Workshop - Multi Model Optimization

AN MSC NASTRAN SOL 200 TUTORIAL



Goal: Minimize the weight of three different models of different analyses under constraints

In the structure design, it is necessary to perform design optimization using multi-models (MMO: Multi-Model Optimization) that combines two or more related optimization tasks into a single combined optimization task. The benefits are as follows:

A: Allows users to have different models that differ in their topology or in their analyses that are created to satisfy different analysis needs with proper models

B: Allows users to design the variants of vehicles or airplane with shared parts or components

C: Help users to get the best trade-off solutions using one combined optimization task rather than get different so-called optimized results from different optimization tasks



Optimization Problem Statements Separate Design Models: Independent Design Variables, Objectives and Design Constraints

Model 1 - m_stress

Analysis: Statics

Objective: Minimize Weight

Constraints:

r1: von Mises of stress, at z1, for PSHELL 1, 7 r2: von Mises of stress, at z2, for PSHELL 1, 7 r3: von Mises of stress, at z1, for PSHELL 3, 8 r4: von Mises of stress, at z2, for PSHELL 3, 8 r5: von Mises of stress, at z1, for PSHELL 8, 9, 10 r6: von Mises of stress, at z2, for PSHELL 8, 9, 10

Variables:

x1, x2, x3, x4, x5, x6, x7, x8, x9, x10



Model 2 - m_modes

Objective: Minimize Weight

Constraints:

r1: Natural frequency of mode 1, 25Hz < r1 r2: Natural frequency of mode 2, 30Hz < r2

Settings

Mode tracking is used

Variables:

x1, x2, x3, x4, x5, x6, x7, x8, x9, x10 and x11







Optimization Problem Statements Separate Design Models: Results





Separate Optimizations Tasks Without MMO

With separate optimizations for each model, different values for the variables are achieved.

For example, the thickness of the door, x8, is different after each optimization. There are 3 different values for the door thickness: .55, .40 and .50.

		Without MMO	
Design Model	Model 1	Model 2	Model 3
Objective			
Minimize Weight	\checkmark	\checkmark	\checkmark
Constraints			
Constraints of Model 1	\checkmark		
Constraints of Model 2		\checkmark	
Constraints of Model 3			\checkmark
Variables			
x1	√ 1.7	√ .30	√ 3.50
x2	√ .45	√ .65	√ 1.05
x3	√ .30	√ .10	√ 1.05
x4	√ .35	√ .55	√ .550
x5	√ .45	√ .65	√ 1.05
хб	√ .55	√ .15	√ .850
x7	√ .90	√ .25	√ 3.50
x8	√ .55	√ .40	√ .500
x9	√ .45	√ .95	√ .700
x10	√ .40	√ .20	√ .350
x11		√ .55	√ .850
Final values of design variables			



Optimization Problem Statements Multi-model Optimization: Merged Design Model

Model 1 - m_stress	Model 2 - m_modes	Model 3 - m_storsp
Analysis: Statics	Analysis: Modes	Analysis: Statics
	Objective: Minimize Weight	
Constraints: r1: von Mises of stress, at z1, for PSHELL 1, 7 r2: von Mises of stress, at z2, for PSHELL 1, 7 r3: von Mises of stress, at z1, for PSHELL 3, 8 r4: von Mises of stress, at z2, for PSHELL 3, 8 r5: von Mises of stress, at z1, for PSHELL 8, 9, 10	Constraints: r1: Natural frequency of mode 1, 25Hz < r1 r2: Natural frequency of mode 2, 30Hz < r2 Settings Mode tracking is used	Constraints: r1: Displacement, y component, of node 19998 15 < r1 < .15 Equation Constraint: R1: 1000 * 2958.4 / b1 (Effective BIW Rotational Stiffness)
r6: von Mises of stress, at z2, for PSHELL 8, 9, 10		5E13 < R1 < 5E14 b1: Displacement, 4 th component, of node 19998

Variables: x1, x2, x3, x4, x5, x6, x7, x8, x9, x10 and x11









Optimization Problem Statements Merged Design Model: Linked Variables

Variables Links

- For the design variables having the same IDs from two or more models, they are optimized as shared variables and indicated as "linked." The shared variables must have the same labels, lower/upper bounds, etc. across several models or all models. Attention is needed to make sure the shared design variables are used for the same physical properties/parts across different models.
- For the design variables existing only in one model, they are unique variables to that specific model and indicated as "not linked"
- Refer to Part B for the details of corrections if there are conflicting in the definition of the design variables across models.



Co	olor	Label	Description	Entry Name	Bounds	m_stress	m_modes	m_storsp	Is variable linked?
		x1	T of PSHELL 1	floor_roll	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x2	T of PSHELL 2	frame	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x3	T of PSHELL 3	floor	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x4	T of PSHELL 4	spoiler	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x5	T of PSHELL 5	front_mount	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x6	T of PSHELL 6	engine_walls	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x7	T of PSHELL 7	front_panel	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x8	T of PSHELL 8	doors_skin	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x9	T of PSHELL 9	roof	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x10	T of PSHELL 10	back_panel	.1 < xi < 10.	\checkmark	\checkmark	\checkmark	Linked
		x11	T of PSHELL 11	windows	.1 < xi < 10.		\checkmark	\checkmark	Linked

T is for thickness



Optimization Problem Statements Merged Design Model: Results





Comparison Without and With MMO

With MMO, a single optimization is performed across multiple models. Single values for the design variables are achieved.

For example, the thickness of the door, x8, is a single value of .525 .

		Without MMO		With MMO
Design Model	Model 1	Model 2	Model 3	Multi Model
Objective				
Minimize Weight	\checkmark	\checkmark	\checkmark	\checkmark
Constraints				
Constraints of Model 1	\checkmark			\checkmark
Constraints of Model 2		\checkmark		\checkmark
Constraints of Model 3			\checkmark	\checkmark
/ariables				
x1	√ 1.7	√ .30	√ 3.50	√ 2.84
x2	√ .45	√ .65	√ 1.05	√ .966
x3	√ .30	√ .10	√ 1.05	√ 1.04
x4	√ .35	√ .55	√ .550	√ .517
x5	√ .45	√ .65	√ 1.05	√ .966
x6	√ .55	√ .15	√ .850	√ .970
x7	√ .90	√ .25	√ 3.50	√ 2.84
x8	√ .55	√ .40	√ .500	√ .525
x9	√ .45	√ .95	√ .700	√ .665
x10	√ .40	√ .20	√ .350	√ .369
x11		√ .55	√ .850	√ 2.84
Final values of design /ariables				



More Information Available in the Appendix

The Appendix includes information regarding the following:

- Manually Configuring Multi Model Optimization
 - Model Conversion for All Models
 - Constructing the Merged Objective
 - Linking Variables
 - Constructing the MMO.xml File
- Why are DELX and CONV2 used in the DOPTPRM entry (Optimization Settings)?

Best Practice		
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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

PART A



Tutorial Overview

Part A

 Perform a multi model optimization with 3 models

Part B

- 1. Repeat Part A
- 2. Add a new model, but the model has errors that must be corrected
- 3. Correct the errors
- 4. Complete a multi model optimization

Special Topics Covered

Multi Model Optimization (MMO) – MMO is the process of optimizing multiple design models concurrently.

Merged Objective - Each design model's objective, or selected objectives, can be combined into one merged objective and a multi model optimization may be performed. This example only considers only 1 objective for the merged objective.

Linked Variables – Design variables in separate models that should be treated as the same design variable must be *linked*. For example, as shown below, the design variables in separate models A and B must be linked.
Variable x1 - Model A - Corresponding to thickness of Panel 1 in model A
Variable x1 - Model B - Corresponding to thickness of Panel 1 in model B



SOL 200 Web App Capabilities

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.

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

Benefits

entries.

- REAL TIME error detection. 200+
- error validations.
- REALT TIME creation of bulk data
- 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.



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



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



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



PBMSECT Web App Generate PBMSECT and PBRSECT entries graphically



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



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



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



browser on Windows and Linux



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



Before Starting

 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.





The Engineering Lab

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.

