Workshop - Global Optimization of a Composite Laminate

AN MSC NASTRAN SOL 200 TUTORIAL

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Global Optimization

This example is a continuation of a previous example titled: Workshop - Automated Optimization of a Composite Laminate

Optimization Problem Statement

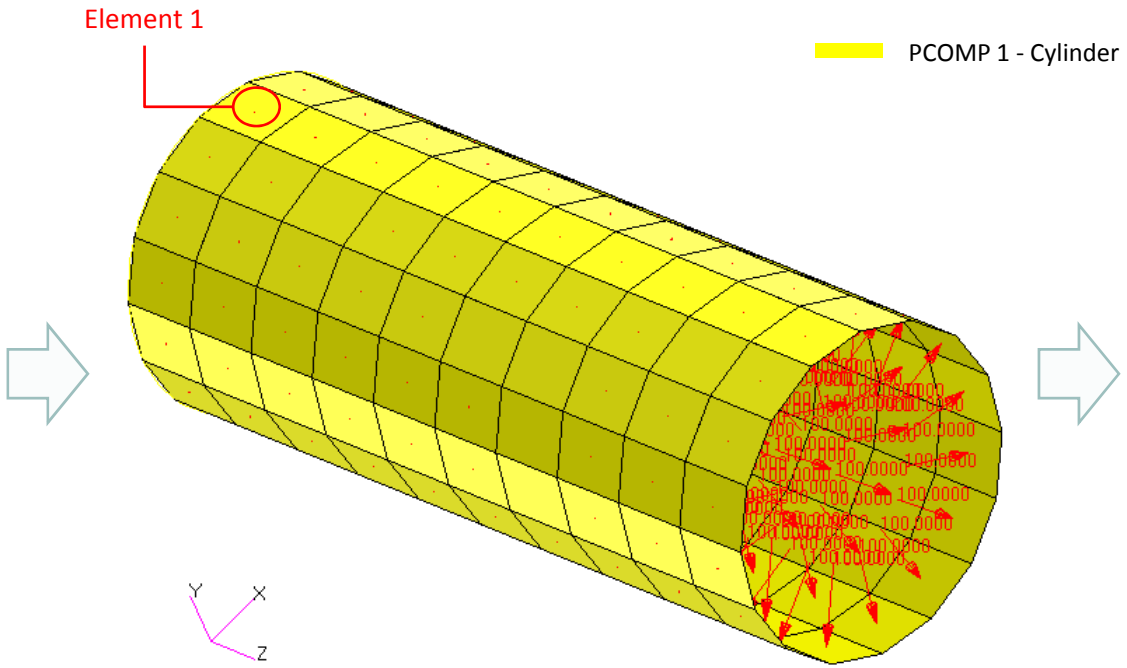
Design Variables

x1: T of lamina 1 of PCOMP 1
x2: T of lamina 2
x3: T of lamina 3
x4: T of lamina 4
x5: T of lamina 5
x6: T of lamina 6
x7: T of lamina 7
x8: T of lamina 8
.001 < xi
x9: Orientation of lamina 1 of PCOMP 1
x10: Orientation of lamina 2
x11: Orientation of lamina 3
x12: Orientation of lamina 4
x13: Orientation of lamina 5
x14: Orientation of lamina 6
x15: Orientation of lamina 7
x16: Orientation of lamina 8

y1: Thickness of layers
y2: Angle of layers (85)
y3: Angle of layers (-85)

.001 < y1 < 10.
-90. < y2 < 90.
-90. < y3 < 90.

Variable Linking
X1, x2, x3, … , x8 = y1
x9, x15 = y2
x10, x16= -1.0 * y2
x11 , x13 = y3
x12, x14 = -1.0 * y3



Design Objective

r0: Minimize weight

Design Constraints

r1: Failure index of lamina 1 of element 1
…
r8: Failure index of lamina 8 of element 1

r1, … r8 < .9

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:
   - Configure Global Optimization
   - Perform optimization with Nastran SOL 200

SOL 200 Web App Capabilities

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

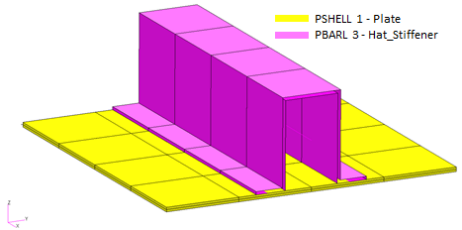
Compatibility

- 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.

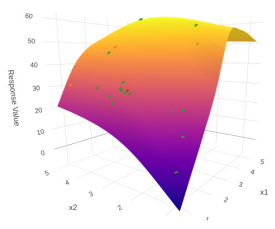
Benefits

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

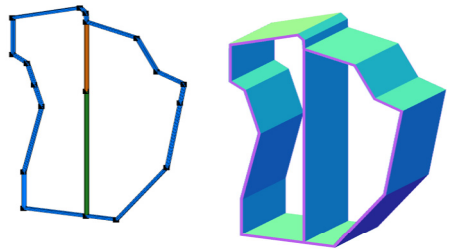
Web Apps



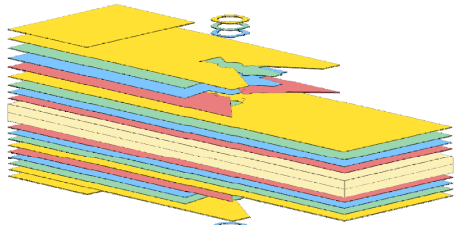
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



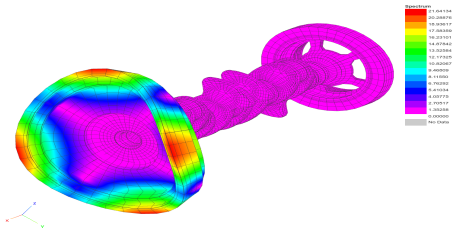
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



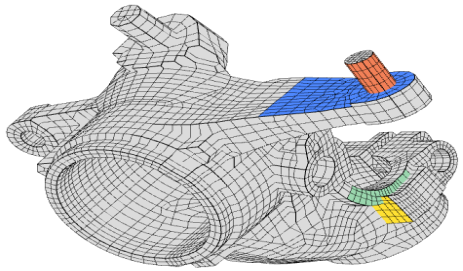
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



