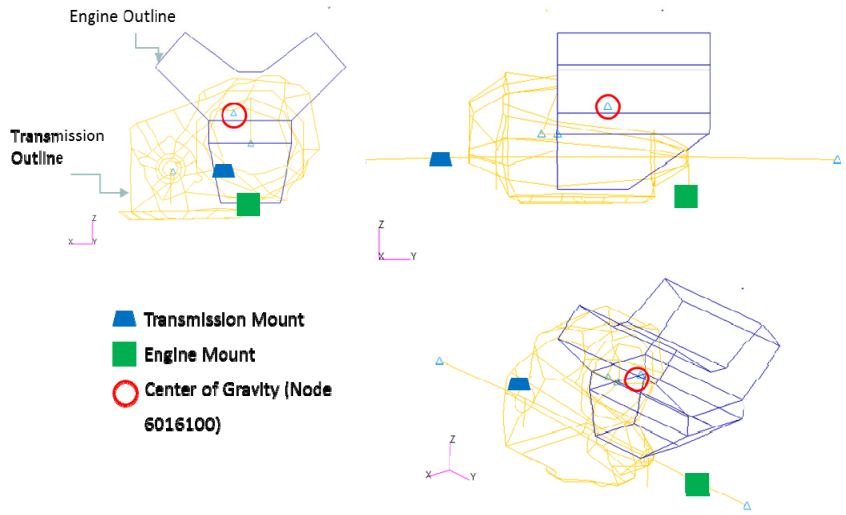
Workshop – Parameter Study, Global Optimization with a Latin Hypercube Design

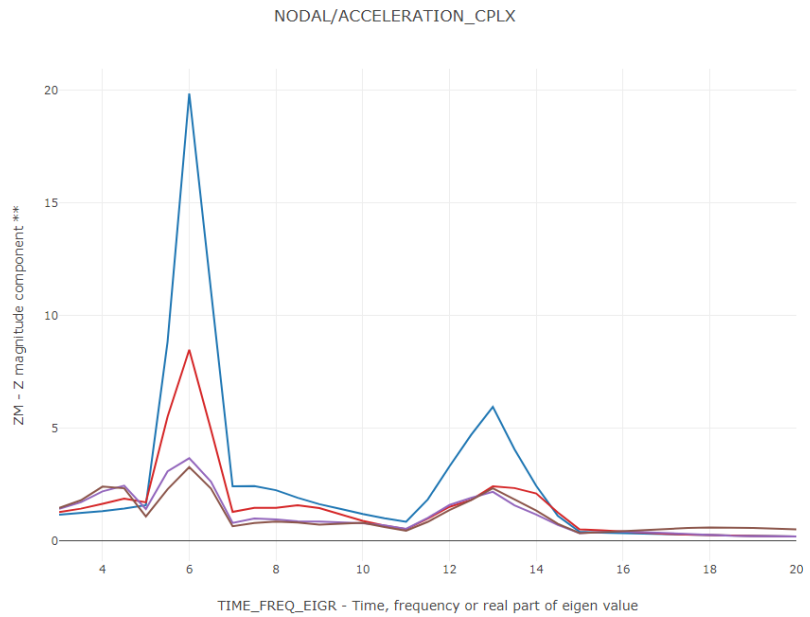
AN MSC NASTRAN MACHINE LEARNING WEB APP TUTORIAL

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

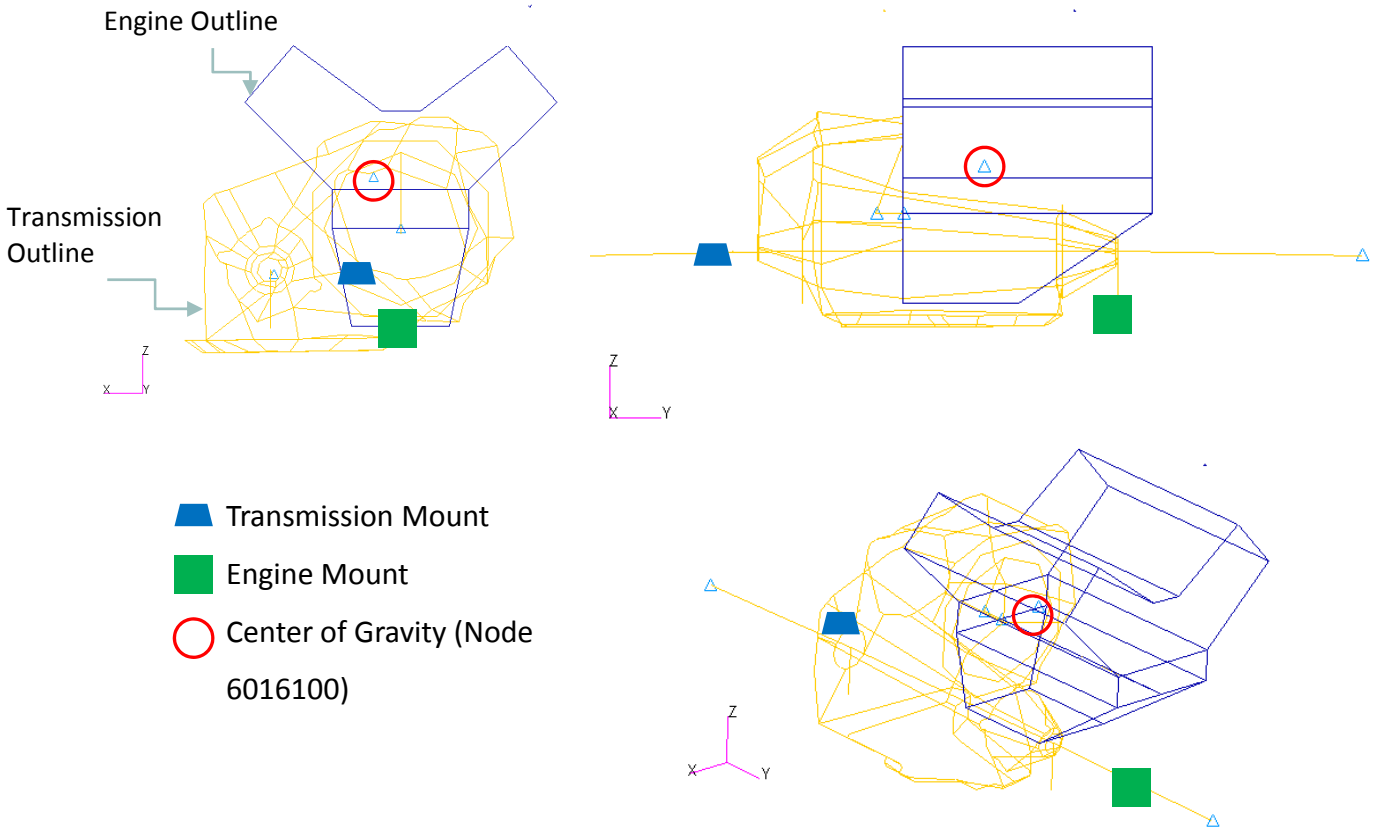
Goal: Perform a global optimization using a Latin Hypercube design

1. Use a Latin Hypercube design to set different initial values of the design variables of an existing SOL 200 input deck
2. Perform an optimization for each sample
3. Compare the final objective of each optimization to identify the global optimal result
4. Create plots for the frequency response and objective histories

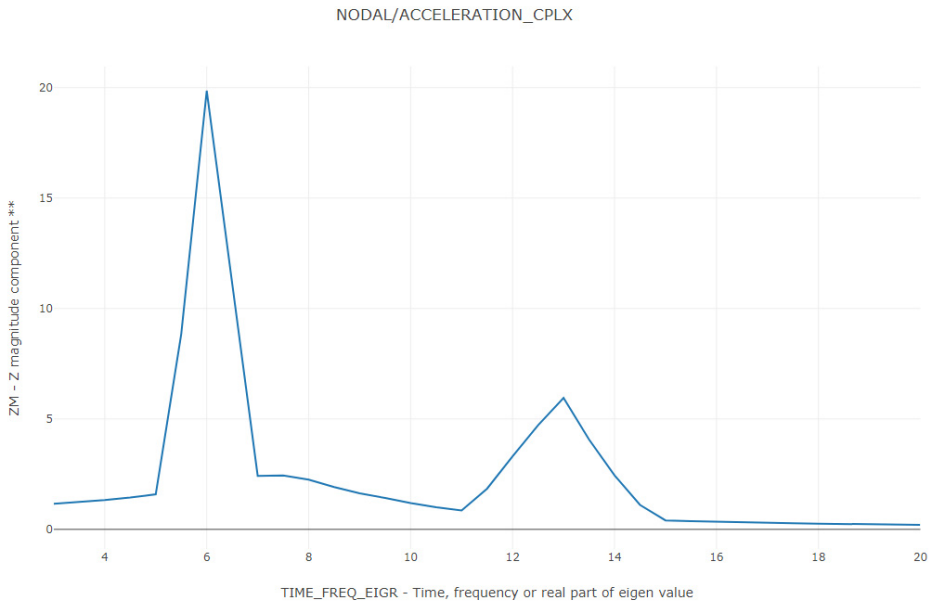




Details of the Structural Model



Frequency Response at CG (Node 6016100)



Reference: Zhang, Shenghua & Yu, Xiaoming & Johnson, Erwin. (2003). A Practical Global Optimization Procedure. 10.2514/6.2003-1671.

Problem Statement

Design Variables

x1: The starting value of design variable 1 (XINIT of DESVAR 6016011)

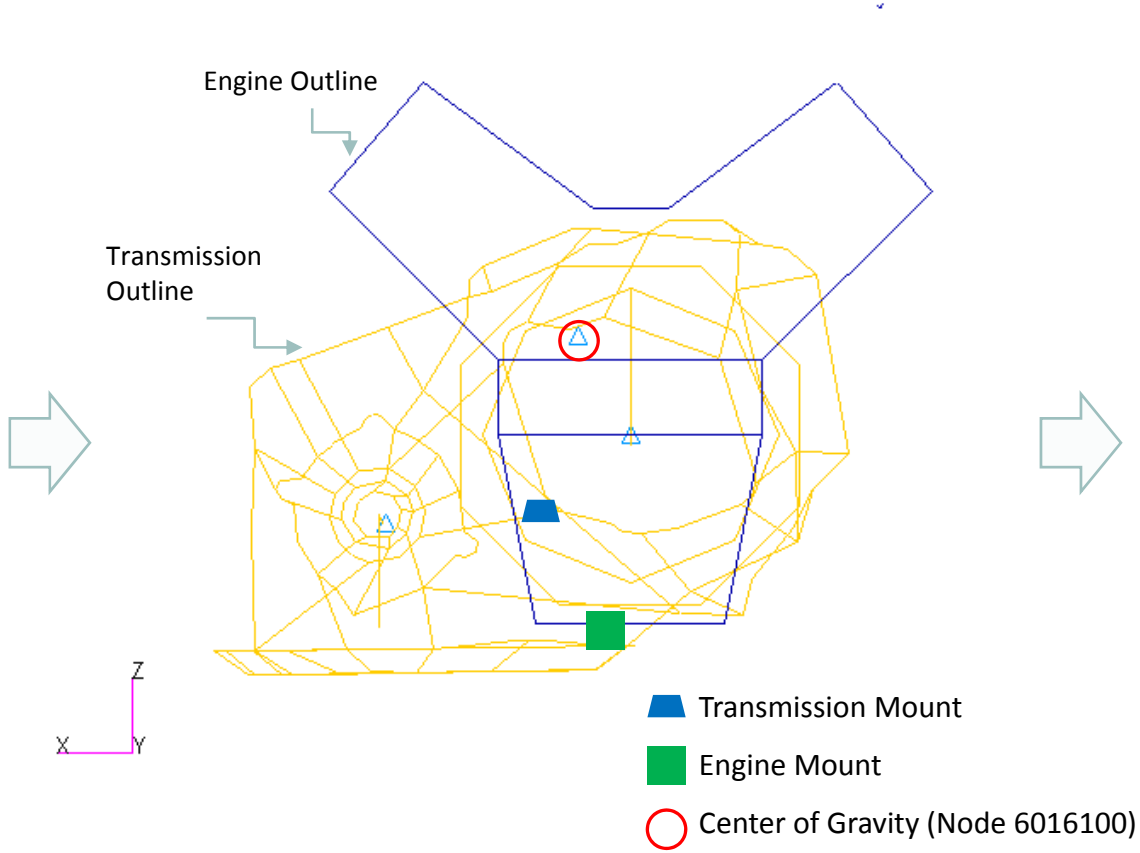
x2: The starting value of design variable 2 (XINIT of DESVAR 6016012)

...

x20: The starting value of design variable 11 (XINIT of DESVAR 6016243)

Samples

A Latin Hypercube design is used. Forty samples are generated, but only the first 20 samples are executed.



Monitored Responses

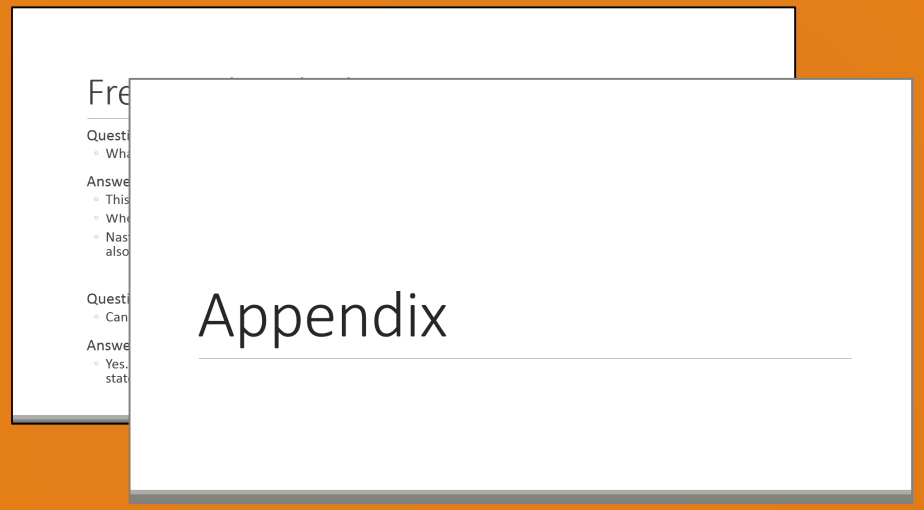
r1: Objective value of the final design cycle

r2: Normalized constraint value of the final design cycle

More Information Available in the Appendix

The Appendix includes information regarding the following:

- Response Configuration
  1. Use FINAL response: Yes, No or blank
- Equivalent Global Optimization
- How to import and edit previous parameter studies



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:
   - Select parameters and configure multiple BDF configurations
   - Select responses to monitor
   - Use MSC Nastran to run each BDF configuration
3. Review the monitored responses

Special Topics Covered

Equivalent Global Optimization - MSC Nastran SOL 200 has a capability to perform Global Optimization. This tutorial describes a procedure to configure multiple local optimizations, track responses and determine global optimal designs. A Maximin Latin Hypercube design is used to configure different initial values for the design variables, and a local optimization is performed for each configuration, or sample. Ultimately, this procedure is comparable to Global Optimization.

Automatic Response Extraction – Often responses are manually or automatically extracted from the F06 file. This becomes challenging when extracting responses from multiple F06 files. This tutorial highlights the web app's ability to automatically extract responses from multiple H5 files with minimal user effort.

SOL 200 Web App Capabilities

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

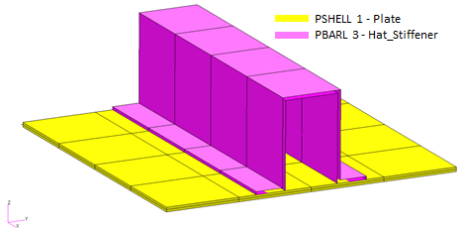
Compatibility

- 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.

