Altair

HyperWorks

Altair HyperStudy 2019 Tutorials

HS-4215: Multi-Disciplinary Design Optimization Study

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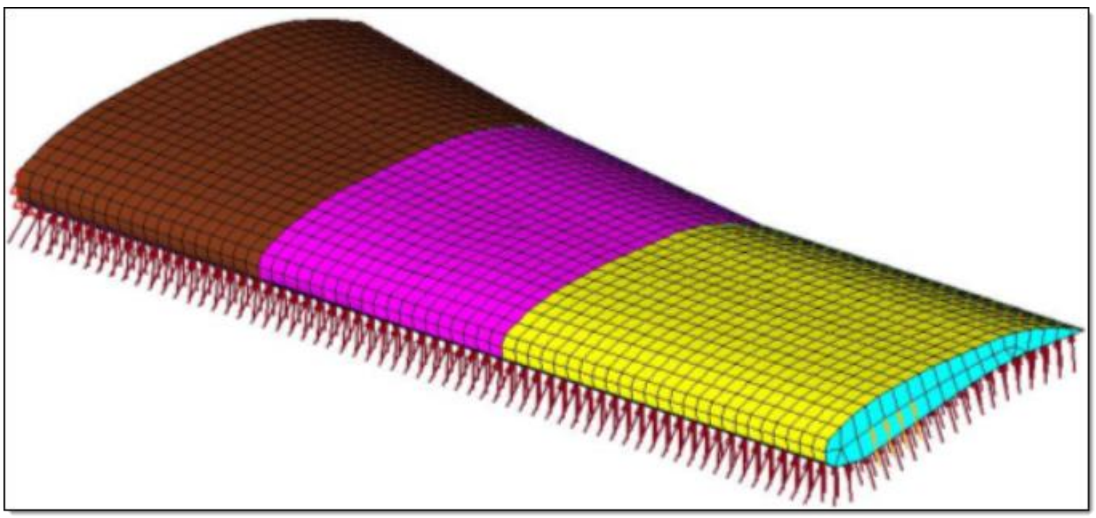
This tutorial demonstrates how to perform a multi-disciplinary design optimization study. The disciplines used in this tutorial are structural performance and cost. Structural performance is simulated using OptiStruct and Cost is simulated using Compose or Python. Optimization parameters for both the simulations are identified in template files corresponding to each input deck (`tail.fem` (OptiStruct) and `tail.oml` (Compose)/`tail.py` (Python).

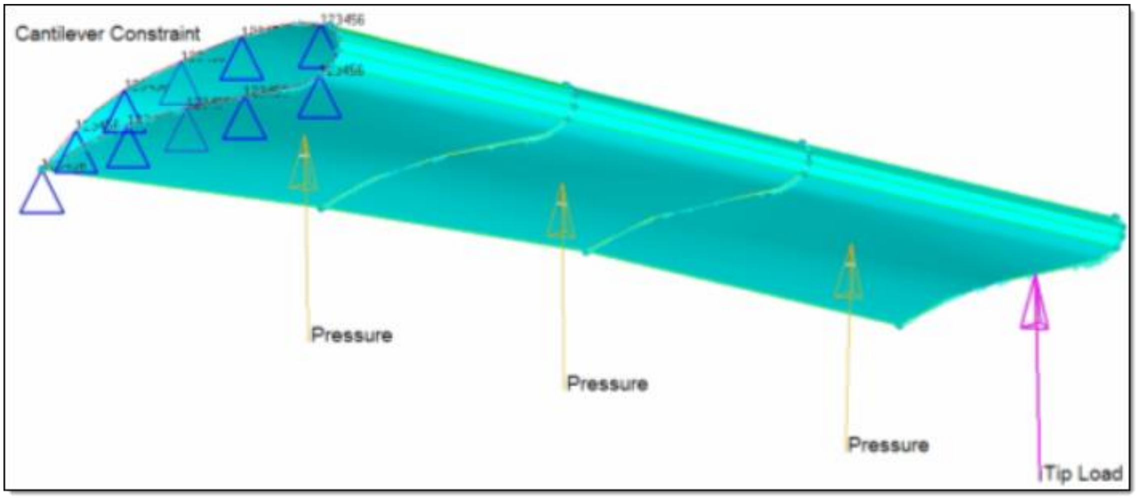
The sample base input templates used in this tutorial can be found in `<hst.zip>/HS-4215/` and copied to your working directory. The tutorial directory includes the following files:

