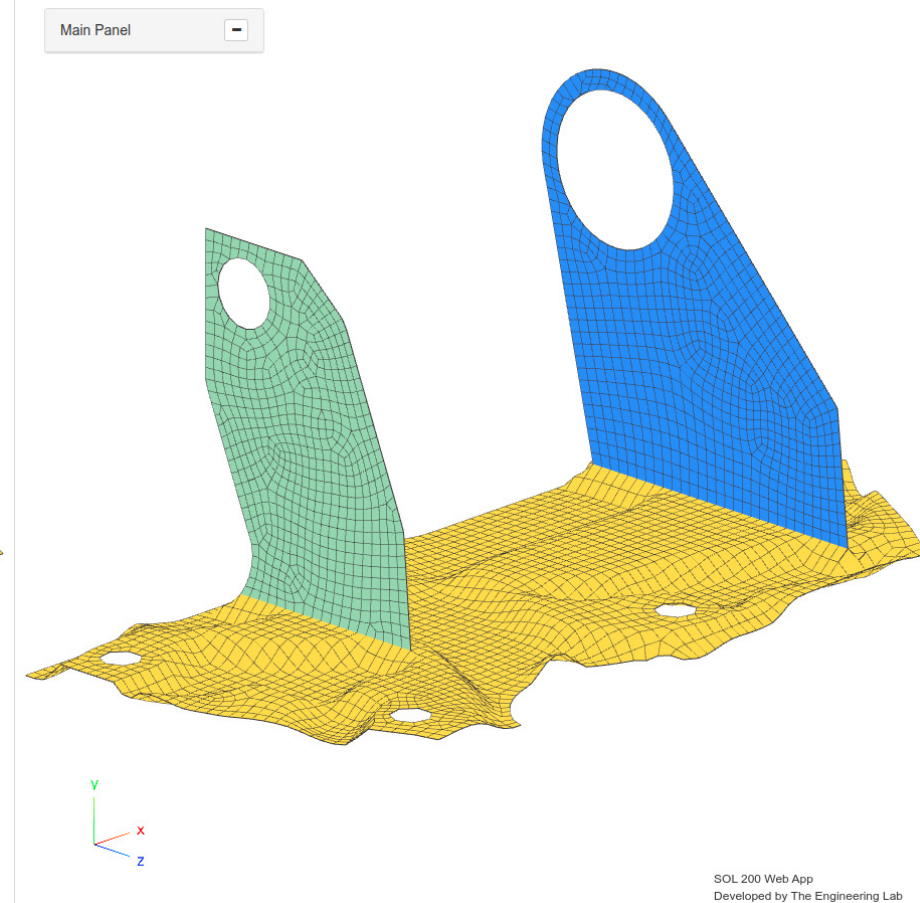
# Post-processor Web App

- 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

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# Appendix Contents

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- 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

### Step 2 - Configure design regions

+ Options

☒ Advanced Configuration

BEADVAR ID	Status	Entry	Entry ID	Entry Name	Minimum Bead Width	Maximum Bead Height	Draw Angle	Buffer Zone	Boundary Skip	Bead Draw Direction	Draw Vector XD	Draw Vector YD	Draw Vector ZD	Coordinate System ID	NGSET	DGSET
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>												
<input type="checkbox"/> 1	<input checked="" type="checkbox"/>	PSHELL	8		6.	6.	70.0	YES - Create a bu	BOTH - Do not design no	Below t	Real Val	Real Val	Real Val	Coordinate !	100	SET1 ID