Select a web app to begin Before After Optimization for SOL 200 Multi Model Optimization Machine Learning | Parameter HDF5 Explorer Viewer Study Tutorials and User's Guide (1)Full list of web apps

SOL 200 Web App





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 Multi Model Optimization

Multi Model Optimization (MMO) is the process of optimizing multiple design models concurrently. Design variables across multiple models can be linked and simultaneously optimized. A merged or combined objective can optimize the objective of each design model. The design constraints of each design model are also included in a multi model optimization.

This tutorial details the procedure to configure a multi model optimization.

Starting BDF Files Link 2 Solution BDF Files: Link





Obtain Starting Files

- Right click on the zip file
- Select Extract All...
- Click Extract
- 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.

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Documents			Open with	
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Pictures			Restore previous versions	
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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.



SOL 200 Web App Select a web app to begin Before After 1 Optimization for SOL 200 Multi Model Optimization Machine Learning | Parameter HDF5 Explorer Viewer Study Tutorials and User's Guide Full list of web apps



Upload BDF Files

- 1. Click Add Model
- 2. Click Select Files
- Navigate to this folder: 1_starting_files_1_m_stress
- Select the BDF files found in the folder
- 5. Click Open
- This multi model optimization example involves 3 separate models. The first model is uploaded to the web app.

SOL 200 Web App - Multi Model Optimization

Add Models







Upload BDF Files

- Click Add Model
- **Click Select Files**
- Navigate to this folder: 1_starting_files_2_m_modes
- Select the BDF files found in the folder
- Click Open
- The second model is uploaded to the web app.

SOL 200 Web App - Multi Model Optimization

Add Models

Model





Upload BDF Files

- 1. Click Add Model
- 2. Click Select Files
- Navigate to this folder: 1_starting_files_3_m_storsp
- 4. Select the BDF files found in the folder
- 5. Click Open
- 6. The cautionary message can be ignored
- 7. Click Upload Files
- Click Upload Files
- Click Upload Files
- The third model is uploaded to the web app.
- Multi model optimization involves handling multiple BDF files, and in the process the same BDF files may be uploaded inadvertently. In this example, model 2 and 3 share the BDF file: fcar_struct.bdf and a cautionary message is displayed regarding the same uploaded BDF file. The cautionary message can be ignored for this example but should be considered in all other examples.

SOL 200 Web App - Multi Model Optimization

Add Models





Modify MMO Task

- 1. Find the section titled Models in Multi Model Optimization (MMO) Task
- Note the names of each model have been automatically generated

• The model names can be customized as shown on the next slide.

SOL 200 Web App - Multi Model Optimization

Add Models

+ Add Model



1 Models in Multi Model Optimization (MMO) Task

			<u> </u>	
Model	Status	m_model	m_model2	m_model3
Use Objective in MMO Task?	9	 Yes At least one objective must be selected. 	 Yes At least one objective must be selected. 	 Yes At least one objective must be selected.
Objective Type		DRESP1	DRESP1	DRESP1
Objective Weight Coefficient	0	0.0	0.0	0.0
Options				
Preview				

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



(2)



Rename the models

- 1. Mark the Options checkbox
- For the 1st model (Column 1), change the model name from m_model to m_stress
- For the 2nd model (Column 2), change the model name from m_model2 to m_modes
- For the 3rd model (Column 3), change the model name from m_model3 to m_storsp

The merged objective will only consider the weight of model m_stress in this workshop.

- 5. Mark the checkbox of the 1st model (Column 1)
- The model names are limited to 8 characters.
- Marking the "Preview" checkbox will show all data changes based on the user's selections for the MMO job settings.

SOL 200 Web App - Multi Model Optimization

Models in Multi Model Optimization (MMO) Task

Model	Status	m_stress	m_modes	m_storsp	×
Use Objective in MMO Task?	0	Yes 5	Yes	Yes	
Objective Type		DRESP1	DRESP1	DRESP1	
Objective Weight Coefficient	0	1.0	0.0	0.0	
✓ Options 1					
Model Name (Max Length: 8)	0	m_stress 2	m_modes 3	m_storsp 4	
Memory (mem)	0	200MB	200MB	200MB	
Number of Processors (smp)	0	1	1	1	
Option for Scratch (scr)		yes	▼ yes	▼ yes	Ŧ
Blocking (blocking)		0 - Serial	O - Serial	O - Serial	T
Preview					



Modify MMO Task

 Unmarking "Show only invalid" box under Linked Variables will show all linked or unlinked variables.

 In the event red status markers are visible, the design variables for the models must be modified for compatibility. Refer to Part B of this tutorial for the details regarding variable corrections.

Linked Variables

1 Show only invalid

Label	Status
x1	0
Variable Linked	
x2	0
Variable Linked	
x3	0
Variable Linked	
x4	0
Variable Linked	
x5	0
Variable Linked	
x6	0
Variable Linked	
x7	0
Variable Linked	
x8	0
Variable Linked	
x 9	0
Variable Linked	
x10	0
Variable Linked	
x11	0
Variable Linked	

m_stress	m_modes	m_storsp
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Linked	Linked	Linked
Variable not in this model	Linked	Linked



Modify MMO Task

- Scrolling down the page, one can see the Merged Objective which is included in the first model of the MMO job.
- Settings for the Merged Model is also generated automatically and it will be output as MMO.XML for the MMO job run.
- This Merged Objective and Settings for Merged Model are auto generated by the MMO Web App. It is highly recommended that this data not be hand edited.
- More details regarding the changes on this page are covered in the Appendix, section Manually Configuring Multi Model Optimization.
- The same section also discusses the validations performed for Linked Variables.



Settings for Merged Model

Preview of Merged Objective

Option	Status	Configure
Minimize or Maximize Combined Objective		MIN
Memory (mem)	0	200MB
Number of Processors (smp)	0	1
Option for Scratch (scr)		yes 🔻







Export New BDF Files

- 1. Find the section titled Download Files
- 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"

1 Download BDF Files

▲ Download BDF Files



Perform the Optimization with Nastran SOL 200

A new .zip file has been downloaded

- 1. Right click on the file
- 2. Click Extract All
- 3. Click Extract on the following window
- Always extract the contents of the ZIP file to a new, empty folder.

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HEXAGON

Technology Partner



Perform the Optimization with Nastran SOL 200

- 1. Inside of the new folder, double click on Start MSC Nastran
- Click Open, Run or Allow Access on any subsequent windows
- 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





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



Open

×

Cancel

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

Status

Name	Status of Job	Design Cycle	RUN TERMINATED DUE TO
m_stress.bdf	Running	None	
m_modes.bdf	Running	None	
m_storsp.bdf	Running	None	



Review Optimization Results

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

1. The final value of objective, normalized constraints (not shown) and design variables can be reviewed.

For all three models involved in the multi model optimization, it can be seen that a single result for the objective and design variables has been obtained and all the design constraints have been satisfied.





Design Variables

1



Label Comments T, Thickness, of PSHELL 1 (floor_roll) T, Thickness, of PSHELL 2 (frame) T, Thickness, of PSHELL 3 (floor) T, Thickness, of PSHELL 4 (spoiler) T, Thickness, of PSHELL 6 (engine walls) T, Thickness, of PSHELL 7 T, Thickness, of PSHELL 8 T, Thickness, of PSHELL 9 (roof) T, Thickness, of PSHELL 10 T, Thickness, of PSHELL 5 (front_mount) T, Thickness, of PSHELL 11



Tutorial

PART B



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.



SOL 200 Web App Select a web app to begin Before After 1 Optimization for SOL 200 Multi Model Optimization Machine Learning | Parameter HDF5 Explorer Viewer Study Tutorials and User's Guide Full list of web apps



Import Existing MMO Files

- 1. Mark the checkbox titled Import Existing MMO XML File
- 2. Click Select files
- Open the directory nastran_working_directory
- 4. Select the MMO.xml file
- 5. Click Open
- The files from a previous MMO configuration can be re-uploaded to the MMO web app. This page shows the start of the re-upload process by uploading the XML file.

