

Project Analyzer

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1.0 Purpose

The project analyzer is a systems engineering visual analytics tool. It converts predefined data sets into a collection of interactive analytical visualizations for the purpose of enabling or enhancing a user's capacity for cognitive reasoning based on perceptual principles. The two primary benefits being:

- An increased conceptual understanding of the data being visualized.
- And an increased transparency as to how one should react to the information embedded in the data.

The tool is organized into tabs corresponding to specific common systems engineering design activities. The visibility of a tab is dependent on the data available.

NOTE:
Not all of the images shown below are of the mass-spring-damper system

2.0 Procedures

The instructions in this manual assume that the user has installed the latest version of GME and/or has access on VehicleFORGE. The actual procedure for starting the project analyzer depends on the operating environment. GME provides a convenient option to start the project analyzer after successfully running a test bench. The project analyzer can also run within the scope of VehicleFORGE. Simply click on any *.project.json file within your repository or use the shortcut on the right hand side of your project page to start the project navigator which has the ability to create custom virtual datasets for the project analyzer.

2.1 Tool

The availability of various features is dependent on the online status of the application and the availability of data. Below is an enumerated list of each feature, along with the conditions for the feature to be enabled.

Feature	Online (Launched from VehicleFORGE)	Specific Data Required	Selections Required
Scoring Data	Running within VF Required		
Requirements Analysis		Requirements definition	
Design Space		Successfully completed testbench results	
Design Space Analysis		Successfully completed testbench results	At least two variables and one design selected
Parametric Design Analysis		PET analysis results	At least one response and two variables selected
Probabilistic Certificate of Correctness		PCC analysis results	
Formal Verification		Verification Results	
Multi-Attribute Decision Analysis		Successfully completed testbench results	At least one variable
Surrogate Modeling Performance		Surrogate summary results	