`tail_structure_optistruct.tpl`	Base input parameterized file model 1.
`tail_cost_compose.tpl`	Base input parameterized file model 2.
`tail_cost_python.tpl`	Base input parameterized file model 2.



Horizontal tail plane model

It is assumed that the tail is cantilevered about its inboard section. Three loading scenarios are considered; one where the tail experiences pressure loads of 0.25 psi on the bottom skin, a second where the tail experiences a tip load of 400 lbs, and a third where the tail experiences both the pressure load and tip load simultaneously. The applied loading is represented in the following figure.



Loading experienced by horizontal tail plane

Problem Formulation for this study is as follows:

Input variables:

- glass fabric thickness at inboards; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- glass fabric thickness at midspan; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- glass fabric thickness at outboards; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- core thickness at inboards; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- core fabric thickness at midspan; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- core fabric thickness at outboards; initial value = 0.1; lower bound = 0.01, upper bound = 2.0
- aluminum rib thickness; initial value = 0.1; lower bound = 0.01, upper bound = 2.0

Note: Both models have seven input variables; however values of the input variables need to be consistent between the two models. In order to obtain this, we will be linking the two sets of input variables to each other.

Objective:

To minimize the cost.

Design constraints:

Maximum displacement must be less than its baseline value of 31.

Step 1: Perform the Study Setup

1. Start HyperStudy.
2. To start a new study, click ***File*** > ***New*** from the menu bar, or click on the toolbar.
3. In the **HyperStudy – Add** dialog, enter a study name, select a location for the study, and click ***OK***.
4. Go to the **Define models** step.
5. Add a Parameterized File model.
   a. From the **Directory**, drag-and-drop the `tail_structure_optistruct.tpl` file into the work area.
   b. In the **Solver input file** column, enter `tail.fem`. This is the name of the solver input file HyperStudy writes during any evaluation.
   c. In the **Solver execution script** column, select ***OptiStruct (os)***.
6. Add a second Parameterized File model.
   a. From the **Directory**, drag-and-drop the appropriate `.tpl` file into the work area.
      - If you are using Python, use the `tail_cost_python.tpl` file.
      - If you are using Compose, use the `tail_cost_compose.tpl` file.
   b. In the **Solver input file** column, enter a name for the solver input file HyperStudy writes during any evaluation.
      - If you are using Python, enter `tail.py`.
      - If you are using Compose, enter `tail.oml`.
   c. In the **Solver execution script** column, select either ***Python (py)*** or ***Compose (oml)*** accordingly.
   d. If you are using Compose as the Solver execution script, in the **Solver input arguments** column, enter `-f` before `$file`.

      Note: If you are using Compose as part the HyperWorks suite, than HyperStudy should automatically point to the correct `.bat` file. If you have Compose as a separate installation, than during the **Register Solver Script** step you must point to `Compose_batch.bat`.

	Active	Label	Varname	Model Type	Resource	Solver input file	Solver execution script	Solver input arguments
1	☑	Model 1	m_1	{} Parameterized File	C:/.../HS-4215/tail_structure_optistruct.tpl	tail.fem	OptiStruct (os)	${file}
2	☑	Model 2	m_2	{} Parameterized File	C:/.../HS-4215/tail_cost_python.tpl	tail.py	Python (py)	${file}

7. Click ***Import Variables***. Fourteen input variables are imported from the two `.tpl` resource files.
8. Go to the **Define Input Variables** step.
9. Review the input variable's lower and upper bound ranges.
10. Click the ***Links*** tab.
11. In the **Varname** column, copy all of the independent variables (all variables from

Model_1).

