Quantitative Methods in Systems Engineering: Project Supplement

General Guidance

This document is intended to supplement the instructions included in the Excel files for the Week 2-4 project.

1. Ensure that you have downloaded both the template file and the example solution. You may refer to the sample solution at any time for an example of formatting and worksheet structure.
2. The example problem you choose has a large impact on the difficulty of the problem. Make sure that your problem is small enough and familiar enough to you personally so that you know where to look for design variable and attribute values, and can fill in any gaps using your experience and engineering judgment. The purpose of the project is to exercise the methods discussed in the course content rather than to design a high-fidelity engineering system – no need to spend undue hours researching your system. **You may need to simplify your problem as you move farther into the project – it is OK to do so.**
3. By default, the project template workbook is locked. This prevents unintentional modifications to the background calculations performed by the workbook. However, if you need to change formatting or cell contents in a non-yellow cell you may unlock a specific sheet or the entire workbook using the **Tools->Protection** menu (Excel for Mac) or using the **Review** tab on the menu ribbon (Excel 2016 for PC). You can also right-click specific worksheet tabs and choose to unprotect them. Similar options exist in earlier versions of Excel.

Week 3, Step 1

Removing weak drivers:

The method for paring down your weak DVs depends on what type of analysis you are doing. In many cases, the purpose of cutting weak variables is to reduce dimensionality prior to high-fidelity modeling and sampling. This can be based on cost attributes, performance attributes, or both. **For this project, you may use any criteria that allows you to choose at least 3 but no more than 6 DVs to carry through the rest of the analysis.**

Defining enumeration range:

There are 2 types of DVs:

1. Numerical continuous: these are numbers, such as “any number 0 through 10” and “2, 3, or 5”
2. Categorical: these are categories expressed in words, such as “small, medium, or large” and “good or bad”

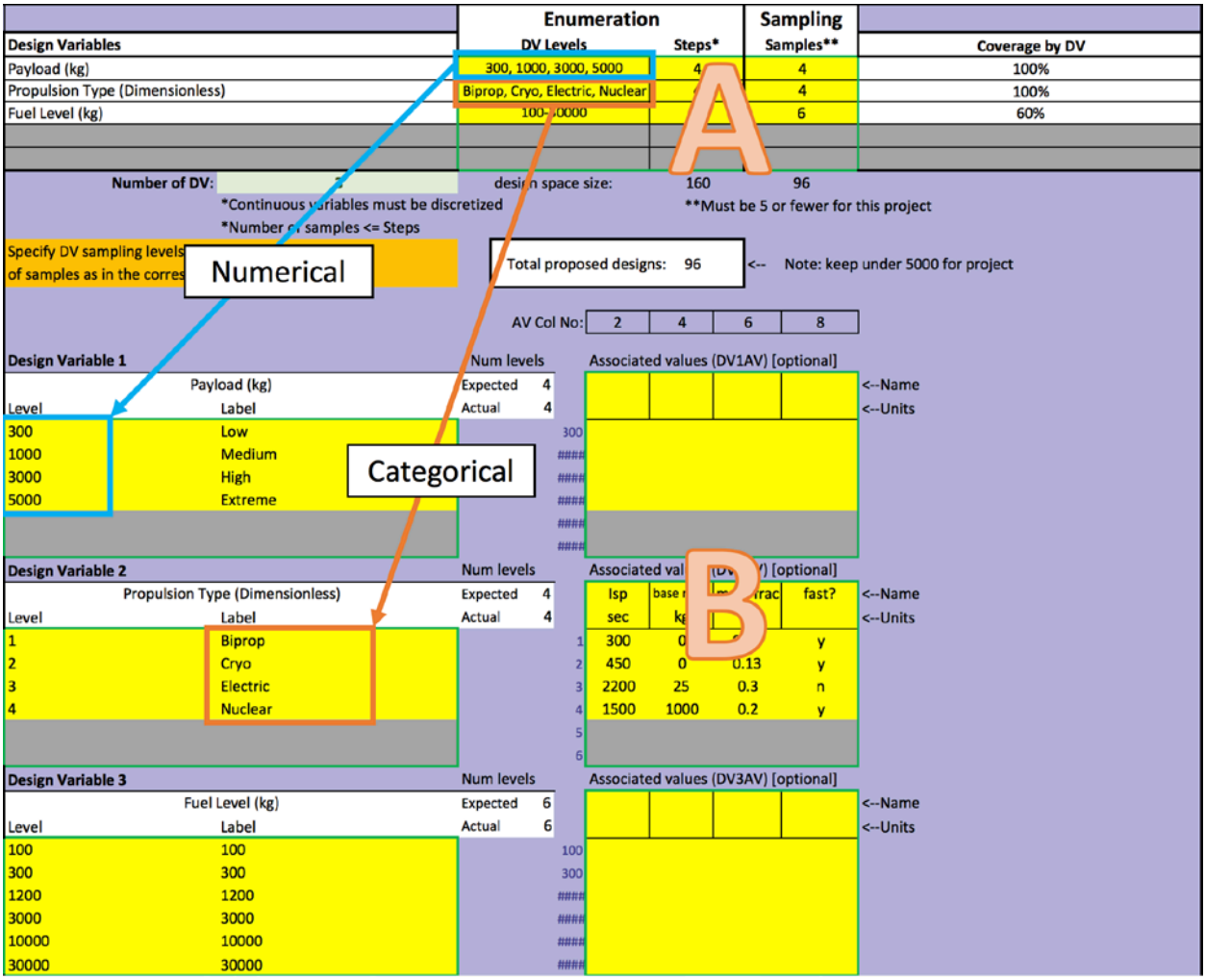
This excel model requires a discrete enumeration of cases to be evaluated. Continuous variables need to be discretized into a subset of values that span the full possible range. Categorical variables need to be assigned numbers (these can be arbitrary) to facilitate Excel analysis.