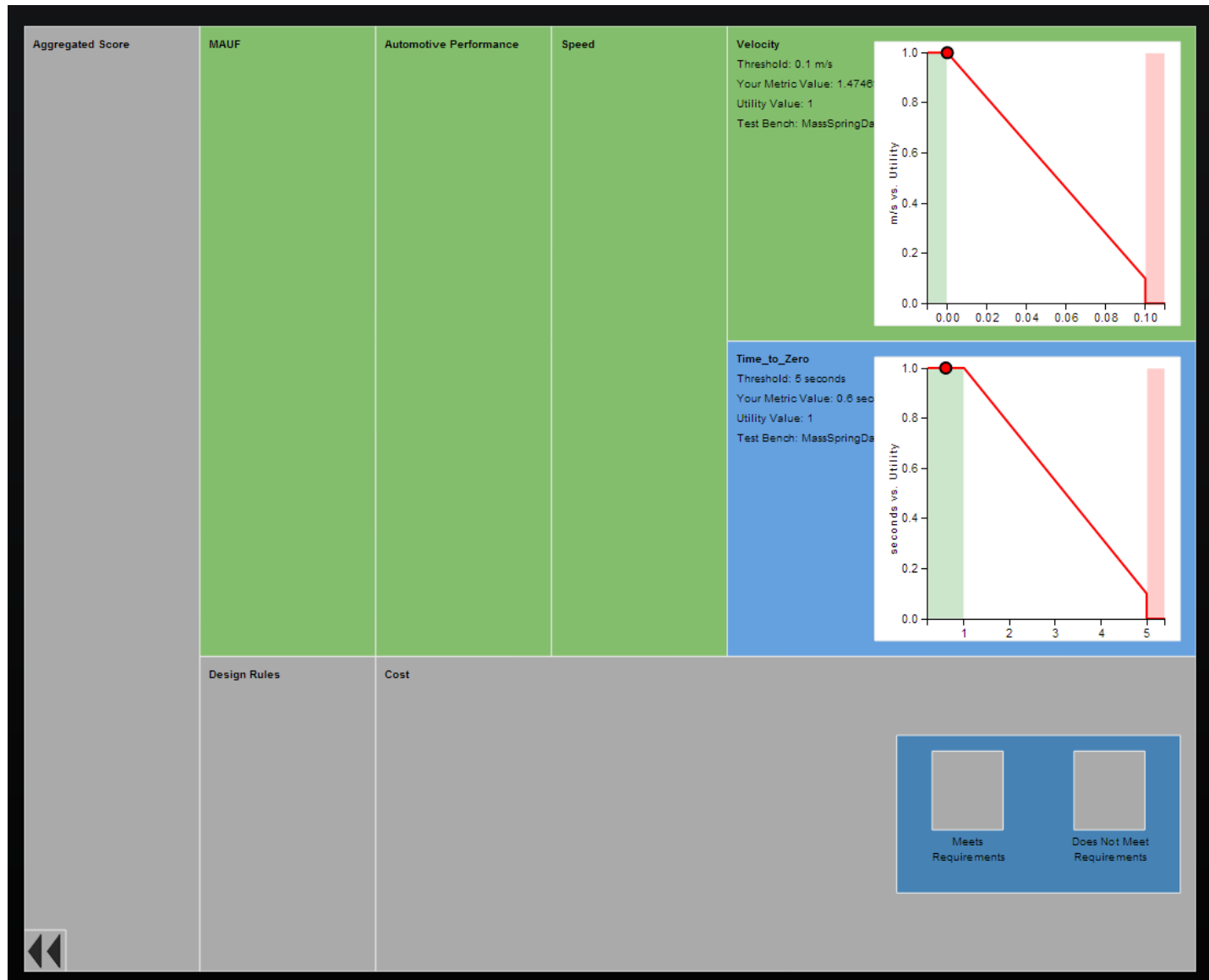
2.2 Use

As it was mentioned above, each tab focuses on a specific design activity. However, the tabs do have integrating elements which tie them together. In the section below, each of these tabs, along with their integrating elements, will be discussed.

2.2.1 Requirements Analysis

The Requirements Analysis tab allows rapid analysis of a configuration in order to analyze which design metrics do and do not meet required values. The results are presented in two tables and a stoplight diagram.

The tables shown are the **design info box** and the **requirements list**, which provide, respectively, all of the data about the design from the test benches and all of the data from the requirements definition. The **stoplight diagram** shows the requirements tree graphically, and is color coded to demonstrate where a design does and does not meet the requirements. Specifically, grey indicates a requirement for which there is no data provided to compare the design, red indicates a requirement in which the threshold is not met, green represents a design in which the threshold is met, but the objective is not, and blue represents a design in which the objective is met. Higher level colorings are indicative of their weakest child.



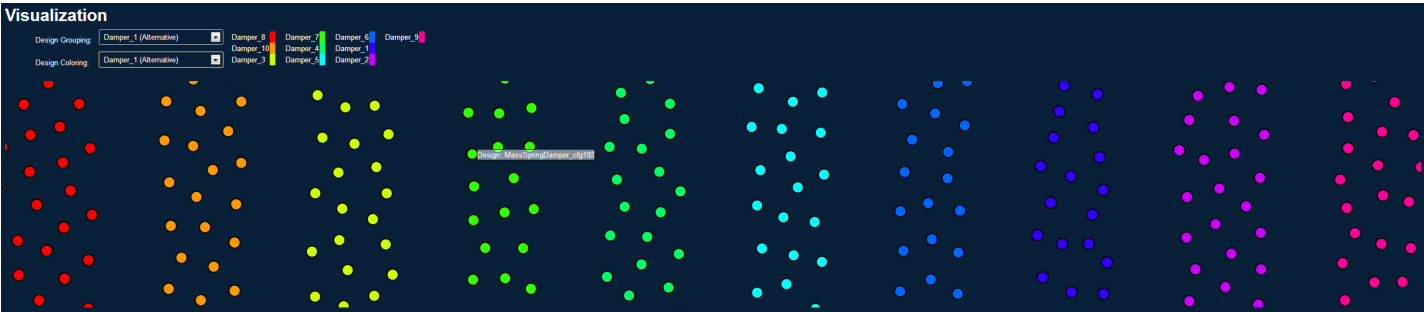
The top two panels are the design info box and the requirements list. These two tables are both controlled in the same manner. First, the configuration whose information should be displayed is selected via the drop down menu labeled "configuration". Changing the configuration field will change all configuration fields in the tab. The number of entries in the table can be controlled via the second drop down menu labeled "show X entries", in which X is the number of entries selected to be shown. If not all entries in a given category are displayed, the list of entries can be browsed by clicking the right and left arrows located at the bottom right corner of the table. The tables can be sorted in either ascending or descending order by clicking the up and down arrows at the right hand side of each column header. A bidirectional arrow indicates no sorting preference, an upward arrow indicates an ascending sort in which low numbers are shown above high numbers for numeric fields and early letters are shown before later letters in alphabetic fields. A downward arrow indicates a descending sort. Finally, typing search terms in the search box separated by spaces will filter results to show only rows that contain all of the listed search terms.

There are three methods of controlling the stoplight diagram: configuration selection, zooming, and checkbox usage. Configuration selection is done in the same manner as it is in the tables. Zooming is one of the primary functions of the stoplight diagram and allows analysis of the components of a specific design category. It is done by clicking on the category of choice, which then zooms the view-able area to show only that category and the children of that category. This allows increased detail to be shown, including data on the requirements and the utility curves for each metric. The stoplight diagram can be zoomed one level up by clicking on the left edge of the diagram and fully zoomed out by clicking the double arrow button in the lower left-hand corner of the diagram. Checkbox usage is straight forward; click on a box to select that option. A

large 'X' will appear in an active box. Selecting a different box will deselect the current box. Clicking on a selected box will also deselect it and will change the metric completeness to 'undefined'.

