

# HEEDS Technical Tip – Eliminating Setup Errors Prior to a Shape Optimization Run

**Level:** Intermediate

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## Introduction

In shape optimization studies, it is important to have a robust parametric model for creating new designs. Since every design in these studies requires the creation of a new finite element input file (or mesh file), errors in the parametric model can result in a large number of design failures if the new finite element model is not recreated properly. This is true for parametric CAD-based shape optimization studies, as well as for studies using morphing models.

Even though HEEDS' default search algorithm, SHERPA, handles design failures well, it is still better to start out with a robust parametric model that contains the least number of errors possible. Any errors that are not due to invalid combinations of CAD dimensions should be avoided, because they can potentially prevent the search from exploring good regions of the design space.

While the model regeneration steps typically complete in a few seconds, the subsequent finite element analyses for each design can take anywhere from a few minutes to a few days. Clearly, a large number of errors in the parametric model (typically >20% design failures) can cause significant delays in a HEEDS study, if those errors are not identified and resolved upfront.

This tip will show you how to quickly identify potential errors in the parametric model prior to running the full HEEDS study.

## Identifying Possible Sources of Error

There are a number of things that can result in errors when creating a new model. Some of the most commonly encountered problems include the following:

1. **An invalid combination of design variables causing CAD regeneration failure.** This can often be resolved either by adding constraints in the CAD model or by defining relationships between variables in the HEEDS model.
2. **Failure to remesh the part(s).** This can typically be addressed by using a finer mesh seed, adding geometric cleanup steps within the parametric regeneration process, partitioning the part, etc.
3. **Boundary conditions/loads being applied to incorrect areas of the part** due to a changing number of geometric entities (points, lines, surfaces) from design to design. This can be addressed by using spatial identification of geometric entities at runtime instead of using IDs. Each parametric tool handles this in a different way.

## Testing the Robustness of the Parametric Model

As mentioned above, it is important to evaluate the robustness of the parametric model for the model re-creation that will be used in your HEEDS study. You can achieve this by running a HEEDS DOE study on just the model regeneration part of the evaluation. The study will not include the FEA analyses, since these can be very computationally expensive.

Running just the model regeneration part of the evaluation for each design allows you to quickly perform a large number of design iterations, using a space-filling DOE like a Latin hypercube, so you can evaluate the robustness of the parametric model. The advantage of using a space-filling DOE is that it will evaluate designs that are evenly distributed across the design space, thereby exposing different combinations of the design variables that may cause regeneration failures.

The errors in design regeneration are detected by tagging a response variable in the finite element input file created by the parametric tool. When the finite element input file fails to be created because of errors, HEEDS will mark that design as an

error. There may be additional errors within the input deck (e.g. application of the boundary conditions on an incorrect part of the geometry) that cannot be detected. Tool-specific actions that can be built into the regeneration process (e.g. exporting a snapshot of the applied boundary condition or load on the part) can help with the recognition of these errors. In general it is good practice to review the input files manually to ensure that there are no errors in the files that did regenerate successfully.

The percentage of designs failing is usually a good measure of the parametric regeneration of the finite element model. However, there may be cases where certain types of design failure, even if small in number, may not be acceptable. This should be taken into account when trying to decide if the model needs to be improved.

## Benefits of this Method

Going through this process to test your parametric model will provide a good measure of the robustness of the model. The results from this method can then be used to improve the robustness, if needed, by modifying the parametric models and/or the variable definitions in the HEEDS study. Depending on the number of issues identified with the parametric model, you may have to repeat the process a few times. However, since each of these test studies is short, this process does not take very long. Finally, you can use the revised parametric model to complete the actual study (optimization, DOE, etc.) with the finite element analyses included.

## Example

In this example, the final optimization study evaluation process includes three analyses:

1. An NX analysis to create new CAD data
2. A HyperMesh batch meshing analysis to create the new mesh, and
3. An LS-DYNA analysis to perform crash analysis on the new design.

The first two analyses take 15 seconds, combined, for each new design. The third analysis (LS-DYNA) takes an hour for each design.

### Step 1

Remove the LS-DYNA analysis. Figure 1 (a) shows the complete evaluation process. Figure 1 (b) shows the modified process for the DOE study to evaluate the robustness of the parametric model. Notice that the LS-DYNA analysis has been removed.

