User Guide
for
S-Curve Tool
Version 1.0

(as of 09/12/12)

Sponsored by:

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Introduction

The purposes of the S-Curve Tool are to allow practitioners to easily and clearly

(1) compare their s-curve to another s-curve;

(2) compare their results to historical coefficients of variations (CVs) and/or cost growth factors (CGFs);

(3) generate graphics for decision briefs.

Table 1 provides a brief description of every tab in the tool. There are ten different tabs; two are introductory tabs (red cells); four are user interface tabs (green cells); and four are for PowerPoint presentations (orange cells). More details/descriptions are provided in the subsequent chapters of this user guide.

# of Tabs	Title of Tab	Description
1	Title	Title page for S-Curve Tool version 1.0.
2	README	Current tab displaying the purpose of the tool, a list of tabs, useful tips, and the flowchart for the tool.
3	Inputs	Tab where all the inputs are stored. S-Curve is generated here.
4	Empirical	"Sub-tab" to the Inputs tab. Users input empirical data here.
5	Benchmarking	Comparison between a single estimate and the estimate's historical adjustment.
6	Reconciliation	Comparison between the 1st estimate vs 2nd estimate and historical adjustment(s).
7	B1 Chart	Tab displaying Estimate 1 Chart in "Benchmarking" tab for PowerPoint presentations.
8	B2 Chart	Tab displaying Estimate 2 Chart in "Benchmarking" tab for PowerPoint presentations.
9	R Chart	Tab displaying Reconciliation Chart in "Reconciliation" tab for PowerPoint presentations.
10	Summary	Tab containing all the stored and derived parameters in the tool.

Table 1: Tabs and Descriptions of Tabs in S-Curve Tool v1.0

Figure 1 shows a flowchart diagram of the S-Curve Tool v1.0. For the estimate(s), the user chooses Empirical (i.e., a set of outcomes from a Monte Carlo risk run), Parametric (e.g., enhanced Scenario-Based Method (eSBM) or parameters from an external risk analysis), or a Point Estimate (i.e., risk analysis not yet done).

If the estimate type is Empirical, the user inputs (1) the number of trials, (2) the cost units for the empirical data, and (3) all of the values for the trial runs. There is an optional feature to assess the empirical data by overlaying a parametric curve created by the empirical parameters on the raw data. For the optional feature, the user selects either the normal or lognormal distribution.

If the estimate type is Parametric, the user defines the type of distribution (either normal or lognormal) and the type of parameters. There are three options for parametric inputs in the tool, (1) Mean and CV, (2) Mean and Specified Cost (Xp) with corresponding %tile (p), and (3) CV and Specified Cost (Xp) with corresponding %tile (p). There are other ways to define a parametric curve (e.g., two percents (p) with two specified costs (Xp)), but they are not implemented in v1.0.

If the estimate type is a Point Estimate, the user defines the type of distribution (either normal or lognormal) and whether the point estimate is a Mean or a Median. If the point estimate is a median, the historical adjustment "pivots" on the median. All other cases (including the Parametric and Empirical cases) "pivot" on the mean when the estimate is historically adjusted.

Historical adjustments are based on the Naval Center for Cost Analysis's (NCCA's) analysis of Selected Acquisition Reports (SARs) and are dependent on five different inputs: (1) commodity, (2) life cycle phase, (3) milestone, (4) inflation, and (5) quantity. After the user selects these inputs, there are three options to apply the historical adjustment to the estimate: (1) apply CV only ("shaping" the s-curve); (2) apply CGF only ("shifting" the s-curve); and (3) apply CV & CGF ("shaping" and "shifting" the s-curve). If users decide not to apply historical adjustments to the estimate, they can proceed with the base s-curve that was generated.

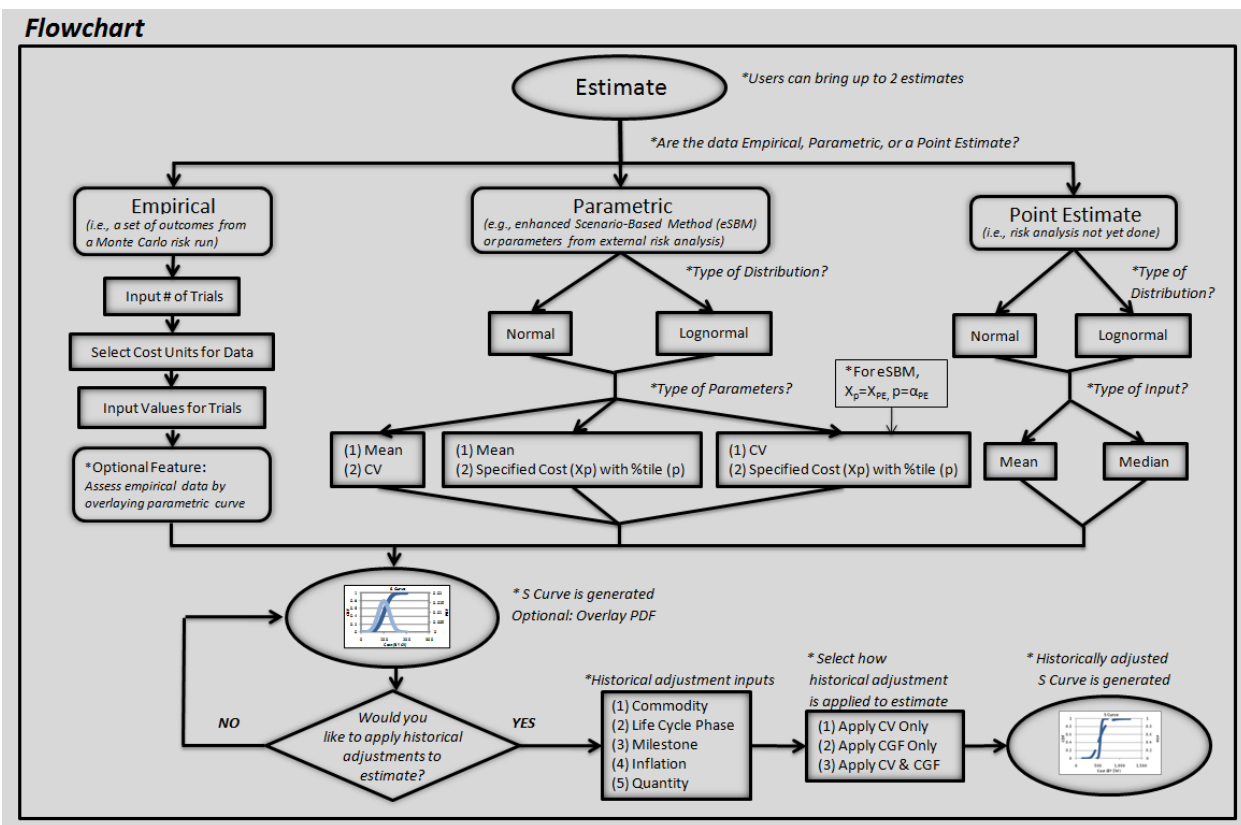


Figure 1: Flowchart Diagram of S-Curve Tool v1.0

Table 2 shows all of the options that the user can select for the historical adjustment inputs (Commodity, Milestones, Phase, Quantity, and Inflation). For the base estimate's commodity list, only the first eight entries are available. The commodity list in the historical adjustments portion of the tool will allow the user to select from among DoD Acquisition, DoN Acquisition, or one of the eight entries selected for the base estimate.

Commodity	Milestones	Phase	Quantity	Inflation
Ships and Submarines	MS A (Planning Estimate)	Acquisition (Development + Production)	adj	BY$
Aircraft and UAVs	MS B (Development Estimate)	Development	not adj	TY$
Missiles and Munitions	MS C (Production Estimate)	Production		
Unmanned Space				
Electronics				
AIS				
WTV				
Custom Commodity				
DoD Acquisition				
DoN Acquisition				

Table 2. All Options for Historical Adjustment Inputs in S-Curve Tool v1.0.

Useful Tips for the Tool

- Throughout the tool, all of the white cells are user inputs, while all grey cells are "read only" cells. Grey cells are typically calculated parameters based on the user inputs.

User Inputs	"Read Only"

- Practitioners may insert up to two different s-curves in the tool. There are options to overlay the PDF on the CDF and also to apply historical adjustment(s) to either/both of the estimates. Estimates are distinguished by the following characteristics.

  - **Estimate 1**: Blue vs. **Estimate 2**: Red
  - **Probability Density Function (PDF)**: lighter hue vs. **Cumulative Distribution Function (CDF)**: darker hue
  - **Base Estimate**: solid line vs. **Historical Adjustment**: dashed line

Table 3 summarizes the above points.

	Estimate 1	**Estimate 2**
PDF of Base Estimate		
CDF of Base Estimate		
PDF of Historical Adjustment		
CDF of Historical Adjustment		

Table 3: Line Colors and Line Styles for Different Estimates

- For the charts in the tool, parameters are distinguished by symbols and dotted black lines. The figure below shows the different parameters that can be applied to a chart (more details in later chapters).

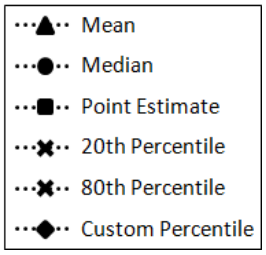


Figure 2: Symbols for Derived Parameters in Chart Options.

1. Inputs Tab

This chapter provides further details for the "Inputs" tab in the S-Curve Tool. This is where the s-curve is defined and generated. Figure 3 shows a snapshot of the "Inputs" tab with additional comments. This tab is categorized in five different sections. Depending on the selections and inputs made from each section, cells will appear/disappear (refer to "Appendix B: Snapshots of the S-Curve Tool" for more details). All s-curves in the tool are generated from inputs in this tab.

The 1st section requires the user to define the estimate by inputting (1) a title for the estimate, (2) the cost units, (3) type of dollars, (4) the commodity, (5) milestone, and (6) life cycle phase. When the user fills in the title for the estimate, all of the charts and labels throughout the tool will be updated dynamically with this title. There are three options for the cost units: (1) $K, (2), $M, (3) $B, and two options for the dollars type, (1) base year and (2) then year. The cost unit and dollars type are applied to both s-curves (the tool does not allow the user to select a different cost unit or dollars type for each s-curve). There is a list of options for the user to choose from for the commodity (e.g., WTV, Aircraft & UAVS), milestone (e.g., MS A (Planning Estimate)), and life cycle phase (e.g., development). There is an option for the user to select a custom commodity. This allows the user to fill in a commodity that the list does not provide (refer to "Appendix B1. Custom Commodity" for more details).

The 2nd section requires the user to define the estimate type (empirical, parametric, or point) and input the parameters to generate the s-curve. The options for the parameter inputs are listed in the flowchart in the introduction. Remember that white cells are user input cells while grey cells are "read only" cells. Depending on the selected estimate type and parameter inputs, different cells within this section will appear and/or disappear. Refer to "Appendix B3. Parametric Case" and "Appendix B4. Point Estimate Case" for more details. Special case: If the "Empirical" option is selected, a link will direct the user to the "Empirical" tab, where the values for the Monte Carlo output can be inserted (refer to "Appendix B2. Empirical Case" for more details).

Sections 3 and 4 provide sanity checks on the user inputs in Section 2. The 3rd section provides the derived parameters based on the user inputs in the 2nd section. All of the cells in this section are "read only" cells. The displayed parameters in this section are the (1) mean, (2) CV, (3) standard deviation, (4) variance, (5) median, (6) mode, and if the lognormal distribution is selected, the (7) mean underlying normal, and (8) standard deviation underlying normal are also displayed (refer to "Appendix B5. Normal Distribution vs. Lognormal Distribution" for more details). The 4th section provides a thumbnail for the s-curve based on the inputs in sections 1 and 2. For more chart options, the user can click on the thumbnail or the link at the bottom of the page to proceed to the Benchmarking tab. More descriptions are provided in Chapter "2. Benchmarking Tab".

