Altair

HyperWorks

Altair HyperStudy 2019 Tutorials

HS-1810: Post Proceesing with HyperStudy

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This tutorial demonstrates how to post process studies with HyperStudy. We will use the model described in the HyperStudy tutorial HS-4415 and create various appraoches (Design of Experiment, Approximation, Optimization, Stochastic) to illustrate the rich variety of tools and post processing methods offered by HyperStudy.

Before running this tutorial, you must complete tutorial HS-4415: Optimization Study of a Landing Beam using Excel or you can import the archive file `HS-4415.hstx`, available in `<hst.zip>/HS-1810/`.

Step 1: Run a DOE Study

1. In the **Explorer**, right-click and select ***Add*** from the context menu.
2. In the **Add - HyperStudy** dialog, select ***DOE*** 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 **Specifications** step.
6. In the work area, set the **Mode** to ***Fractional Factorial***.
7. In the **Settings** tab, set **Resolution** to ***III***.
8. Click ***Apply***.
9. Go to the **Evaluate** step.
10. Click ***Evaluate Tasks***.
11. While the DOE is in progress, click the ***Tasks*** tab to view the feedback on the results of the evaluation.
12. During the execution of the DOE, you can monitor the evaluation of the 16 runs in either the ***Evolution Plot*** or ***Evolution Data*** tabs.
13. Go to the **Post-Processing** step.

Step 2: Post Processing of the Results of the DOE Study

1. Click the ***Summary*** tab to view all input variable and output response run data in a table.

   Tip: Use the **Sort** and **Find** options in the right-click context menu to sort and search data.

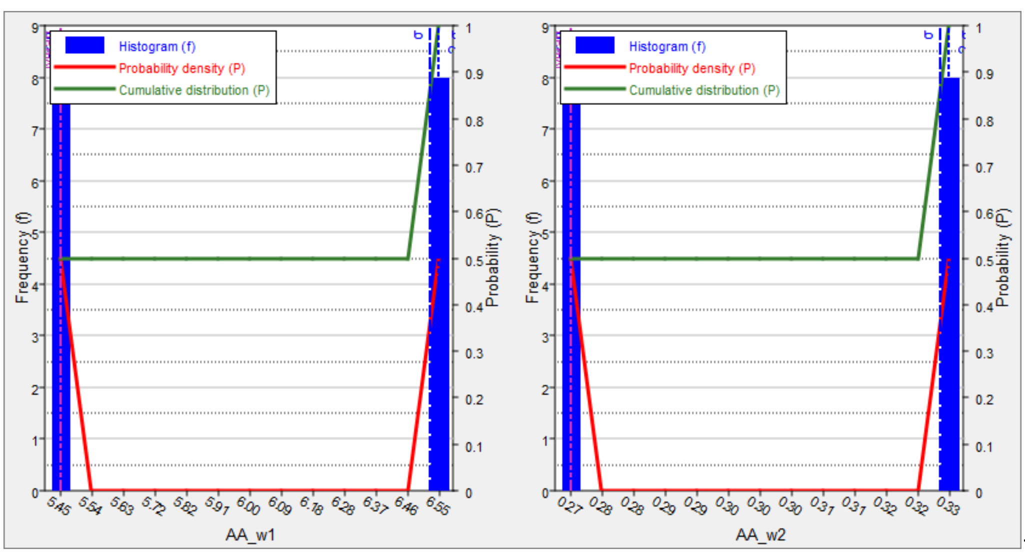
	AA_w1	AA_w2	AA_w3	AA_h1	AA_h2	CC_w1	CC_w2	CC
1	5.4000000	0.2700000	0.1800000	0.3600000	0.6600000	6.6000000	0.3300000	0.220000
2	5.4000000	0.2700000	0.1800000	0.4400000	0.6600000	6.6000000	0.2700000	0.220000
3	5.4000000	0.2700000	0.2200000	0.3600000	0.6600000	5.4000000	0.3300000	0.180000
4	5.4000000	0.2700000	0.2200000	0.4400000	0.6600000	5.4000000	0.2700000	0.180000
5	5.4000000	0.3300000	0.1800000	0.3600000	0.5400000	6.6000000	0.3300000	0.180000
6	5.4000000	0.3300000	0.1800000	0.4400000	0.5400000	6.6000000	0.2700000	0.180000
7	5.4000000	0.3300000	0.2200000	0.3600000	0.5400000	5.4000000	0.3300000	0.220000
8	5.4000000	0.3300000	0.2200000	0.4400000	0.5400000	5.4000000	0.2700000	0.220000
9	6.6000000	0.2700000	0.1800000	0.3600000	0.5400000	5.4000000	0.2700000	0.220000

2. Click the ***Integrity*** tab to view statistical measures over the population (samples of the DOE) for all of the input variables and output responses.