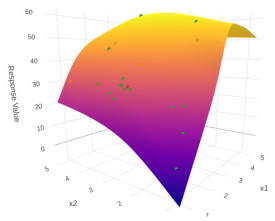
Benefits

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

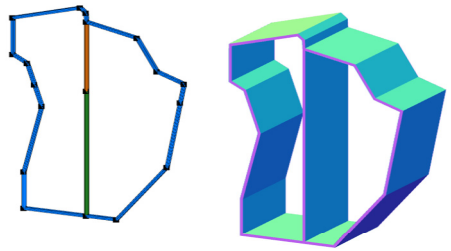
Web Apps



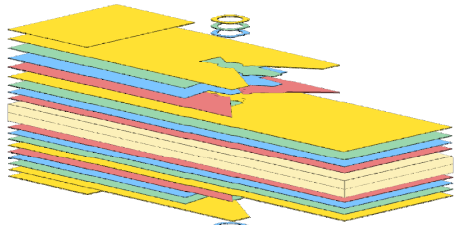
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



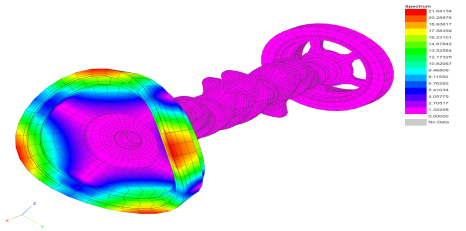
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



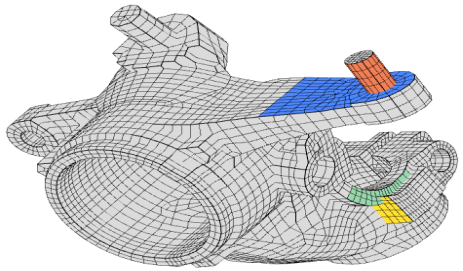
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



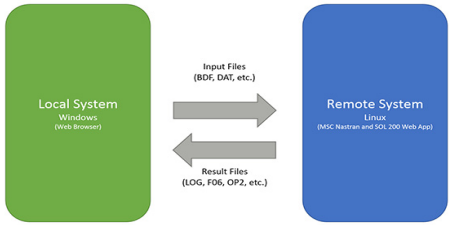
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



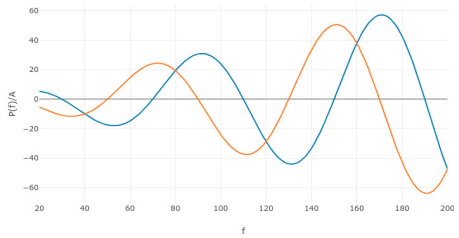
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



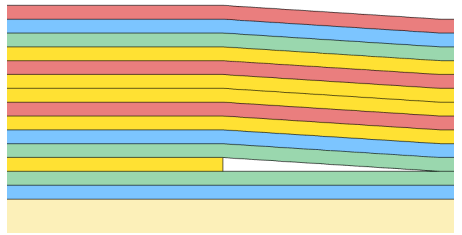
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



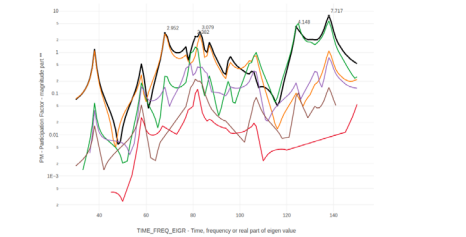
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



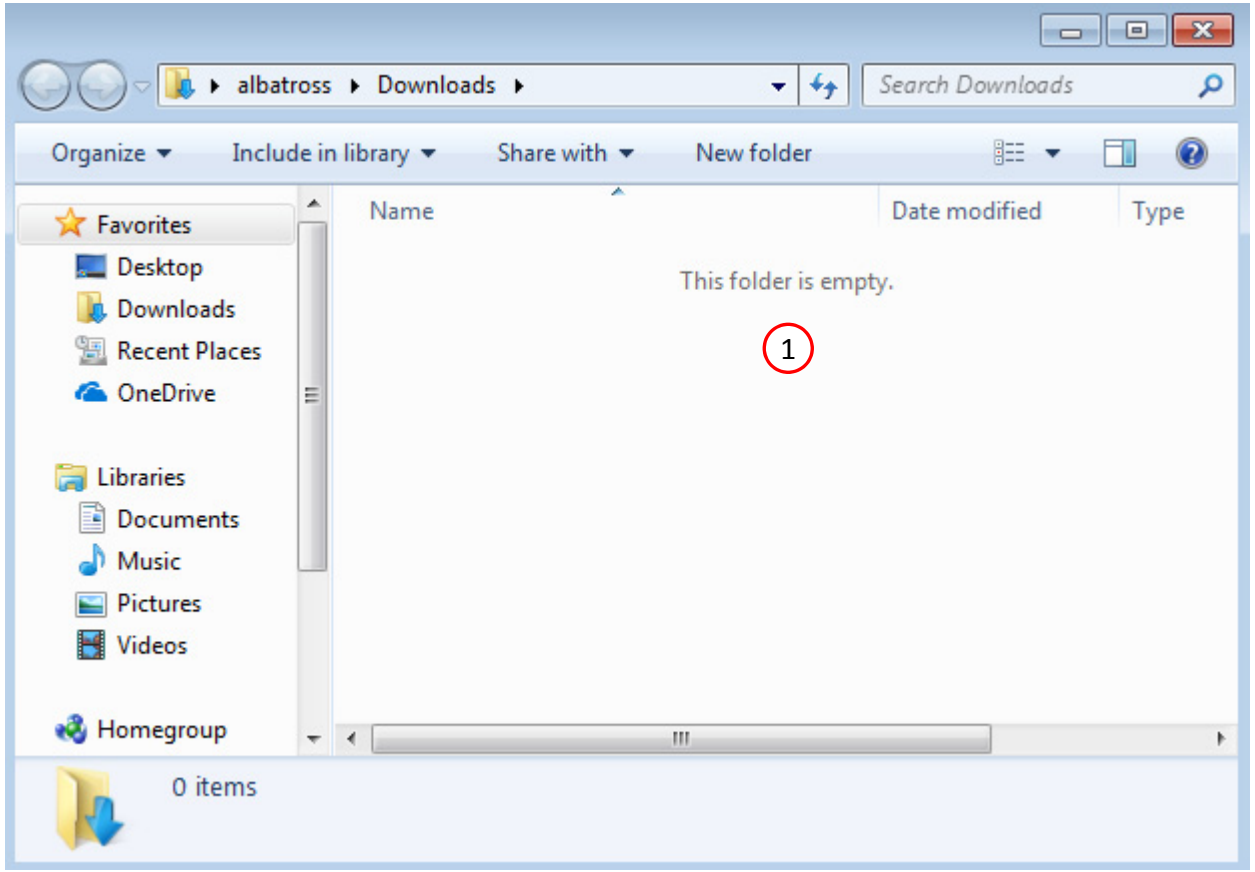
Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies



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

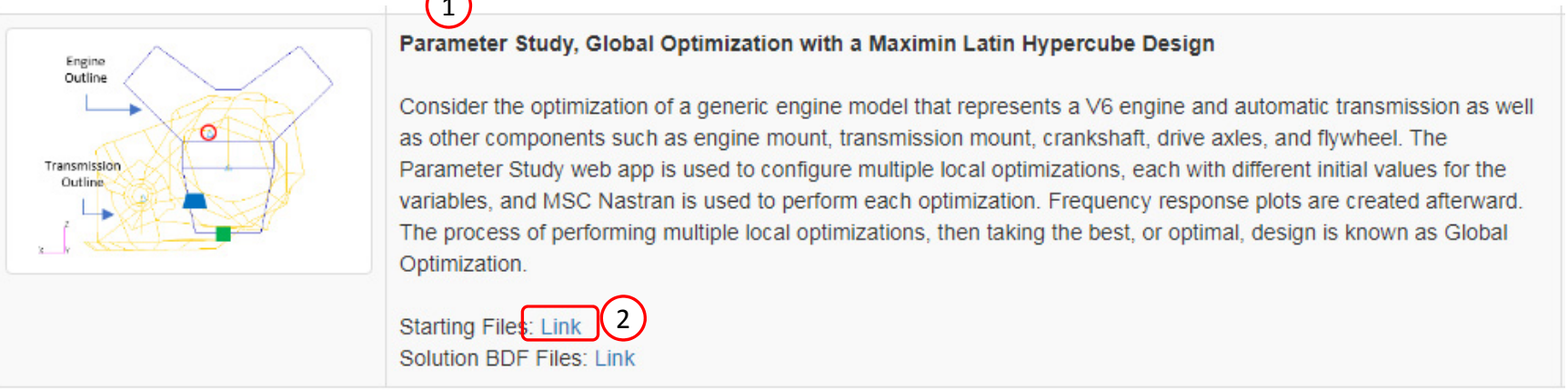
1. Click on the indicated link

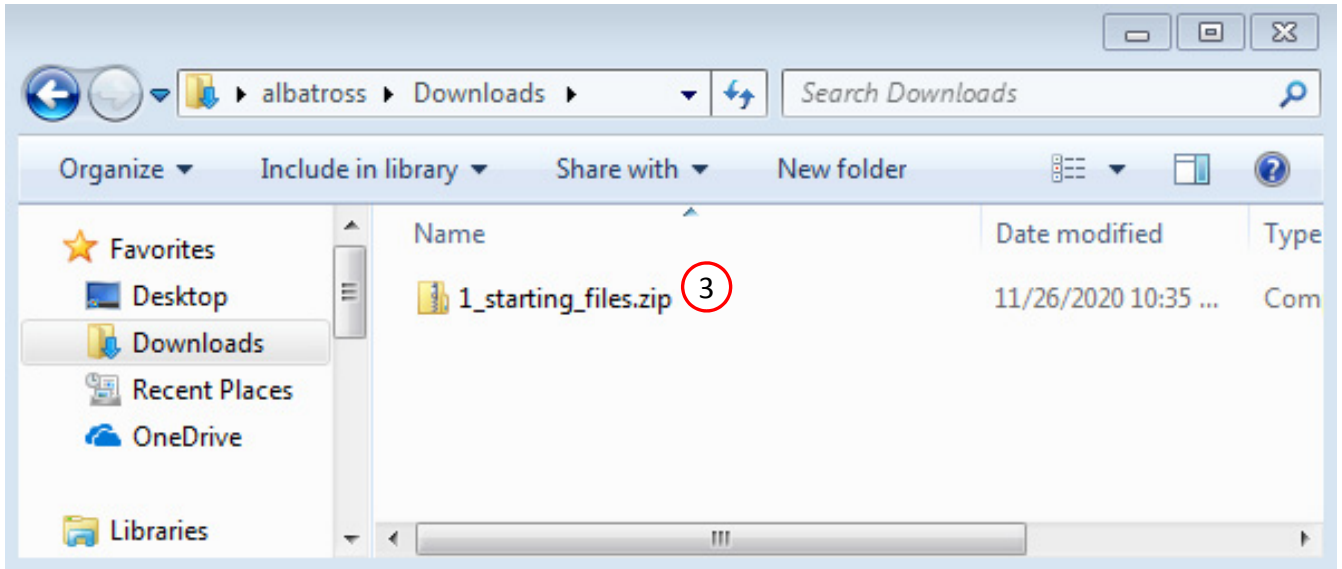
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

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, or DAT, files must be collected and uploaded together. Relevant INCLUDE files must also be collected and uploaded.

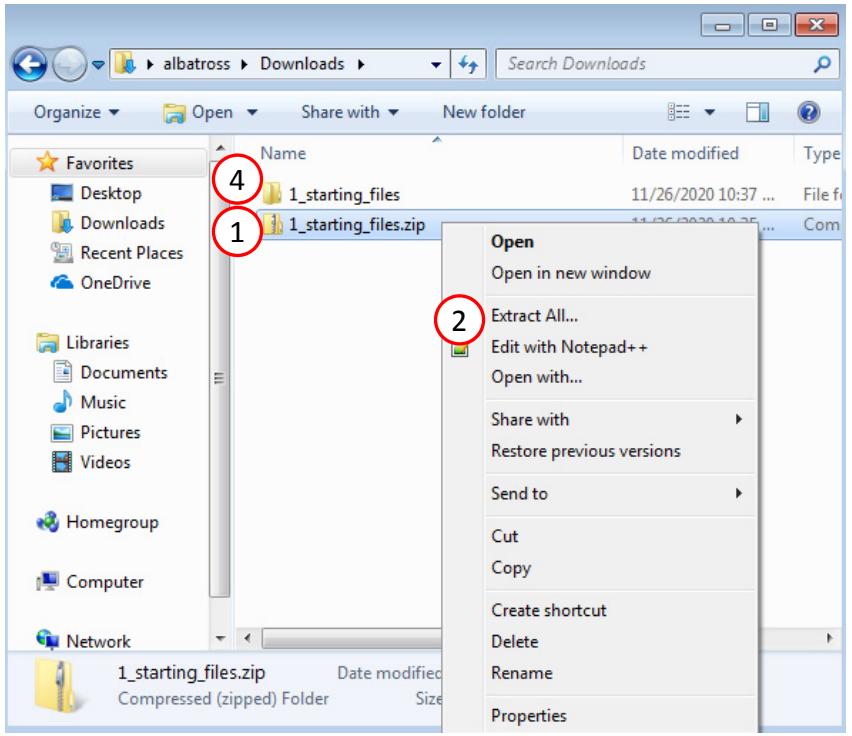


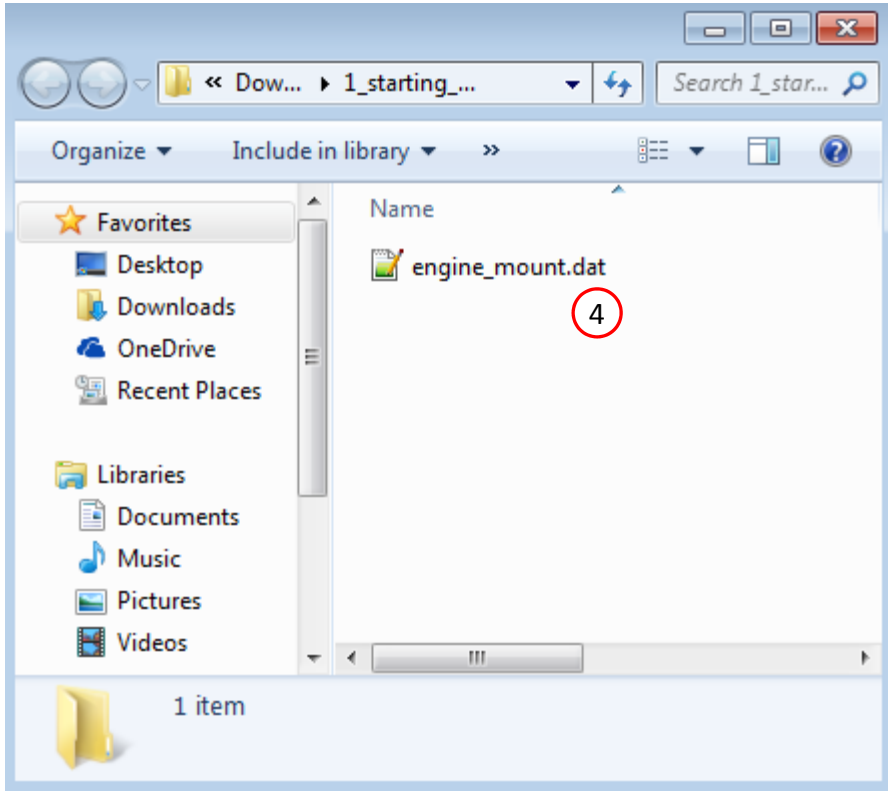


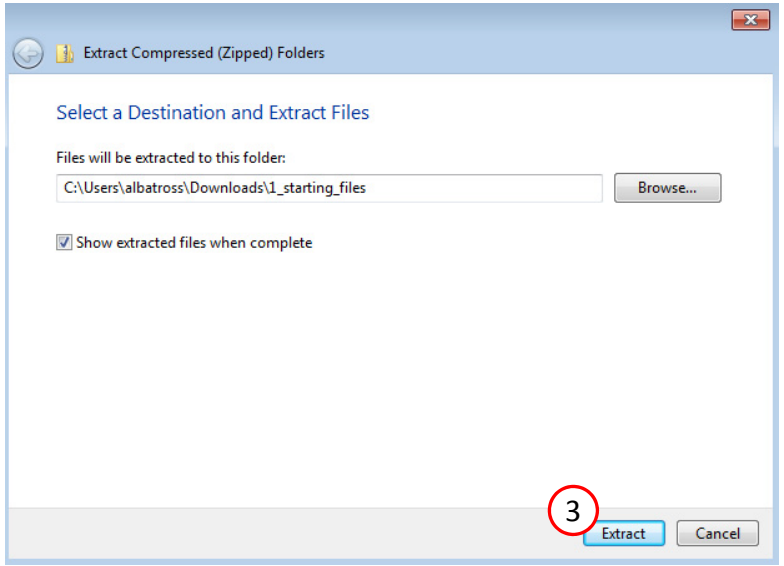
Obtain Starting Files

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

- The starting files for this tutorial are contained in a ZIP file and must be extracted as shown.