12. In the **Expression** column of all of the dependent input variables (all variables from **Model_2**), paste the independent variables.

	Active	Label	Varname	Expression
1	☑	Out_GF_t	m_1_Out_GF_t	...
2	☑	Out_Core_t	m_1_Out_Core_t	...
3	☑	Mid_GF_t	m_1_Mid_GF_t	...
4	☑	Mid_Core_t	m_1_Mid_Core_t	...
5	☑	In_GF_t	m_1_In_GF_t	...
6	☑	In_Core_t	m_1_In_Core_t	...
7	☑	Rib_t	m_1_Rib_t	...
8	☑	Variable 01	m_2_Variable_01	m_1_Out_GF_t ...
9	☑	Variable 02	m_2_Variable_02	m_1_Out_Core_t ...
10	☑	Variable 05	m_2_Variable_05	m_1_Mid_GF_t ...
11	☑	Variable 06	m_2_Variable_06	m_1_Mid_Core_t ...
12	☑	Variable 09	m_2_Variable_09	m_1_In_GF_t ...
13	☑	Variable 10	m_2_Variable_10	m_1_In_Core_t ...
14	☑	Variable 13	m_2_Variable_13	m_1_Rib_t ...

13. Go to the **Specifications** step.

Step 2: Perform the Nominal Run

1. In the work area, set the **Mode** to ***Nominal Run***.
2. Click ***Apply***.
3. Go to the **Evaluate** step.
4. Click ***Evaluate Tasks***. An `approaches/nom_1/` directory is created inside the study directory. The `approaches/nom_1/run__00001/m_1` and `approaches/nom_1/run__00001/m_2` sub-directories contain the `tail.h3d` (for maximum displacement) and `cost.res` (for cost) files, which are the result of the nominal run, and will be used in the optimization.
5. Go to the **Define Output Responses** step.

Step 3: Create and Define Output Responses

In this step you will create two output responses: MaxDisp and Cost.

1. Create the MaxDisp output response.

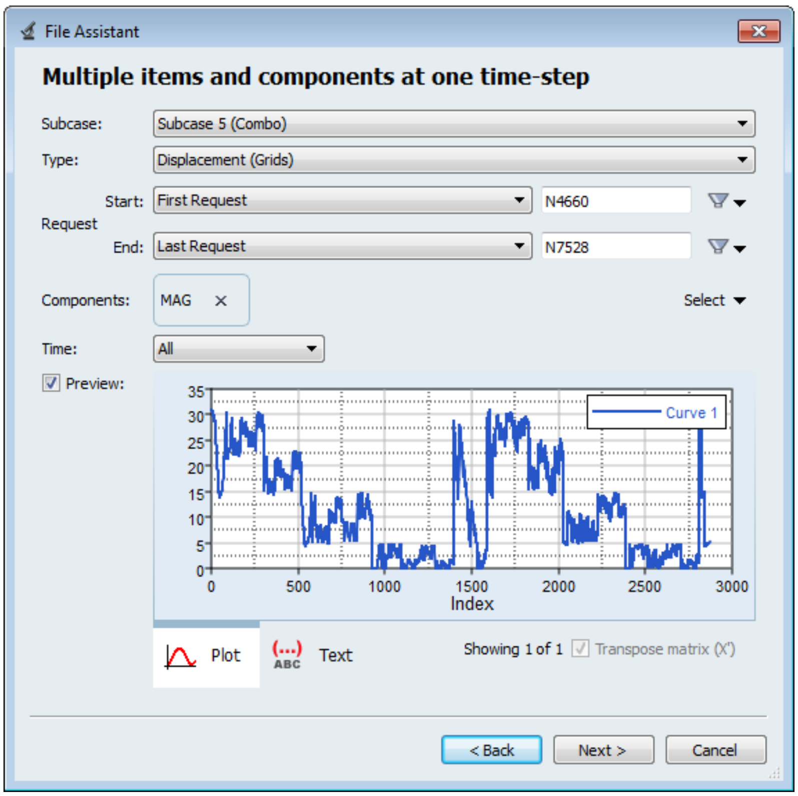
   a. From the **Directory**, drag-and-drop the `tail.h3d` file, located in the `approaches/nom_1/run__00001/m_1` directory, into the work area.