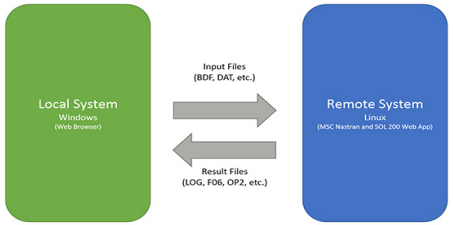
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



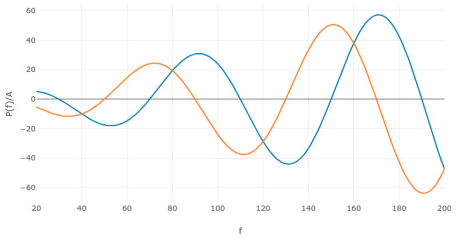
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



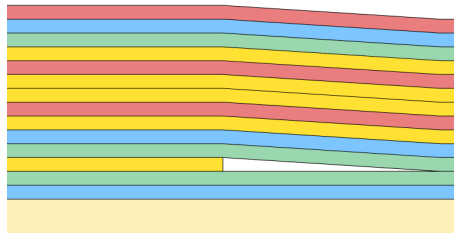
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



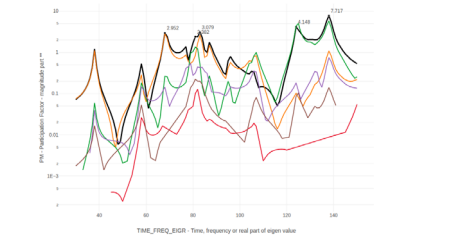
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