Import Existing MMO XML File

Import MMO.xml	Import BDF Files		
Select files MMO.xml	Select files Select the BDF Files		
Importing: 100%	_		
importing. 100%	● Import		





Import Existing MMO XML File

1

Import Existing MMO Files

- 1. Click Select files
- 2. Select all the BDF files
- 3. Click Open
- 4. Click Import

• The re-upload process continues by selecting all the BDF files and uploading.

Import Existing MMO XML File

Import Existing MMO XML File

Import MMO.xml	Import BDF Files
Select files MMO.xml	Select files 10 files selected
Importing: 100%	Import Importing:

ganize 🔻 New fol	lder						0
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Recent Places		🖉 design_model_m_storsp.bdf	9/6/2018 3:29 PM	BDF File	7 KB		
📤 OneDrive		design_model_m_stress.bdf	9/6/2018 3:29 PM	BDF File	8 KB		
-		🖉 design_model_mmo.bdf	9/6/2018 2:49 PM	BDF File	1 KB		
Libraries		🖉 fcar_stress2.bdf	9/6/2018 1:51 PM	BDF File	2,204 KB		
Documents		🖉 fcar_struct.bdf	9/6/2018 1:51 PM	BDF File	831 KB		
J Music		🖉 m_modes.bdf	9/6/2018 3:29 PM	BDF File	6 KB		
Pictures		🖉 m_storsp.bdf	9/6/2018 3:29 PM	BDF File	6 KB		
Videos		🖉 m_stress.bdf	9/6/2018 3:29 PM	BDF File	8 KB		
		MERGE.bdf	9/6/2018 3:29 PM	BDF File	1 KB		
Homegroup							



Add a 4th model

- . Click Add Model
- 2. Click Select files
- Navigate to this directory: 1_starting_files_3_m_storsp_bad
- 1. Select the BDF files found in the folder
- 5. Click Open
- 6. Click Upload files
- The previous MMO task and its settings have been imported.
- A new 4th model will be added. The new model is identical to m_storsp, but has variable discrepancies that will prevent a successful Multi Model Optimization. The following steps discuss how to resolve such variable discrepancies.

SOL 200 Web App - Multi Model Optimization




Export New BDF Files

- 1. Find the section titled Download BDF Files.
- 2. Errors have been detected in the newly added model. Click Jump to section to inspect.

 The purpose of this part of the tutorial is demonstrate the procedure to take in the event a model is uploaded to the MMO web app, but has errors that must be fixed. The validations and status messages are available throughout the MMO web app, and the most significant validation is visible in the Download BDF Files section.

1 Download BDF Files



Errors detected! Check the Status of the following tables. Correct: O. Incorrect: O.
 Linked Variables - Jump to section

(2)



Review Linked Variables

There are 2 visible errors and 1 unlinked variable

- Unmark the checkbox titled Show only invalid
- 2. For linked variable x2, 2 errors have been found:
 - The upper bound of the 4th model (200.) is different from the other models (10.).
 - 2. The DDVAL ID of the 4th model (2001) is different form the other models (2002).
- Always check the status icons in each section of the web app. Red status markers indicate an error that will fail a multi model optimization. Blue status markers indicate the setting is valid.
- Errors found in the Linked Variables section require additional modifications to resolve. The purpose of this part of the tutorial is to demonstrate the process to correct issues found in the Linked Variables section.

Linked Variables

2
2



Open the Correct Page

1. Click on the indicated link

 In order to address the 2 visible errors and 1 unlinked variable detected in the 4th model in the MMO web app, currently named "m_model" in the last step, the 4th model must be taken to the Optimization web app and modified.



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

The Engineering Lab



Upload BDF Files

- 1. Click 1. Select Files
- Navigate to this folder: 1_starting_files_3_m_storsp_bad
- 3. Select all the BDF files found in the directory
- 4. Click Open
- 5. Click Upload Files
- The process starts by uploading all the necessary BDF files.

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Modify Design Variables

1. Find the section titled Step 2 – Adjust design variables

Perform the following edits to variable x2

- 2. Upper Bound: 10.0
- Allowed Discrete Values: .05, THRU, 7.0, BY, .050
- A. Some may notice that there is a trailing zero in the Allowed Values, i.e. .05<u>0</u>: .05, THRU, 7.0, BY, .05<u>0</u>
 The goal of the extra 0 is to make the to make the entire string unique from the other allowed values. This triggers the web app to create a unique DDVAL entry with identification number of 2002. Multi Model Optimization requires that linked variable's (DESVAR and DDVAL entries) entries are identical across models. With this change, all x2 variables point to the same DDVAL 2002 entry.

e lopology	Topometr	y Topogra	phy							
p 2 - Adjı	ist desig	ın variab								BDF Output - Design Model
ntions									X Delete Visible Rows	100006 PVAL DVPREL1 1000007 PSHELL 7 T 1000007 PVAL DVPREL1 1000008 PSHELL 8 T 1000008 PVAL DVPREL1 1000009 PSHELL 9 T
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x2	0	т	Thickness	PSHELL	2	1.0	0.1	10.0	.05, THRU, 7.0, BY, .050	DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001
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p 3 - Cre	ate varia	able links	i							\$ DLINK 1 100005 100002 1.0 \$ Design Variables - Type 2 4
									+ Create DLINK	s S





Export New BDF Files

1. Click on Exporter

2. Click on Download BDF Files

 To ensure this new design model yields the same solution as before, the updated BDF files are downloaded and an optimization is performed.

SOL 200 Web App - Optimization Upload Variables Objective Constraints Subcases Exporter Results

BDF Output - Model

form = formatted, unit = 52
\$ id msc, storsp.dat \$ ehj 30-Jul-2009 mdr4

\$ -----\$ \$ BIW Torsion Analysis

s s -----

s

s

\$ \$

s s

ECHO=NONE

DIAG 8,15 SOL 200 CEND \$ \$ \$ \$

\$ MSC Acoustic Seminar: Car Example

\$ASSIGN INPUTT2='mcar.f70' UNIT=70

TITLE = BIW Static Torsion Tests

Download BDF Files

assign userfile = 'optimization_results.csv', status = unknown,

\$ Assign statement for Akusmod-Nastran binary coupling matrix

\$ Print Matrix & Table Trailers in .f04

Executive Control Section

Case Control Section

Settings Match Other User's Guide Home

< >

BDF Output - Design Model

A		100006	PVAL					
	DVPR	EL1 100000	7 PSHELL	7	т			
		100007	PVAL					
	DVPR	EL1 100000	8 PSHELL	8	т			
		100008	PVAL					
	DVPR	EL1 100000	9 PSHELL	9	т			
		100009	PVAL					
	DVPR	EL1 100001	0 PSHELL	10	т			
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		100011	PVAL					
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	i i							
	DESN	10 100001	~1	1.0	0.1	10	2001	
	DESV	AD 100001	~ ~	1.0	0.1	10.0	2001	
	DESV	HR 100002		1.0	0.1	10.0	2002	
	DESV	AK 100003	X3	1.0	0.1	10.	2001	
	DESV	AR 100004	X4	1.0	0.1	10.	2001	
	DESV	AR 100005	x5	1.0	0.1	10.	2001	
	DESV	AR 100006	X6	1.0	0.1	10.	2001	
	DESV	AR 100007	х7	1.0	0.1	10.	2001	
	DESV	AR 100008	x8	1.0	0.1	10.	2001	
	DESV	AR 100009	х9	1.0	0.1	10.	2001	
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Developed by The Engineering Lab

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

(2)



Perform the Optimization with Nastran SOL 200

- 1. A new .zip file has been downloaded
- 2. Right click on the file nastran_working_directory (1)
- 3. Click Extract All
- 4. Click Extract on the following window
- Always extract the contents of the ZIP file to a new, empty folder.