b. In the **File Assistant** dialog, set the **Reading technology** to ***Altair® HyperWorks®*** and click ***Next***.

c. Select ***Multiple items at multiple time steps (readsim)***, then click ***Next***.

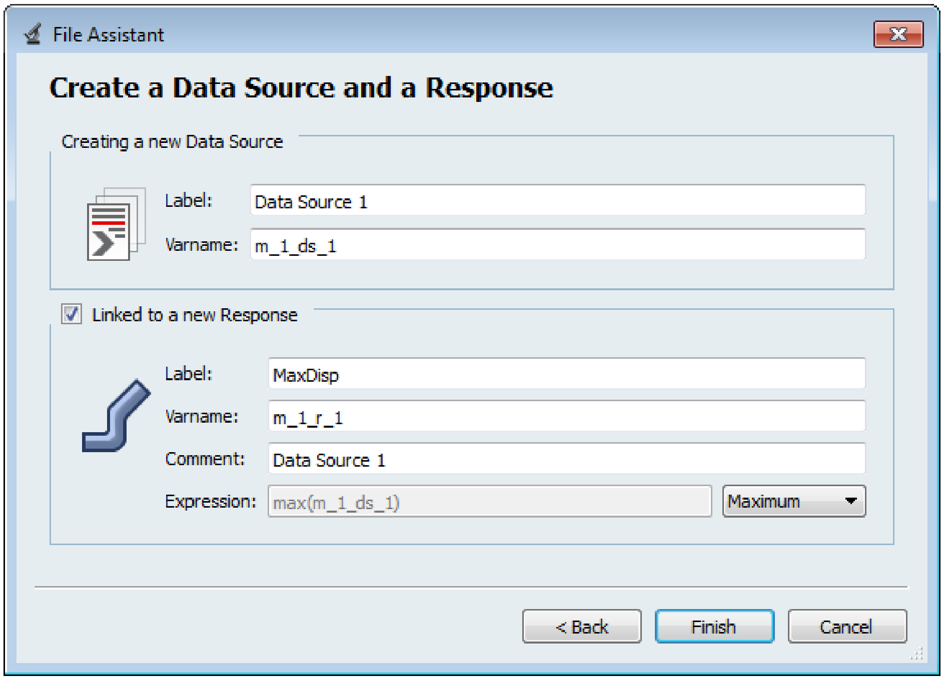
d. Define the following options, then click ***Next***.

- Set **Subcase** to ***Subcase 5 (Combo)***.
- Set **Type** to ***Displacement (Grids)***.
- For **Request**, set **Start** to ***First request*** and enter `N4660`, and set **End** to ***Last request*** and enter `N7528`.
- For **Component**, select ***MAG***.



e. Label the output response MaxDisp.

f. Set **Expression** to ***Maximum***.



g. Click ***Finish***. The MaxDisp output response is added to the work area.

2. Create the Cost output response.

    a. From the **Directory**, drag-and-drop the `cost.res` file, located in the `approaches/nom_1/run__00001/m_2` directory, into the work area. This file contains the analysis results, including stresses.

    b. In the **File Assistant** dialog, set the **Reading technology** to ***Altair® HyperWorks®*** and click ***Next***.

    c. Select ***Single item in a time series***, then click ***Next***.

    d. Define the following options, then click ***Next***.