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

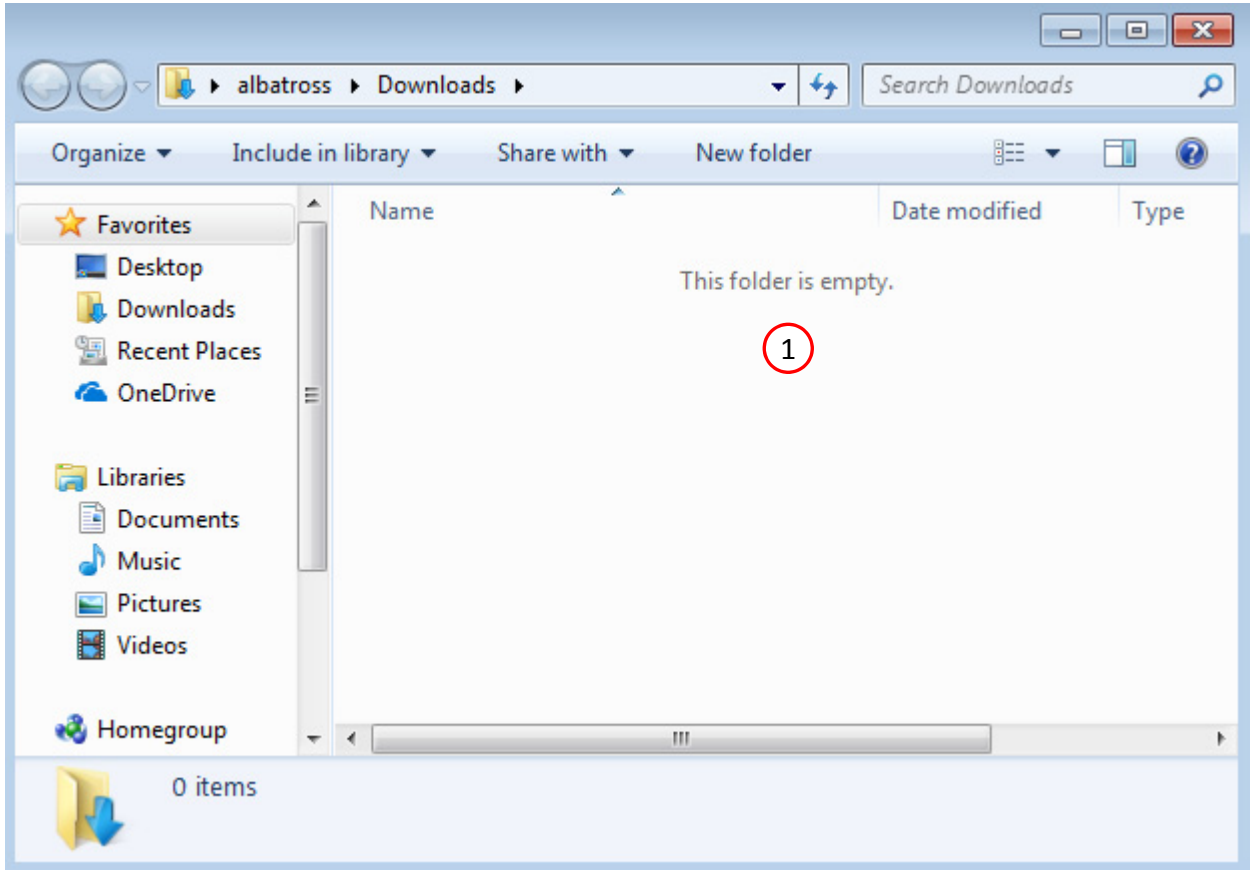


HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

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

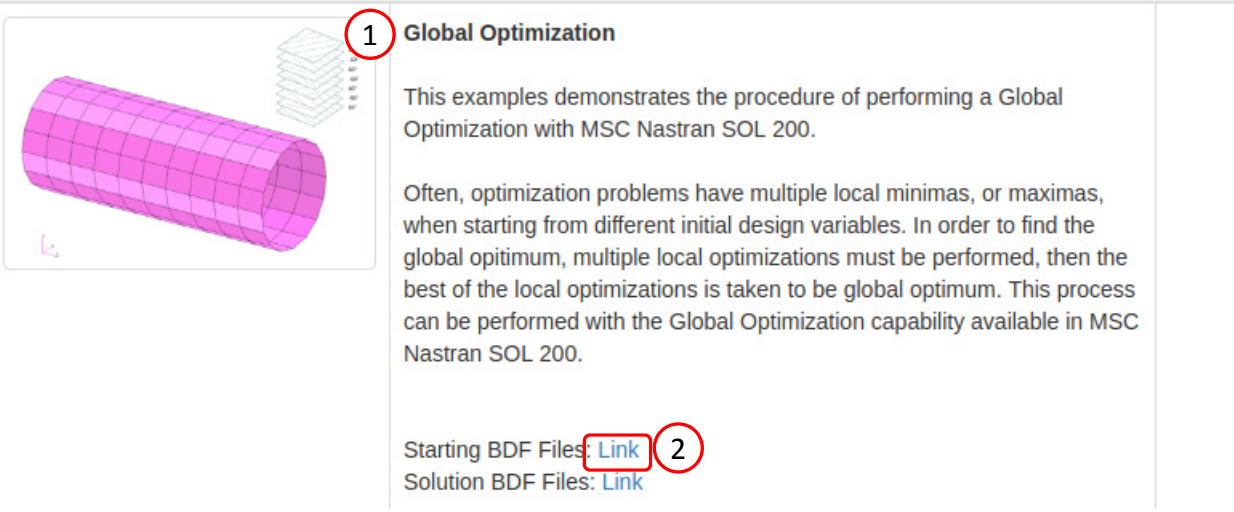
1. Click on the indicated link

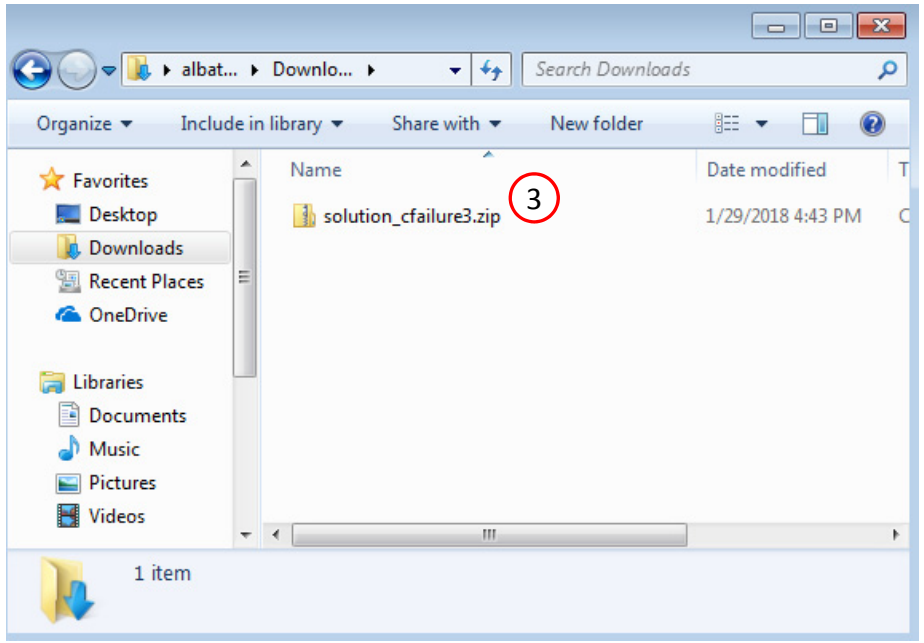
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

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.