				×	
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🐌 Downloads	starting_files_mmo	8/25/2018	3:59 PM	File fol	
🔚 Recent Places	nastran_working_directory.zip	8/25/2018	4:08 PM	Compr	
a OneDrive	starting_files_mmo.zip	8/25/2018	3:54 PM	Compr	
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astran_worki	ng_directory (1).zip Date modified: 8,	Properties	Files wil	l be extra	acted to this folder:
Compressed (zi	ipped) Folder Size: 28.6 M	ИВ	C:\Use	rs\specia	al-sunshine\Downloads\nastran_working_directory (1)
			Shov	v extracte	ed files when complete



Cancel

Extract

3

×

Perform the Optimization with Nastran SOL 200

- 1. Inside of the new folder, double click on Start MSC Nastran
- Click Open, Run or Allow Access on any subsequent windows
- 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



- SYSTEM INFORMATION MESSAGE (pgm: nastran, fn: estimate_job_requirements)
 Starting ESTIMATE, please wait...
- *** USER INFORMATION MESSAGE (pgm: nastran, fn: estimate_job_requirements) Estimated memory=2048.5MB Estimated bpool=512.1MB ISC Nastran beginning job model.

3

- MSC Nastran started c:\msc.software\msc_nastran\20182\msc20182\win64i8\mscdate

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





Name: ...astran_working_directory\Start MSC Nastran.Ink

From: C:\Users\special-sunshine\Downloads\nastran_...

Publisher: Unknown Publisher

Type: Shortcut

X

potentially harm your computer. If you do not trust the source, do not open this software. What's the risk?

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

Registre America 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, normalized constraints (not shown) and design variables can be reviewed.
- This model has been previously optimized. In the last few steps, changes to the design variables have been done, but the optimization results should be identical to the optimization results before modification. Ensure the results are the same.
- This new design model, found in nastran_working_directory (1), has the necessary corrections in order to successfully add this design model to the MMO task.

SOL 200 Web App - Local Optimization Results



RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 13.
 AND HARD FEASIBLE DISCRETE DESIGN OBTAINED

Objective

1







SOL 200 Web App - Multi Model Optimization 1

Add Models

Open the MMO Web App

- 1. Open the existing MMO Web App
- 2. Click the red x to remove the 4th model. Recall that this model has errors and will not be used.

• The old 4th model is removed. This model contained the inconsistent variables x2 and x300.

Model	m_stress	×	m_modes		m_storsp			m_model	(2)	L
	Select files 2 file	es selected	Select files	files selected	Select files	2 files selected		Select files	3 files select	ted
	Inspecting: 1	00%	Inspecti	ng: 100%	Inspe	sting: 100%		Insp	ecting: 100%	
elect and Upload Files	Upload files		Upload files		Upload files			Upload files		
	Uploading: 1	00 %	Uploadii	ng: 100 %	Uploa	ding: 100 %		Uplo	ading: 100 %	
dd Models										
dd Models										
dd Models - Add Model Iodel	m_stress	×	m_modes		m_storsp					
dd Models - Add Model Model	m_stress Select files 2 file	× es selected	m_modes Select files	2 files selected	m_storsp Select files	2 files selecte	R			
dd Models F Add Model Model	m_stress Select files 2 file Inspecting: 1	es selected	m_modes Select files	2 files selected ing: 100%	m_storsp Select files	2 files selecte ecting: 100%	8 d			



Add a 4th Model

- 1. Click Add Model
- 2. Click Select Files
- Navigate to this folder: nastran_working_directory (1)
- Select the BDF files found in the folder
- 5. Click Open
- 5. Click Upload Files
- The new 4th model is added. This model was modified in the Optimization web app and is contained in the folder named nastran_working_directory (1).

Add Models







Review Linked Variables

- L. Note the 2 errors for x2 from <u>before</u>:
 - 1. The upper bound of the 4th model (200.) is different from the other models (10.).
 - The DDVAL ID of the 4th model (2001) is different form the other models (2002).
- 2. After taking the 4th model, and updating the design model using the Optimization web app and the CSV file, the errors have been resolved and a blue checkbox is shown for variable x2.
- The original purpose of this part of the tutorial was to demonstrate the process to correct issues found in the Linked Variables section. As shown in the New View, the status markers for x2 is blue, meaning the variables are properly configured.

Linked Variables

Show only invalid

Label	Status	m_stress	m_modes	m_storsp	m_model
x1	0				
Variable Linked		Linked	Linked	Linked	Linked
x2	0				
Variable Linked		Linked	Linked	Linked	Linked
Upper Bound	0	10.	10.	10. (1.1)	200.
ID of DDVAL	0	2002	2002	2002	2001
x3	0			Ŭ	
Variable Linked		Linked	Linked	Linked	Linked
x4	0				
Variable Linked		Linked	Linked	Linked	Linked

New View

Old View

Linked Variables

Show only invalid

Label	Status	m_stress	m_modes	m_storsp	m_model
x1	0				
Variable Linked		Linked	Linked	Linked	Linked
x2	•				
Variable Linked		Linked	Linked	Linked	Linked
x3	0				
Variable Linked		Linked	Linked	Linked	Linked
x4	0				
Variable Linked		Linked	Linked	Linked	Linked



Modify MMO Task

- Find the section titled Models in Multi Model Optimization (MMO) Task
- 2. Mark the Options checkbox
- For the 4th model (Column 4), change the model name to m_stors2
- 4. Click the red x to remove the 3rd model.
- Only the following 3 models should be included:
 - m_stress
 - m_modes
 - m_stors2
- Four models should not be included since the 3rd model and the 4th model are the same.

Model	Status	m_stress	m_modes	m_storsp	m_stors2
Use Objective in MMO Task?	0	✓ Yes	Yes	Yes	Yes
Objective Type		DRESP1	DRESP1	DRESP1	DRESP1
Objective Weight Coefficient	0	1.0	0.0	0.0	0.0
✓ Options 2					
Model Name (Max Length: 8)	0	m_stress	m_modes	m_storsp	m_stors2 3
Memory (mem)	0	200MB	200MB	200MB	200MB
Number of Processors (smp)	0	1	1	1	1
Option for Scratch (scr)		yes •	yes 🔻	yes 🔻	yes 🔻
Blocking (blocking)		0 - Serial 🔻	0 - Serial 🔻	0 - Serial	0 - Serial
Preview					

(1)

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

Models in Multi Model Optimization (MMO) Task



Export New BDF Files

- 1. Find the section titled Download Files
- 2. Click on Download BDF Files
- 3. Extract the contents of the .zip file and click Start MSC Nastran to begin the optimization (Not Shown)
- 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"
- This example requires the use of MSC Nastran's MultiOpt utility. The MultiOpt utility does not allow directory name to have any special characters such as spaces,), (, !, ?.
 Name this directory with no special characters. For example, this directory name is valid: nastran_working_directory_1

Download BDF Files





Review Optimization Results

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

1. The final value of objective, normalized constraints (not shown) and design variables can be reviewed.

- It should be noted that the results from Part A should match the results from this part, Part B (shown right).
- The main purpose in Part B is to show the procedure to make corrections when one finds any problem in some of the multiple models for MMO job run.







O Display None C Display All Label Comments

52

End of Tutorial



Appendix



More Information Available in the Appendix

The Appendix includes information regarding the following:

- Manually Configuring Multi Model Optimization
 - Model Conversion for All Models
 - Constructing the Merged Objective
 - Linking Variables
 - Constructing the MMO.xml File
- Why are DELX and CONV2 used in the DOPTPRM entry (Optimization Settings)?

Best Practice		
For best Nastran		
CLIC	Appendix	



Appendix Contents

- Manually Configuring Multi Model Optimization
 - Model Conversion for All Models
 - Constructing the Merged Objective
 - Linking Variables
 - Constructing the MMO.xml File
- Why are DELX and CONV2 used in the DOPTPRM entry (Optimization Settings)?



Manually Configuring Multi Model Optimization



Best Practice

For best results, each separate design model must already run successfully, for one or more design cycles, in MSC Nastran before including in Multi Model Optimization.



Final Message in .f06

0 RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 11. 0

AND HARD FEASIBLE DISCRETE DESIGN OBTAINED

Objective







Final Message in .f06

0 RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 17. 0 AND HARD FEASIBLE DISCRETE DESIGN OBTAINED

Objective







Final Message in .f06



Objective





Manually Configuring Multi Model Optimization

The process is done in 4 steps:

- 1. Model Conversion for All Models
- 2. Constructing the Merged Objective
- 3. Linking Variables
- 4. Constructing the MMO.xml File

The MMO Web App automates these steps and no hand editing is necessary.