    - Set **Type** to ***Unknown***.
    - Set **Request** to ***Block 1***.
    - Set **Component** to ***Column 1***.

    e. Label the output response Cost.

    f. Set **Expression** to ***First Element***.

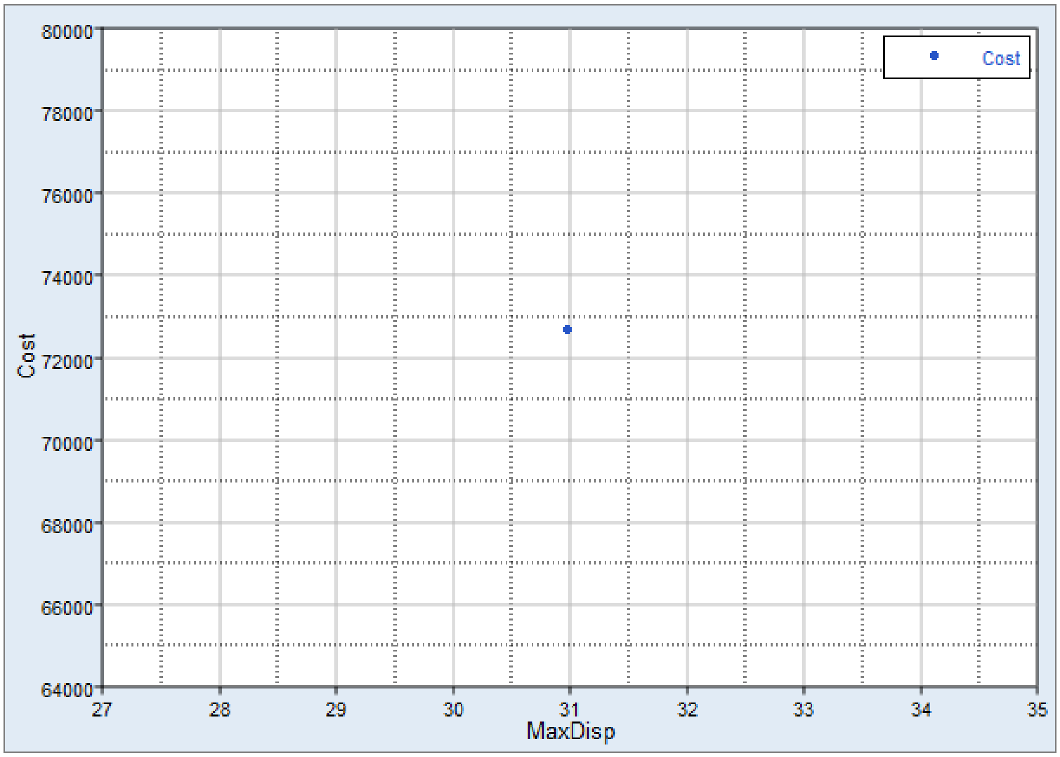
    g. Click ***Finish***. The Cost output response is added to the work area.

3. Click ***Evaluate Expressions*** to extract the output response values.

	Active	Label	Varname	Expression	Value	Comment
1	☑	MaxDisp	m_1_r_1	max(m_1_ds_1) ...	30.968294	Data Source 1 ...
2	☑	Cost	m_2_r_1	m_2_ds_1[0] ...	72715.000	Data Source 2 ...

4. Go to the **Post-Processing** step.

5. Click the ***Scatter*** tab to compare Cost versus MaxDisp.



Step 4: Run an Optimization Study

1. In the **Explorer**, right-click and select ***Add*** from the context menu.
2. In the **Add - HyperStudy** dialog, select ***Optimization*** and click ***OK***.
3. Go to the **Select Input Variables** step.
4. Review the input variable's lower and upper bound ranges.
5. Go to the **Select Output Responses** step.
6. Apply an objective on the Cost output response.
   a. In the **Objectives** column of Cost, click .
   b. In the pop-up dialog, set **Type** to ***Minimize*** and click ***OK***.