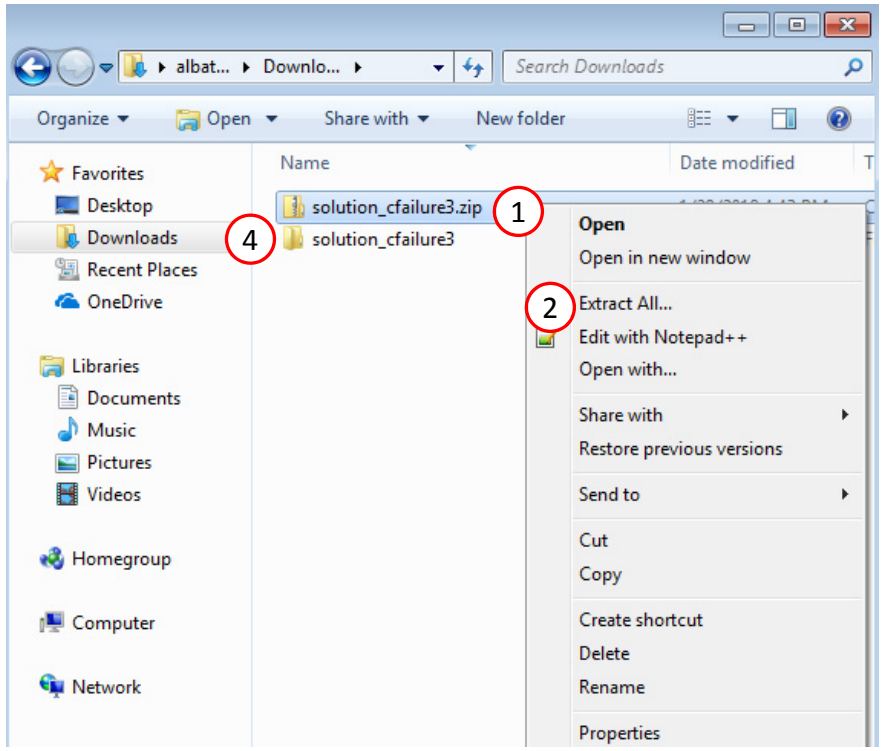


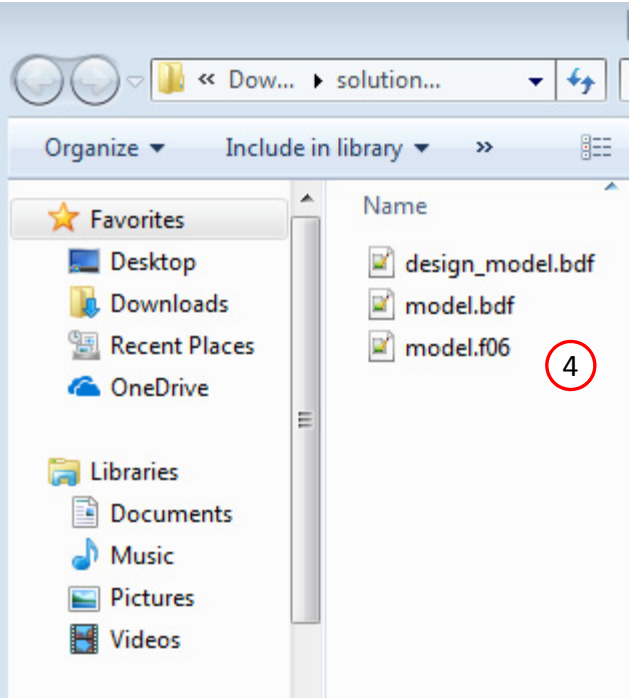


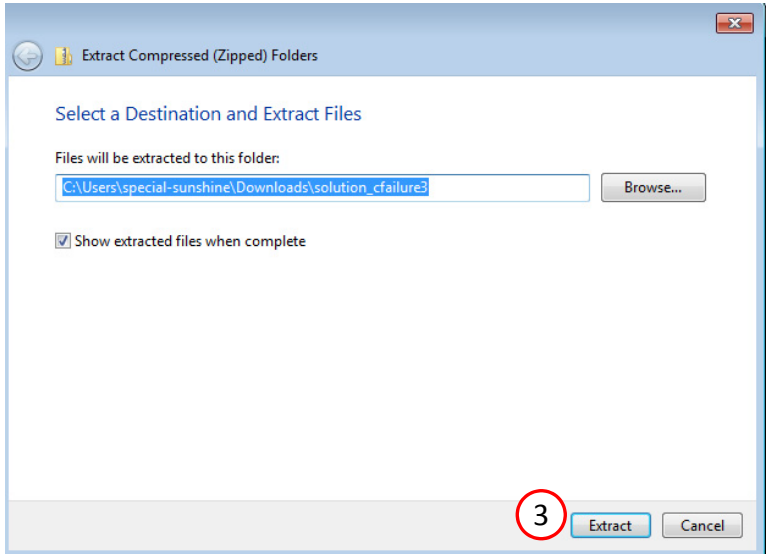
Obtain Starting Files

1. Right click on the zip file
2. Select Extract All…
3. Click Extract
4. The starting files are now available in a folder

- This example is using a previously created design model. The design model is a model that has been converted to SOL 200 and contains bulk data entries describing the optimization problem statement, e.g. variables, objective and constraints.







Open the Correct Page

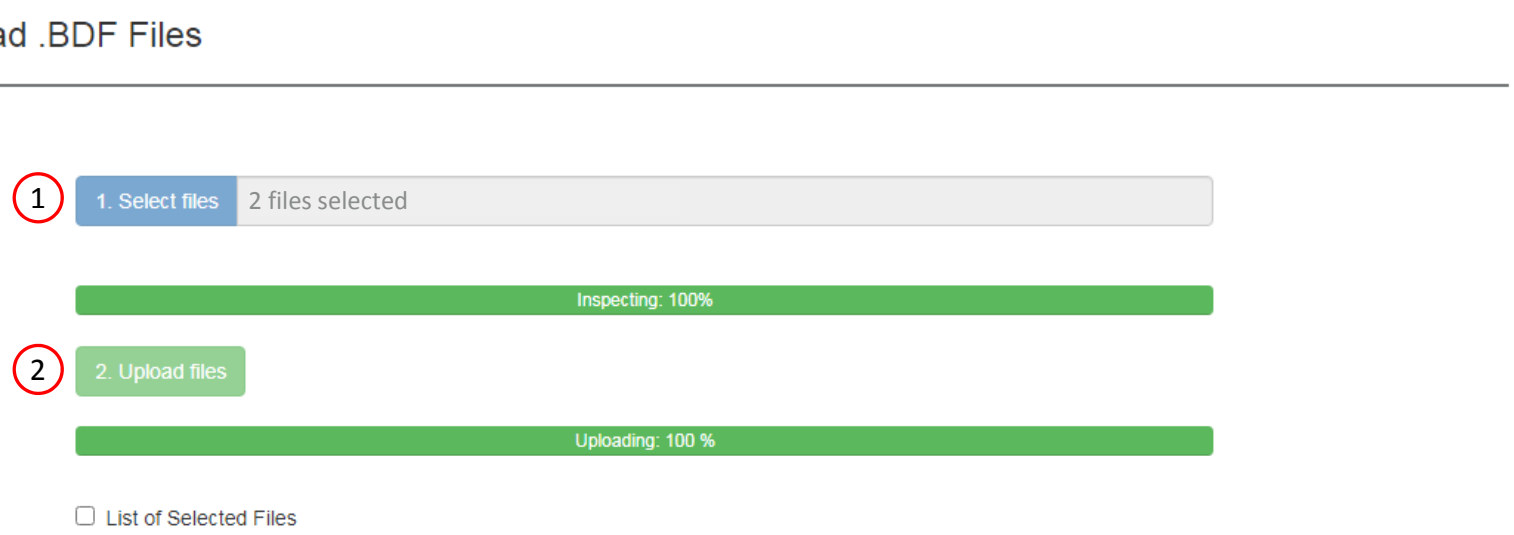
1. Click on the indicated link

- 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 model.bdf and design_model.bdf
2. Click Upload Files