See figure below:

- Area A is where you plan the specific levels to be enumerated for each DV in the full model, and how many you intend to sample for the purpose of the modeling exercise. **For the model you build in this project, you may choose no more than 5 “sample” levels to model for each DV.**
- Area B is where you define in detail the enumeration levels to be sampled for each DV. There are two columns: “Level” and “Label.” For Excel purposes, the “Level” column must contain numbers, while the “Label” column is used for assigning the levels labels for better interpretation of results and can be a number or text. For numerical DVs, copy the desired DV levels into the “Level” column (as numbers).

Assign a textual label to each level. For categorical DVs, copy the textual DV labels into the "Label" column and assign integer values in the "Level" column.

- The "Associated values" sections in Area B are optional, but may be important for calculations later in the project. They are especially useful for categorical DVs, since it is difficult to do math on categorical labels alone. For example, what are some numerical constants associated with different types of propulsion systems? Think of mass, fuel type, range, launch capability, subsystem cost, etc. **If the "Level" column for your DV provides all required information for evaluation models, no Associated Values are necessary for that DV.**



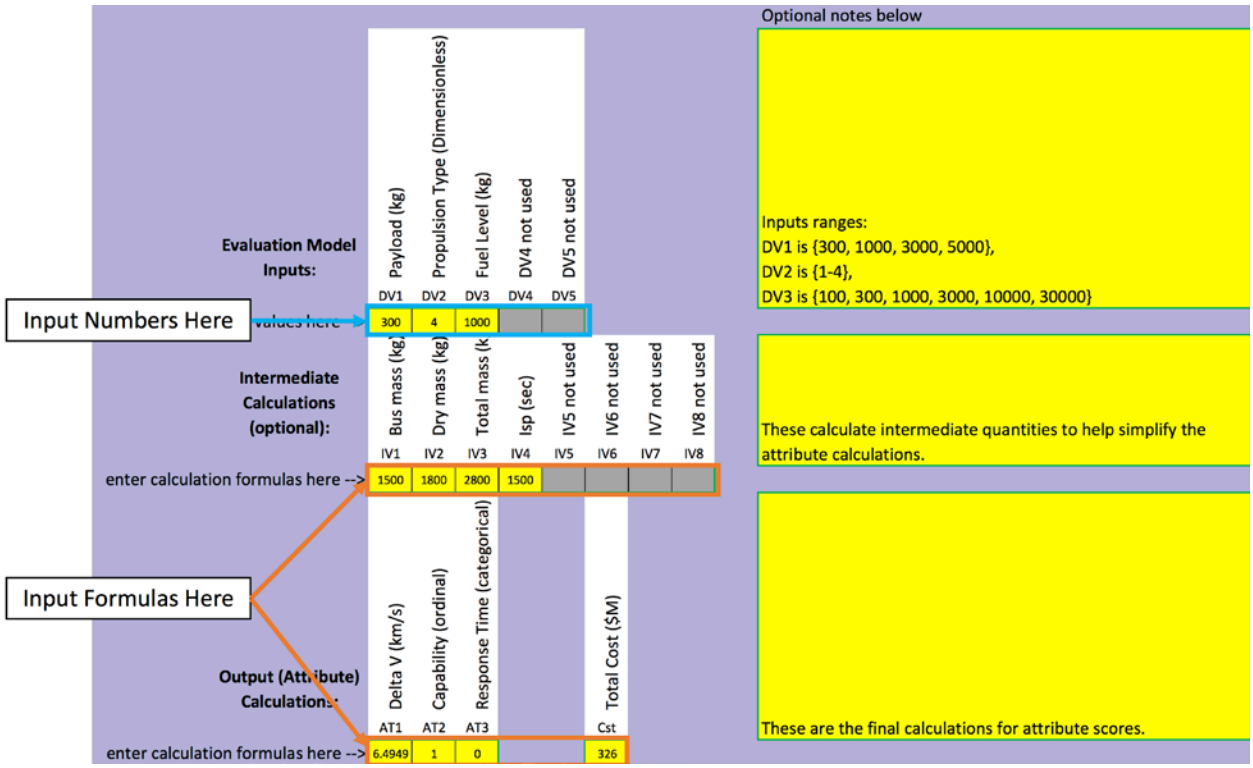
Week 3, Step 2

First, a note on terminology: changing the level of a design variable cascades to a change in system attributes. Put simply, changing inputs to a system changes the outputs. "DV to attribute mapping" refers to this relationship between inputs and outputs – sometimes a single input impacts multiple outputs or the reverse. "DV to attribute testing" is the process of evaluating a system's attributes for sensitivity to various combinations of DV levels.

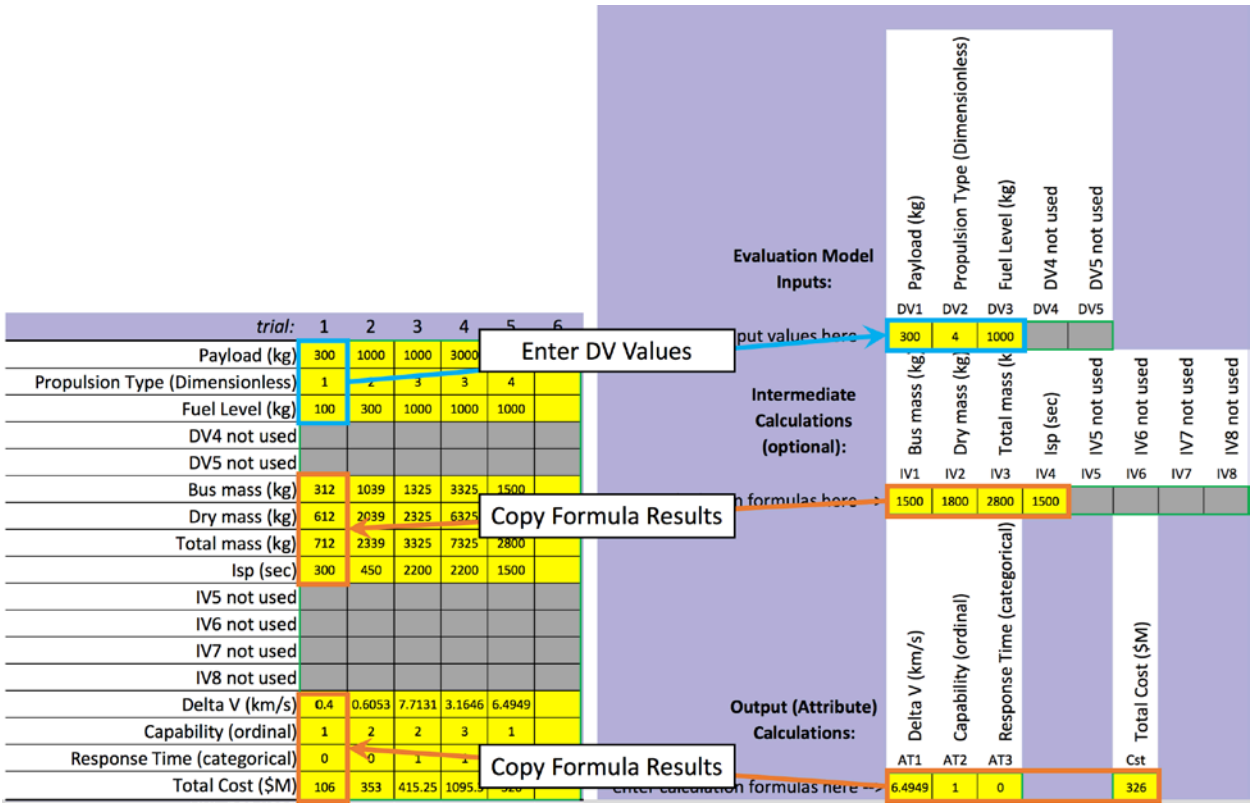
The goal of this step is the development of *evaluation models* that can calculate attribute levels for each particular design specified by particular levels of the DVs. The *evaluation models* are the set of formulas you develop here.