The 5th section allows the user to apply historical adjustments to the s-curve. As stated before, the historical adjustment inputs, (1) commodity, (2) life cycle phase, (3) milestone, (4) inflation, and (5) quantity, are based on NCCA's SAR analysis. The life cycle phase and the milestone selections are

maintained from section 1. The historical adjustment requires the user to select whether or not the suggested CVs and CGFs include inflation and quantity risk. The commodity list in the historical adjustment section allows the user to select from three different options: (1) DoD Acquisition, (2) DoN Acquisition, and (3) the commodity that the user selects in Section 1. Based on the five historical adjustment inputs, a suggested CV and suggested CGF are displayed. If the user selects a custom commodity, the user inserts a custom CV and a custom CGF. The tool allows the user to apply either the custom/suggested CV and/or CGF to the s-curve (refer to "Appendix B1. Custom Commodity" for more details).

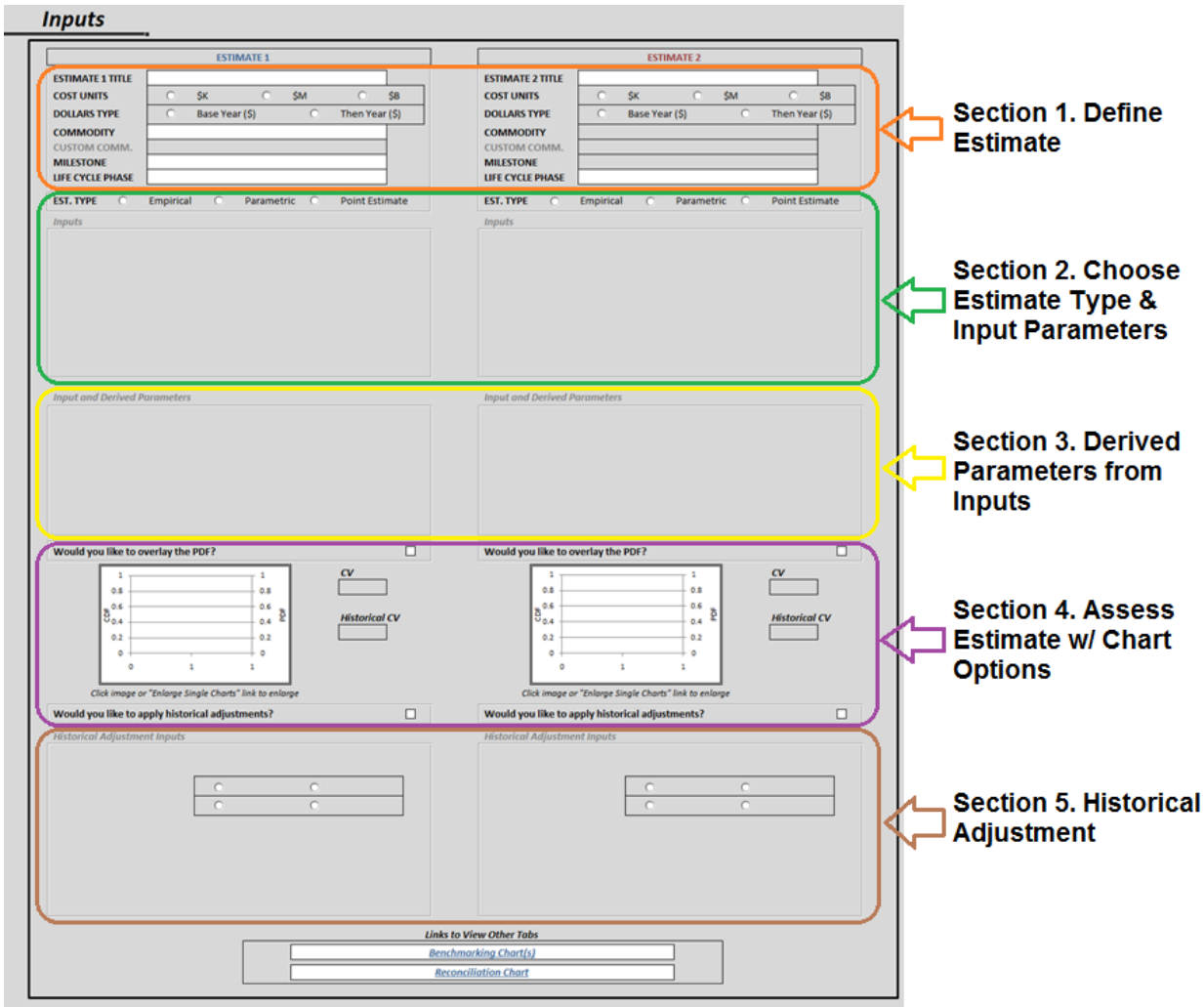


Figure 3: Snapshot of "Inputs" Tab, with Comments

1a. Empirical Tab

This chapter provides further details for the "Empirical" tab in the S-Curve Tool. This tab is a "sub-tab" to the "Inputs" tab. The S-Curve Tool allows users to input up to a maximum of 10,000 Monte Carlo risk runs. This tab is where the 10,000 values are stored. When the user selects "Empirical" as the estimate type in the "Inputs" tab, a link directs the user to this page. Figure 4 shows a snapshot of the "Empirical" tab with additional comments.

The 1st section requires the user to define the cost units of the empirical data. The green circles in Figure 4 show cells that display the number of trials entered from the "Inputs" tab, the cost units selected from the "Inputs" tab, and a cell where the user selects the cost units of the empirical data. This will convert the cost units of the empirical data to the cost unit that is selected from the "Inputs" tab. For example, if the user selects $K in the "Inputs" tab and the Monte Carlo risk run is outputted in dollars, the S-Curve Tool will convert the values from the Monte Carlo risk run from dollars to $K.

The next step is to insert the values that are shown in the area within the orange shapes in Figure 4. These cells are dependent on the number of trials entered from the "Inputs" tab. The cells in the input columns will become white after the user enters a value into the "# of trials" in the "Inputs" tab. For example, if you enter "100" into your "# of trials", the cells corresponding to rows 1 to 100 will become white. There is also an optional feature in the tool to validate/compare the number of values stored in the column to the specified number of trials from the "Inputs" tab.

After the empirical values are inserted, the user can either click on the link labeled "Back to Inputs" to return to the "Inputs" tab or assess the empirical data with the tool's optional feature. The derived parameters from the empirical data appear in Section 3 of the "Inputs" tab (refer to Figure 3).

The optional feature in the "Empirical" tab is shown in the purple box in Figure 4. This feature allows the user to assess the empirical data. To proceed with this option, the user selects either "Estimate 1" or "Estimate 2" after the empirical data is stored in the tool. The derived parameters from the empirical data will then appear in the Section 2O. The derived parameters include the (1) Mean, (2) CV, (3) Std Dev, (4) Variance, (5) Median, and (6) Mode. Section 3O of the optional feature section requires users to select whether they want to overlay a normal or a lognormal distribution curve on the empirical data. The CDF and the PDF of the raw empirical data will be shown in section 4O of the optional feature section.

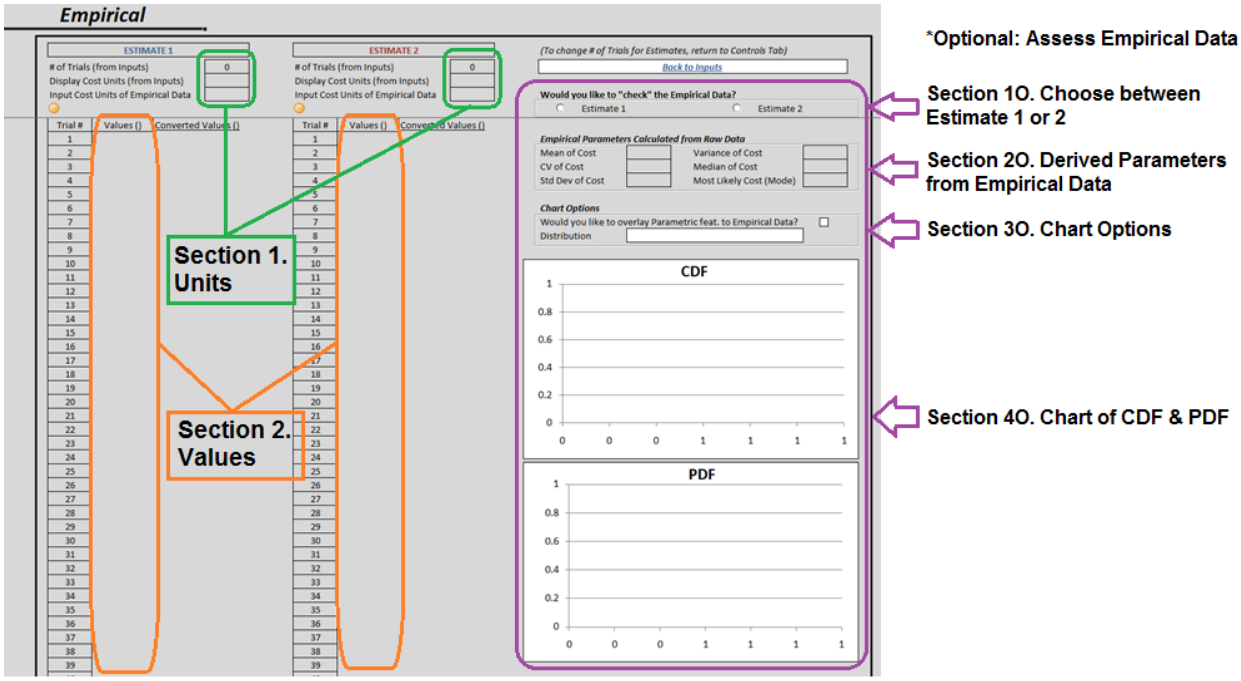


Figure 4: Snapshot of "Empirical" Tab, with Comments

2. Benchmarking Tab

This chapter provides further details for the "Benchmarking" tab in the S-Curve Tool, as shown in Figure 5. The purpose of this tab is to analyze a single estimate or compare a single estimate to its historical adjustment. The s-curves that are displayed in this tab are created by the inputs from the "Inputs" tab.

The first section in this tab shows some of the inputs and derived parameters from the "Inputs" tab. All cells in this section are "read only". Table 4 shows the displayed parameters in the "Benchmarking" tab based on the estimate type selected in the "Inputs" tab. The mean and the CV are always displayed, even if they were not the user inputs. If the user chooses to apply historical adjustments to the base estimate, the bottom portion of the section will appear and/or disappear and it will display the five historical adjustment inputs and how the historical adjustment was applied to the base estimate.

# of Rows	Empirical	Parametric	Point Estimate
1	Estimate Type	Estimate Type	Estimate Type
2	# of Trials	Distribution	Distribution
3	-	Parametric Inputs	Mean or Median
4	Value of Derived Mean	Value of Mean	Value of Mean
5	Value of Derived CV	Value of CV	Value of CV

Table 4: Displayed Parameters in "Benchmarking" Tab

The second section allows the user to select either the base estimate or the base estimate with historical adjustments. When the historically adjusted estimate is selected, both s-curves (base estimate and historically adjusted estimate) are displayed on the charts. The model assumes that the user would never want to see the historically adjusted s-curve without also seeing the base s-curve. Users can apply up to six different parameters on the chart. The parameters are (1) the mean, (2) median, (3) a custom cost, (4) the 20th percentile, (5) the 80th percentile, and (6) a custom percentile. This tool allows the user to type in a label for the custom cost and/or the custom percentile. This label will appear in the legend of the chart.

The third section contains the chart(s) that are defined by the user in the previous sections. The charts always display the base estimate CV and the historically adjusted CV in the top left corner. The base estimate CV is in a box with a solid line border and the historically adjusted CV is in a box with a dashed line border (refer to "Useful Tips for the Tool").