	Label	Varname	Category	Points	Unique	No Values	Bad Values	Range
1	AA_w1	dv_1	Variable	16	2	0	0	1.2000000
2	AA_w2	dv_2	Variable	16	2	0	0	0.0600000
3	AA_w3	dv_3	Variable	16	2	0	0	0.0400000
4	AA_h1	dv_4	Variable	16	2	0	0	0.0800000
5	AA_h2	dv_5	Variable	16	2	0	0	0.1200000
6	CC_w1	dv_6	Variable	16	2	0	0	1.2000000
7	CC_w2	dv_7	Variable	16	2	0	0	0.0600000
8	CC_w3	dv_8	Variable	16	2	0	0	0.0400000

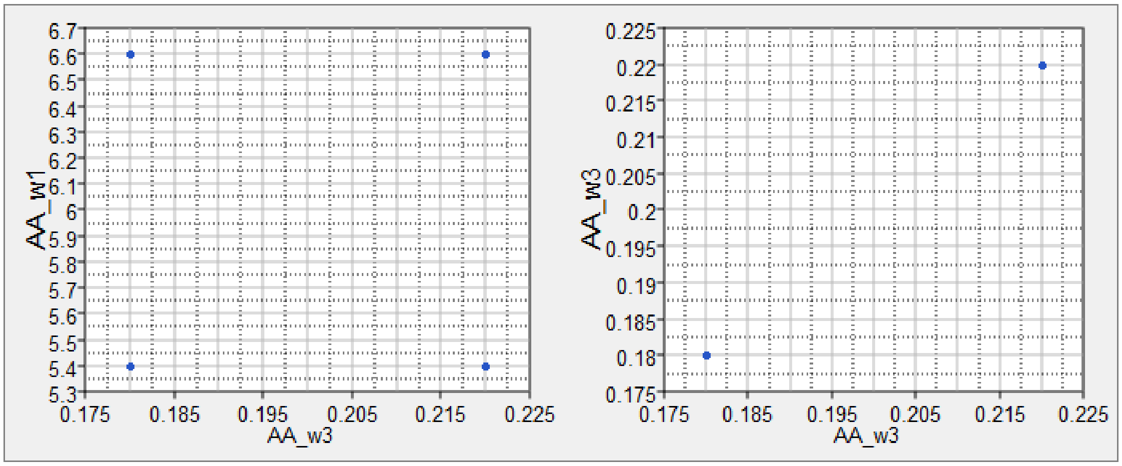
3. Click the ***Distribution*** tab to view a histogram of the DOE results.

   Display the entities in one or multiple plots by clicking . Each plot presents the range of the entity in abscissa (an input variable or an output response), the histogram (red bar chart for frequency), probability distribution function (PDF in green) and cumulative probability distribution function (CDF in blue).



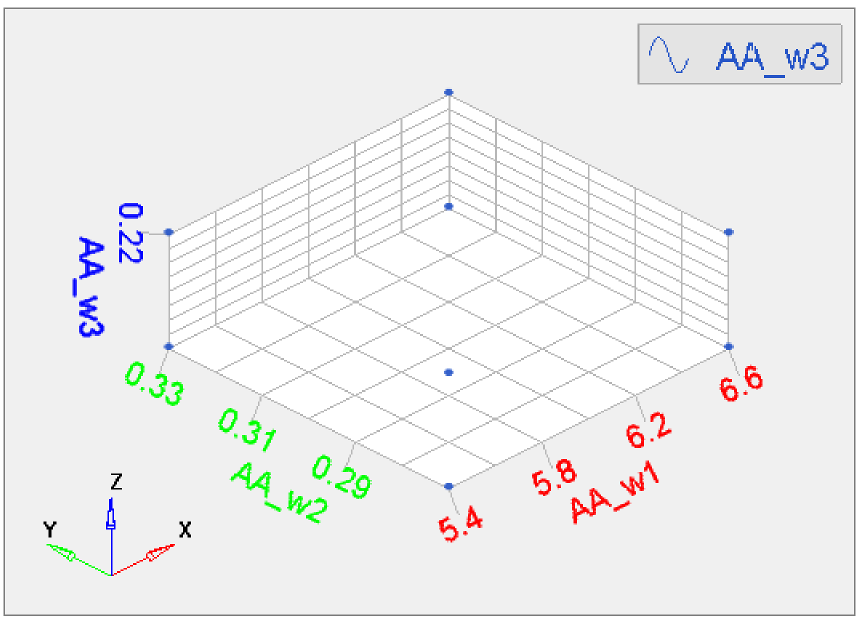
4. Click the ***Scatter*** tab to plot the DOE results.

   Use the **Channel** selector to select entities to plot. Select one entity for the X-Axis, and select one or more entities for the Y-Axis.



