9. Economic Analysis

9.1 Cost Model - C-Class

Cost models are now available at www.worldautosteel.org under Projects. We welcome you to download the working Excel model and use them for your own investigations.

9.2 Cost Model - PNGV-Class

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9.3 Uncertainty Analysis

9.3 Uncertainity Analysis Description

9.3.1. Key Assumptions

The error analysis employed in this effort is a reflection of these considerations. The key structural assumption drawn from the field of statistics is the Central Limit Theorem. This cornerstone of experimental statistics asserts that, for any given sample of data taken from a random data source, as the number of samples increases, the data will be distributed according to a normal distribution – irrespective of the actual statistical distribution that underlies the random data source. Given the central limit theorem, it can then be appropriate to model any statistically random data source as a normal distribution.

The second structural assumption is that, for a normally distributed variable, the standard deviation of the sum of several normally distributed variables is equal to the sum of the individual standard deviations. This is a direct consequence of the mathematics of the distribution, and can easily be confirmed.

Armed with these two key structural assumptions, it is possible to construct a method for the estimation of error in the cost estimates of the ULSAB-AVC study. However, a couple of further assumptions must be made:

- The errors in the cost estimates for each of the subsystems are independent from one another;
- The range of the errors on the cost estimates can be estimated by the analyst, either from experience or based upon cost modeling assessments of input uncertainties; and
- The confidence of the analyst in the range of the errors can be estimated by the analyst.

With these final assumptions, the tool for analyzing the errors in cost estimation can be constructed.

9.3.2 Tool Description

3		Vehicle Subsystem	Cost Estimate	Max Cost Estimate	Min Cost Estimate	Probability that Cost Estimate Is Between Max and Min Estimate
4	1	Powertrain	$1,000	$1,500	$900	95%
5	2	Chassis	$2,000	$2,500	$1,500	95%
6	3	HVAC	$3,000	$4,000	$2,500	95%
7	4	Interior	$2,000	$2,500	$1,500	95%
8	5	Body	$1,250	$2,000	$1,000	95%
9	6	Exterior				
10	7	Electrical				
11	8	Control & Information Systems				
12	9	Assembly/ Vehicle Manufacturing				
13	10	Painting				
14	11	ss10				
15	12	ss11				
16	13	ss12				
17	14	ss13				
18	15	ss14				
19						

Figure 9.3.2-1 Screen shot of error analysis model tool

The above figure shows a set of sample inputs to the error analysis model. Essentially, the analyst must supply five inputs:

- The name of the cost element/vehicle subsystem;
- The baseline cost estimate – i.e., the bottom line estimate of the cost of that vehicle subsystem;
- The maximum and minimum credible costs of the subsystem. These costs can be based on the use of a cost model, using best case and worst case scenarios, or they can be based upon the analyst's experience with the costs of purchased components. In either case, these maximum and minimum costs should represent a credible range of cost values for the specific subsystem; and
- The analyst's estimate of the probability that the actual cost of the subsystem is no greater than the maximum cost and no less than the minimum cost. Again, this probability can be developed using cost modeling tools, or from the analyst's experience with the costing area.

With this information, the model can now estimate the individual variance of each of the cost estimates, and to use them to construct a final error estimate. The estimation of the individual variances takes place in the workarea depicted below:

3	Range	Mean	Implicit # Sigma	Estimated Std. Deviation	Estimated Variance	% variance from symmetry	Weighted Skew Variance	Is there a cost estimate?	Consistent Data?
4	600	1200	1.9	316	99,723	20.00%	200000	1	1
5	1000	2000	1.9	526	277,008	0.00%	0	1	1
6	1500	3250	1.9	789	623,269	8.33%	750000	1	1
7	1000	2000	1.9	526	277,008	0.00%	0	1	1
8	1000	1500	1.9	526	277,008	20.00%	312500	1	1
9								0	1
10								0	1
11								0	1
12								0	1
13								0	1
14								0	1
15								0	1
16								0	1
17								0	1
18								0	1
19									
20	Range	Mean	Implicit # Sigma	Resulting Std. Deviation	Calculated Variance	% variance from symmetry	Weighted Variance (result)	Is there a cost estimate?	Consistent Data?
21									
22	2894	9386.4865	1.2	1206	1,454,294	1.48%	136	1	1

Figure 9.3.2-2 Screen shot of variance tool

Given the maximum and minimum cost estimates, the range (or span) of the estimates is first calculated, followed by an estimate of the mean of the cost estimate (which is essentially the average of the maximum and the minimum estimates). Next, the spreadsheet looks up in a table of the standard normal distribution the number of standard deviations that the range should represent, given the confidence value supplied by the inputs. This result is given in the column titled “Implicit # sigma,” in terms of normalized standard deviations. By dividing the range (or span) by this value, the standard deviation of the distribution implicit in the inputs can be calculated. Finally, by summing the standard deviation of each estimate, the standard deviation of the total cost estimate can be calculated. The variance of the estimate is, of course, merely the square root of the standard deviation.

Because of the nature of the cost inputs, there is no guarantee that the baseline cost estimate and the mean of the distribution will coincide. In order to assure that this “skewness” in the analyst’s inputs is preserved, the percent deviation of the supplied baseline cost estimate from the estimated mean is calculated as “% variance from symmetry,” and this percentage is multiplied by the cost estimate to generate a scaled skewness to be applied to the final results. This “skewness” is summed and then divided by the sum of the cost estimated to yield a weighted skew to be applied to the “central” cost estimate to reflect the asymmetry of the individual estimates.

With these results, the final cost estimate, with error estimates, can be presented, as shown in this example below:

	Resulting Cost Estimate	Max Cost at 80% confidence	Min Cost at 80% confidence	Desired Confidence Level
				1.2 sigma
Base Cost Estimate	$10,393	$10,795	$9,888	80%

Figure 9.3.2-3 Screen shot of resulting cost estimates

The “Resulting Cost Estimate” is merely the sum of the individual cost estimates supplied as inputs. The user supplies the “Desired Confidence Interval” in order to set the desired range of the errors to be represented in the final estimate. This value is again translated into a number of normalized standard deviations, reported in the black cell just above the supplied confidence interval. This factor is multiplied by the sum of the estimated standard deviations of each cost, and the square root is taken to calculate the span of the errors, adjusted by the weighted skew. These maximum and minimum cost estimates are then presented in the two columns adjacent to the final cost estimate.

9.3.3. Summary and Results

This mechanism for estimating the error of a sum of several cost estimates is a reasonable compromise between precision and data availability. While the application of complex Monte Carlo modeling tools is sometimes suggested in these cases, these tools have important limitations. First, they require information that is not generally available, such as the explicit description of the statistics underlying each estimate of every “random” variable in the cost estimate. Second, and more importantly, the central limit theorem guarantees that, irrespective of the specifics of each random variable, the results will converge to a normally distributed value anyway.

The model does put an implicit burden onto the cost estimator to be able to judge the reliability and confidence that should be placed upon the individual estimates generated. However, in many respects, the analyst is likely to be the best person to make such an assessment. And, it is always possible for the users to modify the estimates supplied by the analyst to assess the implications of their own judgments at any time, while the spreadsheet assures that the structure underlying the final error estimates is preserved.