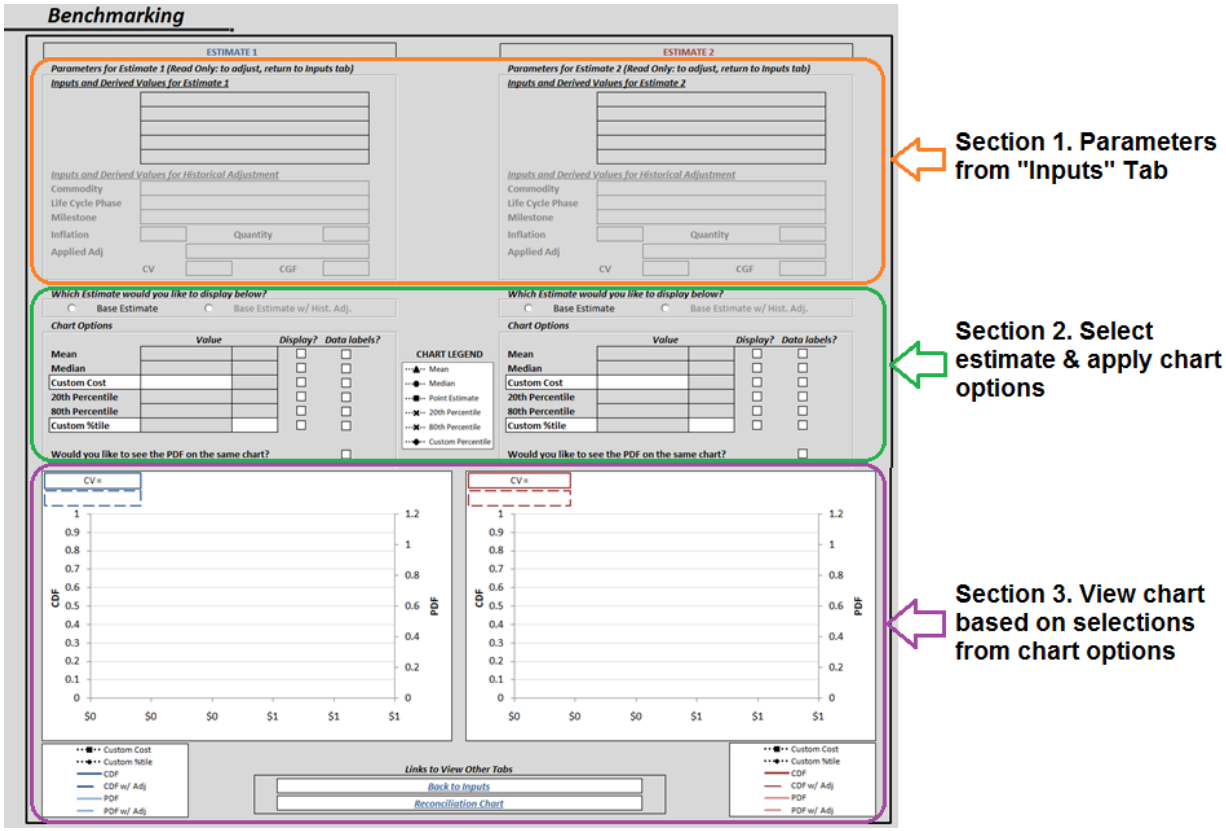


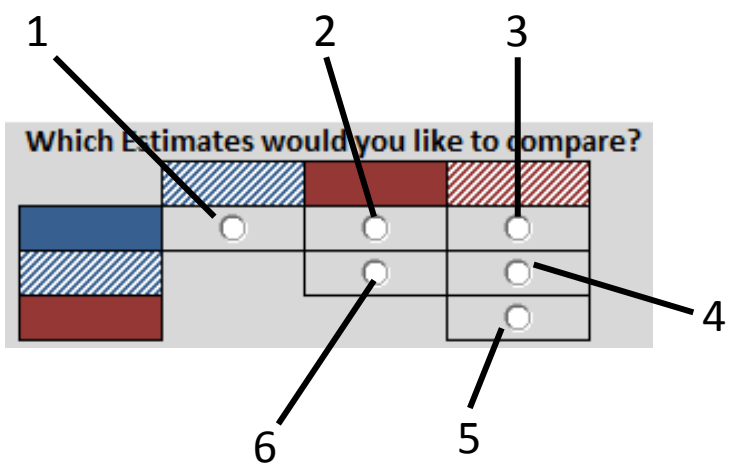
Figure 5: Snapshot of "Benchmarking" Tab, with Comments

3. Reconciliation Tab

This chapter provides further details for the "Reconciliation" tab in the S-Curve Tool, as shown in Figure 7. The purpose of this tab is to compare all estimates defined in the "Inputs" tab. This chart can contain anywhere from one s-curve (user only inputs one estimate with no historical adjustments) to four s-curves (user inputs two estimates and applies historical adjustments to both).

The first section in this tab shows some of the parameters for the estimates that were defined from the "Inputs" tab. The parameters include the (1) mean, (2) median, (3) custom cost, (4) 20th percentile, (5) 80th percentile, and (6) custom percentile. These are the same parameters provided in the chart options (section 2) of the "Benchmarking" tab. Users can also type in a label for their custom cost and/or their custom percentile. This label will appear in the legend of the chart.

The second section allows the user to apply options to the chart. The user first selects a comparison between two s-curves. This is accomplished by choosing one of the radio buttons shown in Figure 6. Users can apply up to two different comparisons on the chart. Based on the comparison that the user selects, the cost and CDF differences are calculated and displayed in Section 2 of the "Reconciliation" tab. Users select the parameters that are displayed in the chart in Section 3 of the "Reconciliation" tab by checking the boxes in Section 2.



*Refer to "Useful Tips for the Tool" for patterns on row and column headers

# from image above	Pattern on column	Pattern on row	Description
1			Estimate 1 vs. Estimate 1 w/ hist. adj.
2			Estimate 1 vs. Estimate 2
3			Estimate 1 vs. Estimate 2 w/ hist. adj.
4			Estimate 1 w/ hist. adj. vs. Estimate 2 w/ hist. adj.
5			Estimate 2 vs. Estimate 2 w/ hist. adj.
6			Estimate 1 w/ hist. adj. vs. Estimate 2

Figure 6: Selecting Estimates to Compare in Reconciliation Tab

The third Reconciliation tab section contains the chart that was defined by the user in the previous sections. This chart displays the CVs for estimate 1 in the top left corner and the CVs for estimate 2 in the top right corner. The base estimate CV is in a box with a solid line border and the historically adjusted CV is in a box with a dashed line border (refer to “Useful Tips for the Tool”).

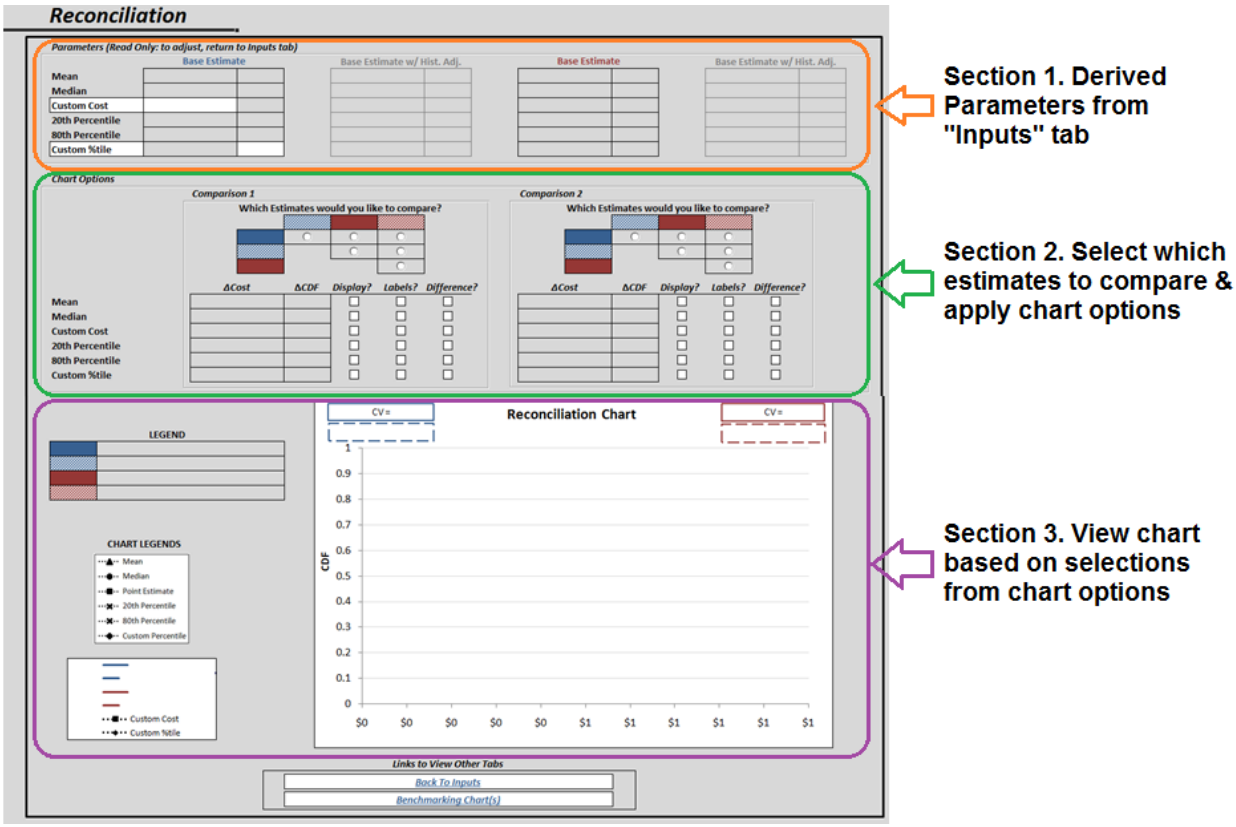


Figure 7: Snapshot of “Reconciliation” Tab, with Comments

4. Tabs for PowerPoint

There are four tabs in the tool that are created for PowerPoint presentations; (1) B1 Chart, (2) B2 Chart, (3) R Chart, (4) Summary. These tabs are highlighted in orange in the S-Curve Tool v1.0.

There are no snapshots of the “B1 Chart”, “B2 Chart”, and “R Chart” tabs in the current version of the user guide. These tabs contain the Estimate 1 chart in the “Benchmarking” tab, the Estimate 2 chart in the “Benchmarking” tab, and the Reconciliation chart in the “Reconciliation” tab, respectively. These tabs allow users to edit and polish the charts for presentation purposes. For example, data labels can be covered by other data labels on the chart. After users have finished applying all of the desired lines and labels, they can proceed to the corresponding tab with the desired chart and shift the data labels around for clarity. Users can also insert text boxes in this tab.

Figure 8 shows a snapshot of the “Summary” tab with additional comments. All of the parameters for estimates 1 and 2 are displayed within the purple lines. These parameters are primarily obtained from the “Inputs” tab. The user selects the parameters to display in the PowerPoint table by checking/un-checking the boxes within the green lines. Once checked, the parameters are displayed in the table within the orange lines. The user can then copy and paste this table into PowerPoint. For v1.0, the user can select up to 12 different parameters for the base estimate and up to 10 different parameters for the historical adjustment parameters.