Manually Configuring Multi Model Optimization

MODEL CONVERSION FOR ALL MODELS



Model 1

	ATTEN (IM_STRESS.DDT)
<pre>assign userfile = 'optimization_results.csv', status = new, form = formatted. unit = 52</pre>	assign userfile='m_stress.csv', status=UNKNOWN, form=formatted, unit=52
	DIAG 8,15 \$ Print Matrix & Table Trailers in .f04
DIAG 8,15 \$ Print Matrix & Table Trailers in .f04	50L 200
SOL 200	CEND
CEND	TITLE = BIW No Windows Inertia Relief 18 Attach dof
TITLE = BIW No Windows Inertia Relief 18 Attach dof	ECHO=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA)
ECHO=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA)	\$ Output Control
\$ Output Control	\$
\$	Ş
\$	DISP(PLOT) = ALL
DISP(PLOT) = ALL	STRESS(PLOT) = ALL
STRESS(PLOT) = ALL	ESE(PLOT) = ALL
ESE(PLOT) = ALL	DESOBJ(MIN) = 5000000
DESOBJ(MIN) = 8000000	\$ DESGLB Slot
\$ DESGLB Slot	DESMOD = m_stress
<pre>\$ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL</pre>	SUBCASE 13
SUBCASE 13	ANALYSIS = STATICS
ANALYSIS = STATICS	DESSUB = 40000013
DESSUB = 40000013	\$ DRSPAN Slot
\$ DRSPAN Slot	SUBTITLE = Front Left Interior Pillar Z
SUBTITLE = Front Left Interior Pillar Z	LOAD = 113
LOAD = 113	SUBCASE 33
SUBCASE 33	ANALYSIS = STATICS
ANALYSIS = STATICS	DESSUB = 40000033
DESSUB = 40000033	\$ DRSPAN Slot
\$ DRSPAN Slot	SUBTITLE = Center Left Pillar Z
SUBTITLE = Center Left Pillar Z	LOAD = 133
LOAD = 133	SUBCASE 53
SUBCASE 53	ANALYSIS = STATICS
ANALYSIS = STATICS	DESSUB = 40000053
DE55UB = 40000053	\$ DRSPAN Slot
\$ DRSPAN Slot	SUBTITLE = Rear Left Pillar Z
SUBTITLE = Rear Left Pillar Z	LOAD = 153
LOAD = 153	\$
\$	BEGIN BULK
BEGTN BULK	INCLUDE './design_model_m_stress.bdf'



Model 2

BEFORE (MODEL.BDF)	AFTER (M_MODES.BDF)
assign userfile = 'optimization_results.csv', status = new, form = formatted, unit = 52	assign userfile='m_modes.csv', status=UNKNOWN, form=formatted, unit=52
<pre>torm = formatted, unit = 52 DIAG 8,15 \$ Print Matrix & Table Trailers in .f04 Sol 200 CEND \$ TITLE = BIW Static Torsion Tests ECHO=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA) \$ SET 1 = 19998 DISP = 1 \$ \$DISP(PLOT) = ALL STRESS(PLOT) = ALL STRESS(PLOT) = ALL ESE(PLOT) = ALL SPCF = ALL \$ DESOBJ(MIN) = 8000000 \$ DESOBJ(MIN) = 8000000 \$ DESOBJSlot \$ DESOBJ(MIN) = 8000000 \$ DESOLB Slot \$ DESOLB = 40000001 \$ DESOLB Slot \$ SUBTILE-DEFault SUBTILE-DEFault SUBTILE-DEFault SUBTILE-DEFault SUBTILE-DEFault SUBTILE-DEFAULt SCFORCES(SORTI,REAL)=ALL modtrak=800 </pre>	<pre>DIAG 8,15 \$ Print Matrix & Table Trailers in .f04 SOL 200 CEND \$ TITLE = BIW Static Torsion Tests ECH0=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA) \$ SET 1 = 19998 DISP = 1 %DISP(PLOT) = ALL STRESS(PLOT) = ALL ESE(PLOT) = ALL SPCF = ALL \$ SPC = 6 \$ DESOBJ(MIN) = 8000000 * DESOBJ Sint DESMD = m_modes SUBCASE 1 ANALYSIS = MODES DESSUB = 40000001 \$ DESSAN Slot \$ Subcase name : Default SUBTITLE=Default METHOD = 1 VECTOR(SORT1,REAL)=ALL SPCFORCES(SORT1,REAL)=ALL modtrak=800 BEGIN BULX</pre>



Model 3





Manually Configuring Multi Model Optimization

CONSTRUCTING THE MERGED OBJECTIVE



Merged Objective

A new file named design_model_mmo.bdf is created

This file contains a DRESP2 entry with ID=5000000

DRESP2	500000 RO 570000	
	DTABLE c1 c2 c3	
	DRESP1 8000000 8000000 8000000	
DEQATN	570000	
	g(c1, c2, c3, r1, r2, r3) = c1 * r1 + c2 * r2 + c3	* r3
DTABLE	c1 1.0 c2 0.0 c3 0.0	

This file is auto generated by the MMO Web App. It is highly recommended that this file not be hand edited. design_model_mmo.bdf



Merged Objective

The edit on the next slide happens only to the first model when the checkbox is marked.

In this example, m_stress is the 1st model. Models in Multi Model Optimization (MMO) Task

Model	Status	m_stress	🙁 m_modes	🙁 m_	_storsp	8
Use Objective in MMO Task?	0	Ves	C Yes		Yes	
Objective Type		DRESP1	DRESP1	DF	RESP1	
Objective Weight Coefficient	0	1.0	0.0		0.0	
ℓ Options						
Nodel Name (Max Length: 8)	0	m_stress	m_modes		m_storsp	
Memory (mem)	0	200MB	200MB		200MB	
Number of Processors (smp)	0	1	1		1	
Option for Scratch (scr)		yes	• yes	•	yes	,
Blocking (blocking)		0 - Serial	• 0 - Serial	•	0 - Serial	
Preview						



Only the first model is edited

BEFORE (M_STRESS.BDF)

assign userfile = 'optimization_results.csv', status = new, form = formatted, unit = 52 DIAG 8,15 \$ Print Matrix & Table Trailers in .f04 50L 200 CEND TITLE = BIW No Windows Inertia Relief 18 Attach dof ECHO=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA) DISP(PLOT) = ALLSTRESS(PLOT) = ALL ESE(PLOT) = ALLDESOBJ(MIN) = 8000000 SUBCASE 13 ANALYSIS = STATICS DESSUB = 40000013SUBTITLE = Front Left Interior Pillar Z LOAD = 113SUBCASE 33 ANALYSIS = STATICS DESSUB = 40000033SUBTITLE = Center Left Pillar Z LOAD = 133SUBCASE 53 ANALYSIS = STATICS DESSUB = 40000053 \$ DRSPAN Slot SUBTITLE = Rear Left Pillar Z LOAD = 153BEGIN BULK INCLUDE './design_model.bdf'

AFTER (M_STRESS.BDF)

assign userfile='m_stress.csv', status=UNKNOWN, form=formatted, unit=52

DIAG 8,15 \$ Print Matrix & Table Trailers in .f04 SOL 200

CEND TITLE = BIW No Windows Inertia Relief 18 Attach dof

ECHO=SORT(EXCEPT GRID.COUAD4.CTRIA3.CHEXA.CPENTA.CTETRA) DISP(PLOT) = ALLSTRESS(PLOT) = ALLESE(PLOT) = ALLDESOBJ(MIN) = 5000000 DESMOD = m_stress SUBCASE 13 ANALYSIS = STATICS DESSUB = 40000013 \$ DRSPAN Slot SUBTITLE = Front Left Interior Pillar Z LOAD = 113SUBCASE 33 ANALYSIS = STATICS DESSUB = 40000033 SUBTITLE = Center Left Pillar Z LOAD = 133SUBCASE 53 ANALYSIS = STATICS DESSUB = 40000053SUBTITLE = Rear Left Pillar Z LOAD = 153BEGIN BULK INCLUDE './design_model_m_stress.bdf' INCLUDE './design_model_mmo.bdf



Manually Configuring Multi Model Optimization

LINKING VARIABLES



Linking Variables

In order to Link Variables across models, the DESVAR entry must be identical in every model.

