INTRODUCING
AUTOMATED COST RISK ANALYSIS MODEL (ACRAM)©

What is ACRAM?

1. The Automated Cost Risk Analysis Model (ACRAM)© is a proprietary, analytical, Excel-based tool that determines the risk associated with a total cost or budget estimate, given the component costs of that estimate and their individual risk profiles. All risk profiles - for the total and for each of its individual components - are expressed in terms of minimum, Mode, Mean and maximum values.

2. Unlike many cost analysis tools, ACRAM is able to cater for correlation between cost component pairs, so providing three risk profiles of the total cost, namely the inner and outer bounds and the most likely profile somewhere between the two.[1]

3. ACRAM has been validated against Palisade Corporation's @Risk®. It integrates with and takes advantage of the capabilities of @Risk. The unique features of the two tools now complement each other to provide a comprehensive cost risk analysis tool.

4. Although developed primarily for cost risk analysis, ACRAM may be used in exactly the same way for the summation of any set of linear component values (dollars, wheat yields or whatever), any or all of which may have a risk profile about the most likely value (point estimate).

ACRAM Applications

5. The main applications of ACRAM are budgeting, analysis of costs/prices of projects competing for funds and comparison of total costs of competing projects.

6. In the simplest case, management can use ACRAM to estimate the risk profile of a budget and to use that profile to adjust the nominal budget figure and to determine the most accurate contingency figures.

7. In analysis of costs/prices of projects competing for funds, the aim normally is to determine a point estimate for the Life Cycle Cost (LCC) of each competing project, respective risk profiles and consequent shifts in point estimates (Modes) to the Mean values.

8. The third application is the comparison of projects competing for funds, of which tenders are a special case. In order to know whether competing total costs are statistically equivalent or not, management needs to know how close point estimates for the totals may be and to what extent their respective risk profiles overlap. If management decides that total costs are statistically equivalent, efforts may then be concentrated on the comparison of cumulative benefits of respective projects, rather than trying to compare cost effectiveness.[2] Where profiles overlap but not to a statistically significant extent, management may be prompted to order a more detailed cost analysis. Where profiles do not overlap, at least management will know the profile of the successful tenderer and how to best adjust the project budget and contingency provision.

Why is a Cost Risk Analysis Model Needed?

9. A total cost (or budget) is the sum of several or many cost components that, because of many estimating uncertainties, are stochastic variables. Consequently, the total cost is also a stochastic variable. The variability about a mean, between the minimum and maximum values, is a measure of the risk associated with a cost, be it component or total.

[1] Separate technical papers are available that explain the statistical methods applied by ACRAM, especially for incorporation of correlation.

[2] Evaluation of benefits and of risk itself needs to take into account the concept of 'utility'. In the case of risk, utility is needed to evaluate risk aversion, should the importance of a project so warrant the expense of that level of investigation and analysis.

10. The minimums and maximums of component cost risk profiles cannot be simply added to obtain the risk profile of the total cost. Complicated but well documented statistical methods are involved in an analytical approach, especially where correlation between cost components exists.[3]

11. It is rare in practice, whether in costing, budgeting or similar work, for cost components not to be correlated to some extent. Therefore, it is important to estimate the correlation between cost pairs if the risk associated with the total cost is to be estimated accurately.

12. The statistical distributions of the component cost variables (risk profiles) are rarely if ever known in practice. The best and most common approach is to make a three-point estimate for a variable (minimum, mode and maximum) and to assume a distribution that is a function of these three parameters. Such distributions, and the most commonly used in both cost and schedule risk analysis, are the triangular and the PERT[4] distributions. Summation of these distributions can be done analytically but the use of more sophisticated distributions, if known, may render the problem intractable for an analytical model. In that case, one can resort to use of a simulation tool.

13. However, it is important to note that ACRAM produces valid results for assumed triangular or PERT distributions, without resorting to simulation. Nevertheless, ACRAM had to be validated and the simulation capability of Palisade Corporation's @Risk® was used for that purpose.

14. ACRAM was then modified to integrate with and to take advantage of the capabilities of @Risk V4.5. The unique features of the two tools now complement each other to provide a comprehensive cost risk analysis tool.

Why Use ACRAM?

15. Commercial packages are available as tools for cost risk analysis. Two of particular interest are Palisade Corporation's @Risk® and Telecote Corporation's ACEIT®.

16. While the functionality, reliability and usability of such tools may be comprehensive, the aspect of correlation between component pairs is not always done, done correctly or with ease.

17. Because it exists in practice, correlation has to be dealt with, but its handling poses several challenges: estimation is highly subjective, even for experts, and estimation can be time-consuming because of the potential number of correlation pairs to be estimated (n*(n-1)/2). However, in most practical cases, even for large projects, relatively few of the component costs (probably less than 20 per cent) account for most of the total cost. Consequently, it is necessary only to estimate correlation within these most significant costs. The top 20 candidates may be identified by simple sort and observation, by sensitivity analysis or by using a particular function of @Risk.