2.2.2 Design Space

The design space tab shows each candidate design along with their configuration. A configuration is a collection of components utilized within the design. At the top of the tab, each design is illustrated with a colored circle where the user is able to specify grouping and color coding for visualization purposes.



The example above shows 300 designs being grouped and color coded by the damper used within the mass-spring-damper system.

The Configuration table below shows in detail which components are used within each design.

Configuration Table

25 entries

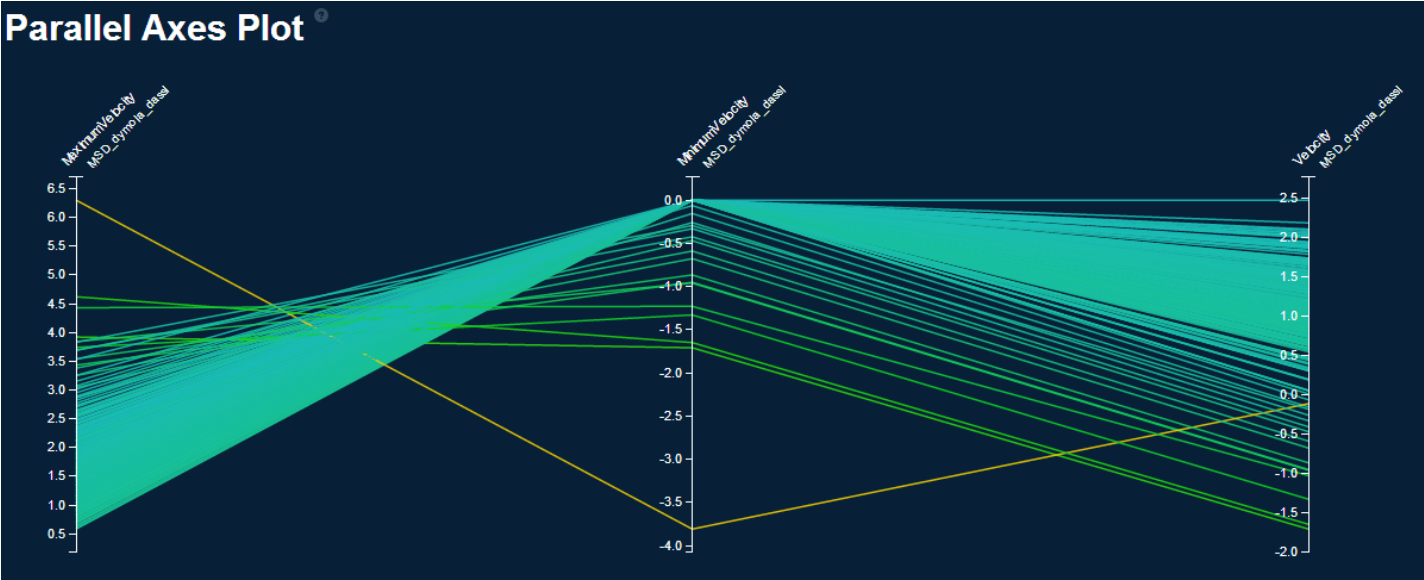
Search

Designs	Damper_1 (Alternative)	Mass_1 (Alternative)	Spring_1 (Alternative)
MassSpringDamper_cfg1	Damper_8	Mass_8	Spring_8
MassSpringDamper_cfg10	Damper_10	Mass_8	Spring_8
MassSpringDamper_cfg100	Damper_3	Mass_3	Spring_8
MassSpringDamper_cfg1000	Damper_7	Mass_7	Spring_7
MassSpringDamper_cfg101	Damper_4	Mass_3	Spring_8
MassSpringDamper_cfg102	Damper_5	Mass_3	Spring_8
MassSpringDamper_cfg103	Damper_6	Mass_3	Spring_8
MassSpringDamper_cfg104	Damper_7	Mass_3	Spring_8
MassSpringDamper_cfg105	Damper_1	Mass_4	Spring_8
MassSpringDamper_cfg106	Damper_10	Mass_4	Spring_8
MassSpringDamper_cfg107	Damper_2	Mass_4	Spring_8
MassSpringDamper_cfg108	Damper_3	Mass_4	Spring_8
MassSpringDamper_cfg109	Damper_4	Mass_4	Spring_8
MassSpringDamper_cfg11	Damper_2	Mass_8	Spring_8
MassSpringDamper_cfg110	Damper_5	Mass_4	Spring_8
MassSpringDamper_cfg111	Damper_6	Mass_4	Spring_8
MassSpringDamper_cfg112	Damper_7	Mass_4	Spring_8
MassSpringDamper_cfg113	Damper_1	Mass_5	Spring_8
MassSpringDamper_cfg114	Damper_10	Mass_5	Spring_8
MassSpringDamper_cfg115	Damper_2	Mass_5	Spring_8
MassSpringDamper_cfg116	Damper_3	Mass_5	Spring_8
MassSpringDamper_cfg117	Damper_4	Mass_5	Spring_8
MassSpringDamper_cfg118	Damper_5	Mass_5	Spring_8
MassSpringDamper_cfg119	Damper_6	Mass_5	Spring_8
MassSpringDamper_cfg12	Damper_3	Mass_8	Spring_8