- Linked Variables The following variables appear in every model and are linked: x1, x2, x3, x4, x5, x6, x7, x8, x9, x10.
- Unlinked Variables The following variable appear only in one model (Model 2) and will change independently during the optimization.

SDESVAR ID LABEL XINIT XLB XUB DELXV DDVAL SDESVAR ID LABEL XINIT XLB ZUB DDVAL DESVAR 100001 X1 1.0 .1 10. 2001 DESVAR 100001 X1 1.0 0.1 10. 2001 DESVAR 100002 x2 1.0 .1 10. 2002 DESVAR 100003 x3 1.0 0.1 10. 2002 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100003 x3 1.0 0.1 10. 2001 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100004 x4 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 .1 10. 2001 DESVAR 100006 x6 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100008 x8 1.0	\$ 1	2	3	4	5	6	7	8	Ş 1	2	3	4	5	6	7		
DESVAR 100001 x1 1.0 .1 10. 2001 DESVAR 100001 x1 1.0 0.1 10. 2001 DESVAR 100002 x2 1.0 .1 10. 2002 DESVAR 100001 x1 1.0 0.1 10. 2002 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100003 x3 1.0 0.1 10. 2001 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 1	\$DESVAF	ID	LABEL	XINIT	XLB	XUB	DELXV	DDVAL	ŞDESVAR	ID	LABEL	XINIT	XLB	XUB	DELXV	DDVAL	
DESVAR 100002 x2 1.0 .1 10. 2002 DESVAR 100002 x2 1.0 0.1 10. 2002 DESVAR 100003 x3 1.0 .1 10. 2001 DESVAR 100003 x3 1.0 0.1 10. 2001 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100004 x4 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 .1 10. 2001 DESVAR 100006 x6 1.0 0.1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 0.1 1	DESVAR	100001	x1	1.0	.1	10.		2001	DESVAR	100001	x1	1.0	0.1	10.		2001	
DESVAR 100003 x3 1.0 .1 10. 2001 DESVAR 100003 x3 1.0 0.1 10. 2001 DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100004 x4 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 .1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100008 x8 1.0 0.1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1	DESVAR	100002	x2	1.0	.1	10.		2002	DESVAR	100002	x2	1.0	0.1	10.		2002	
DESVAR 100004 x4 1.0 .1 10. 2001 DESVAR 100004 x4 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 .1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1	DESVAR	100003	x3	1.0	.1	10.		2001	DESVAR	100003	x3	1.0	0.1	10.		2001	
DESVAR 100005 x5 1.0 .1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100006 x6 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 S 1 2 3 1 4 5 1 6 1 7 8 1 2001 x11 1.0 0.1 10. 2001 \$ 1 2 1 3 1 4 <	DESVAR	100004	x4	1.0	.1	10.		2001	DESVAR	100004	x4	1.0	0.1	10.		2001	
DESVAR 100006 x6 1.0 11 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100007 x7 1.0 .1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100010 x10 .1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 0. 2001 \$ 1 2 3 1 4 5 6 1 7 8 \$ 1 2001 DESVAR 100010 x10 1.0 .1 0. 2001 \$ 5DDVAL ID DDVAL2 DDVAL3 DDVAL4 DDVAL4 </th <th>DESVAR</th> <th>100005</th> <th>x5</th> <th>1 0</th> <th>1</th> <th>10</th> <th></th> <th>2001</th> <th>DESVAR</th> <th>100005</th> <th>x5</th> <th>1.0</th> <th>0.1</th> <th>10.</th> <th></th> <th>2001</th> <th></th>	DESVAR	100005	x5	1 0	1	10		2001	DESVAR	100005	x5	1.0	0.1	10.		2001	
DESVAR 100007 x7 1.0 11 10. 2001 DESVAR 100007 x7 1.0 1 10. 2001 DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 SDEVAL ID DDVAL2 DDVAL2 DDVAL3 DDVAL4 DDVAL5 DDVAL6 1 DDVAL 2001 .05 THRU 7.0 BY .05 THRU 7.0 BY .05 DDVAL 2002 .05 THEU 7.0 BY .050 .05 THRU 7.0 BY .050	DESVAR	100006	x6	1 0	1	10		2001	DESVAR	100006	x6	1.0	0.1	10.		2001	
DESVAR 100008 x8 1.0 .1 10. 2001 DESVAR 100009 x8 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100009 x9 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 S 1 2 1 3 1 4 5 6 7 8 5 1 2 3 1 4 5 6 7 8 5 1 2 3 1 4 1 5 1 6 1 7 8 5 1 2 1 3 1 4 1 5 1 6 1 7 8 5 1 2 1 3 1 4 1 5 1 6 1 7 8 5	DESVAR	100007	x7	1 0	1	10		2001	DESVAR	100007	x7	1.0	0.1	10.		2001	
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DESVAR 100019 X3 1.0 .1 10. 2001 DESVAR 100010 x10 1.0 .1 10. 2001 \$ 1 2 3 1 4 5 6 7 1 8 1 0.1 10. 2001 \$ 5DDVAL ID DDVAL1 DDVAL2 DDVAL3 DDVAL4 DDVAL5 DDVAL6 1 \$ 5DDVAL6 1 \$ 5DDVAL 2001 \$ \$ 1 2 2 3 1 4 1 5 1 6 1 7 1 8 1 \$ 5DDVAL 10 0.1 10. 2001 DDVAL 2001 .05 THRU 7.0 BY .05 .05 THRU 7.0 BY .05 DDVAL 2002 .05 THRU 7.0 BY .05 .05 THRU 7.0 BY .05	DESVAR	100000	×0	1.0	• 1	10		2001	DESVAR	100009	x9	1.0	0.1	10.		2001	
b = 1 1 1 10 10 10 2001 \$ 1 2 3 1 4 5 6 7 1 8 1 5 1 1 1.0 0.1 10 2001 \$ 1 2 1 3 1 4 1 5 1 6 1 7 1 8 1 5 1 4 1 5 1 6 1 7 1 8 1 5 1 4 1 5 1 6 1 7 1 8 1 5 1 1 0 0.1 10 2001 5 1 1 0 0.1 10 2001 5 5 1 1 1 0 0.1 10 0 1 1 0 0.1 10 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 <td< th=""><th>DESVAR</th><th>100009</th><th>x10</th><th>1.0</th><th>• 1</th><th>10</th><th></th><th>2001</th><th>DESVAR</th><th>100010</th><th>x10</th><th>1.0</th><th>0.1</th><th>10.</th><th></th><th>2001</th><th></th></td<>	DESVAR	100009	x10	1.0	• 1	10		2001	DESVAR	100010	x10	1.0	0.1	10.		2001	
S 1 1 2 1 3 1 4 1 5 1 6 7 1 8 1 SDDVAL ID DDVAL1 DDVAL2 DDVAL3 DDVAL4 DDVAL5 DDVAL6 1 DDVAL1 DDVAL1 DDVAL2 DDVAL4 DDVAL5 DDVAL6 1 DDVAL 2001 .05 THRU 7.0 BY .05 05 THRU 7.0 BY .05 DDVAL 2002 .05 THRU 7.0 BY .05 .05 DDVAL 2002	DESVAR	100010	XTO 5	1.0	• 1	10.	11 7	2001	DESVAR	100011	x11	1.0	0.1	10.		2001	
SDDVAL 1D DDVAL2 DDVAL2 DDVAL3 DDVAL3 DDVAL4 DDVAL6 1 DDVAL 2001 .05 THRU 7.0 BY .05 .05 THRU 7.0 BY .05 DDVAL 2002 .05 THRU 7.0 BY .05 DDVAL 2002	Ç T	11 2		4 DDII310					Ş 1	2	3	4	5	6	7		
DDVAL 2001 DDVAL 2001 .05 THRU 7.0 BY .05 THRU 7.0 BY .05 DDVAL 2002 DDVAL 2002 DDVAL 2002	ŞDDVAL	ID 0001	DDVALL	DDVALZ	DDVAL3	DDVAL4	DDVALS	DDVAL6 I	ŞDDVAL	ID	DDVAL1	DDVAL2	DDVAL3	DDVAL4	DDVAL5	DDVAL6	
.05 THRU 7.0 BY .05 DDVAL 2002 05 THRU 7.0 BY .05 DDVAL 2002 DDVAL 2002	DDVAL	2001							DDVAL	2001							
DDVAL 2002 DDVAL 2002		.05	THRU	1.0	BY	.05				.05	THRU	7.0	BY	.05			
05 THRU 7.0 BY 050 of the second second	DDVAL	2002							DDVAL	2002							
.05 THRU /.0 BY .050		.05	THRU	7.0	BY	.050				.05	THRU	7.0	BY	.050			