It is highly recommended that you review the sample solution for guidance on the final format of this sheet.

- Row 50 should be populated with DV levels for a design you want to evaluate. You can use this to explore what the parametric relationships look like as a function of the inputs. These are **numeric inputs from the "Level" column from Week 3, Step 1.**
- Row 53 is optional, depending on whether your model uses intermediate variables. You will **use excel formulas** to calculate the intermediate values based on the DV values from row 50.
- Row 56 is where you input the final calculation **formulas** to get attribute values. These formulas can use values from Row 50, results from Row 53, constants from your constant table, or associated values from the Step 1 worksheet.



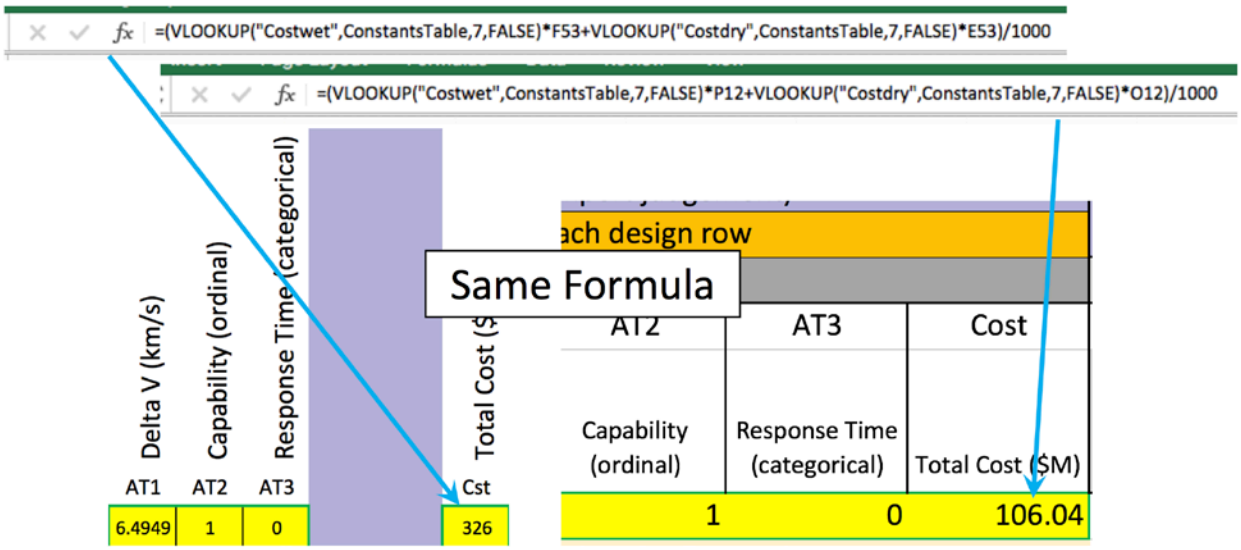
The area below the formulas is a scratchpad to store results for several sample designs. The idea here is that you test out several cases to ensure that your formulas work correctly for a small set of different cases (up to 6). Try enough cases so you are confident that your formulas work correctly and give reasonable values.



Week 3, Steps 3 and 4

This table allows for a full enumeration test of your sample space. The rows of this table are automatically populated based on your definition of the sample design space of each DV from Step 1. You need to input the formulas to calculate attribute values based on the DV inputs. **This step should be very simple based on the work you did in Step 2.**

Enter the same formulas you developed on Rows 53 and 56 of Step 2 in columns N through AA of Step 3, updating the cell references to the new sheet but keeping the underlying math and logic the same:



As always, we encourage you to discuss this project with your group and in the discussion forums.