18. Among other things, ACRAM incorporates a unique, proprietary method of determining correlation coefficients for component cost pairs that is relatively simple, intuitive and quick. While ACRAM has the capability to document detailed formulae for each component cost, if known, it was designed to take single point estimates, ie where formulae are unknown, such as given in tenders. The ACRAM method provides for the analyst to reverse the formulaic approach by defining each cost component as a set of coefficients (from –1 to +1) across a set of cost drivers (independent variables) specified for the problem at hand. ACRAM then uses a

[3] There is one exception to this statement, namely the assumption of total interdependence between all component cost pairs. This assumption allows determination of the outer bounds of the possible risk profile, but does not occur in practice. Conversely, the assumption that all component cost pairs are totally independent allows determination of the inner bounds of the possible risk profile, but this condition does not occur in practice either. The correct profile is somewhere between the inner and outer bounds, as a function of cost pair correlations.

[4] The PERT distribution is a special case of the Beta distribution.

proprietary algorithm to convert the set of coefficients into correlation coefficients for the identified set of cost pairs.

19. Of particular interest and a major reason for integration of the two tools, was that the correlation matrix determined by ACRAM can be used by @Risk.[5] In addition, @Risk is able to test and adjust the 'consistency' of the matrix, a feature not yet incorporated into ACRAM itself.

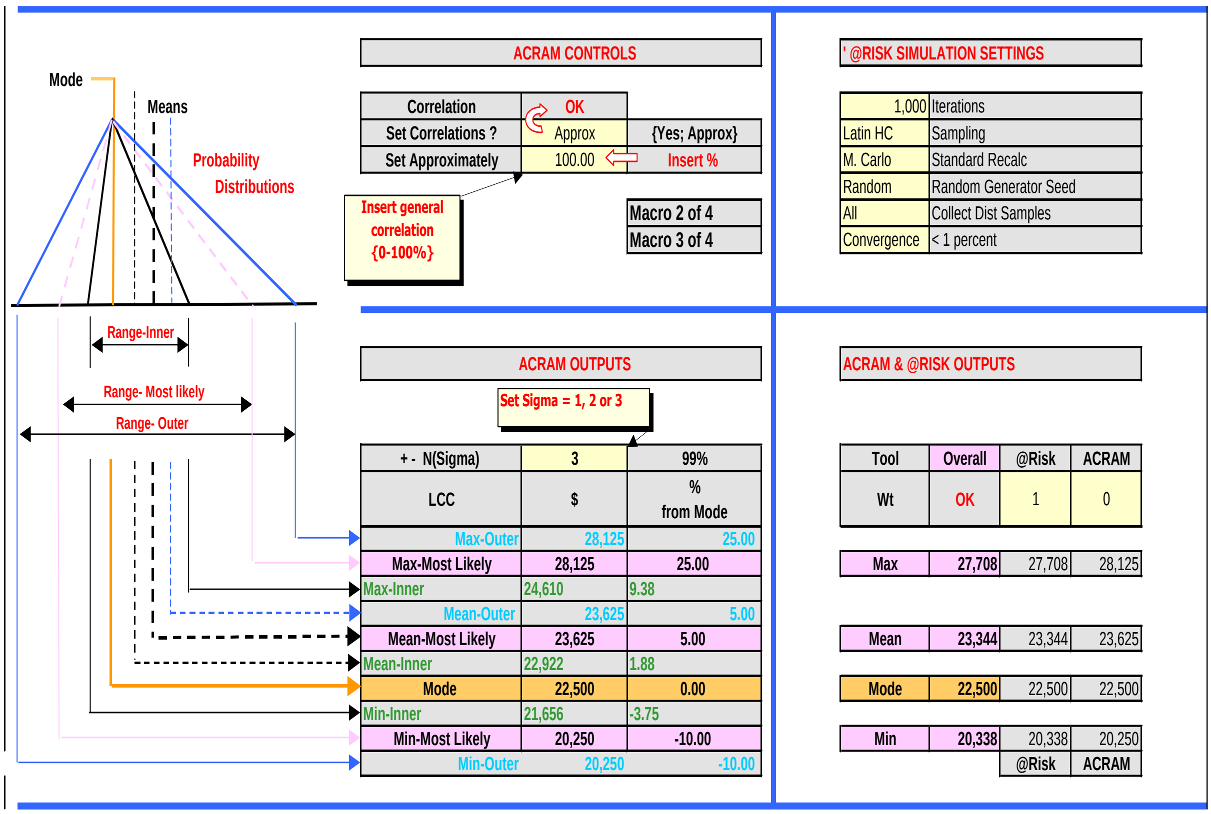

Figure 1
ACRAM Controls & Results

ACRAM Capability

20. ACRAM has the following features and capability:

- analysis of up to 20 cost components (current limitation of correlation matrix, but could be expanded if warranted);
- an analytical mode or simulation mode (using @Risk) or both;
- the analytical mode provides for 'Approximation' and 'Detailed' options for input of correlations;

  ⇒ the 'Approximation' option provides for quick estimates of the outer and inner bounds of the risk ranges, as well as the most likely value, according to the degree of overall correlation across cost pairs[6] (see also Figure 1), and