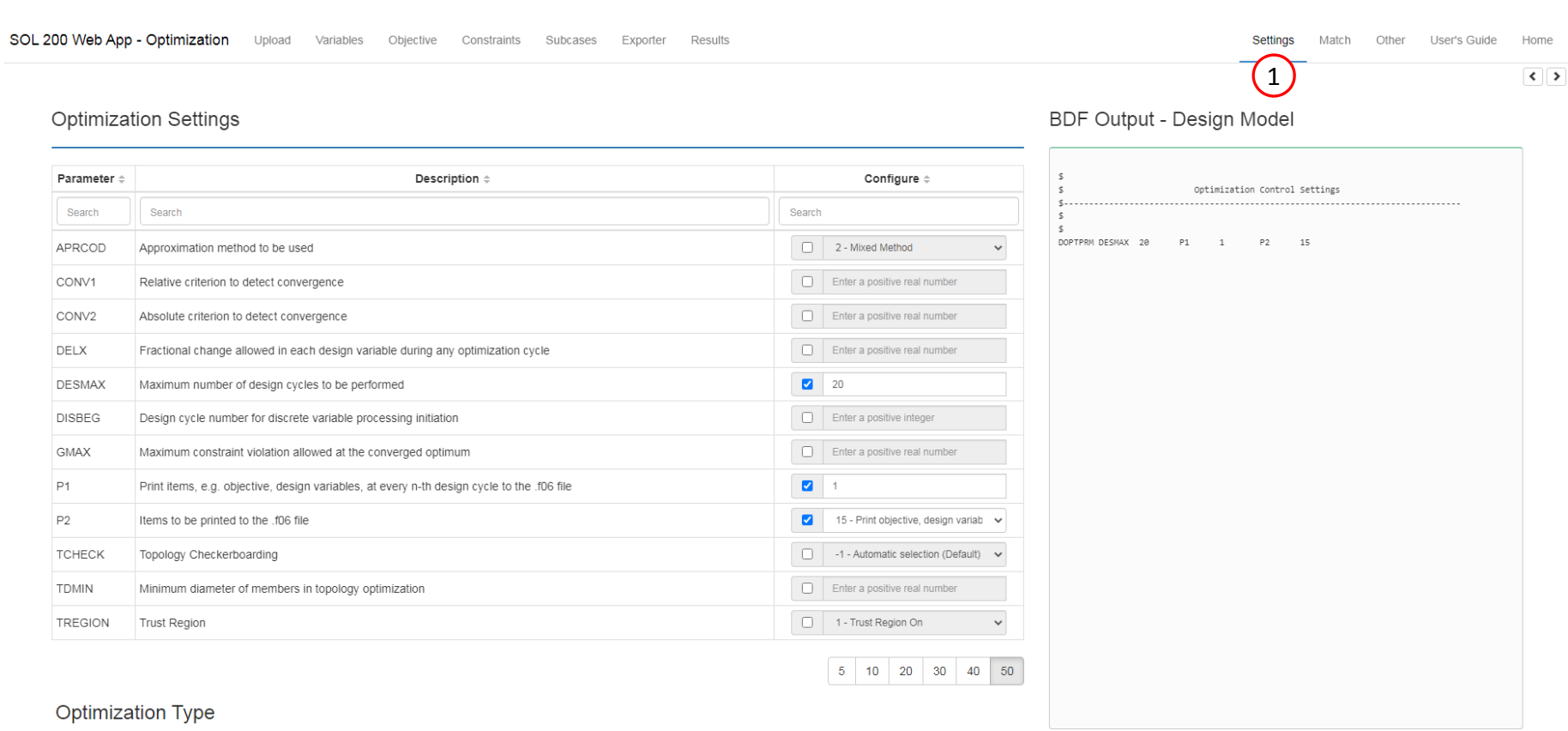
- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.

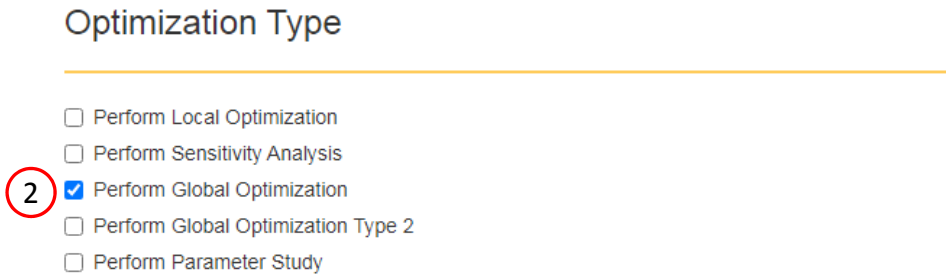


Configure Settings

1. Click Settings
2. Mark the checkbox for “Perform Global Optimization”

- Global Optimization involves performing multiple local optimizations, each at different initial values for the design variables. Design models with numerous design variables may require dozens, possibly hundreds of local optimizations. The reader may realize there are 2 global optimization options in the web app. Here is a summary describing the difference between the options:
  - Perform Global Optimization – To address scenarios where dozens or hundreds of local optimizations are necessary, MSC Nastran employs Heuristic techniques to minimize the number of local optimizations necessary to find the global optimum.
  - Perform Global Optimization Type 2 – In this method, Heuristic techniques are not employed. Instead, each local optimization is performed.