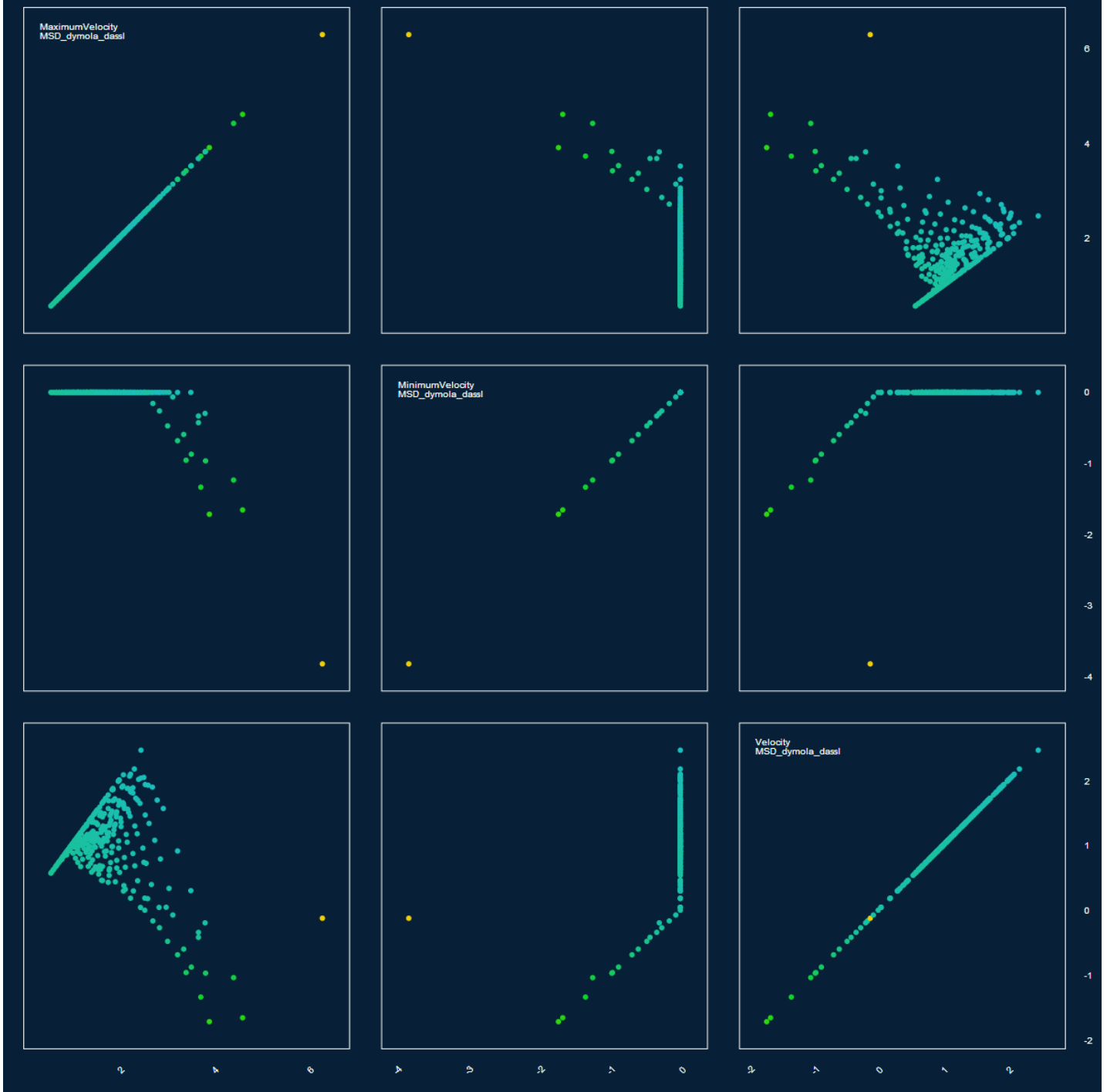
Showing 1 to 25 of 300 entries

2.2.3 Design Space Analysis

The design space analysis tab provides a multidimensional view of each design. Within this tab, each metric of each design can be compared, providing a valuable understanding of the explored design space. If a requirements definition is available, this tab can also visualize the space as it is constrained by the requirements. The tab also allows the user to introduce more dimensionality through color.