DESVAR 100001 x**1** 1.0 0.1 10. 2001 DESVAR 100002 x2 1.0 0.1 10. 2002 10. DESVAR 100003 x3 1.0 0.1 2001 DESVAR 100004 x4 1.0 0.1 10. 2001 DESVAR 100005 x5 1.0 0.1 10. 2001 DESVAR 100006 x6 1.0 0.1 10. 2001 DESVAR 100007 x7 1.0 0.1 10. 2001 DESVAR 100008 x8 1.0 0.1 10. 2001 10. 2001 DESVAR 100009 x**9** 1.0 0.1 DESVAR 100010 x10 10. 2001 1.0 0.1 DESVAR 100011 x**11** 1.0 0.1 10. 2001 2001 .05 THRU ΒY .05 7.0 2002 DDVAL .05 THRU 7.0 BY .050

Model 1 (design_model_m_stress.bdf) Model 2 (design_model_m_modes.bdf) Model 3 (design model m storsp.bdf)



Linking Variables

The Linked Variable section in the MMO Web App performs the validation to ensure the DESVAR entries are matching.

Linked Variables

Show only invalid

Variable Linked

Variable Linked

Variable Linked

Label

x1

x2

х3

x4

Status	m_stress	m_modes	m_storsp
0			
	Linked	Linked	Linked
0			
	Linked	Linked	Linked
0			
	Linked	Linked	Linked
0			



Linking Variables

The following fields on the DESVAR entry must be identical: XINIT, XLB, XUB. If allowable values are used, the DDVAL ID and the values on the DDVAL entry must match.

Commercial Version

The commercial version of the web app is designed to minimize the amount of information displayed. The full set of successful validations are hidden but unsuccessful validations will be fully shown to the user in red status markers.

Linked Variables

Show only invalid			
Label	Status	m_stress	
x1	0		
Variable Linked		Linked	
(2	0		
Variable Linked		Linked	
(3	0		
Variable Linked		Linked	
x4	0		

Development Version

Below is a view of the full set of successful validations that would normally be hidden in the commercial version. This view was generated with a version of the web app only available to the developer of the web app.

Linked Variables

Show only invalid

Label Status		m_stress	m_modes
x1	0		
Variable Linked		Linked	Linked
Initial Value	0	1.0	1.0
Lower Bound	0	.1	.1
Upper Bound	0	10.	10.
ID of DDVAL	0	2001	2001
Allowed Values	0	.05, THRU, 7.0, BY, .05	.05, THRU, 7.0, BY, .05
Туре	0	Independent	Independent



Linked Variables

Show only invalid

An example of the comparison is shown.

	Label	Status	m_stress	m_modes	m_storsp
ſ	x1	0			
)	Variable Linked		Linked	Linked	Linked
on	Initial Value	0	1.0	1.0	1.0
	Lower Bound	0	.1	.1	0.1
	Upper Bound	0	10.	10.	10.
	ID of DDVAL	0	2001	2001	2001
	Allowed Values	0	.05, THRU, 7.0, BY, .05	.05, THRU, 7.0, BY, .05	.05, THRU, 7.0, BY, .05
	Туре	0	Independent	Independent	Independent

\$ 1 \$DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR	ID 100001 100002 100003 100004 100005 100006 100007 100008 100009	1 3 LABEL x1 x2 x3 x4 x5 x6 x7 x8 x9	4 XINIT 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0) 5 XLB .1 .1 .1 .1 .1 .1 .1 .1 .1	10. 10. 10. 10. 10. 10. 10. 10. 10. 10.	7 DELXV	2001 2001 2001 2001 2001 2001 2001 2001		\$ 1 \$DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR DESVAR	II 2 ID 100001 100002 100003 100004 100005 100006 100007 100008 100009	3 LABEL x1 x2 x3 x4 x5 x6 x7 x8 x9	4 XINIT 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0	1 5 XLB 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	10. 10. 10. 10. 10. 10. 10. 10. 10. 10. 10. 10. 10.	DE
DESVAR	100010	x10	1.0	.1	10.		2001		DESVAR DESVAR	100010 100011	x10 x11	1.0	0.1	10. 10.	
\$ 1 \$DDVAL DDVAL	2 ID 2001	3 DDVAL1	4 DDVAL2	H 5 DDVAL3	H 6 DDVAL4	H 7 DDVAL5	DDVAL6]	\$ 1 \$DDVAL	2 ID 2001	3 DDVAL1	1 4 DEVAL2	5 DDVAL3	6 DDVAL4	 DI
	.05	THRU	7.0	BY	.05					.05	THRU	7.0	BY	.05	
DDVAL	.05	THRU	7.0	BY	.050				DDVAL	2002 .05	THRU	7.0	ΒΥ	.050	

Ş 1	2	3	4	5	6	7 8
ŞDESVAF	R ID	LABEL	XINIT	XLB	XUB	DELXV DDVAL
DESVAR	100001	x1	1.0	0.1	10.	2001
DESVAR	100002	x2	1.0	0.1	10.	200
DESVAR	100003	x3	1.0	0.1	10.	2001
DESVAR	100004	x4	1.0	0.1	10.	2001
DESVAR	100005	x5	1.0	0.1	10.	2001
DESVAR	100006	x6	1.0	0.1	10.	2001
DESVAR	100007	x7	1.0	0.1	10.	2001
DESVAR	100008	x8	1.0	0.1	10.	2001
DESVAR	100009	x9	1.0	0.1	10.	2001
DESVAR	10010	x10	1.0	0.1	10.	2001
DESVAR	100011	x11	1.0	0.1	10.	2001
Ş 1	🚽 2	3	4	5	6	7 8
Şddval		DDVAL1	DDVAL2	DDVAL3	DDVAL4	DDVAL5 DDVAL6
DDVAL	2001					
	.05	THRU	7.0	BY	.05	
DDVAL	2002					
	.05	THRU	7.0	BY	.050	

Model 1 (design_model_m_stress.bdf)

Model 2 (design_model_m_modes.bdf)




Manually Configuring Multi Model Optimization

CONSTRUCTING THE MMO.XML FILE

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



A new file named MMO.xml is created

xml version="1.0" ? <rc debug="no" opttype="MMO"></rc>
<job blocking="0" coef="1.0" mem="200MB" name="m_stress" scr="yes" smp="1"></job> <job blocking="0" coef="0.0" mem="200MB" name="m_modes" scr="yes" smp="1"></job> <job blocking="0" coef="0.0" mem="200MB" name="m_storsp" scr="yes" smp="1"></job>
<merge mem="200MB" scr="yes" smp="1"></merge>

MMO.xml





MMO.xml



Models in Multi Model Optimization (MMO) Task

Model	Status	m_stress	m_modes	m_storsp	×
Use Objective in MMO Task?	0	✓ Yes	C Yes	✓ Yes	
Objective Type		DRESP1	DRESP1	DRESP1	
Objective Weight Coefficient	0	1.0	0.0	3.0	
✓ Options					
Model Name (Max Length: 8)	0	m_stress	m_modes	m_storsp	
Memory (mem)	0	200MB	200MB	200MB	
Number of Processors (smp)	0	1]	1	
Option for Scratch (scr)		yes 🔻	yes 🔹	yes	•
Blocking (blocking)		0 - Serial 🔻	0 - Serial 🔻	0 - Serial	