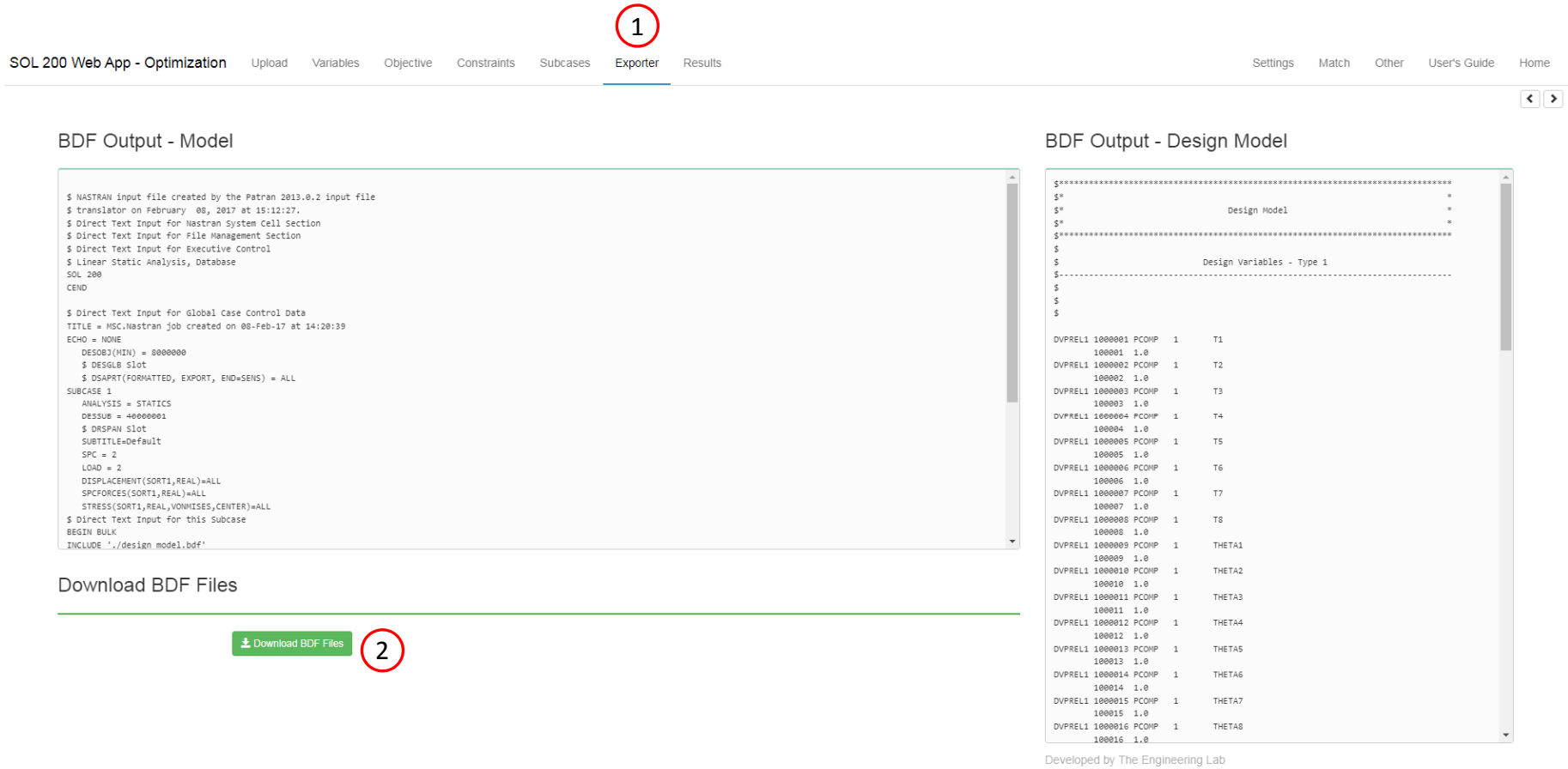




Export New BDF Files

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

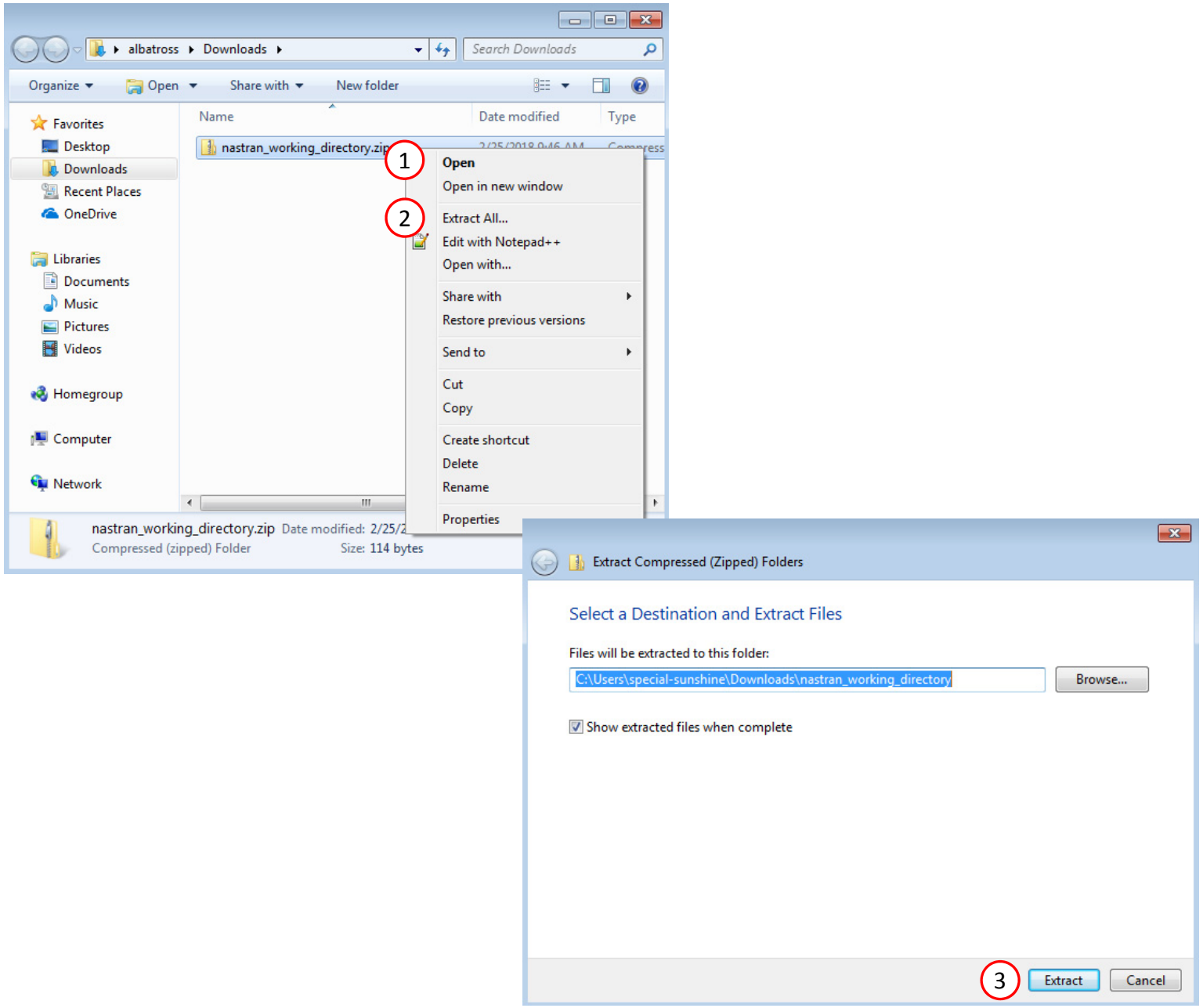
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