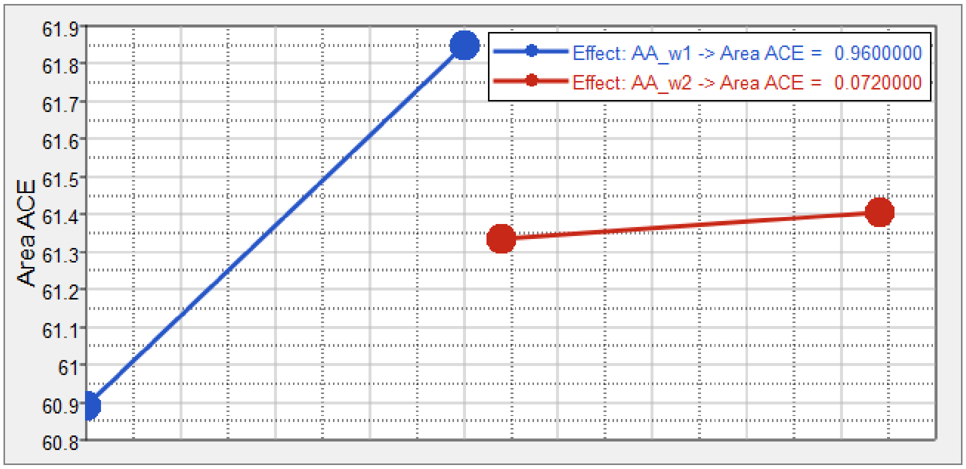
5. Click the ***Scatter 3D*** tab to view DOE results in a scatter plot.

   Only one input variable/output response can be selected for the X and Y axes, whereas multiple input variables/output responses can be selected for the Z axis.



6. Click the ***Linear Effects*** tab to review the effect of an input variable on an output response, ignoring the effects of other input variables.

   a. Above the **Channel** selector, click the linear effects icon to plot the linear effects. Use the Channel selector to select the variables ***AA_w1*** and ***AA_w2*** and the output response ***Area ACE***.



b. Above the **Channel** selector, click [icon] to view the linear effects in a table.

Tip: From the **Channel** selector, use the **Sort** and **Filter** options in the right-click context menu to sort and filter effects.

	Label	Varname	Area ACE
1	AA_w1	dv_1	0.9600000
2	AA_w2	dv_2	0.0720000
3	AA_w3	dv_3	0.4172000
4	AA_h1	dv_4	0.9280000
5	AA_h2	dv_5	0.0240000
6	CC_w1	dv_6	2.8800000
7	CC_w2	dv_7	0.0792000
8	CC_w3	dv_8	1.0828000
9	CC_h1	dv_9	2.7792000
10	CC_h2	dv_10	0.0240000
11	EE_w1	dv_11	7.2960000
12	EE_w2	dv_12	0.0696000
13	EE_w3	dv_13	0.2372000
14	EE_h1	dv_14	7.2432000
15	EE_h2	dv_15	4.26e-14

Step 3: Run a DOE Study

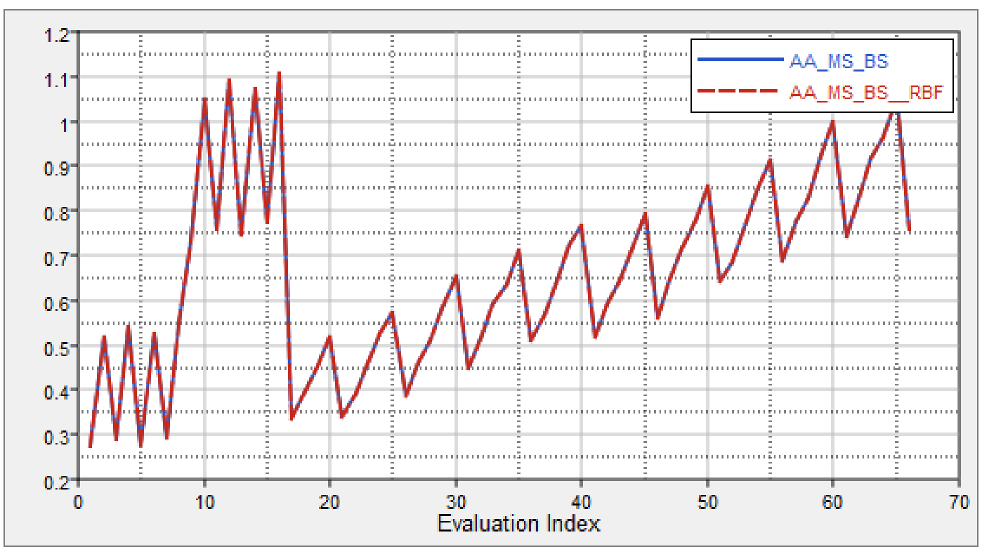
1. Repeat **Step 1: Run a DOE Study** to add a second DOE to the study. In the **Specifications** step, set the **Mode** to ***Hammersley*** and change the **Number of runs** to `50`.
2. Repeat **Step 1: Run a DOE Study** once more to add a third DOE to the study. In the **Specifications** step, set the **Mode** to ***Latin HyperCube*** and change the **Number of runs** to `15`.

Step 4: Run a FIT Study

1. In the **Explorer**, right-click and select ***Add*** from the context menu.
2. In the **Add - HyperStudy** dialog, select ***Fit*** and click ***OK***.
3. Go to the **Select matrices** step.
4. Click ***Add Matrix***.
5. In the **Add - HyperStudy** dialog, add three matrices.
6. Define the matrices by selecting the options indicated in the image below from the **Type** and **Matrix Source** columns.