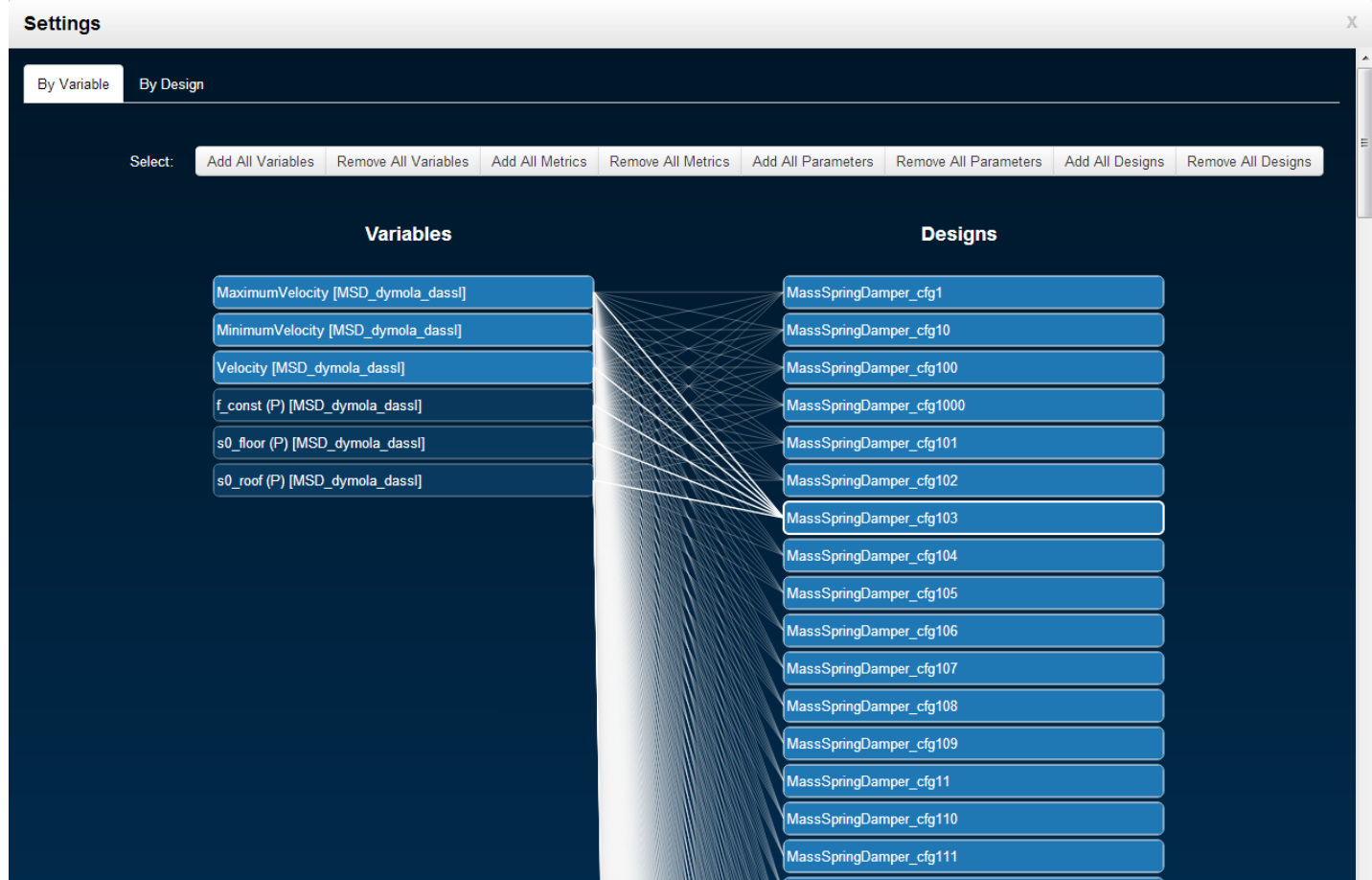


Multivariate Plot ⁹



The designs can be color coded with respect to scores, requirements, MADA results, PCC results, or limit violations. Each color coding allows the user to see how the various types of requirements, constraints, and analyses push designs to particular parts of the design space.

Of course, it is possible to have a mixed dataset where not every design has been run through the same test benches, in which case the tool allows the user to see which designs can be displayed together as shown below.