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

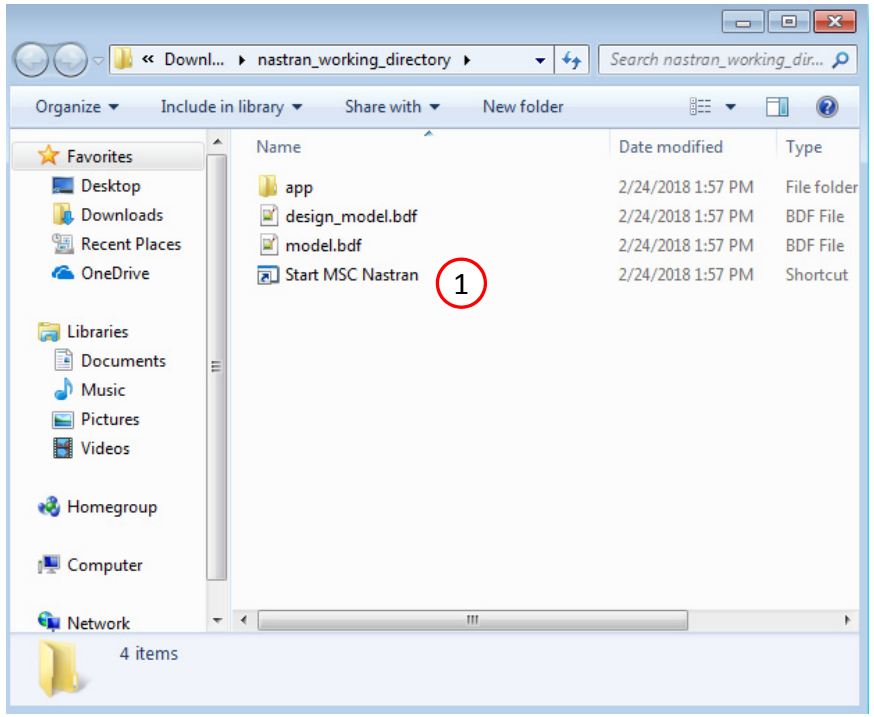
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the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

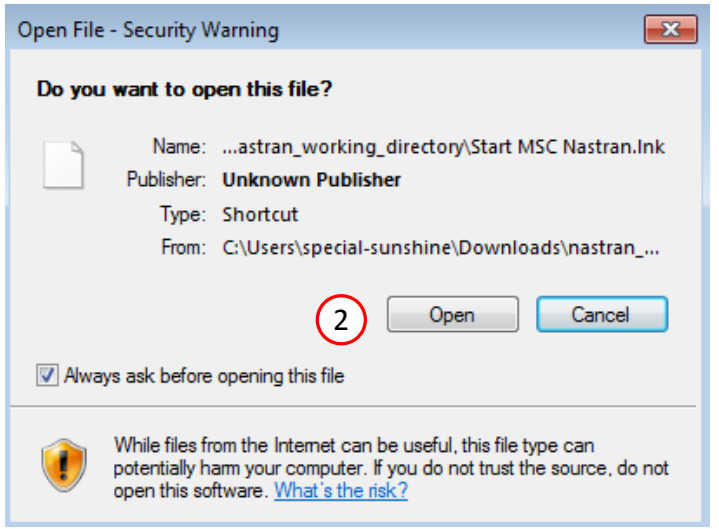
Using Linux?

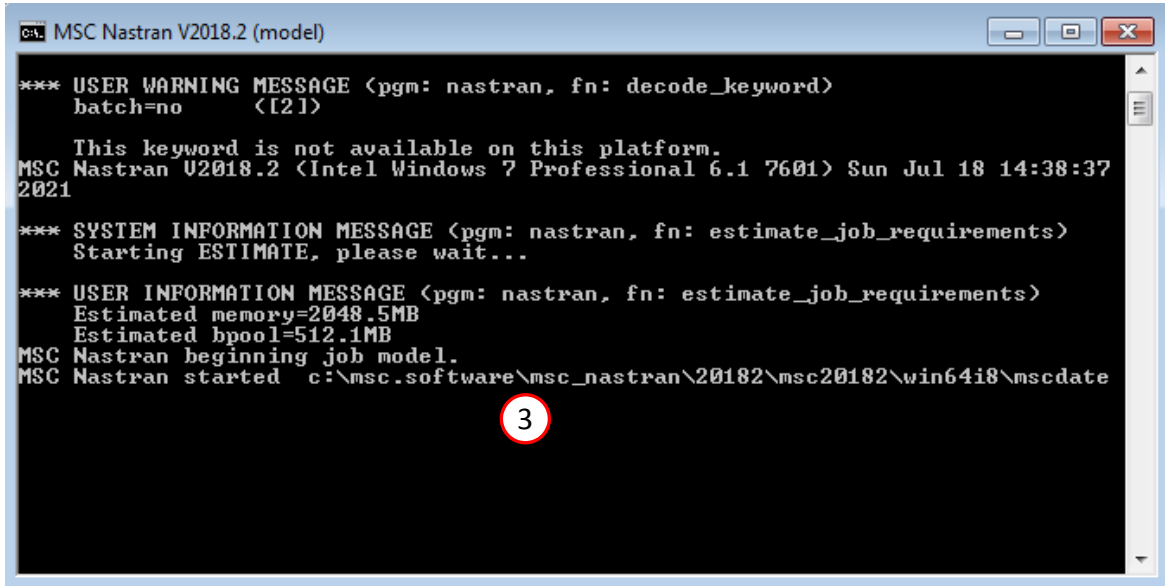
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
cd ./nastran_working_directory
3) Use this command to start the process
./Start_MSC_Nastran.sh