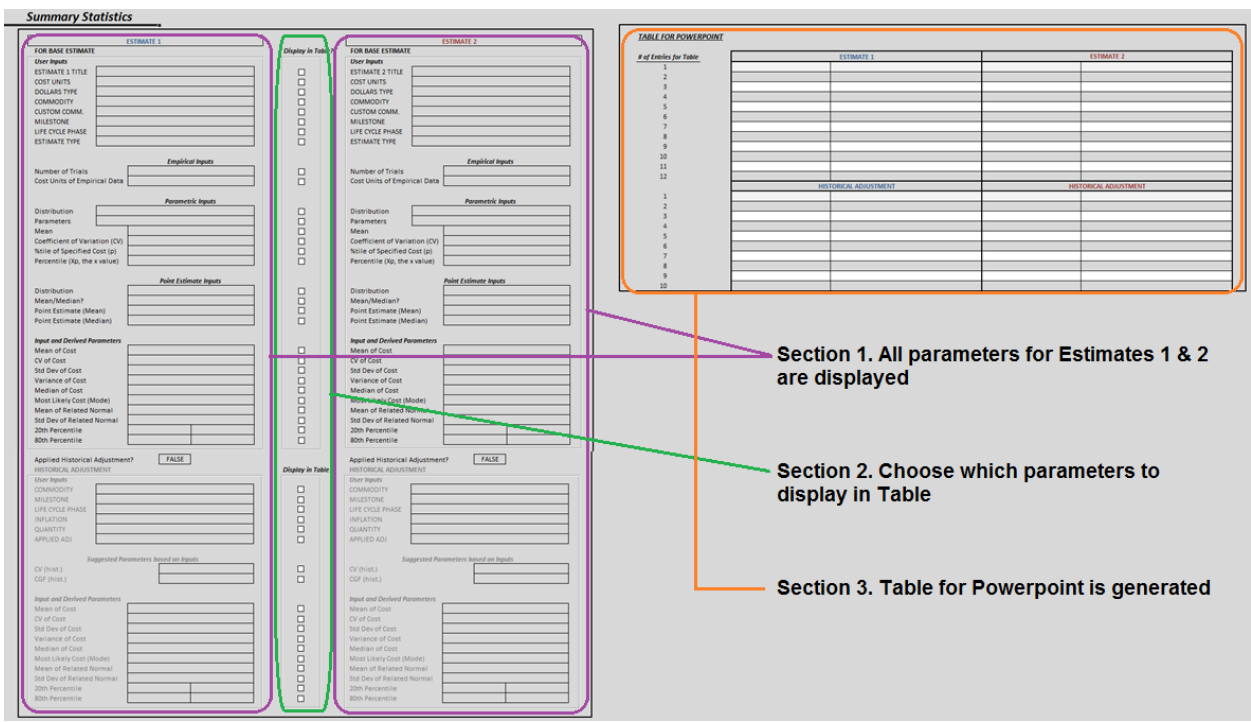


Figure 8: Snapshot of “Summary” Tab, with Comments

Appendix A. Case Studies

Appendix A contains two different case studies, (1) showing the use of the parametric estimate type and (2) showing the use of the empirical estimate type.

Appendix A1. Case Study Showing Parametric Estimate Type

Appendix A1 provides an example for displaying an s-curve using the parametric estimate type. We will attempt to recreate a NATO AGS case study provided by NCCA, which is shown in Figure 9. Listed below are some key points that are used to recreate the chart in the tool.

- Both s-curves have **the same cost value at 50%**
- The blue s-curve has a **CV of 51%**, while the red s-curve has a **CV of 10%**
- The Mean does not equal the Median, implying a **Lognormal distribution**
- **There is a 23% probability of cost increase** relative to the mean of the blue s-curve

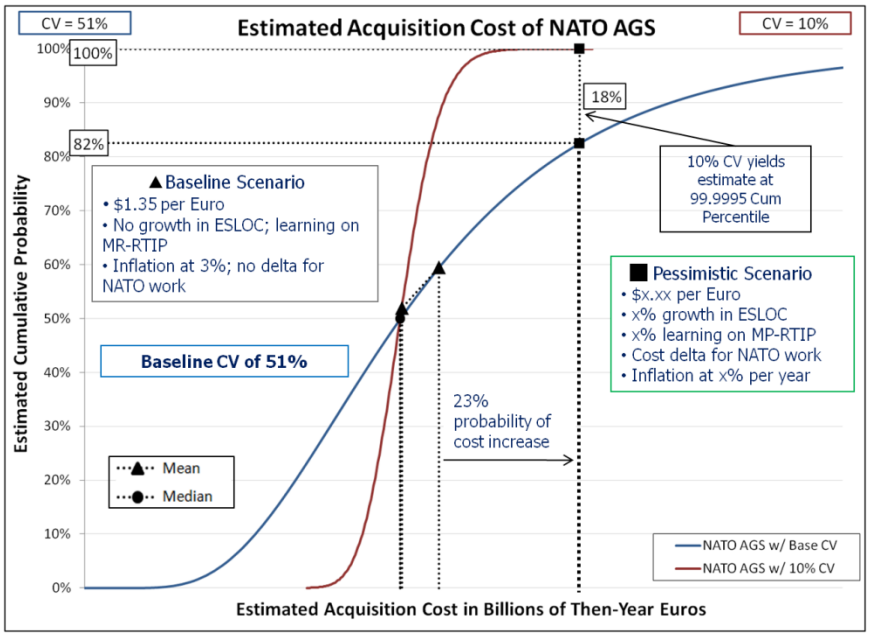


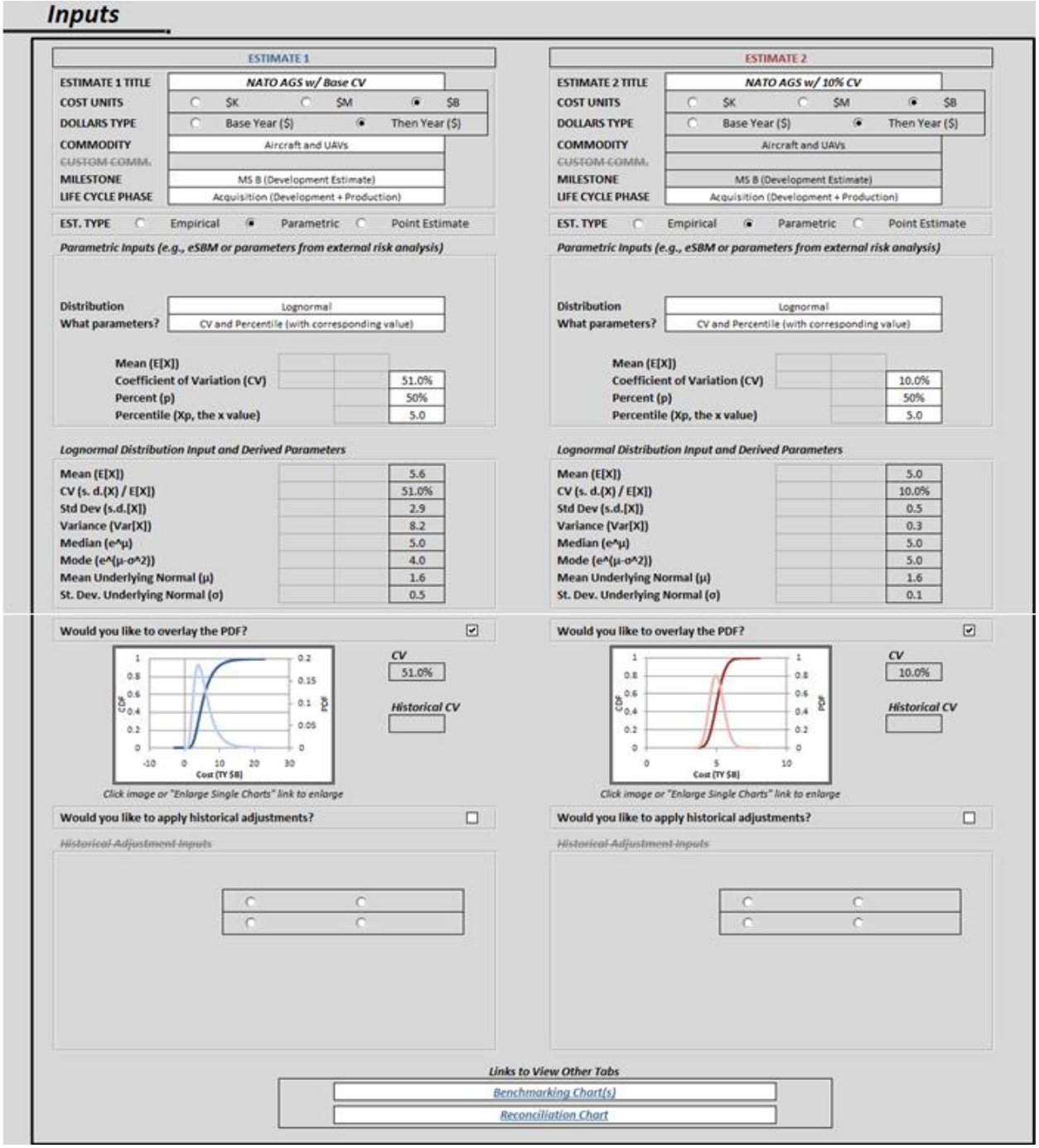
Figure 9: NCCA's NATO AGS Case Study

The first step in recreating the chart is to fill in all of the required parameters in the "Inputs" tab. These inputs are shown in Table 5, which is also developed from the tool ("Summary" tab). Since cost values are not shown in the case study, users can specify any desired "Specified Cost (Xp)", as long as the values are the same. For this example, we used a value of $5 for the "Specified Cost (Xp)" for both s-curves.

ESTIMATE 1		ESTIMATE 2	
ESTIMATE 1 TITLE	NATO AGS w/ Base CV	ESTIMATE 2 TITLE	NATO AGS w/ 10% CV
COST UNITS	$B	COST UNITS	$B
DOLLARS TYPE	TY	DOLLARS TYPE	TY
COMMODITY	Aircraft and UAVs	COMMODITY	Aircraft and UAVs
MILESTONE	MS B (Development Estimate)	MILESTONE	MS B (Development Estimate)
LIFE CYCLE PHASE	Acquisition (Development + Production)	LIFE CYCLE PHASE	Acquisition (Development + Production)
ESTIMATE TYPE	Parametric	ESTIMATE TYPE	Parametric
Distribution	Lognormal	Distribution	Lognormal
Parameters	CV and Percentile (with corresponding value)	Parameters	CV and Percentile (with corresponding value)
Coefficient of Variation (CV)	0.51	Coefficient of Variation (CV)	0.1
Percent (p)	0.5	Percent (p)	0.5
Percentile (Xp, the x value)	5	Percentile (Xp, the x value)	5

Table 5: Required Parameters to Recreate NATO AGS Case Study

Figure 10 shows a snapshot of the "Inputs" tab after all required parameters are filled in. For this example, historical adjustments were not applied to the base estimate. The reasons were (1) the chart already provided CVs for both s-curves, and (2) the chart did not display the historical adjustment inputs (e.g., milestone, life cycle phase) required to obtain the CVs.



Inputs

ESTIMATE 1		ESTIMATE 2	
ESTIMATE 1 TITLE	*NATO AGS w/ Base CV*	ESTIMATE 2 TITLE	*NATO AGS w/ 10% CV*
COST UNITS	$K $M ● $B	COST UNITS	$K $M ● $B
DOLLARS TYPE	Base Year ($) ● Then Year ($)	DOLLARS TYPE	Base Year ($) ● Then Year ($)
COMMODITY	Aircraft and UAVs	COMMODITY	Aircraft and UAVs
CUSTOM COMM.		CUSTOM COMM.	
MILESTONE	MS B (Development Estimate)	MILESTONE	MS B (Development Estimate)
LIFE CYCLE PHASE	Acquisition (Development + Production)	LIFE CYCLE PHASE	Acquisition (Development + Production)
EST. TYPE	Empirical ● Parametric Point Estimate	EST. TYPE	Empirical ● Parametric Point Estimate

Parametric Inputs (e.g., eSBM or parameters from external risk analysis)

Distribution	Lognormal	Distribution	Lognormal
What parameters?	CV and Percentile (with corresponding value)	What parameters?	CV and Percentile (with corresponding value)
Mean (E[X])		Mean (E[X])	
Coefficient of Variation (CV)	51.0%	Coefficient of Variation (CV)	10.0%
Percent (p)	50%	Percent (p)	50%
Percentile (Xp, the x value)	5.0	Percentile (Xp, the x value)	5.0

Lognormal Distribution Input and Derived Parameters

Mean (E[X])	5.6	Mean (E[X])	5.0
CV (s. d.[X] / E[X])	51.0%	CV (s. d.[X] / E[X])	10.0%
Std Dev (s.d.[X])	2.9	Std Dev (s.d.[X])	0.5
Variance (Var[X])	8.2	Variance (Var[X])	0.3
Median (e^μ)	5.0	Median (e^μ)	5.0
Mode (e^(μ-σ^2))	4.0	Mode (e^(μ-σ^2))	5.0
Mean Underlying Normal (μ)	1.6	Mean Underlying Normal (μ)	1.6
St. Dev. Underlying Normal (σ)	0.5	St. Dev. Underlying Normal (σ)	0.1

Would you like to overlay the PDF? ☑

Click image or "Enlarge Single Charts" link to enlarge

CV 51.0%

Historical CV

Would you like to apply historical adjustments? ☐

Historical Adjustment Inputs

Links to View Other Tabs

Benchmarking Chart(s)

Reconciliation Chart

Figure 10: Snapshot of "Inputs" Tab to Recreate NATO AGS Case Study

The second step in recreating the chart is to compare the two s-curves and display the desired parameters. Since we are not comparing a single estimate with its historical adjustment, the "Benchmarking" tab is not used. The "Reconciliation" tab is used to analyze and overlay both s-curves on the same chart. From NCCA's example, one of the displayed parameters is the 23% CDF delta above the mean of the blue s-curve. Therefore, enter in 82.5% (59.5% + 23%) into the custom percentile cell. The calculated cost at 82.5% is $7.8 (assuming that the cost at 50% is 5.0 from the "Inputs" tab). The user will need to enter $7.8 into the custom cost cell to display the difference in CDF (vertical difference). If the user decides to display the custom percentile, the difference in cost (horizontal difference) will be shown. Figure 11 shows a snapshot of the "Reconciliation" tab with all the required inputs to recreate the NATO AGS example.