MMO.xml





Option	Status	Configure	
Minimize or Maximize Combined Objective		MIN	
Memory (mem)	٥	200MB	
Number of Processors (smp)	0	1	-
Option for Scratch (scr)		yes	



<Job name="m_stress" coef="1.0" mem="200MB" smp="1" scr="yes" blocking="0"/>

<?xml version="1.0" ?> <rc OptTYpe="MMO" debug="no" >

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



Model 1 (m_stress.bdf)

assign userfile='m_stress.csv', status=UNKNOWN, form=formatted, unit=52 DIAG 8,15 \$ Print Matrix & Table Trailers in .f04 SOL 200 CEND TITLE = BIW No Windows Inertia Relief 18 Attach dof ECHO=SORT(EXCEPT GRID,CQUAD4,CTRIA3,CHEXA,CPENTA,CTETRA) DISP(PLOT) = ALLSTRESS(PLOT) = ALLESE(PLOT) = ALLDESOBJ(MIN) = 5000000 DESMOD = m_stress SUBCASE 13 ANALYSIS = STATICS DESSUB = 40000013\$ DRSPAN SUBTITLE = Front Left Interior Pillar Z LOAD = 11SUBCASE 33 ANALYSIS = STATICS DESSUB = 40000033 \$ DRSPAN SUBTITLE = Center Left Pillar Z LOAD = 133SUBCASE 53 ANALYSIS = STATICS DESSUB = 40000053SUBTITLE = Rear Left Pillar Z LOAD = 153BEGIN BULK INCLUDE './design_model_m_stress.bdf'

INCLUDE './design_model_mmo.bdf'

Settings for Merged Model

Option	Status	Configure
Minimize or Maximize Combined Objective		MIN
Memory (mem)	0	200MB
Number of Processors (smp)	0	1
Option for Scratch (scr)		yes •



Why are DELX and CONV2 used in the DOPTPRM entry (Optimization Settings)?



Why are DELX and CONV2 used in the DOPTPRM entry (Optimization Settings)?

- 1. Model 2 (m modes) seeks to optimize a natural frequency and requires the use of Mode Tracking.
- 2. The DOPTPRM entry shown makes use of DELX1 and COVN2. The use of DELX and CONV2 are applicable to model 2.

Model 1 - m stress





(1)





Ş	Opt	imizatio	n Control	Settin	gs				
\$ \$ 1 2	3 4	5	6	7	8	9		10	
\$DOPTPRM PARAM1 VAL1	PARAM2	VAL2	PARAM3	VAL3	PARAM4	VAL4			
DOPTPRM DESMAX 20 DELX .1	P1	1	P2	15	CONV2	3.0			



Why is DELX=.1 used?

- 1. If DELX is not specified on the DOPTPRM entry, MSC Nastran uses the default DELX value of .5.
- 2. If model 2 is optimized without DELX specified, after the optimization, the F06 file reveals an error due to mode tracking failure.

\$ \$ \$	Opti	imizatio	n Control	Settin	gs			
\$ 1 2 3 \$DOPTPRM PARAM1 VAL1	4 PARAM2	5 VAL2	6 PARAM3	7 VAL3	8 <u>PARAM</u> 4	9 VAL4	10	
DOPTPRM DESMAX 50 \$	P1	1	P2	15		(1)		

0								111111111111111111111111111111111111111					DES	IGN VARIA	BLE H	ISTORY					SUE	BCASE 1		
-	INTI DV	ERNA . II	AL).		EXTERNAI DV. ID	ь г		LAB	EL		INITI	AL	:	1	:	2	:	3		:	4	:	5	:
		1	1 2 3 4 5 6 7 8 9 0		10000 10000 10000 10000 10000 10000 10000 10000 10001 10001	 1 2 3 4 6 7 8 9 0 1 5		X1 X2 X3 X4 X6 X7 X8 X9 X10 X11 X5 (2001)			1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	0E+00 0E+00 0E+00 0E+00 0E+00 0E+00 0E+00 0E+00 0E+00 0E+00 0E+00		6.0047E- 6.2017E- 5.0000E- 5.0000E- 5.0000E- 5.0000E- 1.2470E+ 5.0000E- 7.5500E- 6.2017E-	01 : 01 : 01 : 01 : 01 : 01 : 00 : 01 : 01			2						
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Why is DELX=.1 used?

- 1. Further inspection of the F06 file reveals recommendations to avoid a mode tracking failure.
- 2. One option is to reduce the move limit DELX.
- 3. After using a DELX value of .1, mode tracking is successful and the optimization is able to proceed.

Large changes in design variables may cause mode tracking to fail. For model 2, a DELX value of .5 resulted in too large of variable changes for mode tracking to operate. The idea is to limit the changes of the design variables so that the modes are better tracked.

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		2. DECR	EASE TH	HE FILT	ERING	PARAMET	ER, I	ATFILTE	er, o	R											
	_	3. BOTH	I AND	2																	
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	DOI	PTPRM I	DESMA	X 50)	P1		1		P2		1	15		D	ELX		1			

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



(3)

Why is CONV2=3.0 used?

The CONV2 value is adjusted so that the optimization converges sooner.

To the right, a optimization without and with CONV2=3.0 is compared. The optimization with CONV2=3.0 converges sooner.





Why is CONV2=3.0 used?

The CONV2 was determined as follows

1. Search the F06 section for the last reported section titled HARD CONVERGENCE DECISION LOGIC

*

 The value of ABSOLUTE CHANGE IN OBJECTIVE is 1.4253E+00. A value of CONV2 greater than 1.4253 is chosen, e.g. 3.0.

Alternatively, the CONV1 setting can be used instead. The value of RELATIVE CHANGE IN OBJECTIVE is 2.2449E-03. A value of CONV1 greater than 2.2449E-03 is chosen and will result in termination due to convergence. ***** NORMAL CONVERGENCE CRITERIA SATISFIED ***** (HARD CONVERGENCE DECISION LOGIC)

CONVERGENCE ACHIEVED BASED ON THE FOLLOWING CRITERIA (HARD CONVERGENCE DECISION LOGIC)

	RELATIVE	E CHAN	IGE IN	OBJEC	TIVE		2.2449E-03	3 MUST	BE	LESS	THAN	1.0000E-03
OR	ABSOLUTE	E CHAN	IGE IN	OBJEC	TIVE		1.4253E+0	0 MUST	BE	LESS	THAN	3.0000E+00
						AND -						(2)
	MAXIMUM	CONSI	RAINT	VALUE		-	-3.3422E-02	2 MUST	BE	LESS	THAN	5.0000E-03
				(CONVE	RGENCE	το Α	FEASIBLE 1	DESIGN)				
						OR						
	MAXIMUM	OF RE	LATIVE	E PROP	. CHANG	SES	0.0000E+0	O MUST	BE	LESS	THAN	1.0000E-03
AND	MAXIMUM	OF RE	LATIVE	E D.V.	CHANGE	ES	2.5000E-02	2 MUST	BE	LESS	THAN	1.0000E-03
		(CON	IVERGEN	ICE TO	A BESI	COM	PROMISE IN	FEASIBL	E DI	ESIGN)	
*****	*******	*****	*****	*****	* * * * * * *	*****	* * * * * * * * * * * *	* * * * * * *	***	* * * * * *	* * * * * *	* * * * * * * * * * * * * *



Use the same DOPTPRM entry in every model

1. Models 1 and 2 optimize successfully without specifying DELX and CONV2. Since this is a multi model optimization, it is required that the same DOPTPRM entry be used by all models. The DOPTPRM entry from model 2 is used in models 1 and 3.





(1)







Ş		Optimizatio	n Control	L Setting	gs				
\$ \$ 1 2	3	4 5	6	7	8	9		10	
\$DOPTPRM PARAM1	VAL1 PA	RAM2 VAL2	PARAM3	VAL3	PARAM4	VAL4			
DOPTPRM DESMAX DELX	.1	Ţ	PZ	15	CONV2	3.0			