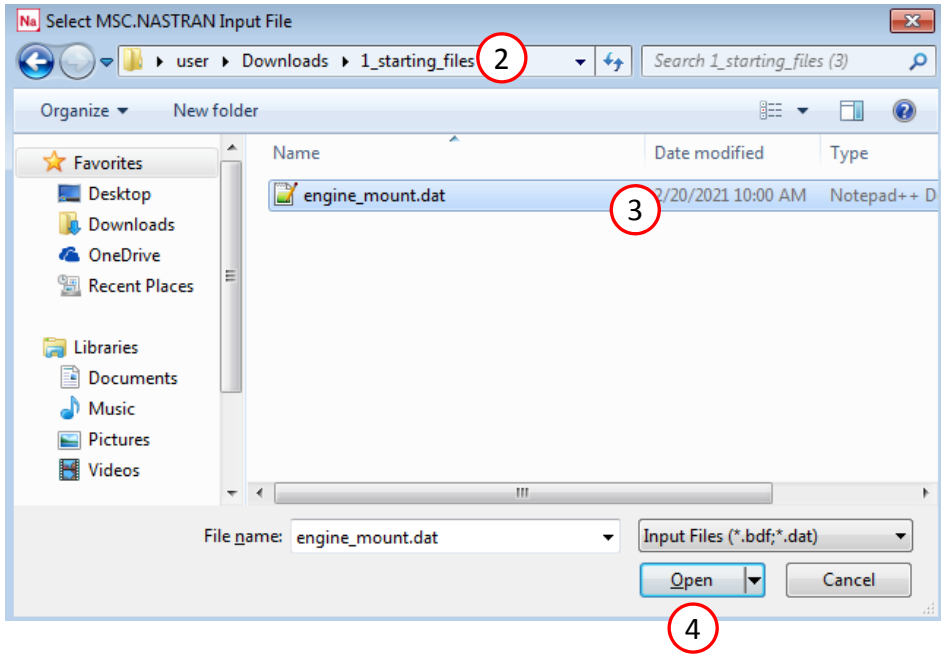


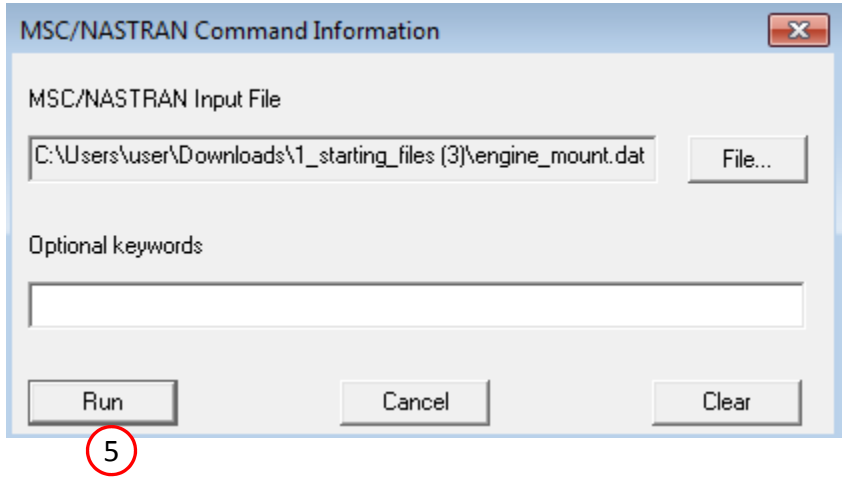


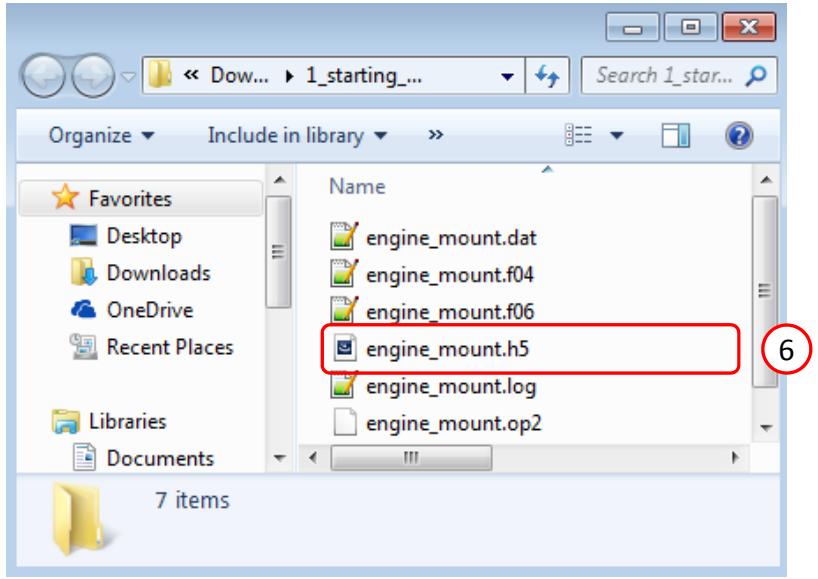
Create the Starting H5 File

A starting H5 file must be created. This H5 file will be used to configure the responses later on.

1. Double click the MSC Nastran desktop shortcut
2. Navigate to the directory named 1_starting_files
3. Select the indicated file
4. Click Open
5. Click Run
6. The starting H5 file is created







Use the same MSC Nastran version throughout this exercise

The following applies if you have multiple versions of MSC Nastran installed.

To ensure compatibility, use the same MSC Nastran version throughout this exercise.
For example, scenario 1 is OK but scenario 2 is NOT OK.

- Scenario 1 - OK
  - MSC Nastran 2021 is used to create the starting H5 file.
  - MSC Nastran 2021 is used for each run during Machine Learning or Parameter study.
- Scenario 2 – NOT OK
  - MSC Nastran 2018.2 is used to create the starting H5 file.
  - MSC Nastran 2021 is used for each run during Machine Learning or Parameter study.

Using the same MSC Nastran version is critical for consistent response extraction from the H5 file. A response configured for Nastran version X may not match in Nastran version Y, which leads to unsuccessful response extraction from the H5 files. The goal is to make sure all H5 files generated are from the same MSC Nastran version.

Open the Correct Page

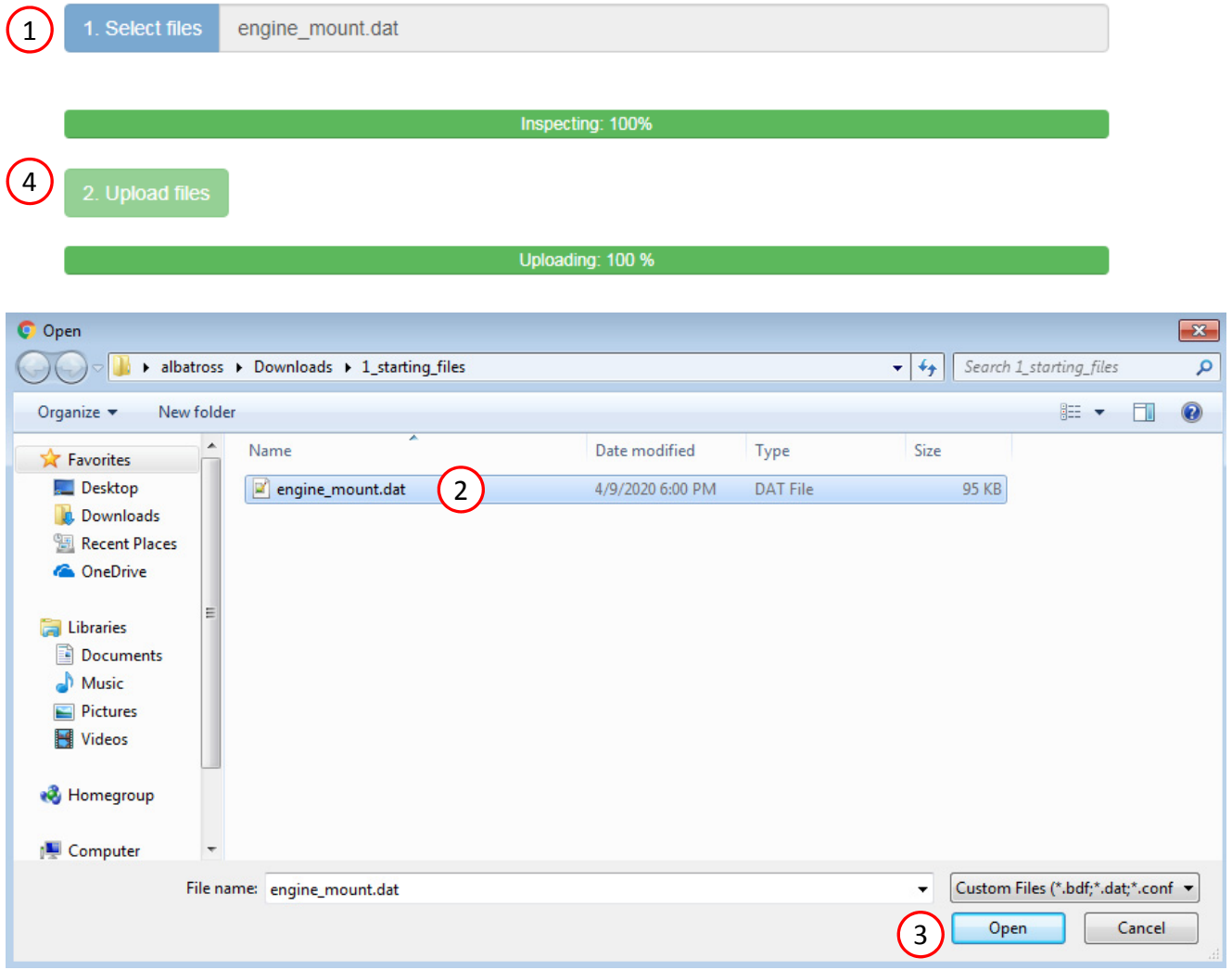
1. Click on the indicated link

- 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.

Select BDF Files

1. Click Select files
2. Select the indicated files
3. Click Open
4. Click Upload files

- When starting the procedure, all the necessary BDF, or DAT, files must be collected and uploaded together. Relevant INCLUDE files must also be collected and uploaded.



Parameters

1. Set the following fields as parameters
   - x1: The starting value of design variable 1 (XINIT of DESVAR 6016011)
   - x2: The starting value of design variable 2 (XINIT of DESVAR 6016012)
   - …
   - x20: The starting value of design variable 11 (XINIT of DESVAR 6016243)
2. A parameter has been created for the selected field

- Bulk data entries will always be displayed in the small field format.
- Only fields that have real or integer data entries may be selected as parameters. If the field is blank or contains only characters, the field may not be selected.

Select Parameters

```
$__1___||__2___||__3___||__4___||__5___||__6___||

DAREA   101     6016999 3       1.E4
DAREA   6016215 6016100 5       10000.0
DAREA   6016223 6016100 3       1000.00
DAREA   6016233 6016100 3       1000.00
DAREA   6016243 6016100 3       1000.00
DAREA   6016253 6016100 3       1000.00
DAREA   6016263 6016100 3       1000.00
DAREA   6016273 6016100 3       1000.00
DAREA   6016283 6016100 3       1000.00
DAREA   6016293 6016100 3       1000.00
DAREA   6016303 6016100 3       1000.00
DAREA   6016997 6016999 3       1.E4
DESVAR  6016011 Trans_KX%x1%    .80000  2.00000
DESVAR  6016012 Trans_KY%x2%    .80000  2.00000
DESVAR  6016013 Trans_KZ%x3%    .80000  2.00000
DESVAR  6016021 EngineKX%x4%    .80000  2.00000
DESVAR  6016022 EngineKY%x5%    .80000  2.00000
DESVAR  6016023 EngineKZ%x6%    .80000  2.00000
DESVAR  6016031 L_Tq_SKX%x7%    .80000  2.00000
DESVAR  6016041 R_Tq_SKX%x8%    .80000  2.00000
DESVAR  6016211 Trans_DX%x9%    1558.0  1758.0  .
DESVAR  6016212 Trans_DY%x10%   -547.0  -347.0  .
DESVAR  6016213 Trans_DZ%x11%   400.0   600.0   .
DESVAR  6016221 EngineDX%x12%   1497.0  1697.0  .
DESVAR  6016222 EngineDY%x13%   180.5   380.5   .
DESVAR  6016223 EngineDZ%x14%   297.0   497.0   .
DESVAR  6016231 L_Tq_SDX%x15%   1258.0  1458.0  .
DESVAR  6016232 L_Tq_SDY%x16%   -265.0  -65.0   .
DESVAR  6016233 L_Tq_SDZ%x17%   849.0   1049.0  .
DESVAR  6016241 R_Tq_SDX%x18%   1258.0  1458.0  .
DESVAR  6016242 R_Tq_SDY%x19%   91.0    291.0   .
DESVAR  6016243 R_Tq_SDZ%x20%   849.0   1049.0  .
DLOAD   6016999 1.00000 1.00000 6016998
```

1

2

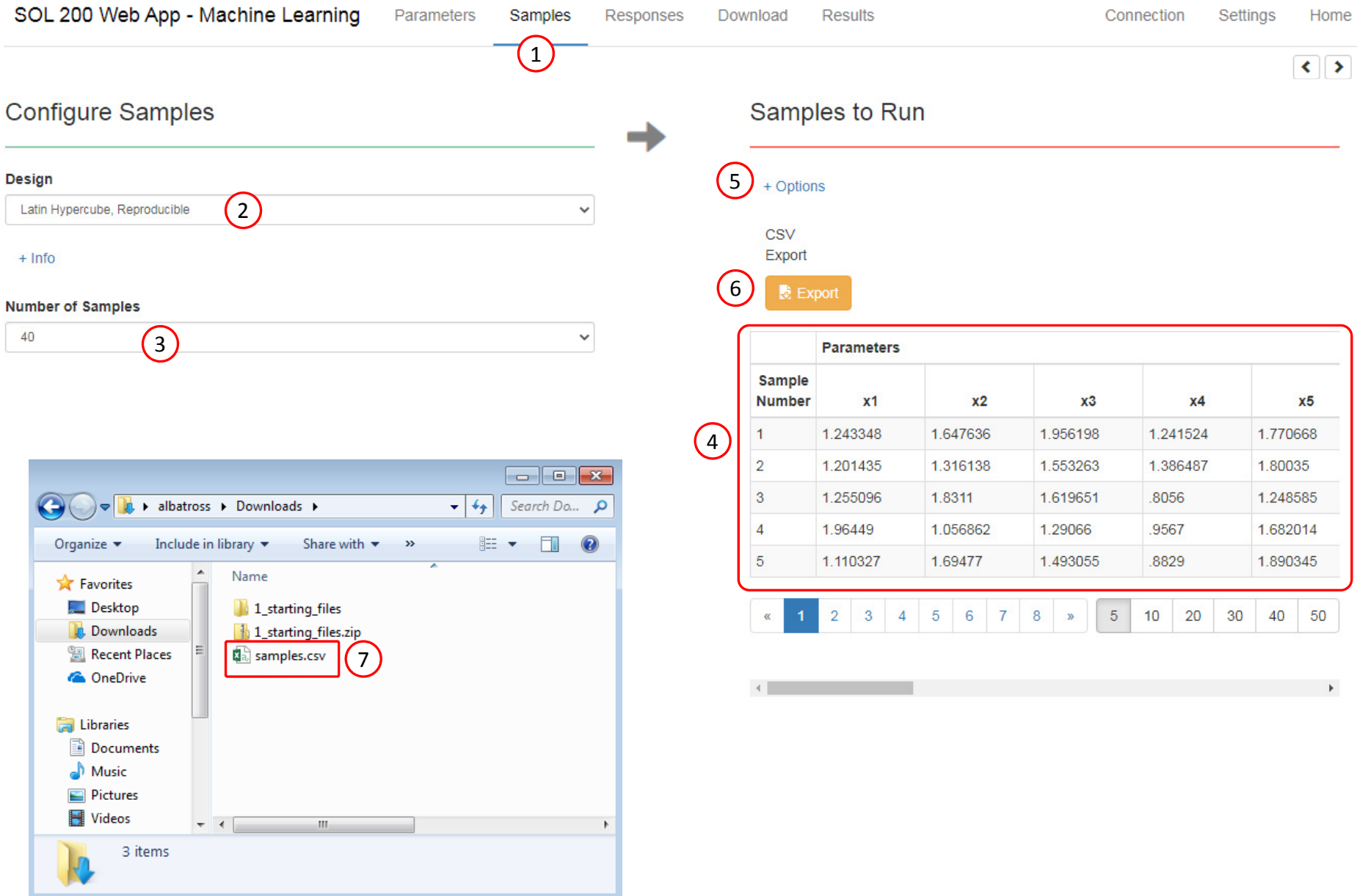
Configure Parameters

Delete	Parameter	Status	Low	High	Comments
✖	x1	✔	.80000	2.00000	Field 4 of DESVAR 6016011
✖	x2	✔	.80000	2.00000	Field 4 of DESVAR 6016012
✖	x3	✔	.80000	2.00000	Field 4 of DESVAR 6016013
✖	x4	✔	.80000	2.00000	Field 4 of DESVAR 6016021
✖	x5	✔	.80000	2.00000	Field 4 of DESVAR 6016022
✖	x6	✔	.80000	2.00000	Field 4 of DESVAR 6016023
✖	x7	✔	.80000	2.00000	Field 4 of DESVAR 6016031
✖	x8	✔	.80000	2.00000	Field 4 of DESVAR 6016041
✖	x9	✔	1558.0	1758.0	Field 4 of DESVAR 6016211
✖	x10	✔	-547.0	-347.0	Field 4 of DESVAR 6016212
✖	x11	✔	400.0	600.0	Field 4 of DESVAR 6016213
✖	x12	✔	1497.0	1697.0	Field 4 of DESVAR 6016221
✖	x13	✔	180.5	380.5	Field 4 of DESVAR 6016222
✖	x14	✔	297.0	497.0	Field 4 of DESVAR 6016223
✖	x15	✔	1258.0	1458.0	Field 4 of DESVAR 6016231
✖	x16	✔	-265.0	-65.0	Field 4 of DESVAR 6016232
✖	x17	✔	849.0	1049.0	Field 4 of DESVAR 6016233
✖	x18	✔	1258.0	1458.0	Field 4 of DESVAR 6016241
✖	x19	✔	91.0	291.0	Field 4 of DESVAR 6016242
✖	x20	✔	849.0	1049.0	Field 4 of DESVAR 6016243

Samples

1. Click Samples
2. Set the Design as Latin Hypercube, Maximin
3. Set the Number of Runs as 40
4. Forty samples have been created
5. Click + Options
6. Click Export
7. A new CSV file named samples.csv has been download