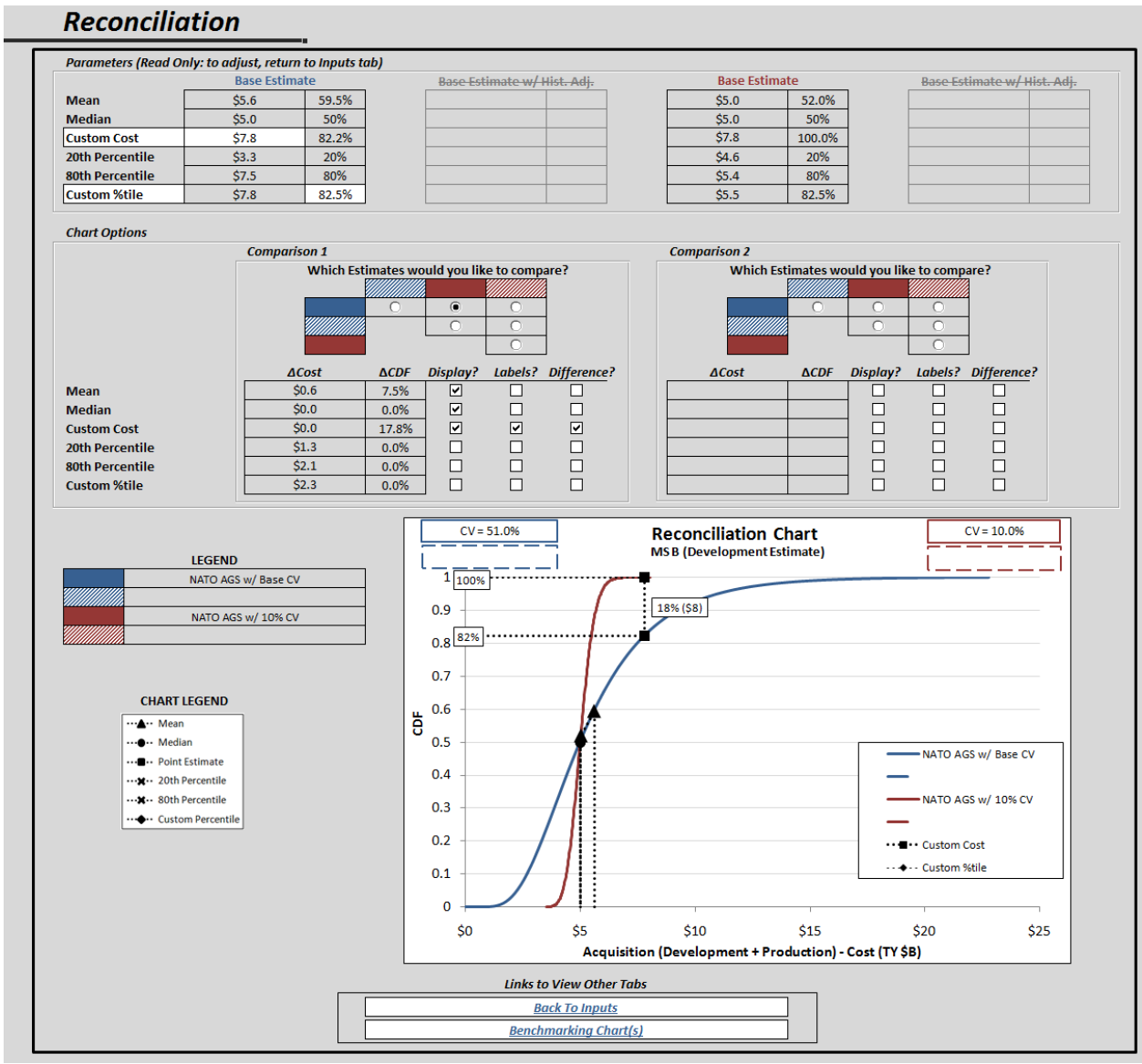


Figure 11: Snapshot of "Reconciliation" Tab to Recreate NATO AGS Case Study

The final step is to add additional text boxes and edit the labels for the chart. The chart shown on the left of Figure 12 is the chart that is displayed in the "R Chart" tab in the tool (also shown in the "Reconciliation" tab). To develop the final chart, which is shown on the right in Figure 12, the following items were added /edited on the chart.

- Edit title, y axis label, and x axis label on chart
- Remove x axis and change units of y axis to "%" (The x axis is only removed from this case study because it did not exist in the original chart due to proprietary reasons. The x axis should not be removed for other analyses.)
- Remove subtitle and CV boxes for historical adjustments
- Remove additional series in the legend
- Add text boxes (e.g., Baseline Scenario and Pessimistic Scenario)

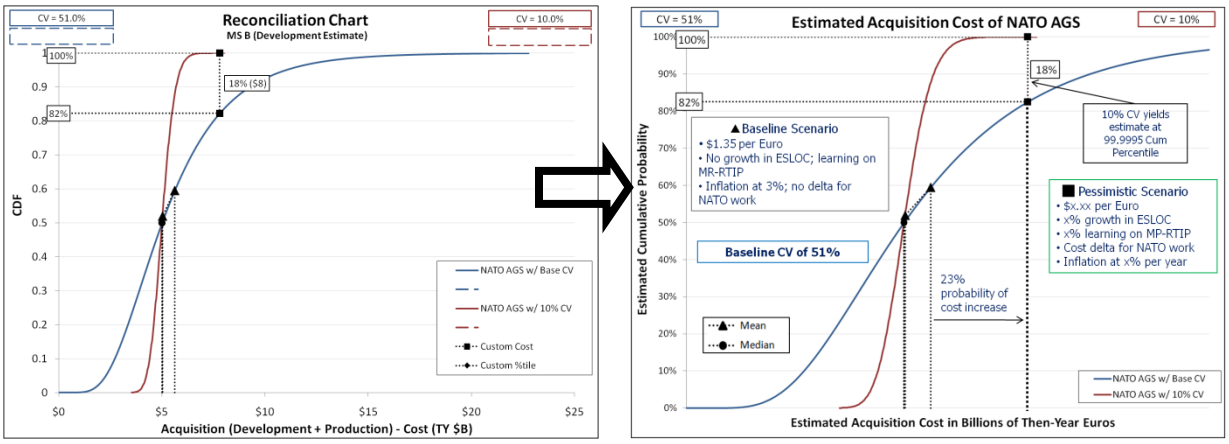


Figure 12: Finalizing the Chart in "R Chart" Tab to Recreate NATO AGS Case Study

Appendix A2. Case Study Showing Empirical Estimate Type

This chapter provides an example for displaying an s-curve using the empirical estimate type in the tool. As previously stated, this tool does NOT perform risk analysis. Therefore, risk analysis will have to be performed with an external program before the empirical data can be inserted into the tool. For this specific example, we are using Crystal Ball as the external program to run Monte Carlo simulations for a sample aircraft program. Listed below are some key points about Figure 13.

- Sample Aircraft Program was based on **500 Monte Carlo simulation trials** using Crystal Ball
- Compared Sample Aircraft Program with historical **DoN Acquisition** Programs
- Displayed the **80th percentile** and the **mean** on the chart

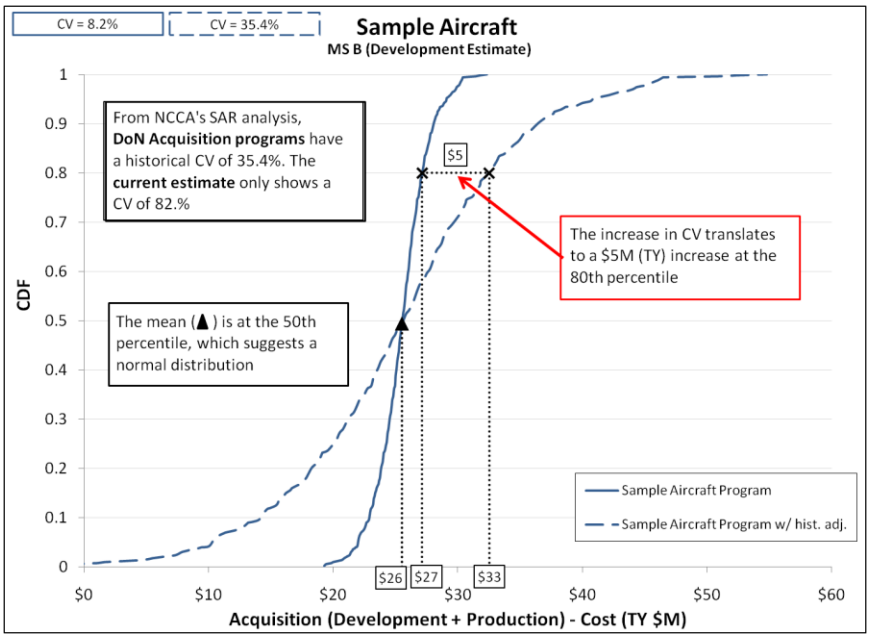


Figure 13: Sample Aircraft Program Using Empirical Data.

The first step is to run the Monte Carlo simulations in Crystal Ball. The risk analysis is not shown in this example. However, we show procedures on how to extract the trial values from the program. The S-Curve Tool can hold up to 10,000 Monte Carlo trials. For this example, we only used 500 trials for our sample aircraft program. The image on the top of Figure 14 shows a snapshot of the Crystal Ball toolbar. After all risk is defined, click on "Run Preferences" in the toolbar and a popup window (shown in the bottom of Figure 14) will appear. Define the number of trials you want to run for the Monte Carlo simulation.

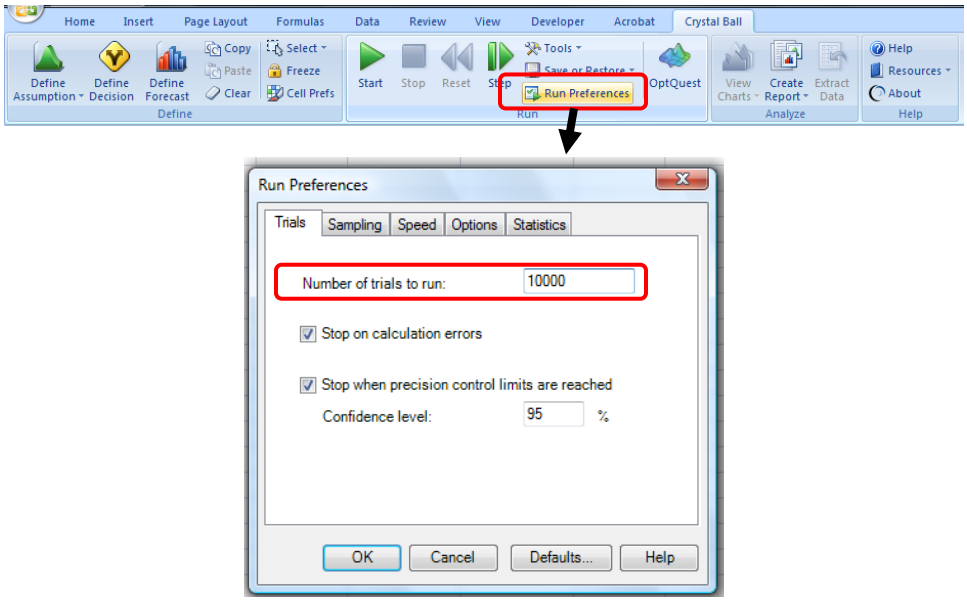


Figure 14: Define the Number of Trials for the Monte Carlo Simulation in Crystal Ball

After Crystal Ball performs the desired number of Monte Carlo trials, the user will have to obtain the raw data and insert it into the S-Curve Tool. To extract the raw data, click on "Extract Data" in the Crystal Ball toolbar (shown in the top of Figure 15) and a popup window (shown in the bottom of Figure 15) will appear. Check the "Trial values" box and click OK. Crystal Ball will open a separate file that contains all of the trial values (shown on the left of Figure 17). This is the complete data set that will be inserted into the S-Curve Tool (more details below).