	Active	Label	Varname	Type	Matrix Source	Matrix Origin	Status
1	☑	FitMatrix 1	fitmatrix_1	Input	DOE 1 (doe_1)	DoeDOE 1	Import Pending
2	☑	FitMatrix 2	fitmatrix_2	Input	DOE 2 (doe_2)	DoeDOE 2	Import Pending
3	☑	FitMatrix 3	fitmatrix_3	Validation	DOE 3 (doe_3)	DoeDOE 3	Import Pending

7. Click ***Import Matrix***.
8. Go to the **Specifications** step.
9. In the work area, set the **Mode** to ***Radial Basis Function (RBF)***.
10. Click ***Apply***.
11. Go to the **Evaluate** step.
12. Click ***Evaluate Tasks***.
13. To review the values of the output responses and their approximations while the evaluation is in progress, click the ***Evaluation Data*** and ***Evaluation Plot*** tabs.



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

Step 5: Post Processing of the Results of the FIT Study

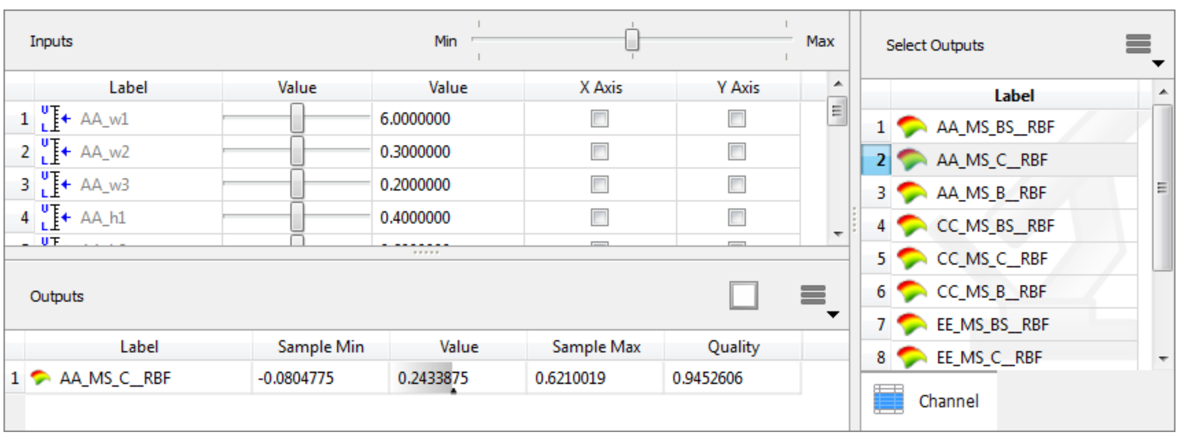
1. Click the ***Residuals*** tab to identify errors for each design.

   The error (and percentage) between the original output response and the approximation is listed for each run of the input, cross-validation, or validation matrices.

	EE_h1	EE_h2	AA_MS_BS	AA_MS_BS_RBF	Error	Percent Error
1	2.7000000	0.6600000	0.2718140	0.2718140	3.89e-16	1.43e-13
2	3.3000000	0.5400000	0.5189317	0.5189317	0.0000000	0.0000000
3	3.3000000	0.5400000	0.2877813	0.2877813	3.89e-16	1.35e-13
4	2.7000000	0.6600000	0.5395643	0.5395643	-6.66e-16	-1.23e-13
5	3.3000000	0.5400000	0.2766586	0.2766586	1.67e-16	6.02e-14
6	2.7000000	0.6600000	0.5253068	0.5253068	2.22e-16	4.23e-14
7	2.7000000	0.6600000	0.2926431	0.2926431	6.11e-16	2.09e-13
8	3.3000000	0.5400000	0.5455962	0.5455962	1.11e-16	2.03e-14
9	2.7000000	0.5400000	0.7291716	0.7291716	1.11e-16	1.52e-14
10	3.3000000	0.6600000	1.0493089	1.0493089	0.0000000	0.0000000
11	3.3000000	0.6600000	0.7600648	0.7600648	-3.33e-16	-4.38e-14