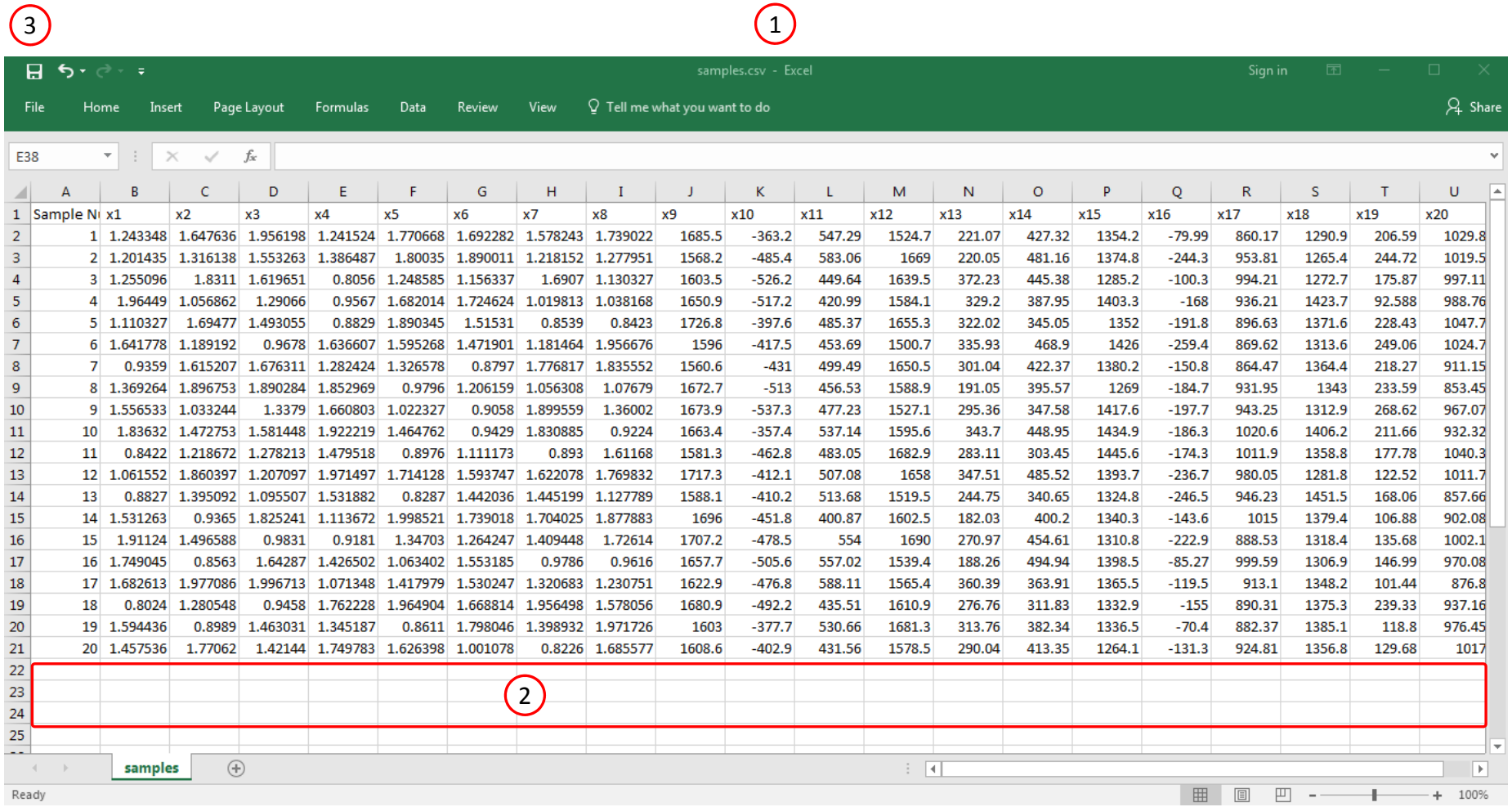
- The samples were created as follows:
  1. A Latin Hypercube design is used to generate 40 samples.
  2. An optimization is performed on all 40 samples using the Maximin Distance Criterion to ensure the sampling points are better uniformly distributed across the design space.
- The traditional Latin Hypercube design uses randomization to generate the sampling points. In the interest of reproducibility, the web app uses a static and pre-calculated Latin Hypercube design.



Samples

1. Open the CSV file samples.csv in Excel
2. Delete samples 21 through 40, the CSV file should only have samples 1 through 20
3. Save the CSV file

- Time or computer resource constraints may limit the number of samples that can be evaluated. For this tutorial, only half of the samples are evaluated.
- Samples 0 and 1-20 are considered for evaluation. Excel is used to customize the samples. On the next slide, the CSV file is uploaded to the Parameter Study web app.

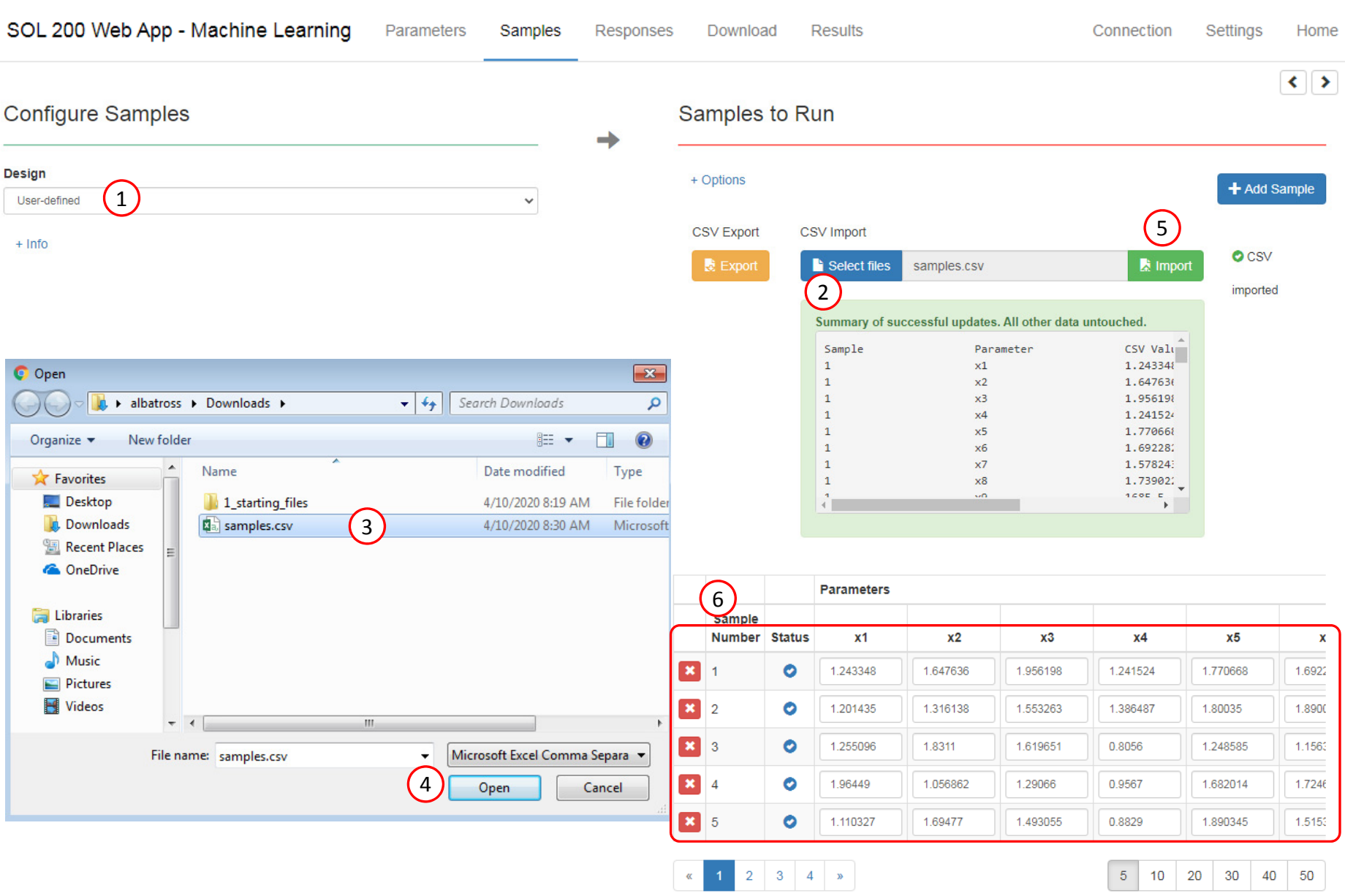


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Sample N	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20
2	1	1.243348	1.647636	1.956198	1.241524	1.770668	1.692282	1.578243	1.739022	1685.5	-363.2	547.29	1524.7	221.07	427.32	1354.2	-79.99	860.17	1290.9	206.59	1029.8
3	2	1.201435	1.316138	1.553263	1.386487	1.80035	1.890011	1.218152	1.277951	1568.2	-485.4	583.06	1669	220.05	481.16	1374.8	-244.3	953.81	1265.4	244.72	1019.5
4	3	1.255096	1.8311	1.619651	0.8056	1.248585	1.156337	1.6907	1.130327	1603.5	-526.2	449.64	1639.5	372.23	445.38	1285.2	-100.3	994.21	1272.7	175.87	997.11
5	4	1.96449	1.056862	1.29066	0.9567	1.682014	1.724624	1.019813	1.038168	1650.9	-517.2	420.99	1584.1	329.2	387.95	1403.3	-168	936.21	1423.7	92.588	988.76
6	5	1.110327	1.69477	1.493055	0.8829	1.890345	1.51531	0.8539	0.8423	1726.8	-397.6	485.37	1655.3	322.02	345.05	1352	-191.8	896.63	1371.6	228.43	1047.7
7	6	1.641778	1.189192	0.9678	1.636607	1.595268	1.471901	1.181464	1.956676	1596	-417.5	453.69	1500.7	335.93	468.9	1426	-259.4	869.62	1313.6	249.06	1024.7
8	7	0.9359	1.615207	1.676311	1.282424	1.326578	0.8797	1.776817	1.835552	1560.6	-431	499.49	1650.5	301.04	422.37	1380.2	-150.8	864.47	1364.4	218.27	911.15
9	8	1.369264	1.896753	1.890284	1.852969	0.9796	1.206159	1.056308	1.07679	1672.7	-513	456.53	1588.9	191.05	395.57	1269	-184.7	931.95	1343	233.59	853.45
10	9	1.556533	1.033244	1.3379	1.660803	1.022327	0.9058	1.899559	1.36002	1673.9	-537.3	477.23	1527.1	295.36	347.58	1417.6	-197.7	943.25	1312.9	268.62	967.07
11	10	1.83632	1.472753	1.581448	1.922219	1.464762	0.9429	1.830885	0.9224	1663.4	-357.4	537.14	1595.6	343.7	448.95	1434.9	-186.3	1020.6	1406.2	211.66	932.32
12	11	0.8422	1.218672	1.278213	1.479518	0.8976	1.111173	0.893	1.61168	1581.3	-462.8	483.05	1682.9	283.11	303.45	1445.6	-174.3	1011.9	1358.8	177.78	1040.3
13	12	1.061552	1.860397	1.207097	1.971497	1.714128	1.593747	1.622078	1.769832	1717.3	-412.1	507.08	1658	347.51	485.52	1393.7	-236.7	980.05	1281.8	122.52	1011.7
14	13	0.8827	1.395092	1.095507	1.531882	0.8287	1.442036	1.445199	1.127789	1588.1	-410.2	513.68	1519.5	244.75	340.65	1324.8	-246.5	946.23	1451.5	168.06	857.66
15	14	1.531263	0.9365	1.825241	1.113672	1.998521	1.739018	1.704025	1.877883	1696	-451.8	400.87	1602.5	182.03	400.2	1340.3	-143.6	1015	1379.4	106.88	902.08
16	15	1.91124	1.496588	0.9831	0.9181	1.34703	1.264247	1.409448	1.72614	1707.2	-478.5	554	1690	270.97	454.61	1310.8	-222.9	888.53	1318.4	135.68	1002.1
17	16	1.749045	0.8563	1.64287	1.426502	1.063402	1.553185	0.9786	0.9616	1657.7	-505.6	557.02	1539.4	188.26	494.94	1398.5	-85.27	999.59	1306.9	146.99	970.08
18	17	1.682613	1.977086	1.996713	1.071348	1.417979	1.530247	1.320683	1.230751	1622.9	-476.8	588.11	1565.4	360.39	363.91	1365.5	-119.5	913.1	1348.2	101.44	876.8
19	18	0.8024	1.280548	0.9458	1.762228	1.964904	1.668814	1.956498	1.578056	1680.9	-492.2	435.51	1610.9	276.76	311.83	1332.9	-155	890.31	1375.3	239.33	937.16
20	19	1.594436	0.8989	1.463031	1.345187	0.8611	1.798046	1.398932	1.971726	1603	-377.7	530.66	1681.3	313.76	382.34	1336.5	-70.4	882.37	1385.1	118.8	976.45
21	20	1.457536	1.77062	1.42144	1.749783	1.626398	1.001078	0.8226	1.685577	1608.6	-402.9	431.56	1578.5	290.04	413.35	1264.1	-131.3	924.81	1356.8	129.68	1017
22																					
23																					
24																					
25																					

Samples

1. Set the Design as User-defined
2. Click Select Files
3. Select the CSV file samples.csv
4. Click Open
5. Click Import
6. The samples from the CSV file have been imported to the web app, the Samples table now has 20 samples

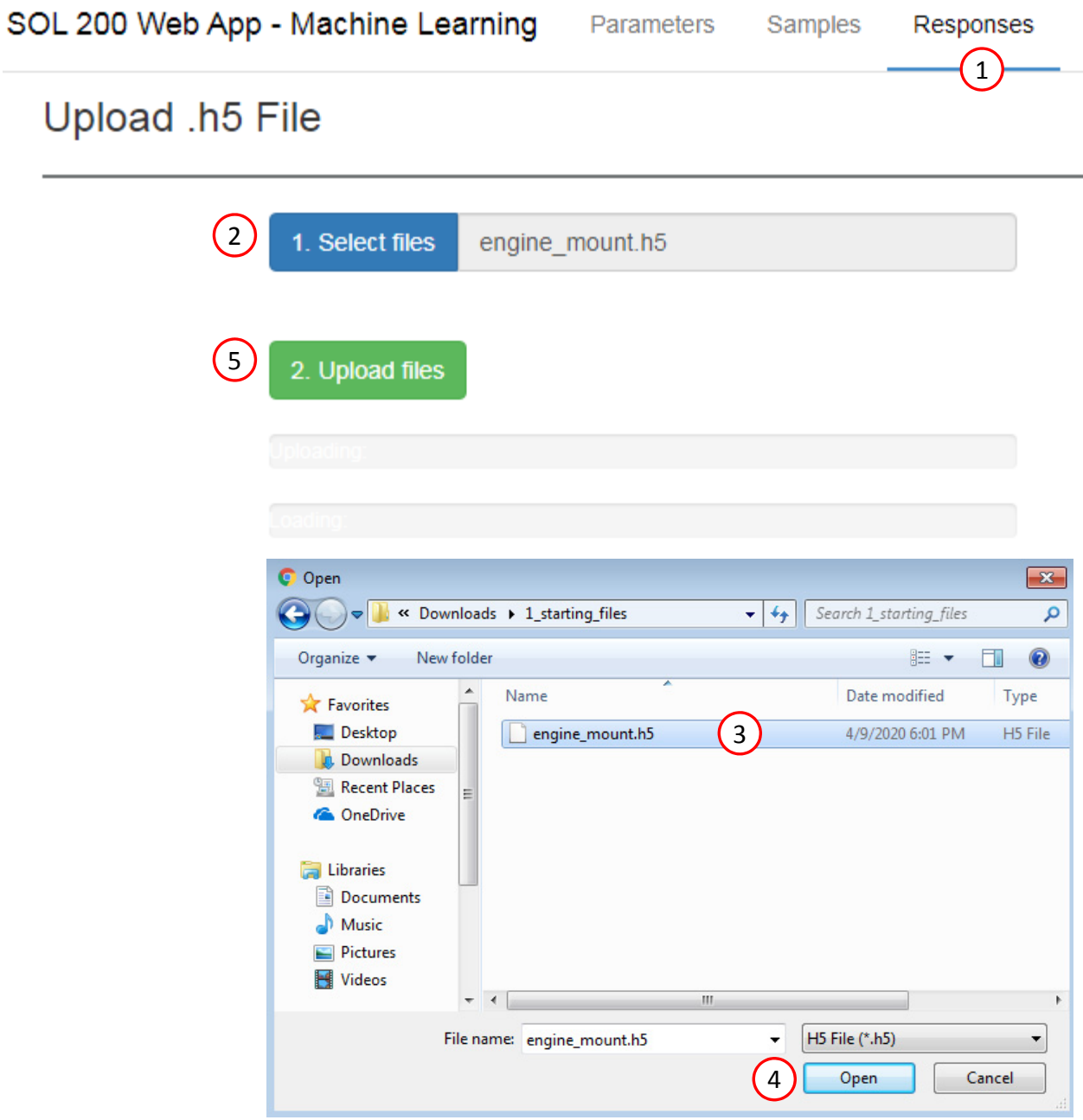
- On import, a summary is displayed in the green box. This summary lists each change that has been performed.