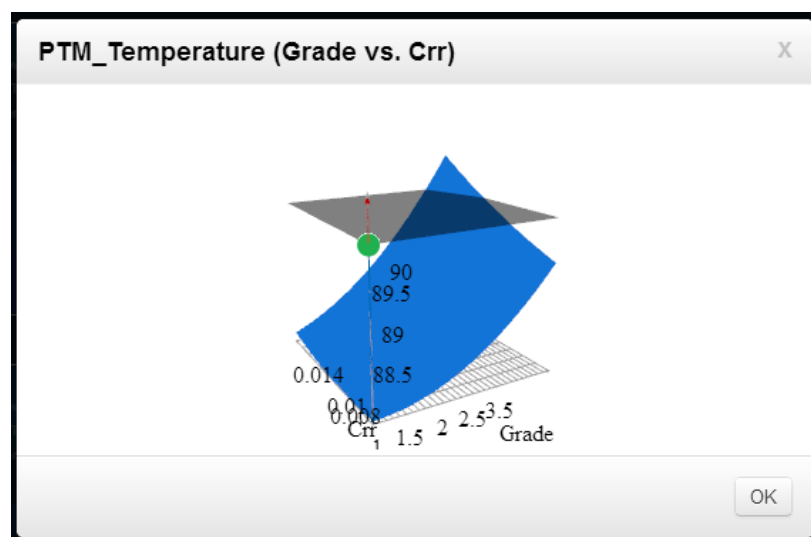
2.2.4 Parametric Design Analysis

If the user has performed a PET (Parametric Exploration Tool) analysis, the parametric design analysis tab will be available. This tab specializes in "what if" scenarios. To start, the user must select at least two variables and one response. At the top of the tab is a constraint plot illustrating the design space after constraints initially based on the requirements definitions are applied. The user is able to explore the space in terms of the constraints, visualizing the effects of relaxing or restricting each constraint.



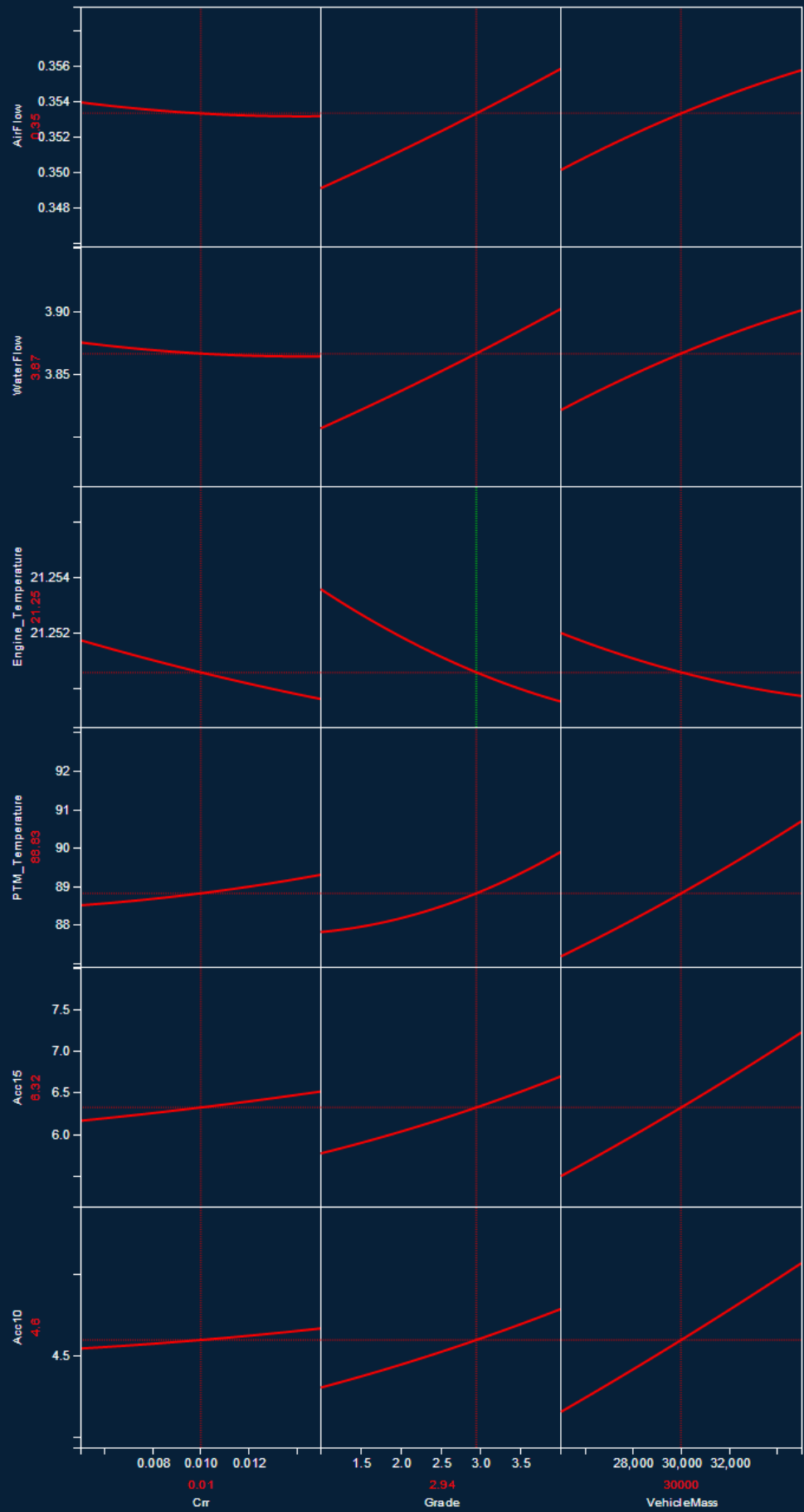
The colored regions within the constraint plot are regions which are not feasible. Thus, the visualization shows the design space as if the constraints were encroaching upon it.