	Active	Label	Varname	Objectives	Constraints	Evaluate From	Expression	Comment
1	☑	MaxDisp	m_1_r_1			Solver	max(m_1_ds_1)	Data Source 1
2	☑	Cost	m_2_r_1	Minimize		Solver	m_2_ds_1[0]	Data Source 2

7. Apply a constraint on the MaxDisp output response.
   a. In the **Constraints** column of MaxDisp, click .
   b. In the pop-up dialog, define the following and click ***OK***.

- Set **Type** to ***Deterministic***.
- Set **Bound Type** to **<=**.
- For **Bound Value**, enter `31.0`.

	Active	Label	Varname	Objectives	Constraints	Evaluate From	Expression	Comment
1	☑	MaxDisp	m_1_r_1		<= 31.000000	Solver	max(m_1_ds_1)	Data Source 1
2	☑	Cost	m_2_r_1	Minimize		Solver	m_2_ds_1[0]	Data Source 2

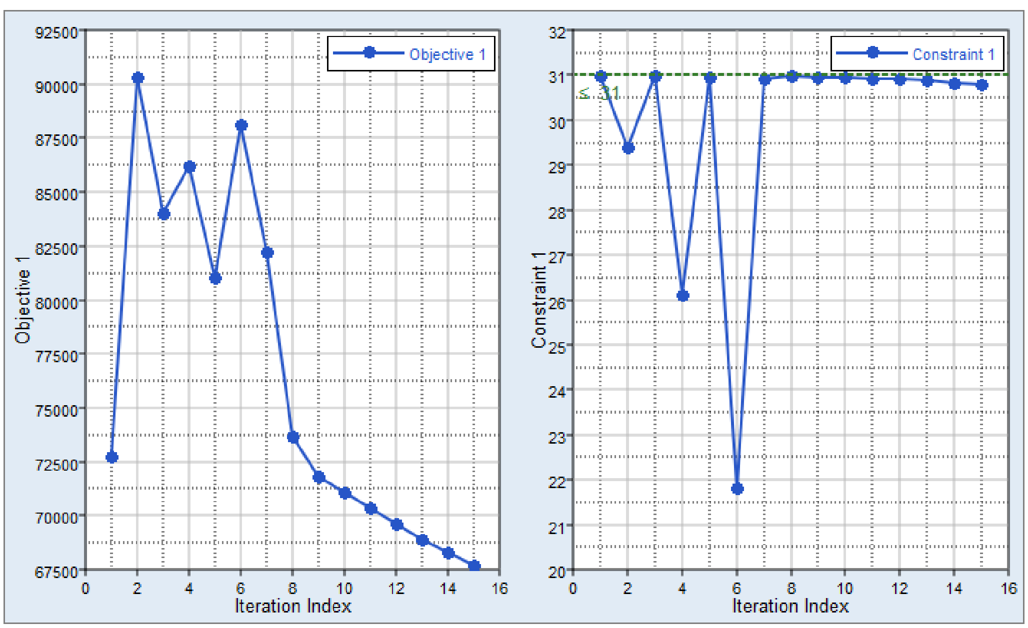
8. Click ***Apply***.
9. Go to the **Specifications** step.
10. In the work area, set the **Mode** to ***Adaptive Response Surface Method (ARSM)***.

    Note: Only the methods that are valid for the problem formulation are enabled.
11. Click ***Apply***.
12. Go to the **Evaluate** step.
13. Click ***Evaluate Tasks***.

Step 5: View the Iteration History of an Optimization Study

Click the ***Iteration Plot*** tab to plot the progress of the Optimization iteration..

Using the **Channel** selector, select ***Objective_1*** and ***Constraint_1***. The evolution of the objective function and constraint vs. iterations is 2D plotted. You can see that the cost of the horizontal tail plane is reduced from 72715 to 67700 (7% reduction), while keeping the structural performance the same.



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