Responses

1. Click Responses
2. Click Select files
3. Select the indicated file
4. Click Open
5. Click Upload files

- On this page, the H5 file is uploaded to the web app.

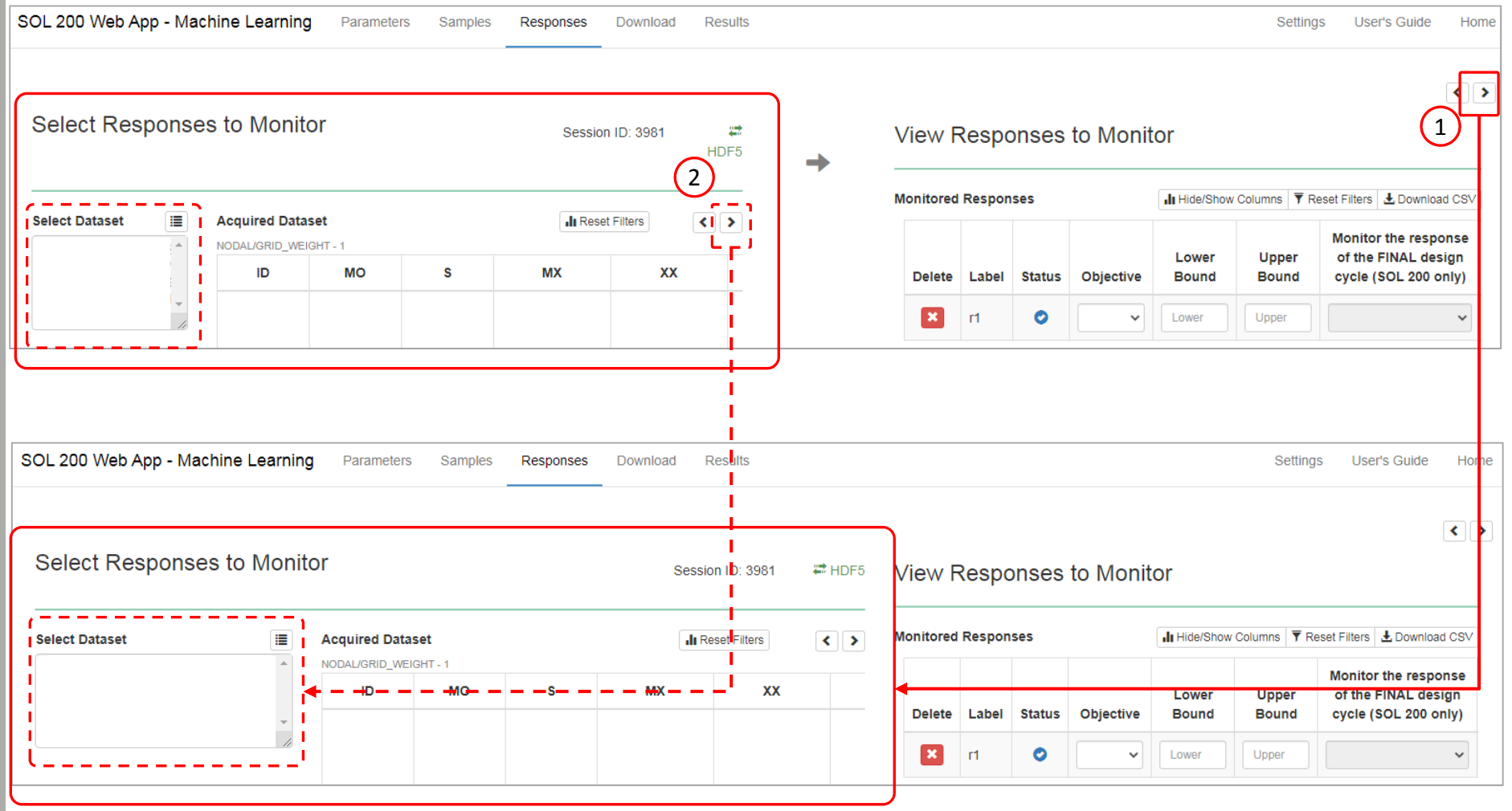


Adjust the Column Width

1. Optional - Use at your liking the buttons at the top right hand corner to adjust the width of the left and right columns

2. Optional – Use the indicated buttons to adjust the width of the column Select Dataset

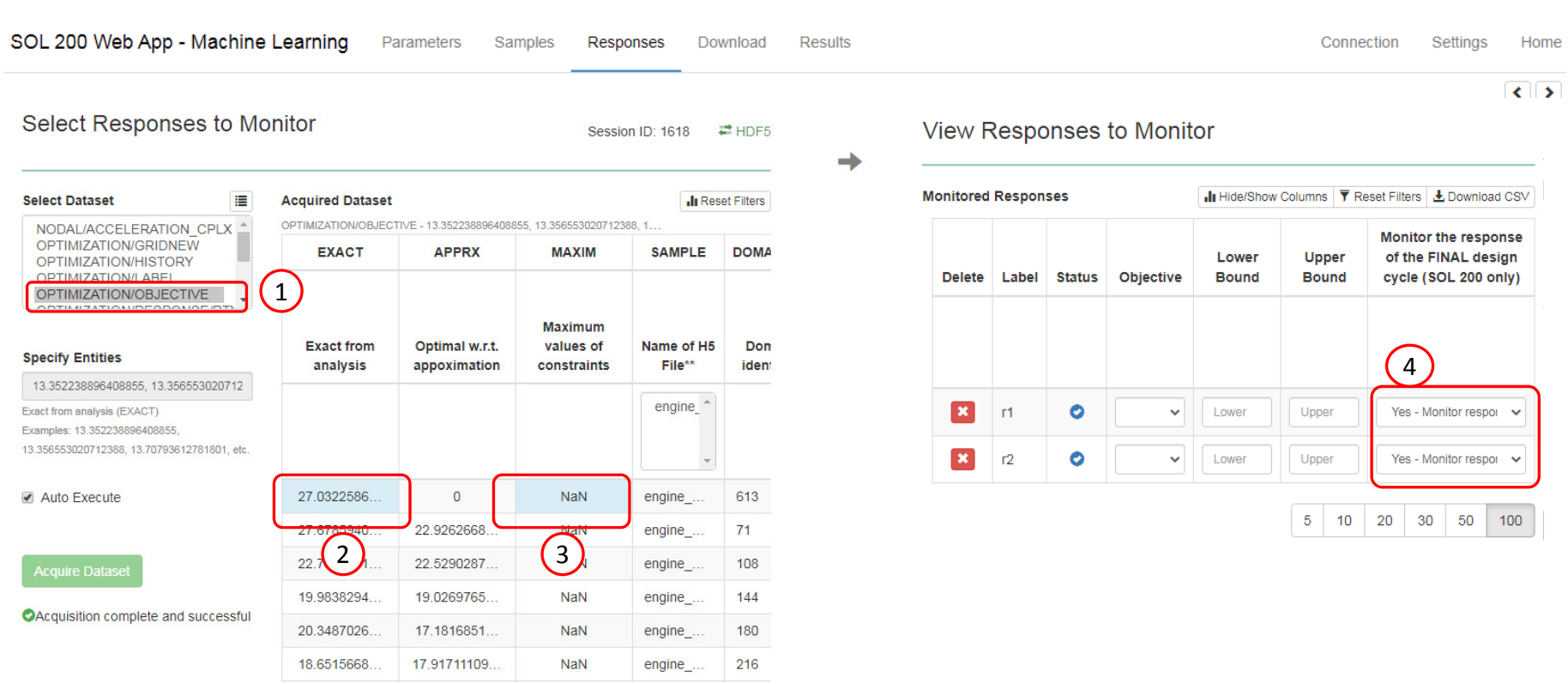
- IMPORTANT! This image is not meant to match exactly what you see in your view. The text in this image is expected to be different from your view. The purpose of this page and image is to demonstrate how to increase the width of the indicated sections.



Select Responses

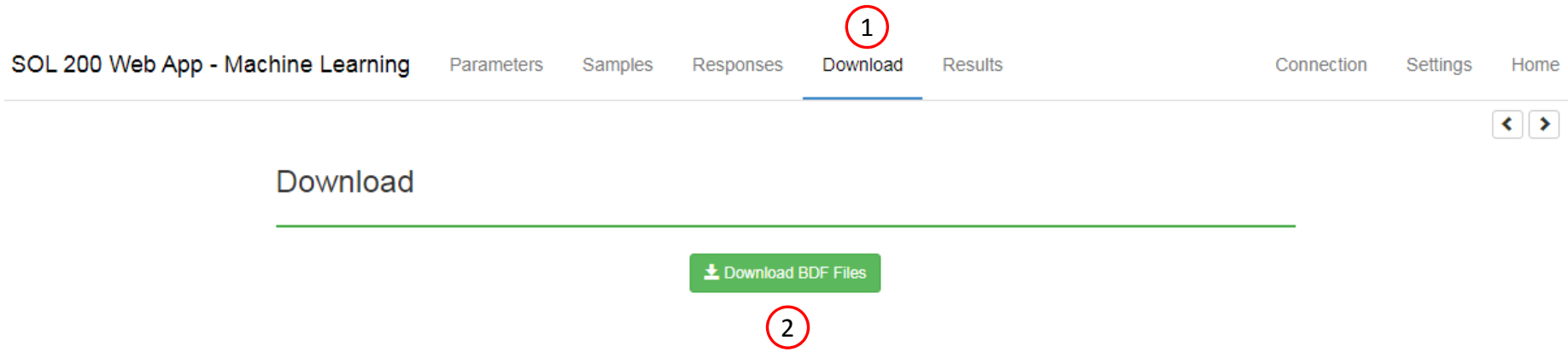
1. Select the following dataset: OPTIMIZATION/OBJECTIVE
2. Select the indicated cell, a new response r1 is created
3. Select the indicated cell, a new response r2 is created
4. Ensure Yes is set for both responses

- Refer to the Appendix for an explanation on the use of the following:
  - Monitor the response of the FINAL design cycle (SOL 200): Yes



Download

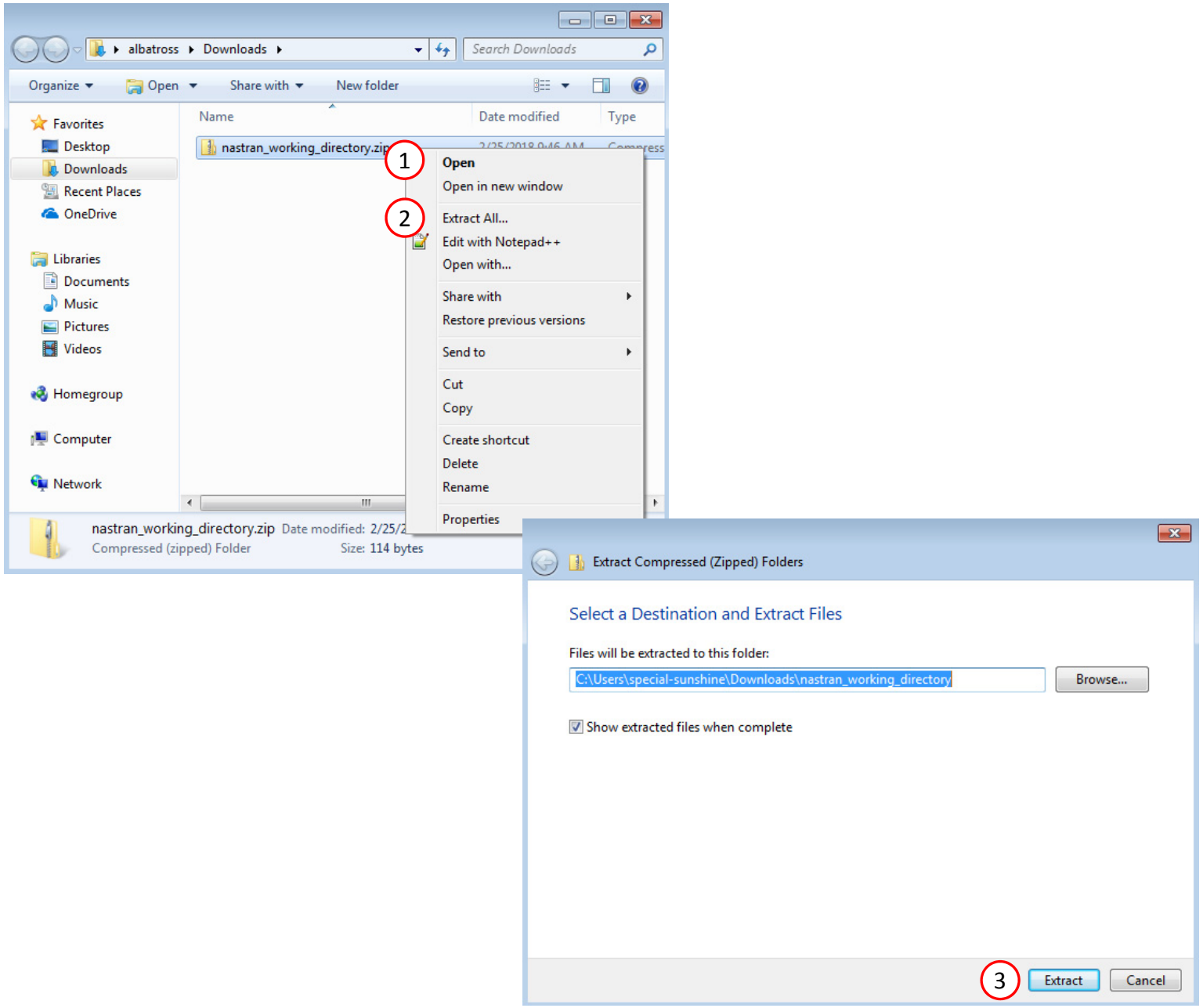
1. Click Download
2. Click Download BDF Files



Start MSC Nastran

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.



Start MSC Nastran

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

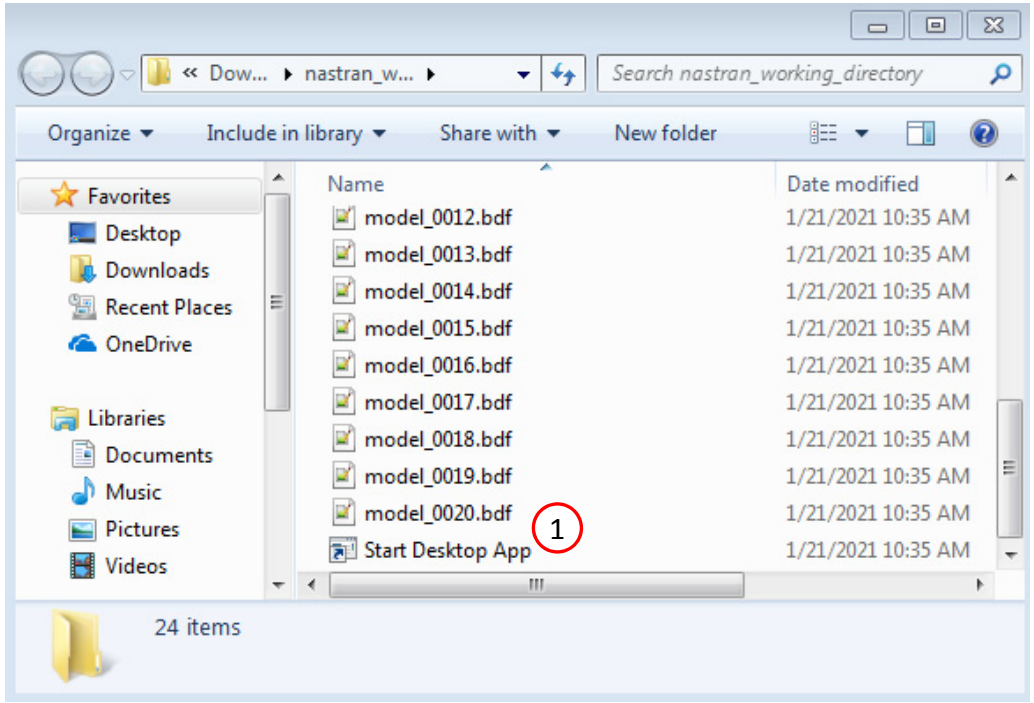
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the remote machine. 3) After completion, copy the BDF, F06, LOG, H5 files to the local machine. 4) Click "Start MSC Nastran" to display the results.

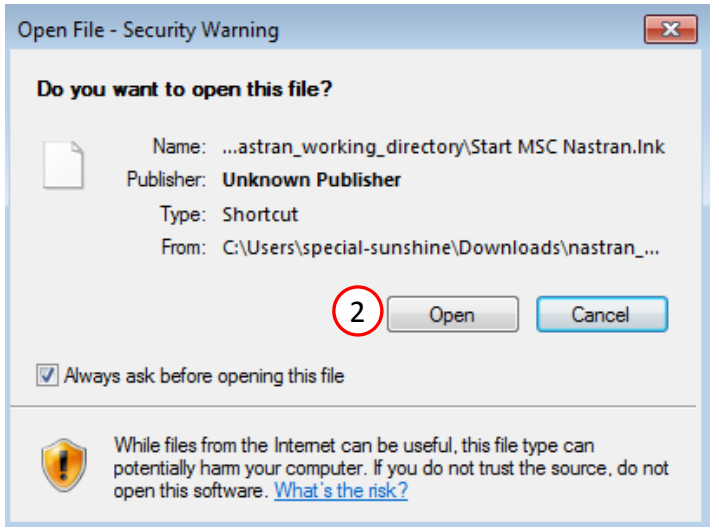
Using Linux?