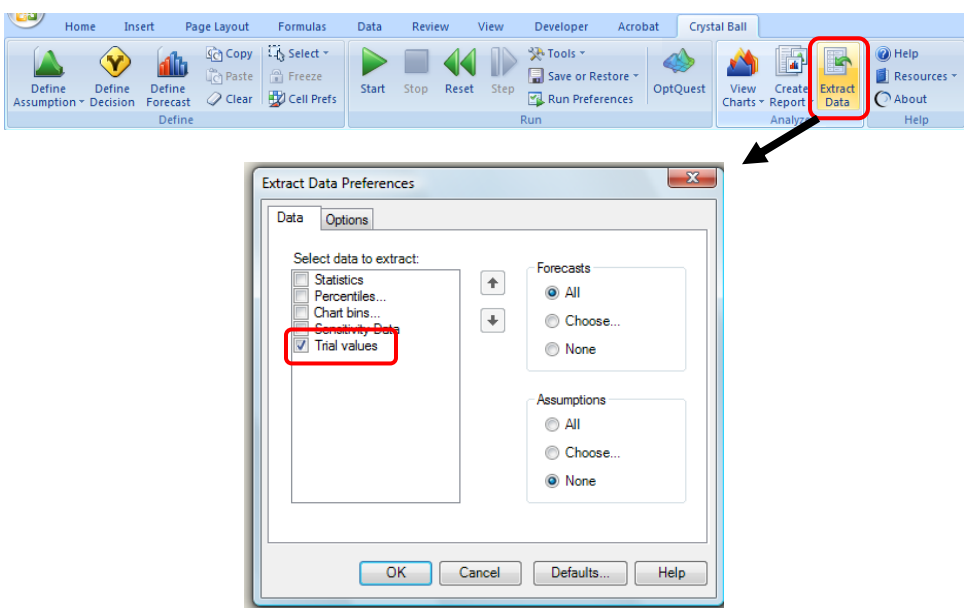


Figure 15: Extract the Trial Values from Crystal Ball

After running the Monte Carlo simulations and extracting the data from Crystal Ball (or any other external program), the second step is to define the estimate and insert the data into the S-Curve Tool. For this example, the parameters used for the sample aircraft program are listed in Table 6. This table is also created in the tool ("Summary" tab).

ESTIMATE 1		HISTORICAL ADJUSTMENT	
ESTIMATE 1 TITLE	Sample Aircraft Program	COMMODITY	DoN Acquisition
COST UNITS	$M	MILESTONE	MS B (Development Estimate)
DOLLARS TYPE	TY	LIFE CYCLE PHASE	Acquisition (RDT&E + Procurement)
COMMODITY	Aircraft and UAVs	INFLATION	BY$
MILESTONE	MS B (Development Estimate)	QUANTITY	adj
LIFE CYCLE PHASE	Acquisition (RDT&E + Procurement)	APPLIED ADJ	Apply only CV
ESTIMATE TYPE	Empirical	CV (hist.)	35.5%
# of Trials	500	CGF (hist.)	1.23
Value for Trials	Values Equal to # of Trials		

Table 6: Required Parameters to Recreate Sample Aircraft Program Case Study

Figure 16 shows a snapshot of the "Inputs" tab after all required parameters are filled in. This excludes the Monte Carlo trials, which are inserted in the Empirical tab (shown in Figure 17). To get to the Empirical tab, users should click on the hyperlink labeled "Click to enter Empirical Data" (circled in red in Figure 16). This hyperlink appears after the user selects "Empirical" as the estimate type.

Based on the five historical adjustment inputs (commodity, milestone, life cycle phase, inflation, and quantity), a suggested CV and a suggested CGF will appear. As stated before, these metrics are derived from NCCA's SAR analysis. In this example, we are comparing the estimate to DoN Acquisition programs. We can also compare the estimate to "DoD Acquisition" programs and "Aircraft and UAVs". These selections are in the commodity list in the "historical adjustments" section of the "Inputs" tab (highlighted in green in Figure 16).

For this example, we elected to apply only the suggested CV for the estimate. Users can also choose to "apply only CGF" or "both CV and CGF" (highlighted in blue in Figure 16).

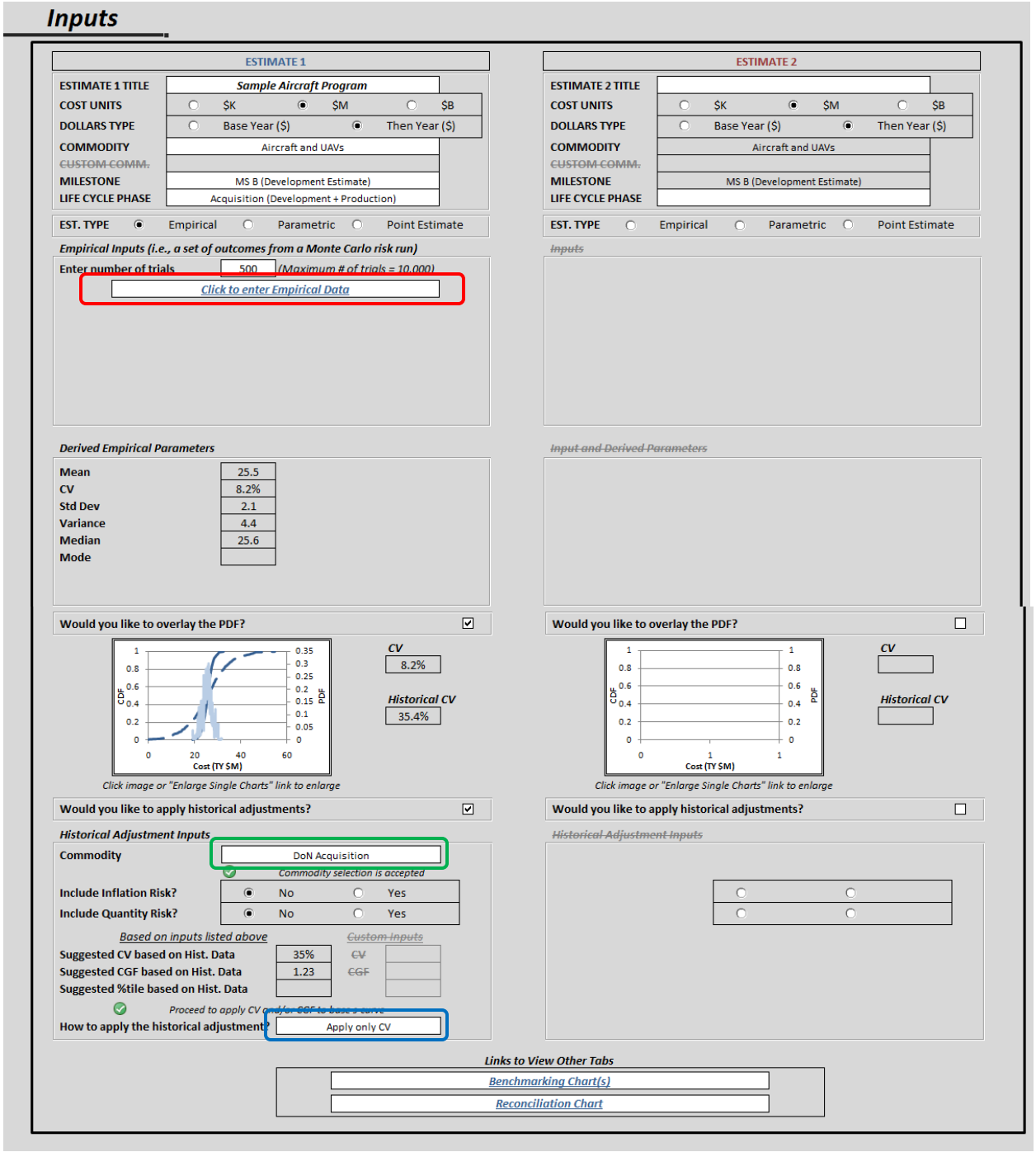


Figure 16: Snapshot of "Inputs" Tab to Recreate Sample Aircraft Program

To enter in all the values for the Monte Carlo simulation, the user will have to proceed to the "Empirical" tab. Figure 17 shows a snapshot the raw data from Crystal Ball (shown on the left) and the location where the data is inserted in the S-Curve Tool (shown on the right). Values extracted from Crystal Ball are usually in dollars. Users will have to define these cost units in the "Empirical" tab (highlighted in green in Figure 17). The tool will convert the units of the Monte Carlo trials into the cost units that were selected in the "Inputs" tab (for this example, converted dollars ($) to millions ($M)).

Users also have an option to assess the Monte Carlo simulation for the sample aircraft program (highlighted in red in Figure 17).

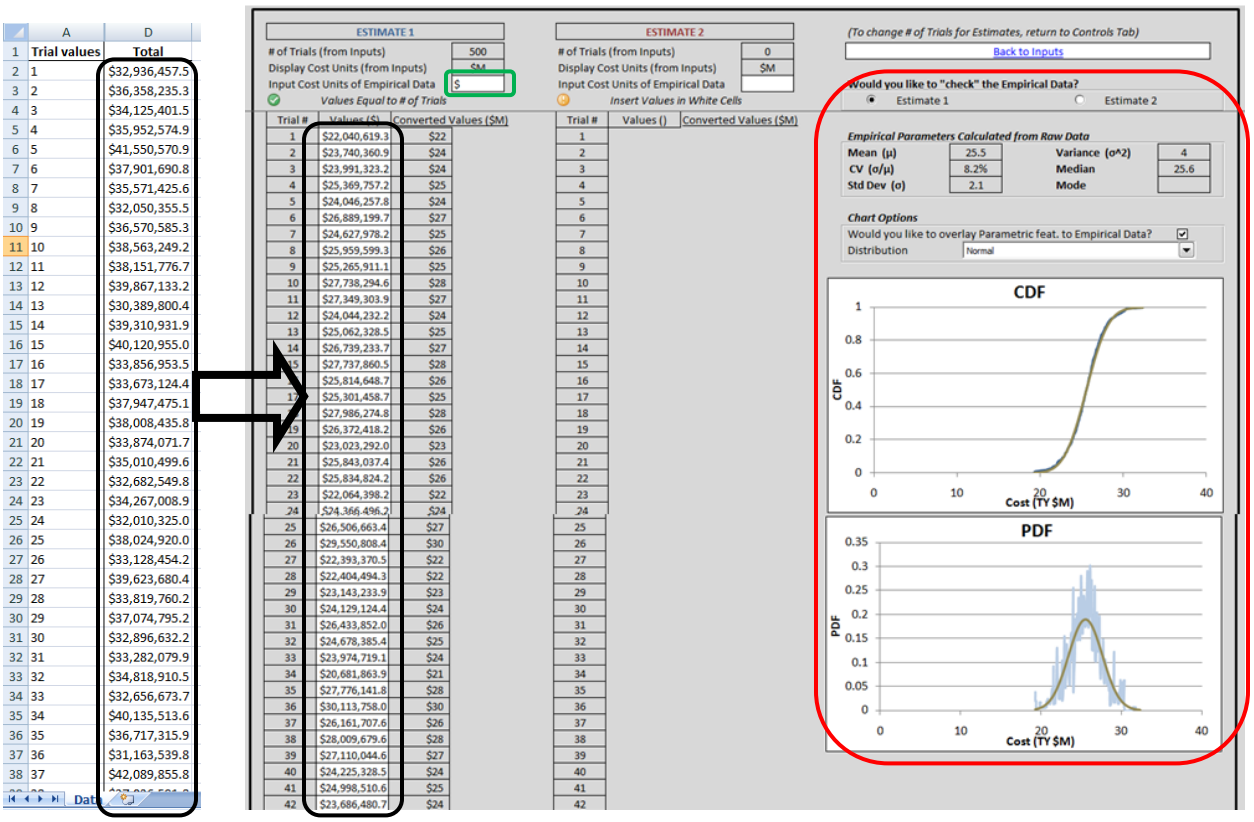


Figure 17: Extracting Data from Crystal Ball (left) and Inserting Data into the Tool (right)

The third step is to apply the chart options on the s-curve. For this example, the “Reconciliation” tab is used to compare the two s-curves. Since this is a comparison between an estimate and the historical adjustment to the estimate, the “Benchmarking” tab can also be used for other analyses. The chart shows the data labels for the mean and the 80th percentile, and the difference in cost at the 80th percentile. Figure 18 shows a snapshot of the “Reconciliation” tab after all the selections have been made. Users can also apply other parameters by clicking the checkboxes.