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



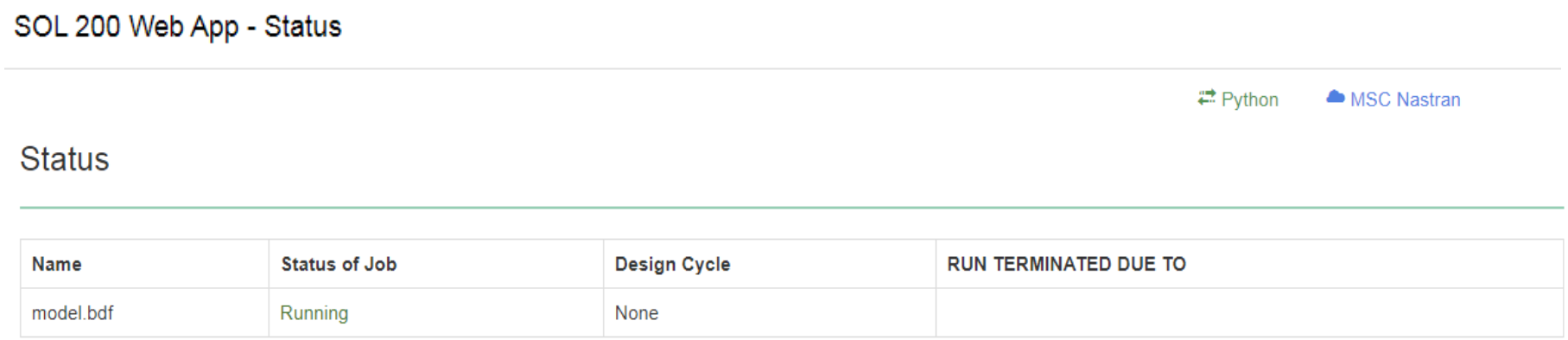




Status

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.



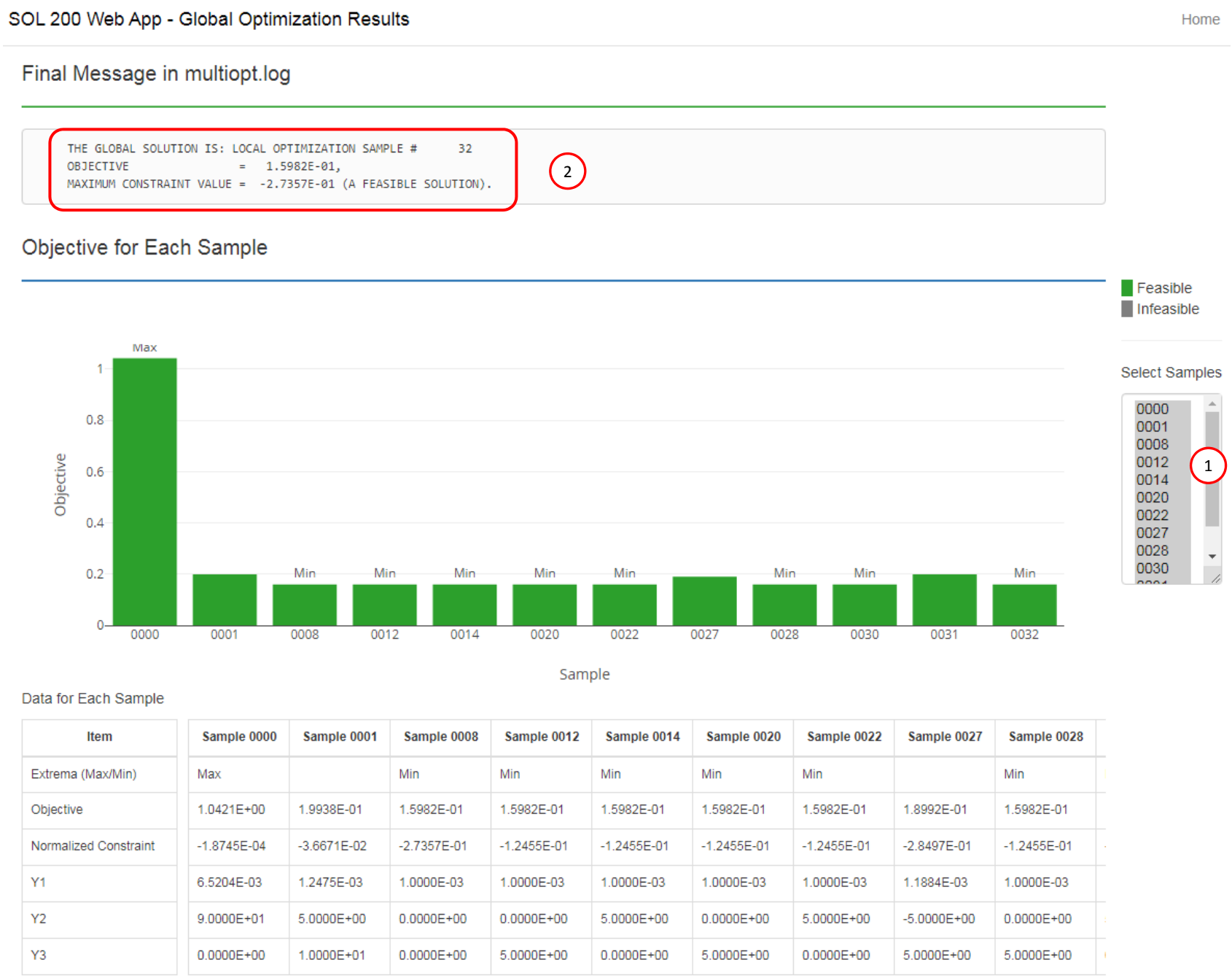
Review Optimization Results

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

For each sample the objective, normalized constraints, and design variables are displayed in a bar chart and table.

1. The select box can be used to display specific samples.
2. The Final Message found in the multiopt.log file provides information regarding the global minimum or maximum

- The Global Optimization has performed multiple local optimizations and are labeled by different Sample numbers. Out of all the local optimizations performed or samples, the global optimum is the better of all. The sample that is the global optimum is reported in the section Final Message in multiopt.log. The sample and its respective objective and variables are listed in the bar chart and table.



Item	Sample 0000	Sample 0001	Sample 0008	Sample 0012	Sample 0014	Sample 0020	Sample 0022	Sample 0027	Sample 0028
Extrema (Max/Min)	Max		Min	Min	Min	Min	Min		Min
Objective	1.0421E+00	1.9938E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.8992E-01	1.5982E-01
Normalized Constraint	-1.8745E-04	-3.6671E-02	-2.7357E-01	-1.2455E-01	-1.2455E-01	-1.2455E-01	-1.2455E-01	-2.8497E-01	-1.2455E-01
Y1	6.5204E-03	1.2475E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.1884E-03	1.0000E-03
Y2	9.0000E+01	5.0000E+00	0.0000E+00	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	-5.0000E+00	0.0000E+00
Y3	0.0000E+00	1.0000E+01	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	5.0000E+00

End of Tutorial