In order to see the slope or sensitivity of each constraint, the user can double-click on the constraint name to show a three-dimensional visualization. The constraint is marked at the intersection of the response surface and the flat constraint plane. The 3D view can be rotated to view the surfaces from different angles. The blue arrow indicates which side of the constraint plane is feasible.



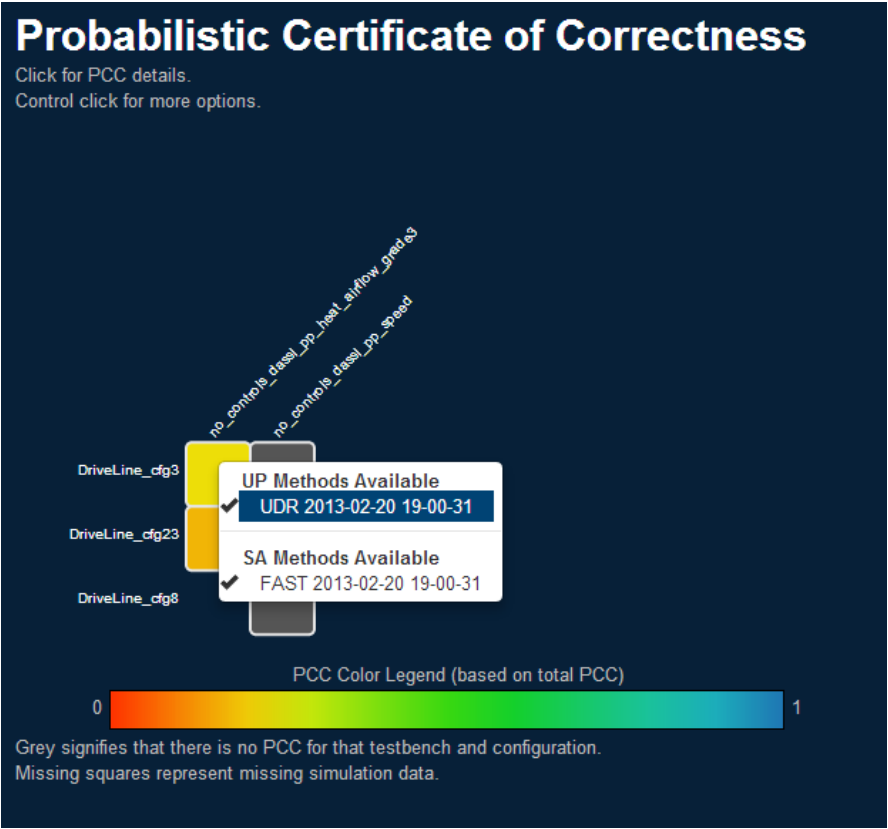
Below the constraint plot is the prediction profiler. This tool allows the user to quickly review the relationships between the parameters and the responses. The user can dial-in specific parameter values and instantly see the resulting response values by dragging the vertical cross hairs. The curves show the partial derivatives at the specific parameter values. The visualization also shows the maximum and minimum response values.

Prediction Profiler



2.2.5 Probabilistic Certificate of Correctness

If the data set contains the results of a PCC analysis then the probabilistic certificate of correctness (PCC) tab will be available. This tab provides a measure of robustness with respect to upper and lower limits of the metrics. The overall robustness of a design is displayed within a heat map. The designs are automatically sorted by the first column. The user can change the column order by dragging the columns into a new order.



If the data set contains multiple sets of results the result sets are listed in a context menu which is available by ctrl-left-clicking a box in the heat map. A standard left-click will present the user with a more detailed view of the PCC results.