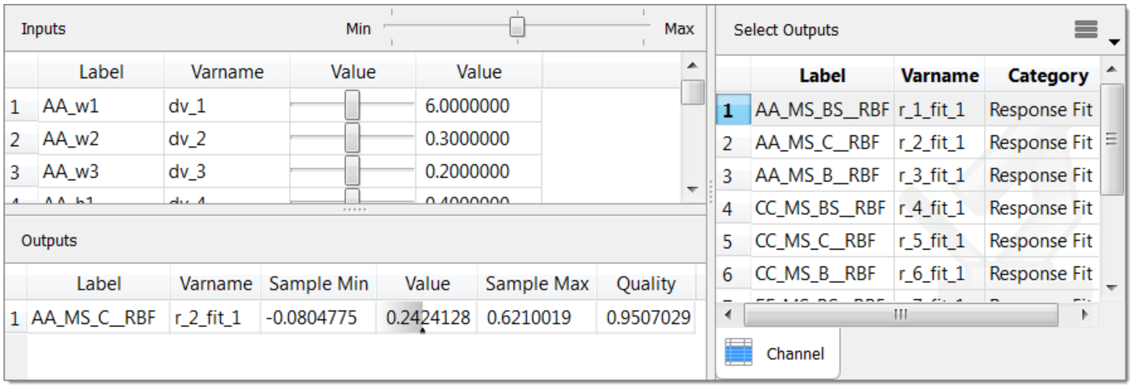
2. Click the ***Diagnostics*** tab to assess the accuracy of a Fit. Different criteria is displayed for the Input, Validation, and merged matrices.

   Use the **Channel** selector to select a specific output response for which to review diagnostics.



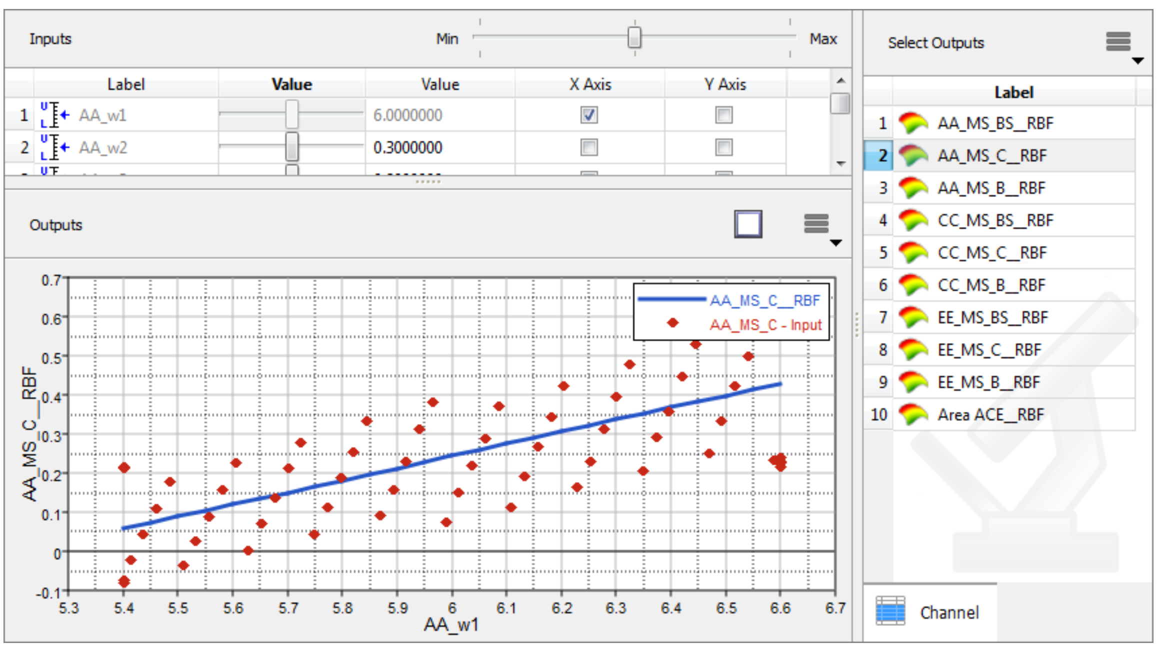
3. Click the ***Trade-Off*** tab to modify the values of input variables in order to see their effect on the output response approximations.

   Use the **Channel** selector to select the desired output responses to display in the **Outputs** pane. Input variable controls are located in the in the top frame (**Inputs**). Change each input variable by moving the slider in the first **Value** column, or by entering a value into the second **Value** column. Set input variables to their initial, minimum, or maximum values by moving the slider in the upper right-hand corner of the Inputs frame.



4. In the ***Trade-Off*** tab plot variables and output responses in order to see the input variables effect on the output response approximations.

   Select input variables to plot by enabling its corresponding **X Axis** checkbox in the **Inputs** pane. Use the **Channel** selector to select output responses to plot. The values for the input variables which are not plotted are modified in the top frame (Inputs). Move the sliders in the **Value** column to modify the other input variables, while studying the output response throughout the design space.



Step 6: 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. Add an objective.
   a. Click ***Add Objective***.
   b. In the **Add - HyperStudy** dialog, add one objective.
   c. Define the objective.
      - Set **Type** to ***Minimize***.
      - Set **Apply On** to ***Area ACE (r_10)***.