[5] In @Risk, correlation of cost pairs has to be determined separately and input manually, one by one, into a matrix.
[6] The outer and inner bounds are for respective assumptions of total dependence between cost pairs (all correlation coefficients = 1) and total independence (all correlation coefficients=0). The approximation option

⇒ the 'Detailed' option provides for complete analysis;

- assumption of Triangular or PERT distributions for component cost distributions[7];
- presentation of analytical and simulation mode results, separately, or as a weighted combination;
- provides for results by specified confidence level (up to +- 3 sigma);
- provision for input by analyst of relative weightings for Triangular versus PERT distributions and for ACRAM analytical results versus @Risk simulation results;
- use of a simple and intuitive approach for analysts to estimate cost-pair correlations that demands least time and intellectual effort by analysts and managers;
- provision to specify up to 20 of the most significant cost drivers, as may be most relevant to a given analysis problem, as the basis of estimating cost pair correlations;
- use of a unique and advanced, proprietary algorithm to estimate cost-pair correlations from cost/cost-driver relationships established by the analyst;
- use of software algorithms based on well-established statistical methods;
- detailed instructions for use; and
- fully automated using VBA for Excel.

What the Analyst has to Do.

1. ACRAM is designed to minimise the analyst's effort, according to the difficulty and importance of the problem at hand.
2. In using ACRAM, the analyst:
   - inputs the set of cost components, from whatever source, by Work Breakdown Structure, Cost Name and Cost Value, and flags the lowest indentured component costs[8];
   - assigns a cost risk profile to each cost component, by risk level (from a list of standardised levels based on capital project experience);
   - runs macro 'Data In' [1 of 4];
   - chooses option for setting cost-pair correlations (Approximate or Detailed), depending on importance of analysis and time constraints;
   - for the 'Approximate' option:

     ⇒ inputs a general level of correlation thought to exist across the suite of component costs (from 0.0 to 1.0; the a priori default value of 0.50), and

     ⇒ runs macro 'Do Approx' [2 of 4];
   - for the 'Detailed' option:

     ⇒ reviews and amends the suite of 20 cost-drivers, as relevant to the problem at hand,

     ⇒ sets the coefficients for each cost driver, as applicable to each cost component, and

gives accurate results for these. The approximation option caters mainly for a quick result, given intermediate degrees of correlation, based on an analyst's best guess at overall correlation for the type of problem at hand.

[7] Other distributions could be specified for the simulation solution, if relevant data are known. However, use of the Triangular or PERT distribution is relatively easy and results are satisfactory for LCC applications.

[8] Obviates double-counting in aggregation.

⇒ runs macro ‘Do Detailed’ [3 of 4];[9]

- opens @Risk, reviews simulation settings and runs simulation;
- specifies the confidence range for the LCC estimate (up to +- 3 sigma);
- copies Min, Mean and Max statistics from @Risk Results Window to spreadsheet; runs macro ‘Sort Costs’ [4 of 4];
- sets relative weightings for distributions and analytical versus simulation results[10];
- checks consistency of ACRAM and @Risk results; and
- reads the LCC result in terms of Min, Mode, Mean and Max values.

[9] Macro ‘Do Detailed’ applies the proprietary algorithm that converts the coefficients into cost pair correlations.
[10] May be set for ACRAM only, @Risk only or a weighted combination of the two.

Assumptions

1. Four principal assumptions underlie ACRAM:

   - All cost components follow a Triangular distribution or all a PERT distribution, both forms of which are defined by a minimum, most likely (Mode) and maximum value. This assumption is robust, accurate enough given the subjective nature of risk analysis, and is supported by academics and industry as simple yet effective.
   - In the analytical mode, each side of the assumed distribution, about the Mode, is assumed to approximate one side of a normal distribution. It is further assumed that the relationship between Standard Deviation and the normal probability distribution will hold also for the assumed distribution, eg that plus or minus three Sigma encompasses about 99.6 per cent of all values in the cost distribution.
   - The 'Approximate' option assumes a general level of correlation to exist across the suite of component costs and the selected value for correlation is assumed to apply to all cost-pairs. A general value from 0.0 to 1.0 may be set. In the absence of better information, the a priori default value of 0.50 should be used.
   - In determining correlations, their values are a function only of the coefficients assigned to the independent variables (cost drivers) for each cost component in a correlation pair.

How to Best Apply ACRAM?

1. While it may be modified, ACRAM is currently limited to evaluation of 20 lowest indenture costs comprising an aggregation.
2. Because the purpose of ACRAM is to perform risk analysis and not cost analysis such as an LCC, it need only consider the most significant costs of a cost analysis. These rarely exceed 20.
3. If significant cost components (drivers) should exceed 20, sub-aggregations need to be defined. In the case of an LCC, the first level should comprise the recognised sub-divisions of LCC, namely Research and Development Cost (if applicable), Acquisition Cost, Operating & Support Cost and Disposal/Redeployment Cost (if applicable).
4. Where ACRAM is used for sub-aggregations only, the total cost results, including its risk profile, need to be aggregated on a separate spreadsheet.

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