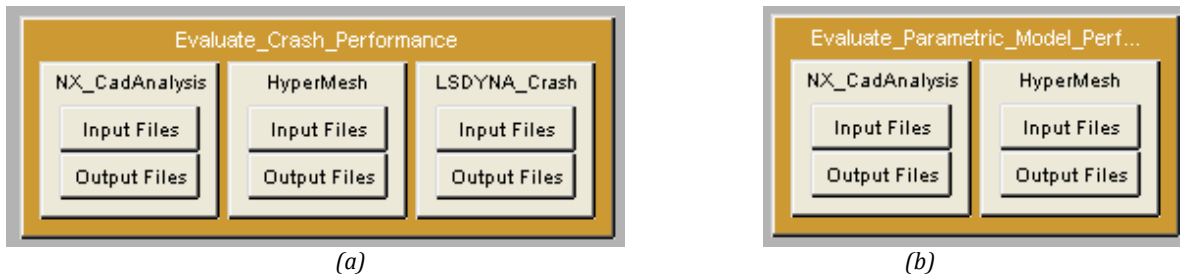


Figure 1. (a) The design evaluation process for the complete optimization study and (b) the design evaluation process of the DOE study for evaluating robustness of the parametric model.

### Step 2

Add the LS-DYNA file generated by HyperMesh as an output file to the second analysis.

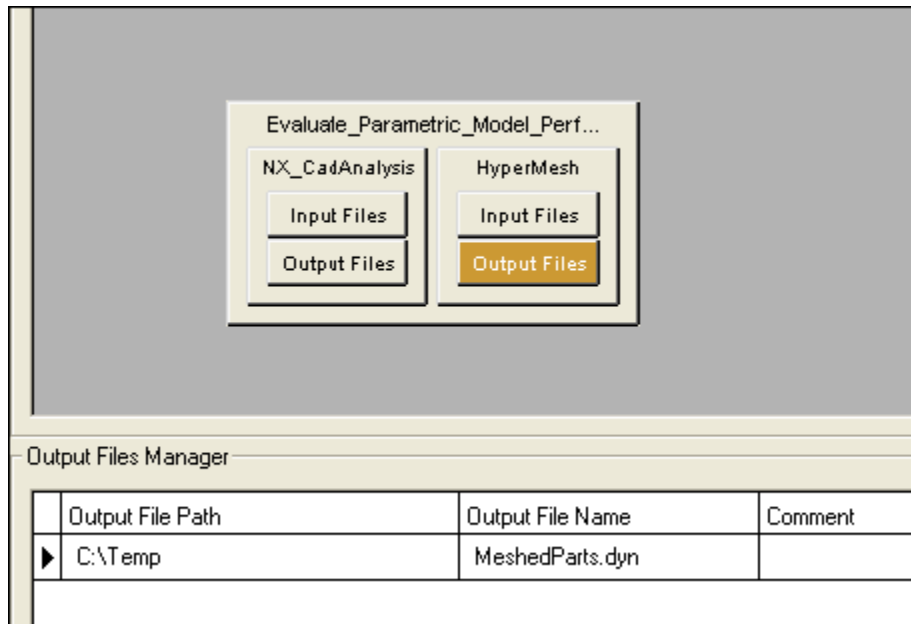


Figure 2. The LS-DYNA mesh file generated by HyperMesh is added as an output file to the second analysis.

### Step 3

Use a response variable to tag a nodal coordinate in this file.

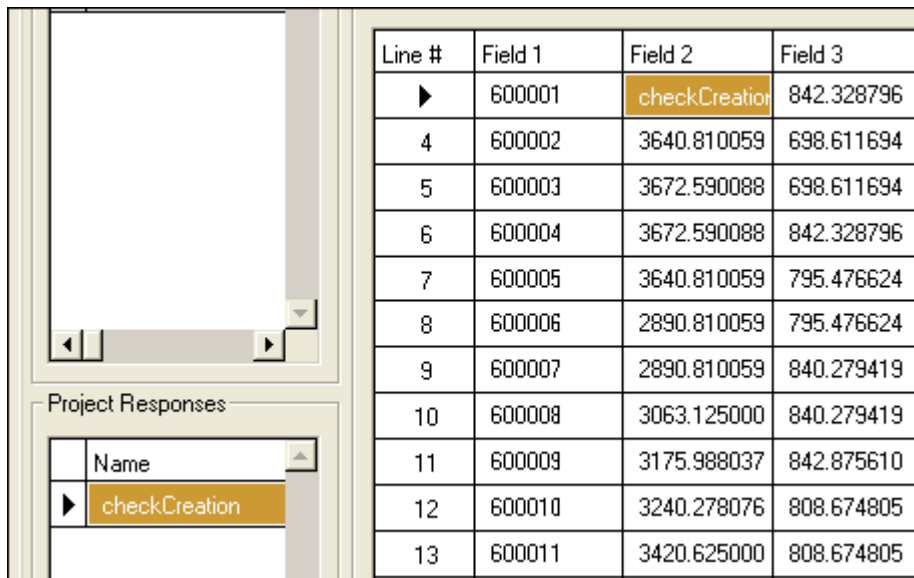


Figure 3. Tagging the mesh file generated by the meshing analysis with a response variable.

### Step 4

Set up and execute a DOE study. The agent type used for this study is a DOE agent with Latin Hypercube as the recommended sampling technique.

After the completion of the DOE study, the results can be examined to evaluate if any changes need to be made to the parametric setup to improve the robustness of the setup.