	Active	Label	Varname	Type	Apply On	Evaluate From
1	☑	Objective 1	obj_1	Minimize	Area ACE (r_10)	SOLVER

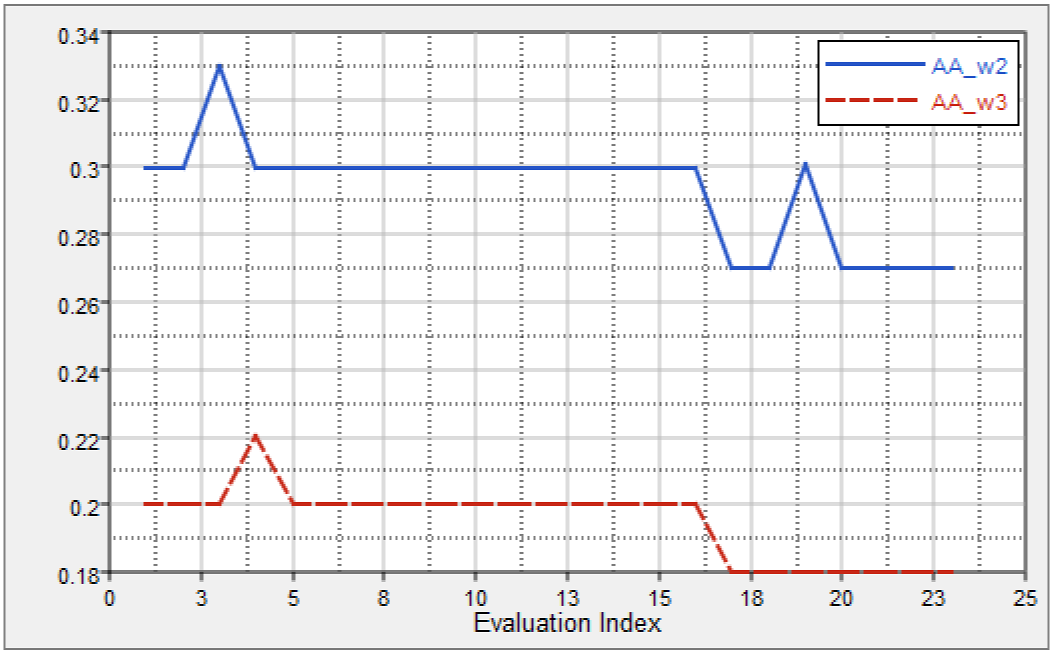
7. Add constraints.
   a. Click the ***Constraints*** tab.
   b. Click ***Add Constraint***.
   c. In the **Add - HyperStudy** dialog, add nine constraints.
   d. Define **Constraint 1** through **Constraint 9** by selecting the options indicated in the image below from the **Apply On**, **Bound Type**, and **Bound Value** columns.

	Active	Label	Varname	Type	Apply On	Bound Type	Bound Value
1	☑	Constraint 1	c_1	Deterministic	AA_MS_BS (r_1)	>=	0.0000000
2	☑	Constraint 2	c_2	Deterministic	AA_MS_C (r_2)	>=	0.2000000
3	☑	Constraint 3	c_3	Deterministic	AA_MS_B (r_3)	>=	0.2000000
4	☑	Constraint 4	c_4	Deterministic	CC_MS_BS (r_4)	>=	0.0000000
5	☑	Constraint 5	c_5	Deterministic	CC_MS_C (r_5)	>=	0.2000000
6	☑	Constraint 6	c_6	Deterministic	CC_MS_B (r_6)	>=	0.2000000
7	☑	Constraint 7	c_7	Deterministic	EE_MS_BS (r_7)	>=	0.0000000
8	☑	Constraint 8	c_8	Deterministic	EE_MS_C (r_8)	>=	0.2000000
9	☑	Constraint 9	c_9	Deterministic	EE_MS_B (r_9)	>=	0.2000000

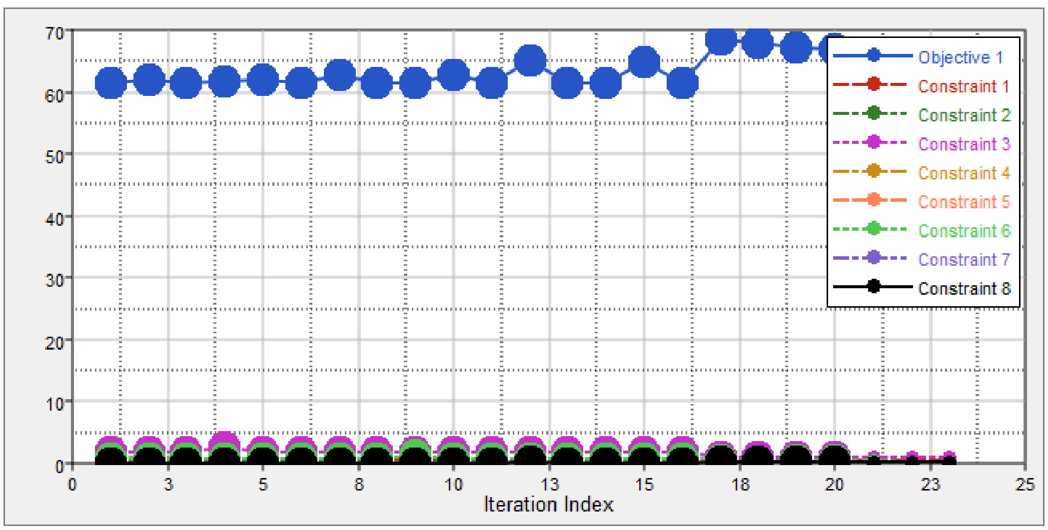
8. Click ***Apply***.
9. Go to the **Specifications** step.
10. In the work area, set the **Mode** to ***Adaptive Response Surface Method (ARSM)***.