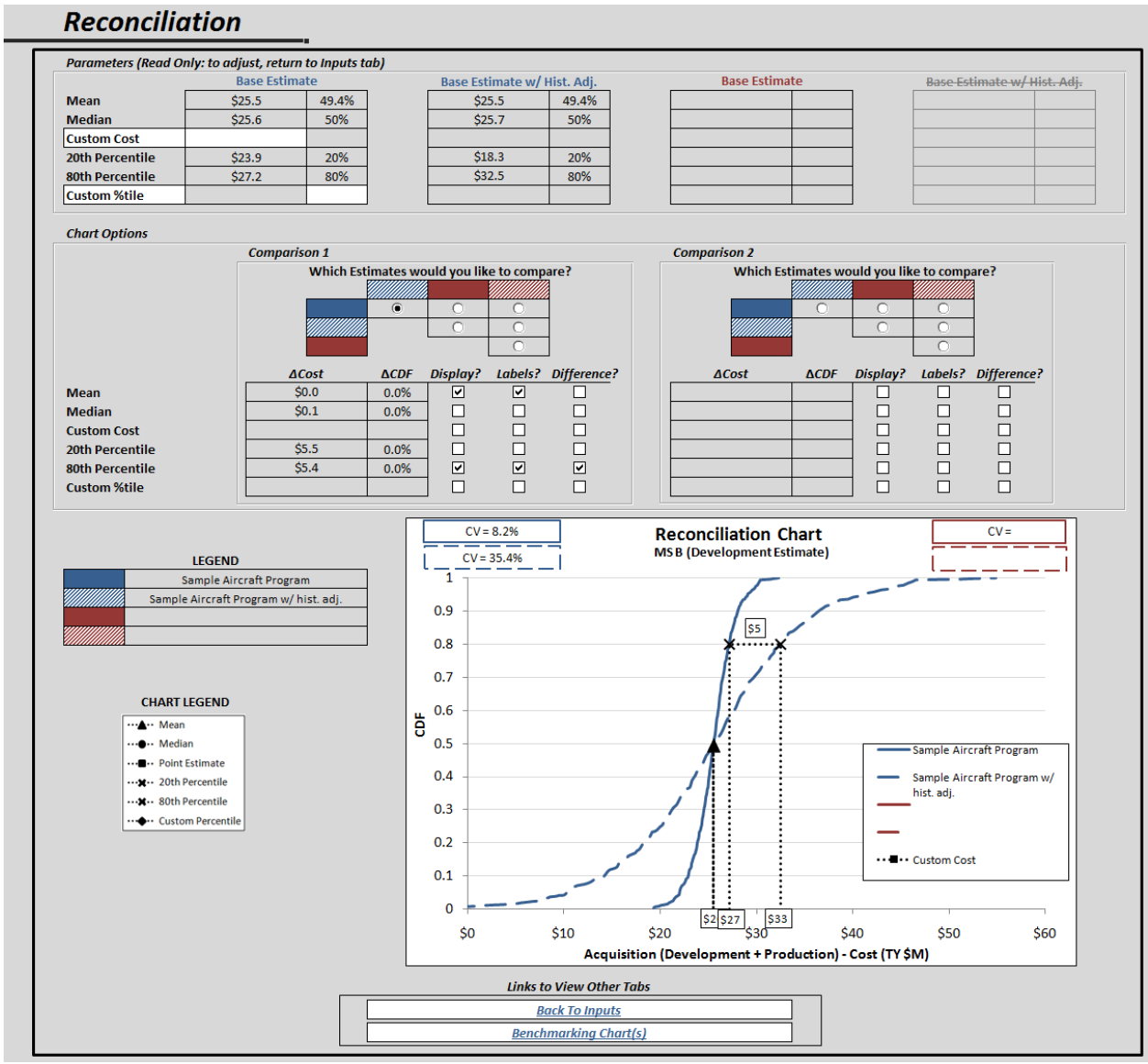


Figure 18: Snapshot of “Reconciliation” Tab to Recreate Sample Aircraft Program

The final step is to add additional text boxes and edit the labels for the chart. The chart shown on the left of Figure 19 is the chart that is displayed in the "Summary" tab in the tool (also shown in the "Reconciliation" tab). To obtain the final chart, which is shown on the right of Figure 19, the following items were edited on the chart.

- The title was changed
- CV boxes for "estimate 2" were removed and CV boxes for "estimate 1" were relocated
- Inputs were removed from the legend
- Text boxes were added

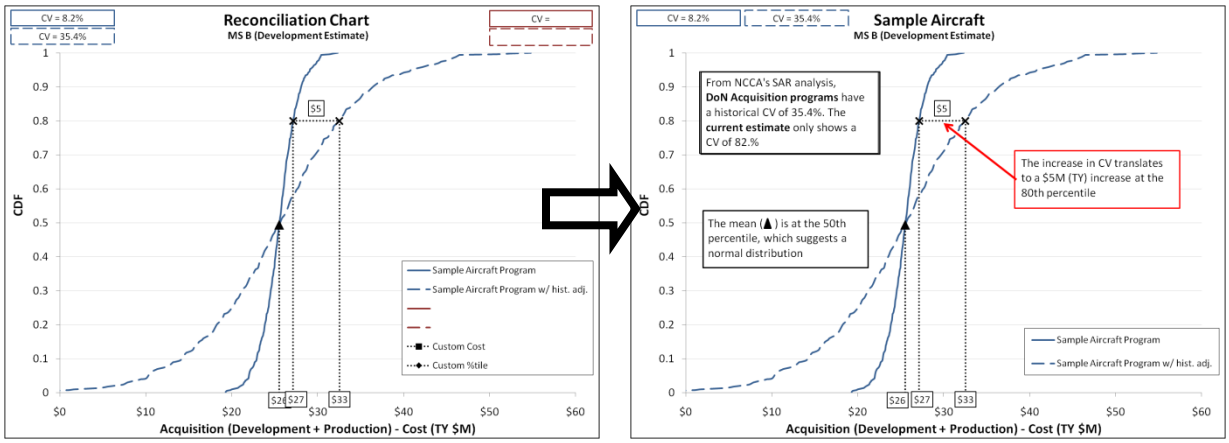


Figure 19: Finalizing the Chart in "Summary" Tab to Recreate Sample Aircraft Program

Appendix B. Snapshots of the S-Curve Tool

This appendix provides more snapshots/details of the tool. The tool contains many cells that appear/disappear based on the selections from the drop down menus or radio buttons. An example is the selection of the estimate type. Table 7 lists all of the possible scenarios for the estimate types. This table will increase if more options are added to the estimate type, distribution, or type of input in future versions of the tool.

# of Scenarios	Estimate Type	Distribution	Type of Input
1	Empirical	-	-
2	Parametric	Normal	Mean and CV
3			Mean and Specified Cost (w/ %tile)
4			CV and Specified Cost (w/ %tile)
5		Lognormal	Mean and CV
6			Mean and Specified Cost (w/ %tile)
7			CV and Specified Cost (w/ %tile)
8	Point Estimate	Normal	Mean
9			Median
10		Lognormal	Mean
11			Median

Table 7: All Possible Estimate Types Incorporated in v1.0

Appendix B1. Custom Commodity

This section explains the "custom commodity" features of the S-Curve Tool. There are currently eight different commodity class options for the base estimate (shown on the left of Table 8). If the commodity for the estimate is not listed in the commodity classes, the user can choose to select "custom commodity" to input a different commodity. The commodity list in the historical adjustment section will only contain DoD Acquisition, DoN Acquisition, and the commodity that the user selects for the base estimate (shown on the right of Table 8).

Commodity List for Base Estimate
Ships and Submarines
Aircraft and UAVs[2]
Missiles and Munitions
Unmanned Space
Electronics
AIS[4]
WTV[5]
Custom Commodity

Commodity List for Historical Adjustment
DoD[1] Acquisition
DoN[3] Acquisition
*Selection from Commodity List for Base Estimate

Table 8: Commodity Lists for Base Estimate and Historical Adjustments

Selecting a custom commodity also means that the tool does not contain a suggested CV and a suggested CGF. Therefore, there is a section where the user can input a custom CV and/or a custom CGF if the custom commodity option is selected (shown in Figure 20).

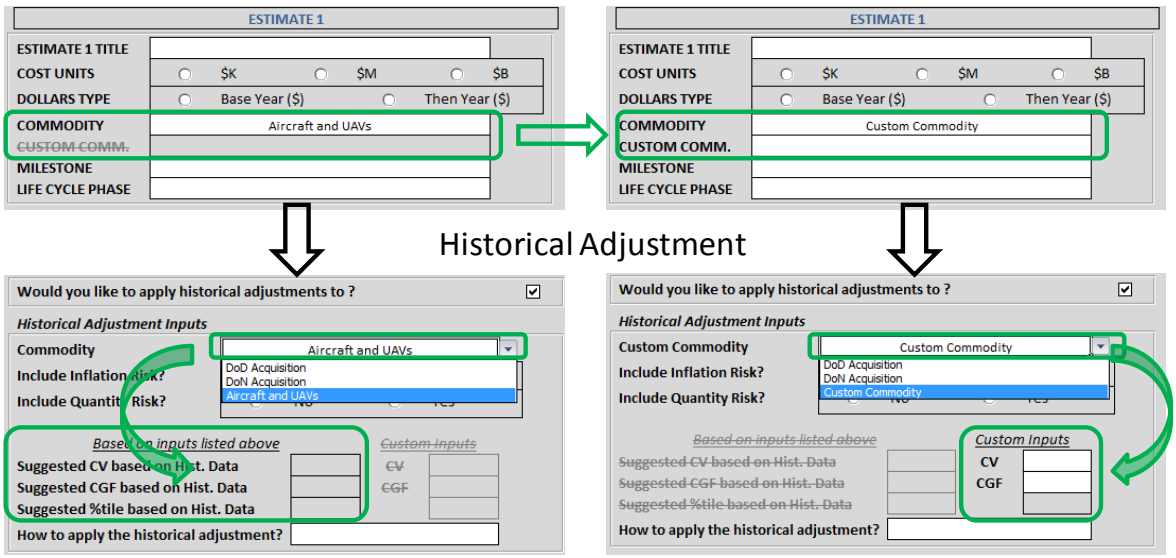


Figure 20: Features in the S-Curve Tool for Selecting Custom Commodity

[1] DoD stands for Department of Defense
[2] UAVs stand for Unmanned Aerial Vehicles
[3] DoN stands for Department of Navy
[4] AIS stands for Automated Identification Systems
[5] WTV stands for Wheeled and Tracked Vehicles

Appendix B2. Empirical Case

This section shows the features of the tool when the user inputs empirical data. When “Empirical” has been selected in the “Inputs” tab for the estimate type, a white cell will appear and the user will have to specify the number of trials. The tool can handle up to 10,000 values. Afterwards, a link is provided to lead the user to the “Empirical” tab. Depending on the number of trials entered in the “Inputs” tab, the same number of cells will appear in white for the user to enter in the empirical data. If the cells are empty, a yellow icon and a message showing “Insert Values in White Cells” will appear. If there are not enough values, a red icon and a message showing “Not Enough Cells” will appear. If there are too many values, the values will appear in yellow and a red icon and a message showing “Too Many Values” will appear. When the user enters in the correct number of values, a green icon and a message showing “Values Equal to # of Trials” will appear.