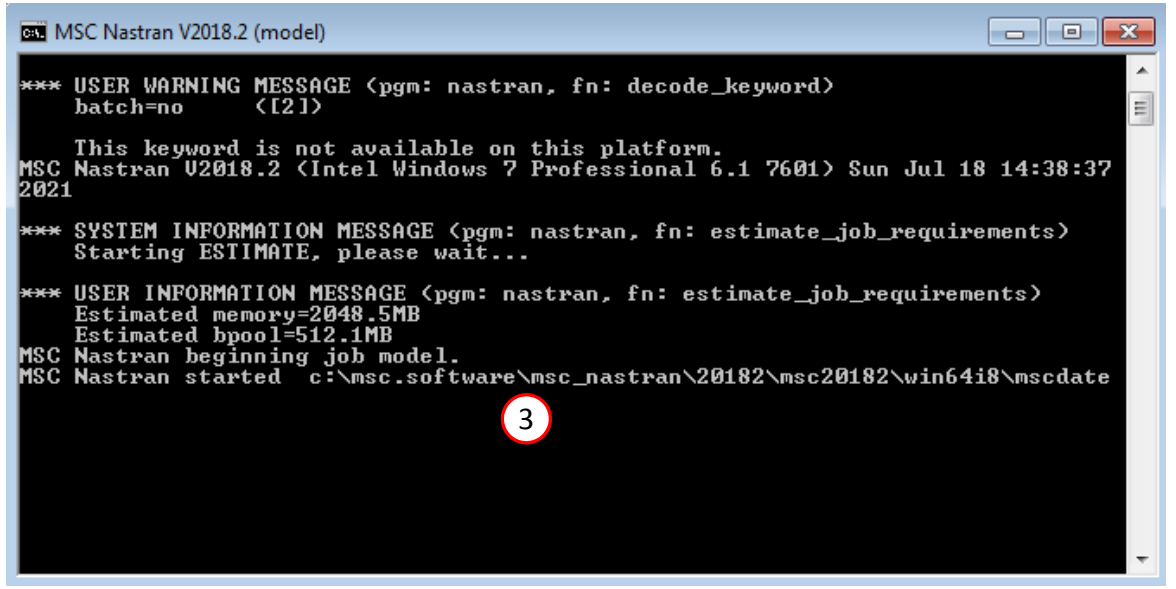
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
cd ./nastran_working_directory
3) Use this command to start the process
./Start_MSC_Nastran.sh

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

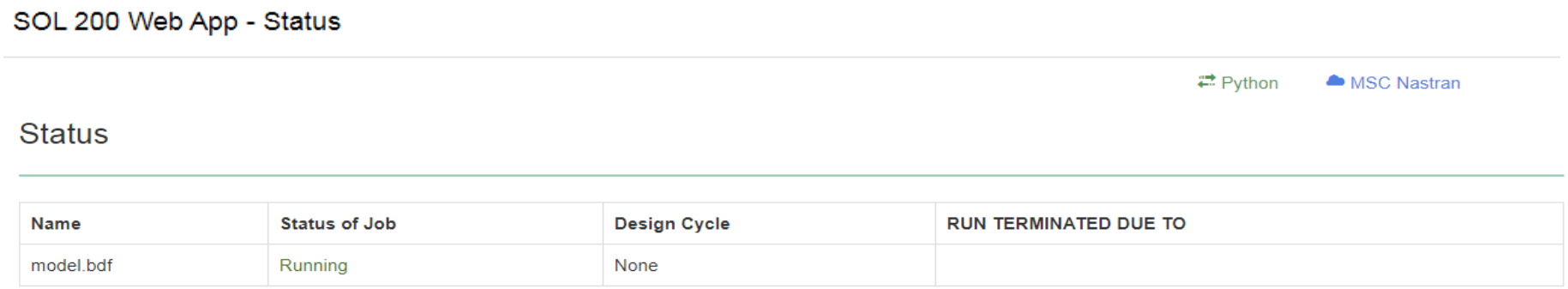






Status

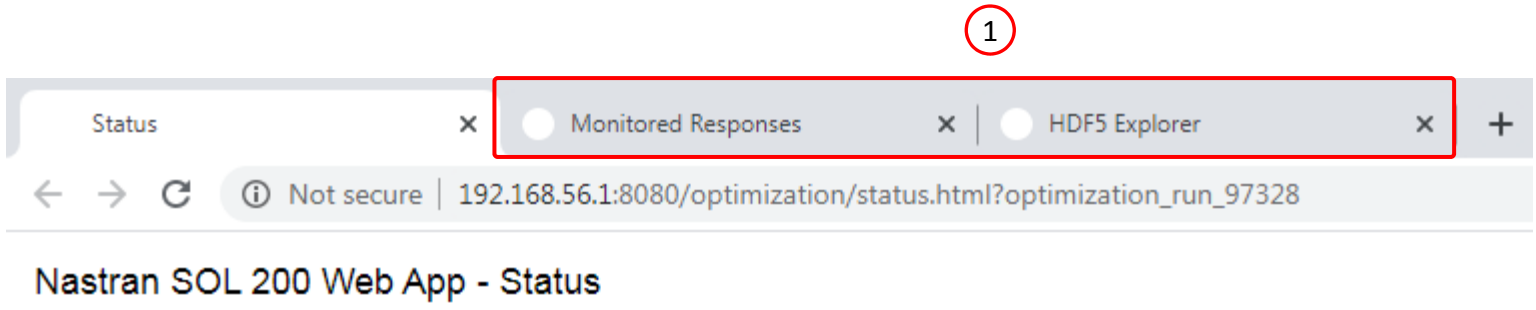
- While MSC Nastran is running, a status page will show the current state of MSC Nastran



Results

After each MSC Nastran analysis is complete, multiple web apps are automatically opened to display the results.

1. Use the tabs to switch between each web app
2. A description of each web app is given in the table.



2

Name of Web App	Purpose	Description
Monitored Responses	• The response value from each sample can be compared.	• After each MSC Nastran analysis, the response values are extracted from the H5 file and contained in a file named app_monitored_responses.csv. The Monitored Responses web app is used to create a bar chart of the values contained in this CSV file.
HDF5 Explorer	• This web app is used to probe each H5 file and generate XY plots.	

Difference in Results

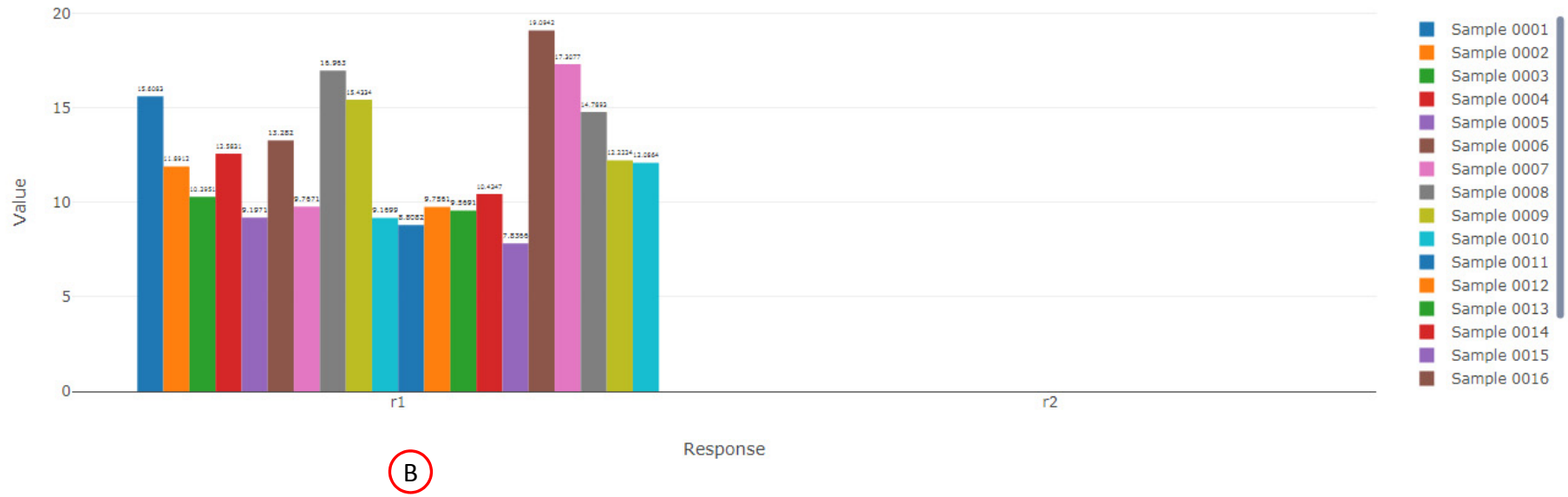
- It is likely the results you obtain are different from those shown in this tutorial. The differences can be due to many factors, some of which include:
  - Using Linux or Windows operating systems
  - Using a different version of MSC Nastran
- The results show in this tutorial were produced by a Windows 7 environment running MSC Nastran 2018. Different environments may produce slightly different results.

Review Results

1. The Monitored Responses web app is opened
2. The r1 response corresponds to the Max Normalized Constraint of the last design cycle, or FINAL design. For this tutorial, the r1 response is reported as “nan” indicating the response is empty. The optimization did not have any design constraints defined, i.e. no DCONSTR entries were defined, so there were no normalized constraints to report and are listed as empty or “nan.” The r1 response is not necessary for this tutorial, but was configured so the user is aware of the process to track the Max Normalized Constraint of the last design cycle.

A. The table titled Monitored Response can be interacted with. Each column in the table contains filters. Once a filter is modified, the Bar Chart will instantly update.
B. Additional functions include the ability to highlight the MAX and MIN bars, download a CSV file and reset the filters.

SOL 200 Web App - Monitored Responses (1) Home



B

Monitored Responses — Display MAX and MIN | Download CSV | Reset Filters

Label	Dataset Name	Field	Field Description
r1 r2	OPTIMIZATION/OBJECTIVE (A)	EXACT MAXIM	Exact from analysis Maximum values of constraints
r1	OPTIMIZATION/OBJECTIVE	EXACT	Exact from analysis
r2	OPTIMIZATION/OBJECTIVE	MAXIM	Maximum values of constraints

5 | 10 | 20 | 30 | 50 | 100

Monitored Responses from Each Sample

0001	0002	0003	0004
15.608307348441018	11.891231588105237	10.295095395470057	12.583072653377371
nan	nan	nan	nan

(2)

Review Results

1. In the filters, select only response r1

The range of the vertical axis must be adjusted

2. Move the mouse cursor to the top number of the vertical axis
3. Single click the number
4. A new value can be supplied, type 10.00 press the Enter key
5. The range of the vertical axis has now been adjusted to be between 0 and 10
6. After inspection, the lowest responses are yielded by samples 0011 and 0015

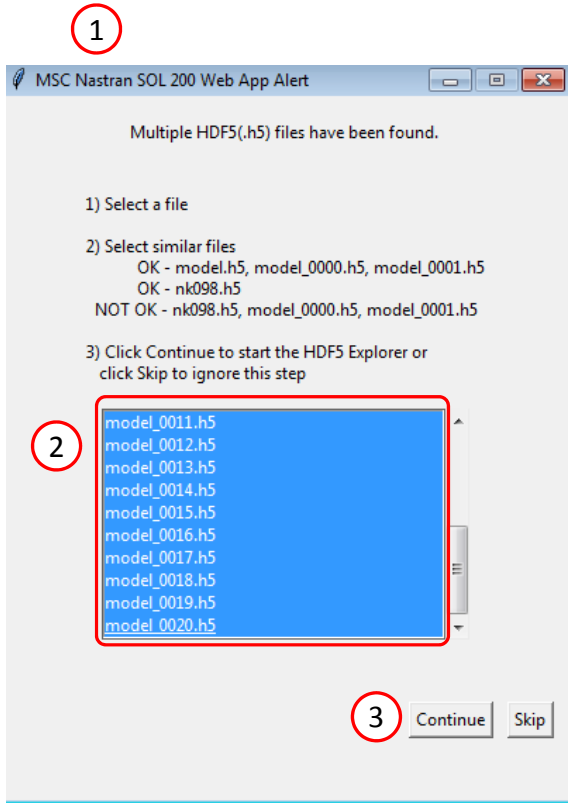
A. The table titled Monitored Response can be interacted with. Each column in the table contains filters. Once a filter is modified, the Bar Chart will instantly update.
B. Additional functions include the ability to highlight the MAX and MIN bars, download a CSV file and reset the filters.

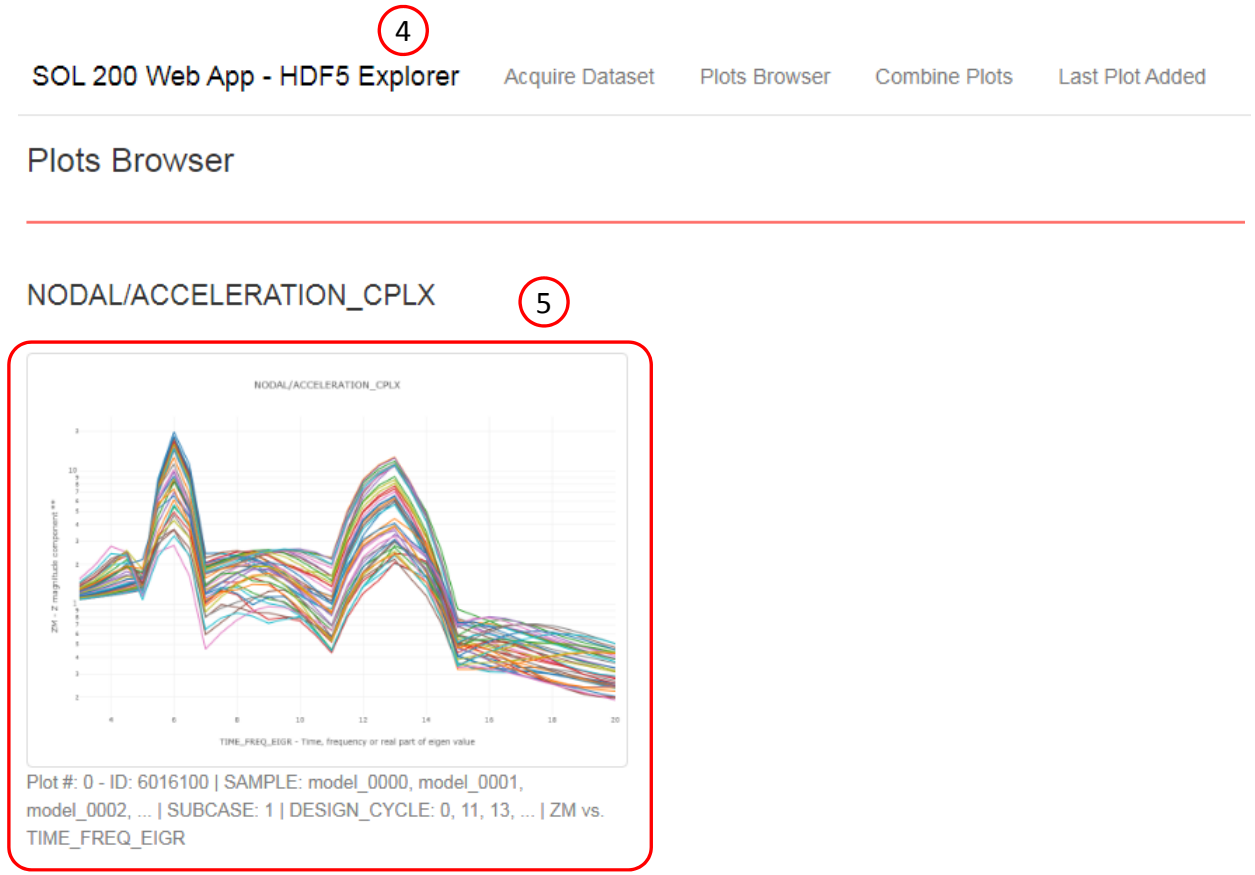
Review Results

1. A new window is opened
2. Select all 20 H5 files
3. Click Continue
4. The HDF5 Explorer is automatically opened.
5. Click the indicate image

The HDF5 Explorer is broken into sections.