    Note: Only the methods that are valid for the problem formulation are enabled.

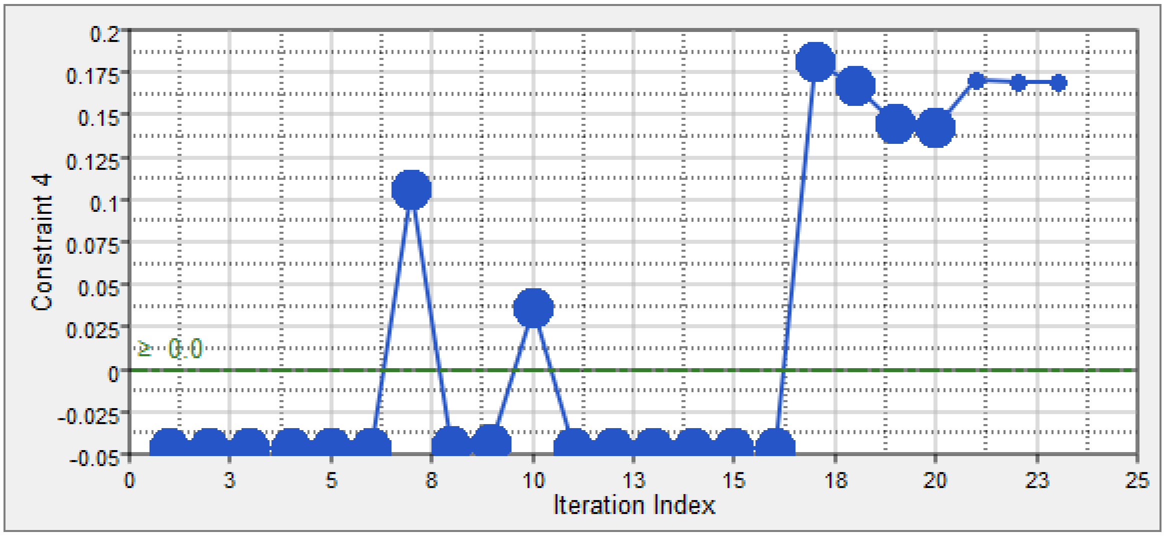
11. Click ***Apply***.
12. Go to the **Evaluate** step.
13. Click ***Evaluate Tasks*** to launch the Optimization.
14. Click the ***Evaluation Plot*** tab to plot variables and output responses across runs (abscissa are run numbers, not iterations).



15. Click the ***Iteration Plot*** tab to plot variables and output responses against iterations.



When the constraint history is plotted, the constraint bounds can be marked with a datum line. Use the **Channel** selector to select a constraint, then click (located above the Channel selector) and select ***Bounds***.