On the first column to the left is a list of the metrics from the selected test bench. The next column shows the resulting metric distributions from the uncertainty propagation analysis. The last column shows the sensitivity of each parameter to the metric specified in the same row. The probability distribution function also indicates the PCC index indicating the percentage of the results which fall between the defined limits. The complexity index is a measure of how complex the metric result is. Thus, the PCC index is a measure of the probability that the metric meets the requirements. The complexity index is a measure of level of interdependence within the metric calculation. The probability density function (PDF) provides a visualization of the distribution of the results of each metric.

Sensitivity analysis is accomplished using a Pareto plot, which provides a visualization of which parameters control the most variability in reaching the metric goals. Pareto analysis uses the Pareto principle, which states that 80% of the variability of a design is controlled by 20% of the parameters. The red dashed line separates the top, most influential parameters (80% of the variability) from the bottom, less impactful parameters (20% of the variability).

2.2.6 Multi-Attribute Decision Analysis

The Multi-Attribute-Decision-Analysis tab allows a set of designs (configurations) to be quickly ranked with respect to a user defined preference. The results are based on a modified technique called TOPSIS.

If this tab is opened without a valid set of preferences defined by the user, the settings dialog is automatically opened, giving the user an opportunity to select which variables in which to provide preferences. All of the available variables (or variables without preferences) are listed in the left-hand plane of the dialogue. All of the selected variables (or variables with preferences) are listed in the right-hand plane. Clicking on a variable within either plane will toggle the variable status as having a preference or not having a preference. The multi-attribute decision analysis algorithm will ignore all variables without preferences. Each design is ranked relative to each other within the currently loaded dataset.

At the top of the dialog several shortcuts have been provided to help the user quickly select a subset of the available variables. Of course, all variables will either add or remove all of the variables. All metrics will add or remove variables which are outputs of test benches. All parameters will add or remove all variables which are inputs to test benches. Finally, all requirements will add or remove all variables which are associated with a requirement. Please note that the all requirements shortcut require a valid requirements definition. Close the dialog box in order to finalize a selection of variables. The dialog box can always be reopened by pressing the settings button within the menu bar of the project analyzer.

Multi-Attribute-Decision-Analysis Settings

Select:

Add All Variables

Remove All Variables

Add All Metrics

Remove All Metrics

Add All Parameters

Remove All Parameters

Add All Requirements

Remove All Requirements

Available

Test Bench	Variable
MSD_dymola_dassl	f_const (P)
MSD_dymola_dassl	s0_floor (P)
MSD_dymola_dassl	s0_roof (P)

Selected (Choose at least one)

Test Bench	Variable
MSD_dymola_dassl	MaximumVelocity
MSD_dymola_dassl	MinimumVelocity
MSD_dymola_dassl	Velocity

The body of the multi-attribute decision analysis tab is divided into a left and right plane. The left plane contains the ordered rankings of all of the designs (configurations) with respect to the user's preferences. The blue horizontal bars indicate relative closeness of a given design to the positive ideal design and the negative ideal design as defined by the TOPSIS technique. Thus, a design with a blue bar that spans its entire column is mathematically equivalent to the positive ideal design. A design with no bar is mathematically equivalent to the negative ideal design.

Designs (Ordered by User Preferences)

Click on a design (configuration) to set it as the current design in all the other tabs

Designs	Rankings
MassSpringDamper_cfg108	<div></div>
MassSpringDamper_cfg101	<div></div>
MassSpringDamper_cfg100	<div></div>
MassSpringDamper_cfg163	<div></div>
MassSpringDamper_cfg955	<div></div>
MassSpringDamper_cfg161	<div></div>
MassSpringDamper_cfg939	<div></div>
MassSpringDamper_cfg553	<div></div>
MassSpringDamper_cfg745	<div></div>
MassSpringDamper_cfg155	<div></div>

User Preferences

Show 10 entries

Search:

Variable	Test Bench	Direction	Weight
MaximumVelocity	MSD_dymola_dassl	<div>MinMax</div>	<div></div>
MinimumVelocity	MSD_dymola_dassl	<div>MinMax</div>	<div></div>
Velocity	MSD_dymola_dassl	<div>MinMax</div>	<div></div>

Showing 1 to 3 of 3 entries

The right plane within the body of the multi-attribute decision analysis tab contains all of the variables with preferences. By default, each variable with a preference is set to a preference of 50%. A preference is defined by its direction and weighting. The direction indicates whether or not a variable should be maximized or minimized. The weighting indicates the relative importance of a variable compared to all other variables with preferences.

2.2.7 Limit Violations Summary

The limit violation summary tab shows occurrences of designs where maximum or minimum limits have been exceeded. The presence of a red exclamation point in the tab title indicates that limit exceeded errors were detected during the file load process. The table shows test benches and designs that produce the limit error. The name of the limit exceeded is displayed along with the predefined limit value and the actual value generated when the design was run through the test bench.