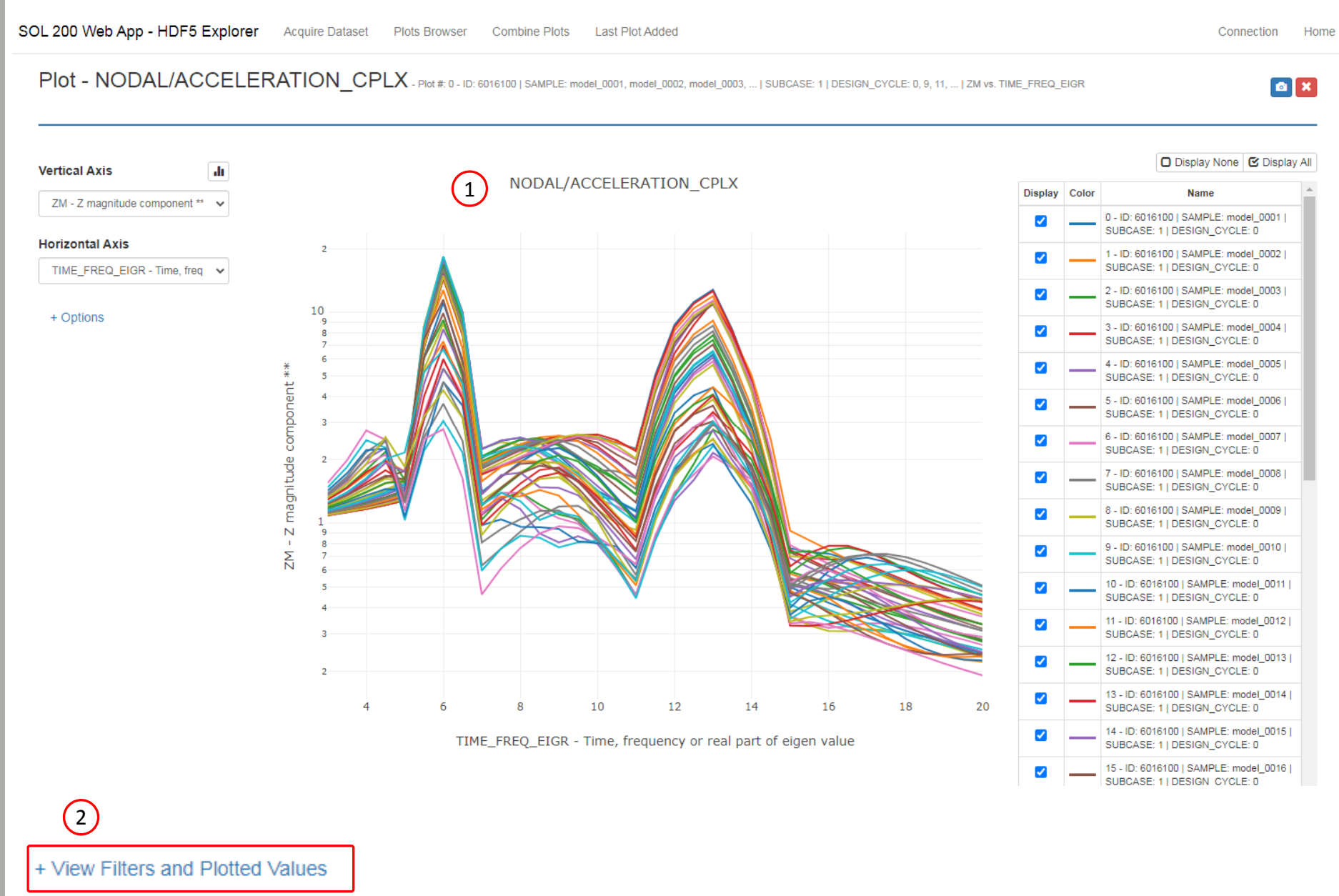
- Acquire Dataset – Specific datasets from the H5 file can be extracted in this section.
- Plots Browser – Use this section to navigate every plot created.
- Combine Plots – This section allows you to combine multiple plots. For example, you can create Load vs. Displacement plots in this section.
- Last Plot Added – The Acquire Dataset section has a button titled “Create Plot.” This button, when clicked, creates a new plot. When the link “Last Plot Added” is clicked, the new plot is displayed.





Review Results

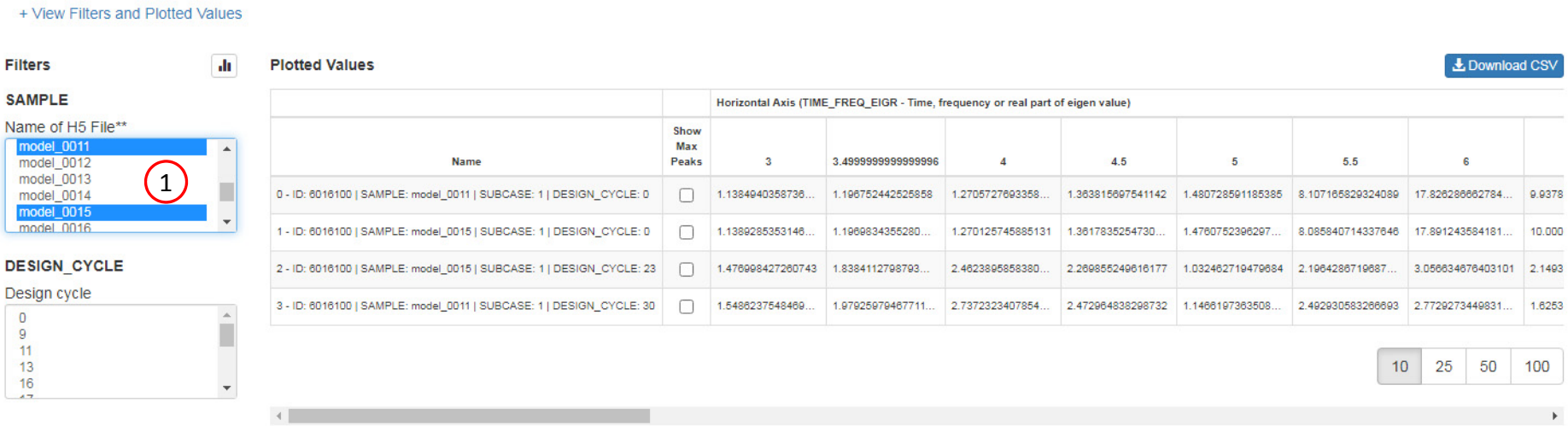
1. An Acceleration vs Frequency plot is displayed, but displays the INITIAL and FINAL results of each sample
2. Click + View Filters and Plotted Values



Review Results

Previously, samples 0011 and 0015 have been identified for further study

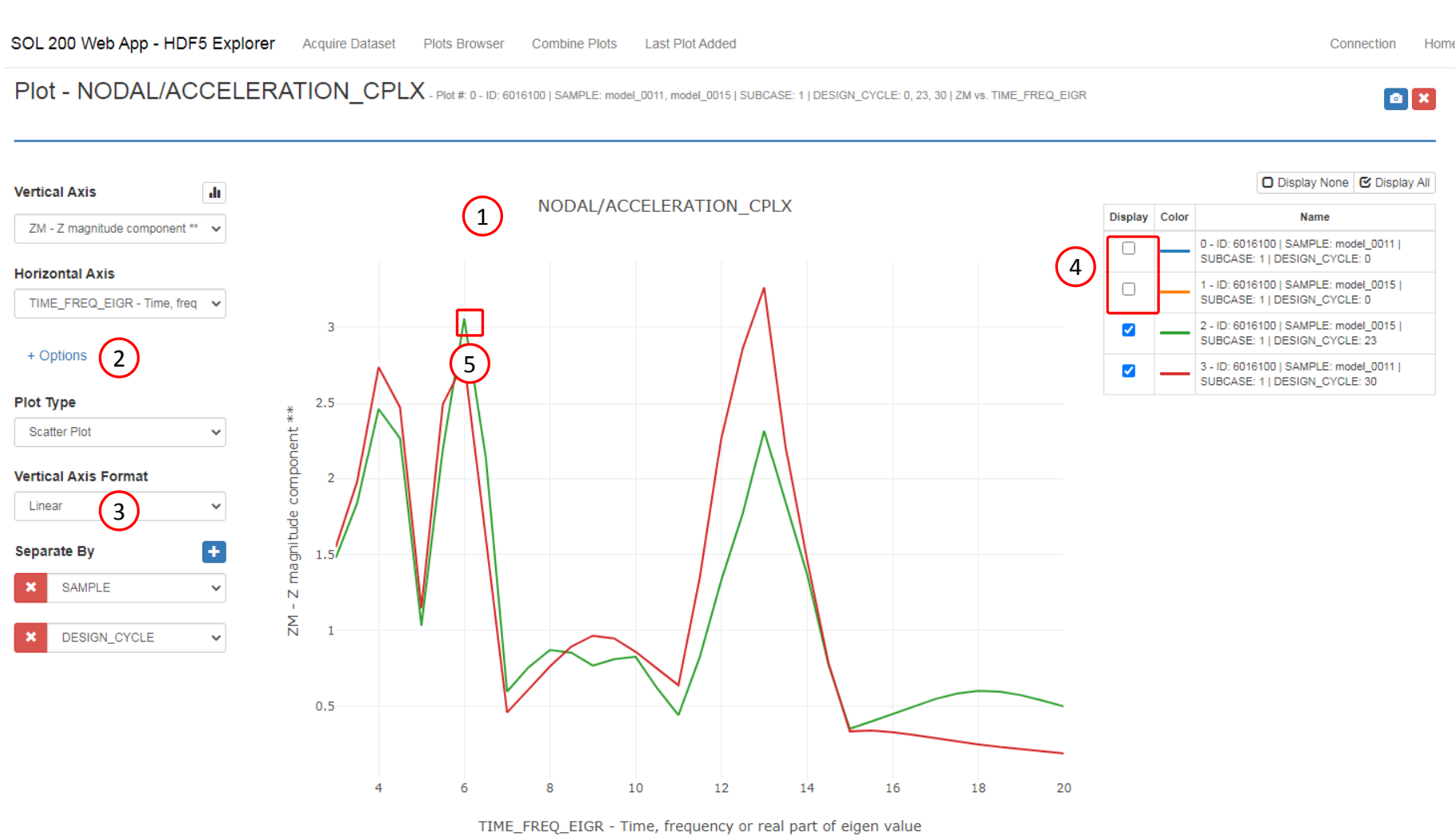
1. Use the SAMPLE filter and only select the following samples (Hold down the CTRL key on the keyboard to select multiple options):
    - model_0011
    - model_0015



Review Results

1. After the SAMPLE is modified, the plot now shows data for only samples 0011 and 0015
2. Click + Options
3. Set Vertical Axis Format as Linear
4. Un-check the indicated checkboxes
5. The 3rd trace (The FINAL result of sample 0015) is shown to have the smallest max peak between samples 0011 and 0015

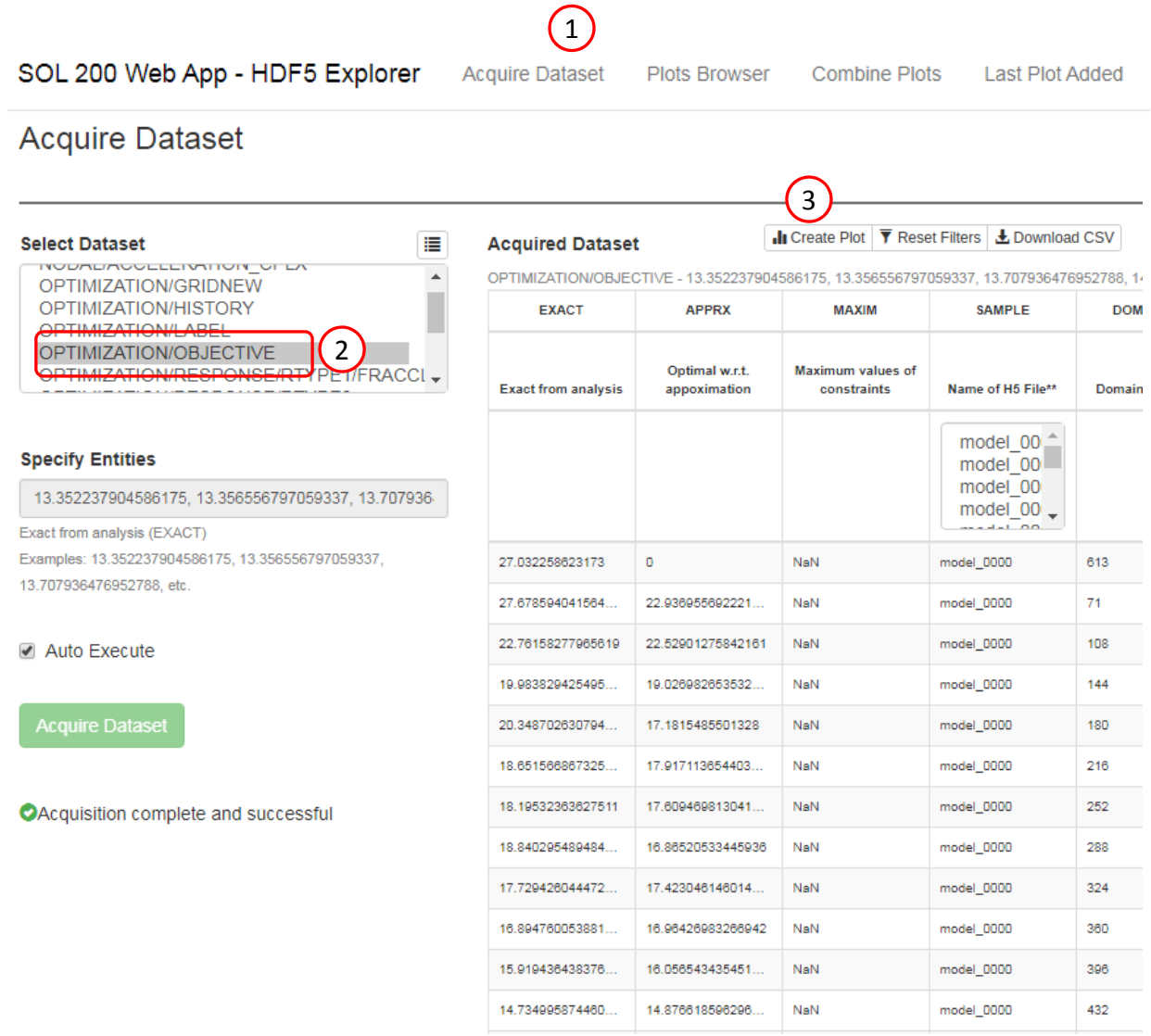
- On this slide, the following is plotted:
  - The FINAL results from samples
    - 0011
    - 0015



Review Results

1. Click Acquire Dataset
2. Select OPTIMIZATION/OBJECTIVE
3. Click Create Plot

- This tutorial involved configuring multiple samples, each sample is configured for SOL 200. The objective histories for 3 samples will be displayed in the following pages.



Review Results

1. Click Last Plot Added
2. Click + View Filters and Plotted Values
3. Similar to before, for the SAMPLE filter select only samples:
   - model_0011
   - model_0015
4. The objective histories for each local optimization is displayed

End of Tutorial

Appendix

Appendix Contents

Response Configuration

- Monitor the response of the FINAL design cycle (SOL 200 only): Yes, No or blank

Equivalent Global Optimization

How to import and edit previous parameter studies

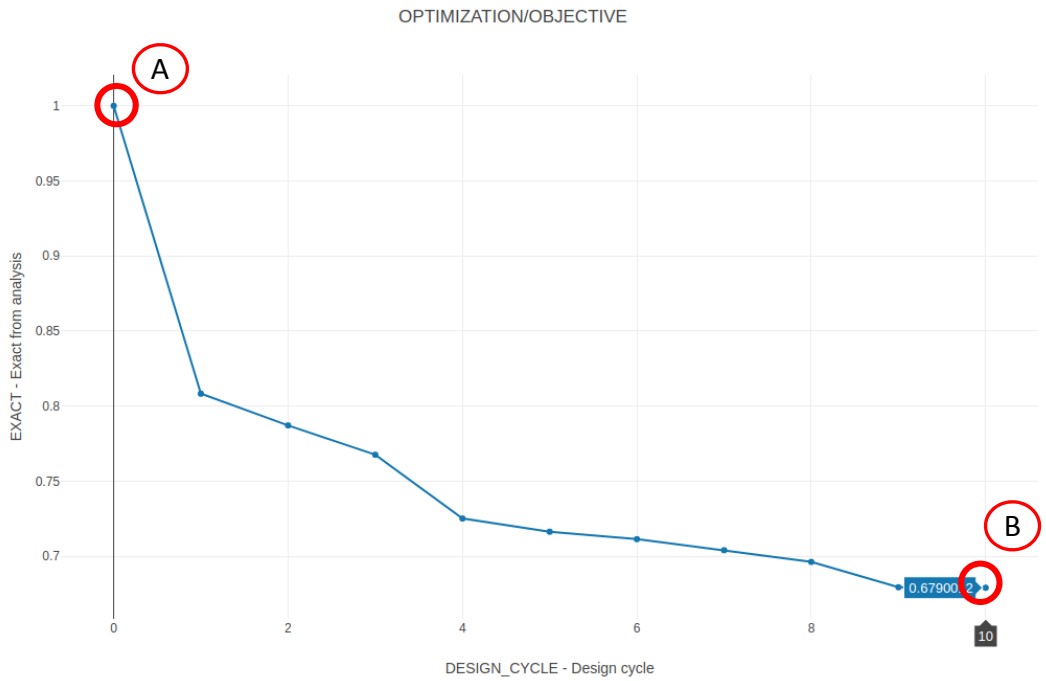
Monitor the response of the FINAL design cycle (SOL 200 only)

A. When the option is *blank* or set to *No*, the monitored response is that of the design cycle listed. In this example, the response of design cycle 0 is monitored. The value of r1 is 1.0.

Delete	Label	Status	Objective	Lower Bound	Upper Bound	Monitor the response of the FINAL design cycle (SOL 200 only)	Monitor the maximum or minimum response, whichever has the greatest absolute value	Dataset Name
	r1			Lower	Upper			OPTIMIZATION/OBJECTIV

B. When the option is set to *Yes*, the monitored response is that of the FINAL design cycle. In this example, the response of design cycle 10 is monitored. The value of r1 is .679.