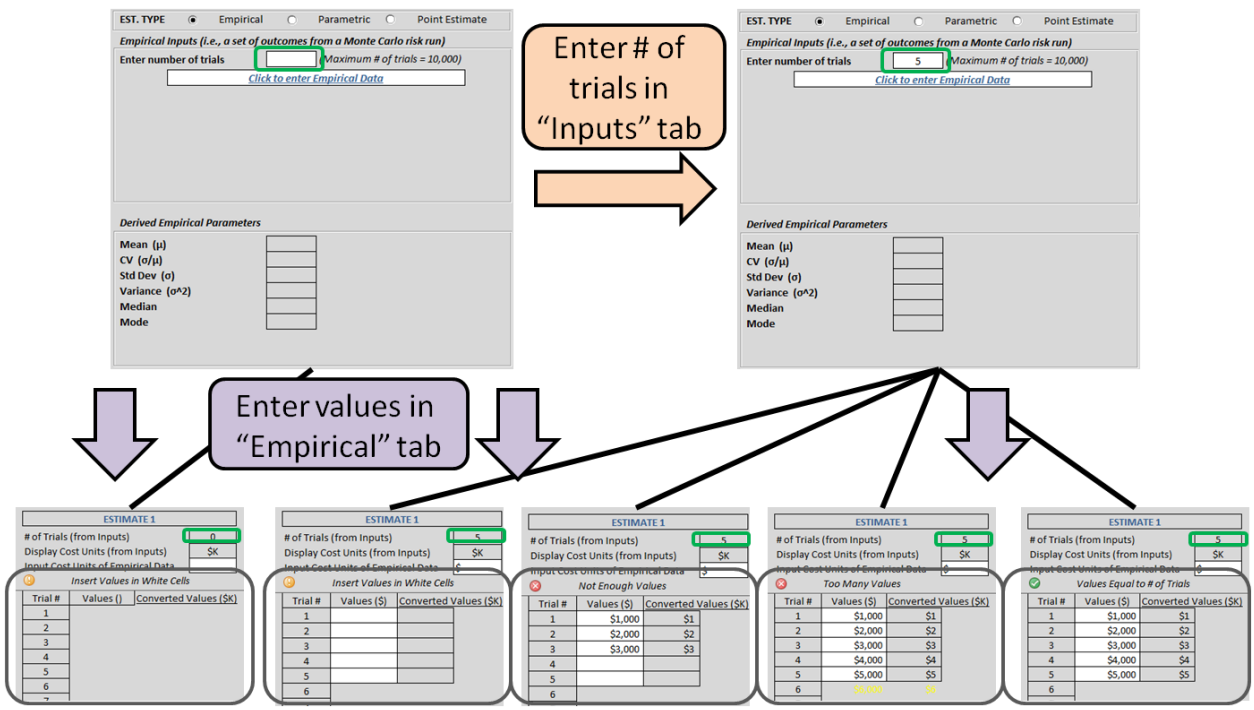


Figure 21: Snapshots of “Inputs” and “Empirical” Tab for Empirical Case

Appendix B3. Parametric Case

This section shows the features of the tool when the user inputs parametric data. After “Parametric” has been selected in the “Inputs” tab for the estimate type, there are two other lists of selections from which the user will have to choose. The first list requires the user to select the distribution, (1) Normal, or (2) Lognormal. The second list requires the user to select the type of parameters, (1) Mean and CV (shown on the left of Figure 22), (2) Mean and Specified Cost w/ corresponding %tile (shown in the middle of Figure 22), and (3) CV and Specified Cost w/ %tile (shown on the right of Figure 22). Depending on the user’s selection of the type of parameters, white cells will appear for the user to enter the corresponding values. After these values have been entered, the grey cells below will be populated with the derived parameters.

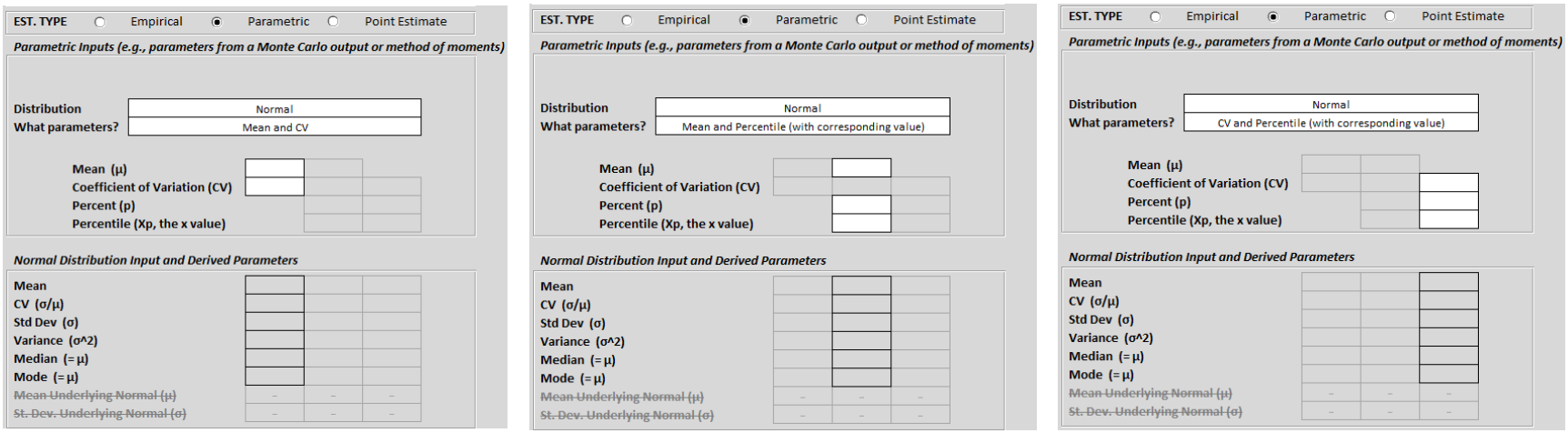


Figure 22 Snapshots of “Inputs” Tab for Parametric Case

Appendix B4. Point Estimate Case

This section shows the features of the tool when the user inputs data for a point estimate. After "Point Estimate" has been selected in the "Inputs" tab for the estimate type, there are two other lists of selections from which the user will have to choose. The first list requires the user to select the distribution, (1) Normal, or (2) Lognormal. The distribution selected will define the distribution applied to the historical adjustment. The second list requires the user to select whether the point estimate represents a (1) Mean (shown on the left of Figure 23), or a (2) Median (shown on the right of Figure 23). When the user selects a mean, the historical adjustment will pivot on the mean, and respectively for the median. Depending on the user's selection of the parameter type, white cells will appear for the user to enter the corresponding values. After these values have been entered, the grey cells below will be populated with the derived parameters.

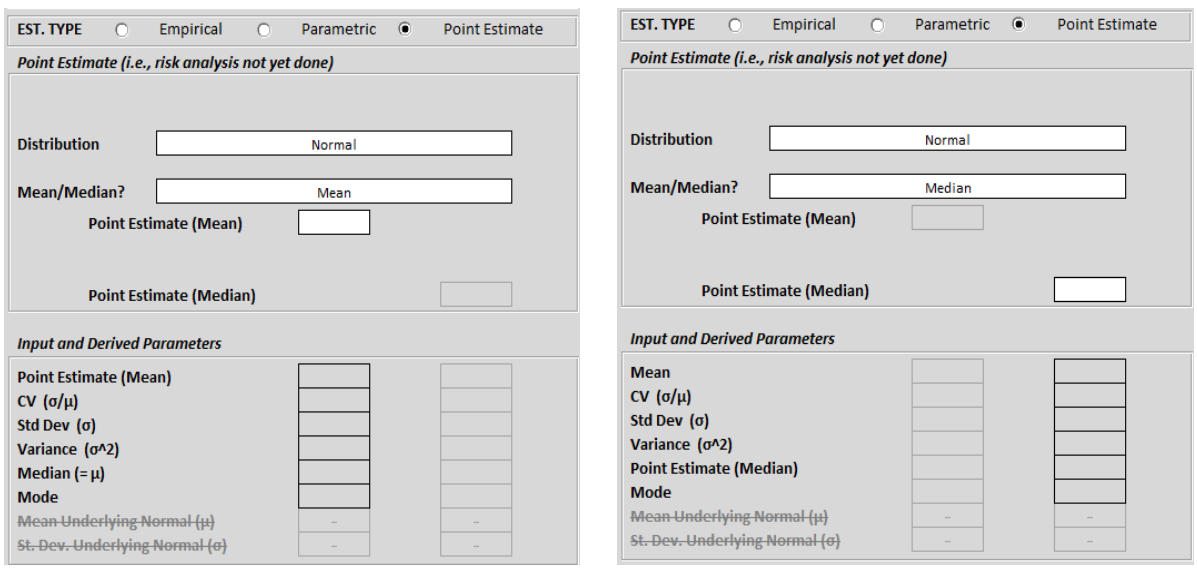


Figure 23: Snapshots of "Inputs" Tab for Point Estimate Case

Appendix B5. Normal Distribution vs. Lognormal Distribution

This section describes the features in the tool when the user selects a normal distribution compared to a lognormal distribution. In the "Inputs" tab, the only difference is in the "Input and Derived Parameters" section. For a lognormal distribution, the mean underlying normal and the standard deviation underlying normal are calculated. For a normal distribution, these parameters are not calculated and the cells are thus greyed out.

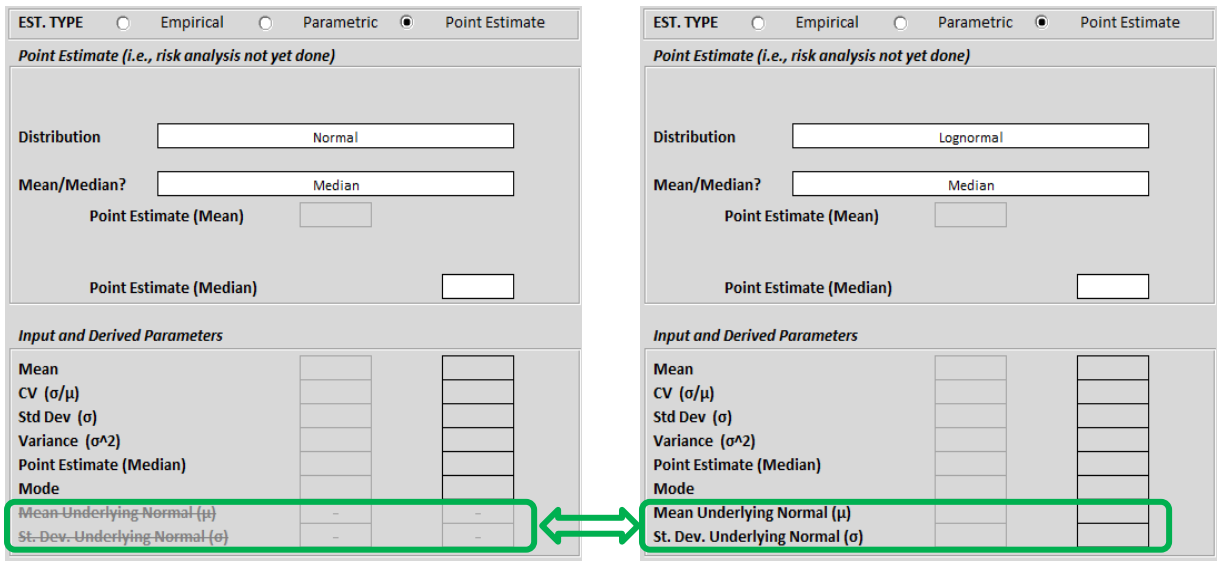


Figure 24: Snapshots of "Inputs" Tab for Normal Distribution vs. Lognormal Distribution