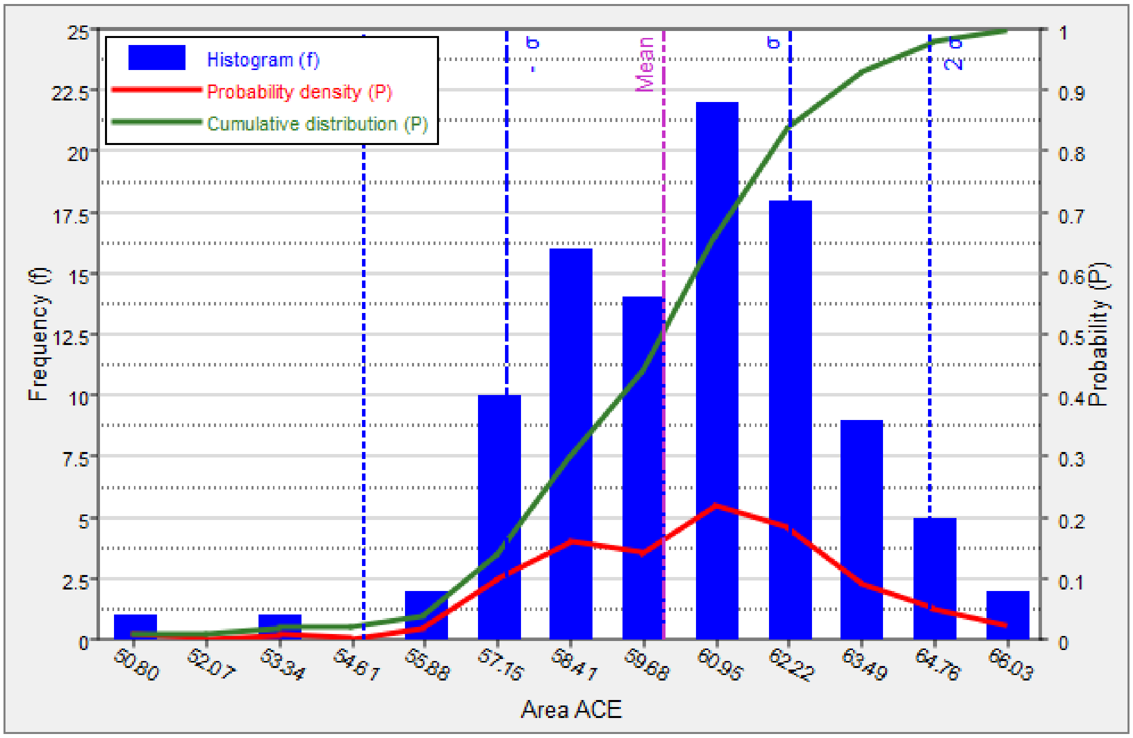
Step 7: Run a Stochastic Study

1. In the **Explorer**, right-click and select ***Add*** from the context menu.
2. In the **Add - HyperStudy** dialog, select ***Stochastic*** and click ***OK***.
3. Go to the **Specifications** step.
4. In the work area, set the **Mode** to ***Hammersley***.
5. In the **Settings** tab, change the **Number of runs** to `100`.
6. Click ***Apply***.
7. Go to the **Evaluate** step
8. Click ***Evaluate Tasks***.
9. Go to the **Post-Processing** step.

Step 8: Post Processing the Results of a Stochastic Study

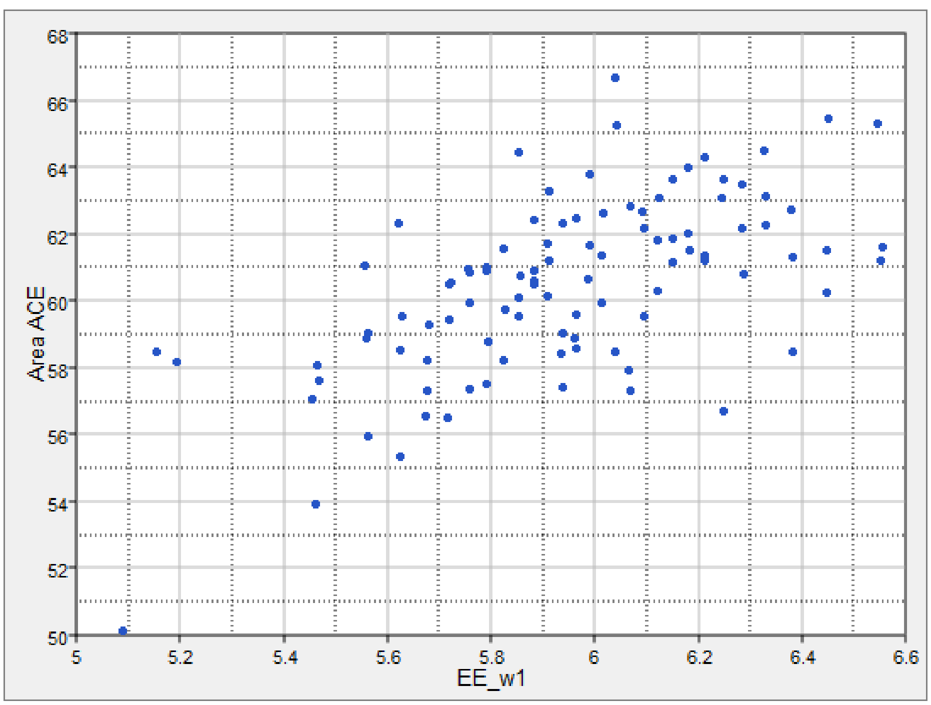
During the Post Processing step of a Stochastic approach, you can access additional result analysis tools.

1. Click the ***Integrity*** tab to access a series of statistical measures on input variables and output responses.
2. Click the ***Distribution*** tab to view variable and output response data in a histogram.



3. Click the ***Scatter*** to view sampling patterns and possible correlations between output responses or between input variables and output responses.

   Use the **Channel** selector to select entities to plot. Select one entity for the X-Axis, and select one or more entities for the Y-Axis.



4. Click the ***Reliability*** tab to compute the probability of failure (bound is violated) and

the reliability (bound is respected).

a. Click ***Add Reliability***.

b. In the **Add - HyperStudy** dialog, add one reliability.

c. Define the reliability.

- Set **Response** to ***Area ACE (r_11)***.
- Set **Bound Type** to **<=** (less than or equal to).
- For **Bound Value**, enter `70.000`.

HyperStudy computes the reliability and probability of failure in the **Reliability** and **Probability of Failure** columns.

	Active	Response	Bound Type	Bound Value	Reliability	Probability of Failure
1	☑	Area ACE (r_10)	<=	70.000000	1.0000000	0.0000000