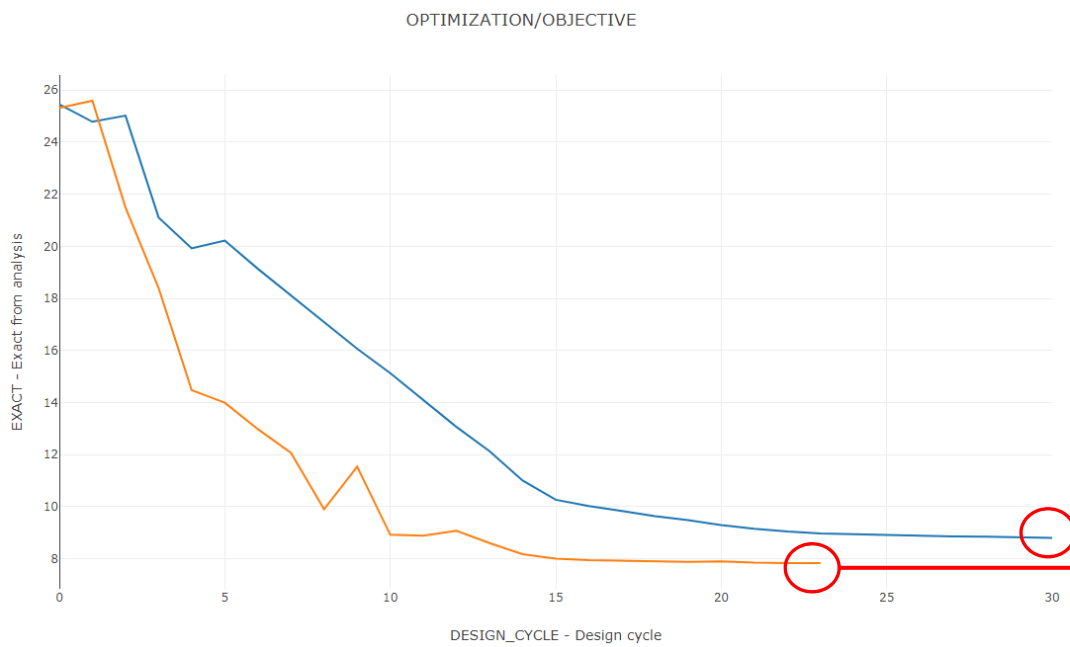
Delete	Label	Status	Objective	Lower Bound	Upper Bound	Monitor the response of the FINAL design cycle (SOL 200 only)	Monitor the maximum or minimum response, whichever has the greatest absolute value	Dataset Name
	r1			Lower	Upper	Yes - Monitor respor		OPTIMIZATION/OBJECTIVE



Monitor the response of the FINAL design cycle (SOL 200 only), Continued

Since the *Monitor the response of the FINAL design cycle (SOL 200 only)* is set to *Yes*, the response r1 takes the value of the last design cycle. The HDF5 Explorer is used to create an XYPLOT of the objective history, and the Monitored Responses web app is used to view the response value that was extracted.

Objective History



Monitored Response r1

Equivalent Global Optimization

A Global Optimization is characterized as follows:

- A local optimization is performed at different starting, or initial, values for the variables
- The best final objective from all the local optimizations it taken as the global optimum.

This tutorial is equivalent to performing a global optimization

- The original BDF files are configured to perform a local optimization with MSC Nastran SOL 200. The Samples section is used to configure multiple local optimizations at different starting values for the variables.
- The Response section is used to monitor the objective and max normalized constraint from each local optimization

How to import and edit previous parameter studies

How to import and edit previous parameter studies

The parameters, samples and responses are contained in the following files

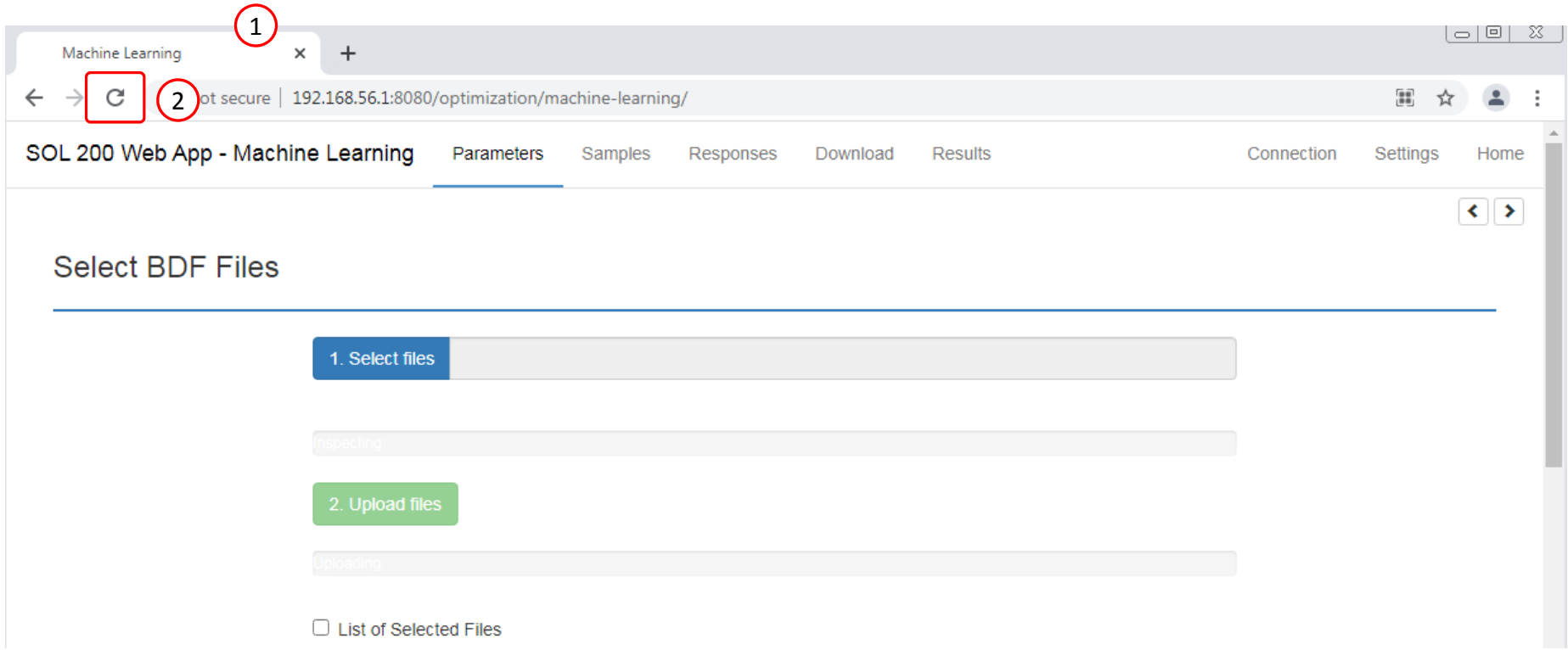
- app.config
- BDF files

These files may be imported back to the Parameter Study web app, and any parameters, samples and responses can be reconfigured

Import

1. Return to the window or tab that has the Machine Learning web app opened
2. Refresh the web page to start a new session

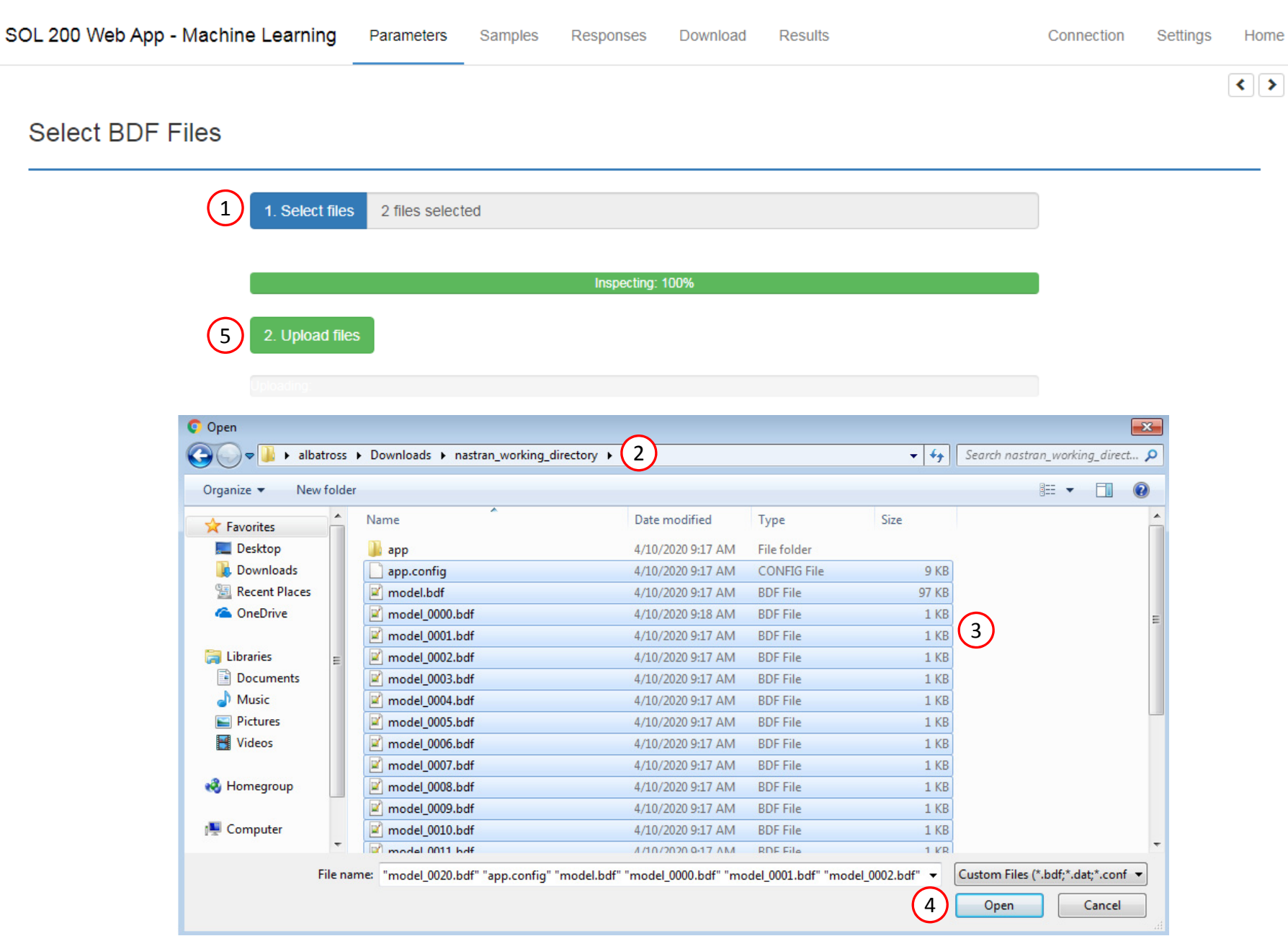
- Refreshing the page is only required when the *Select files* button is disabled.



Import

1. Click Select Files
2. Navigate to the folder named nastran_working_directory
3. Select all the BDF files AND the app.config file.
4. Click Open

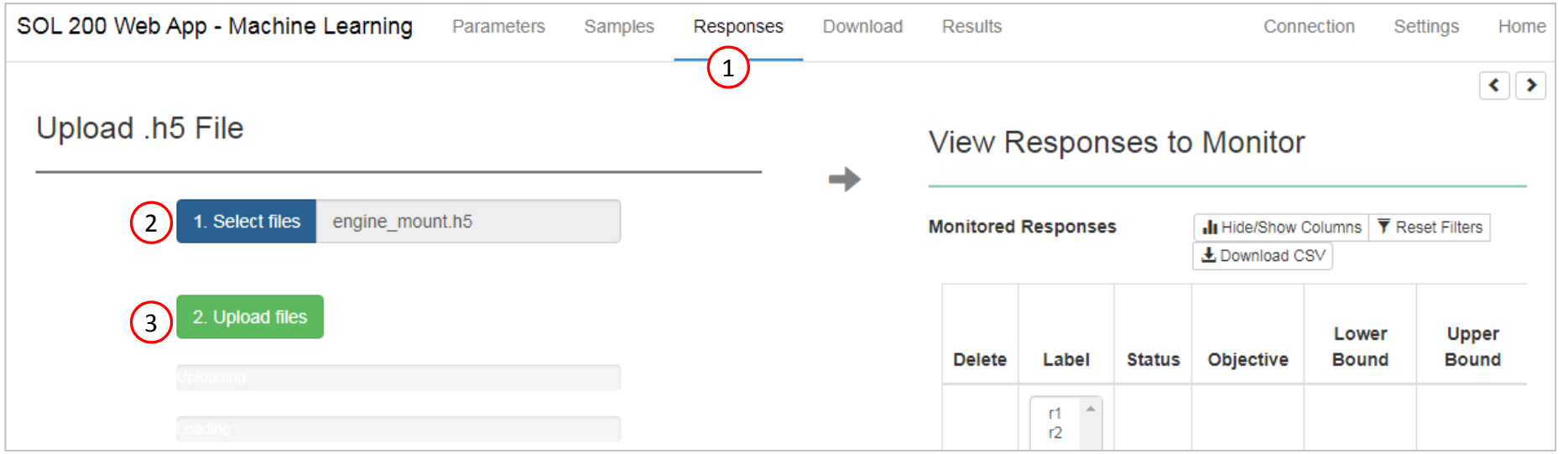
- All imports require the app.config file to be selected.

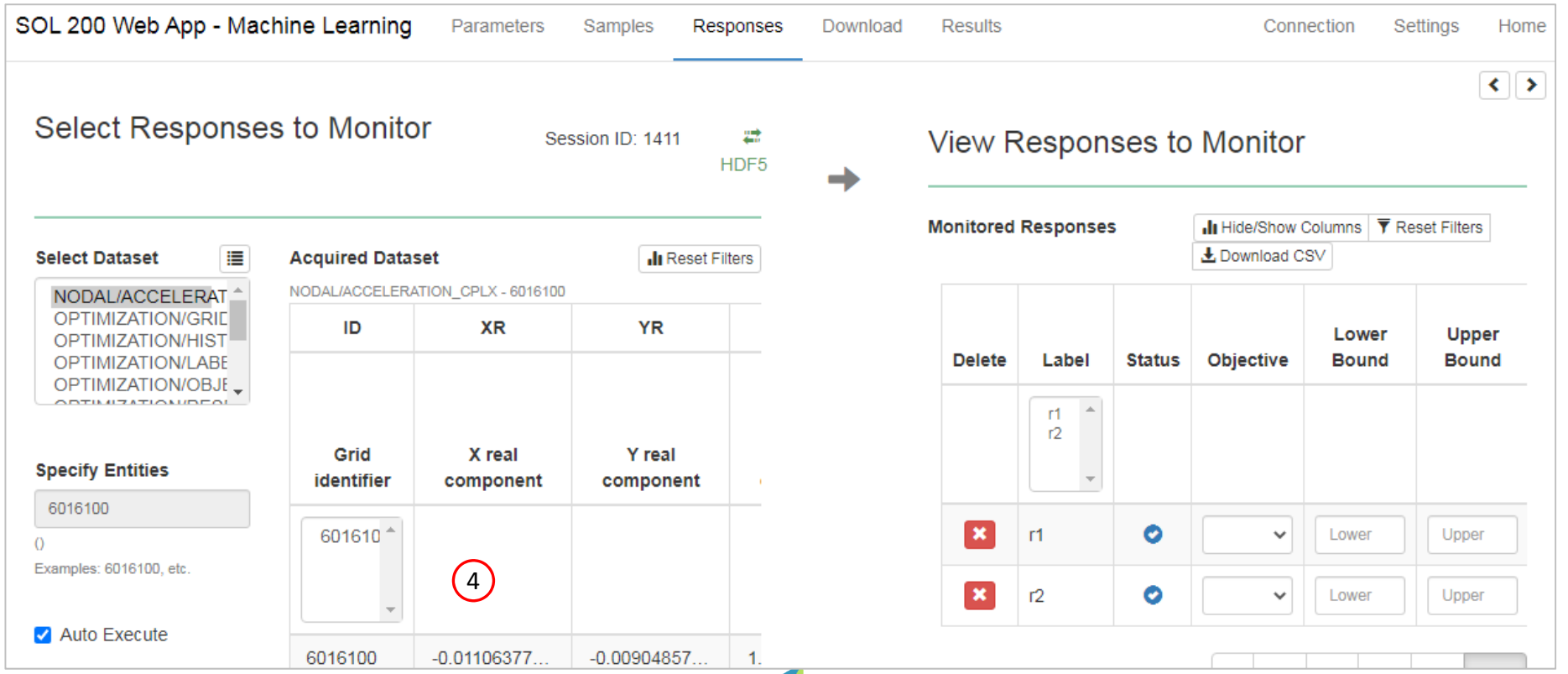


Import

For the Response section, the H5 file will need to be re-uploaded.

1. Click Responses
2. Select the H5 file
3. Click Upload
4. Data from the H5 is loaded and ready to use





Import

After import, any Parameter, Samples or Responses can be modified.