RISK CUBE METHOD to DERIVE COST RISK

This paper describes a means to derive cost reserves to add to point estimates to accommodate identified risks.

Description of Risk Cube

The Risk Cube Methodology is used by the National Reconnaissance Office (NRO), the Missile Defense Agency (MDA), Navy Air Systems Command (NAVAIR), and other Defense Agencies in assessing and managing cost risk. It focuses on identifying risk sources, their severities, and consequences. Figure 1 shows the "standard" version of the (color coded) Risk Mapping Matrix where the vertical axis indicates increasing probability of occurrence of the identified risk item and the horizontal axis the increasing consequence of the risk actually occurring. In this figure, L means Low (green), M medium (yellow), and H high (red)[1].

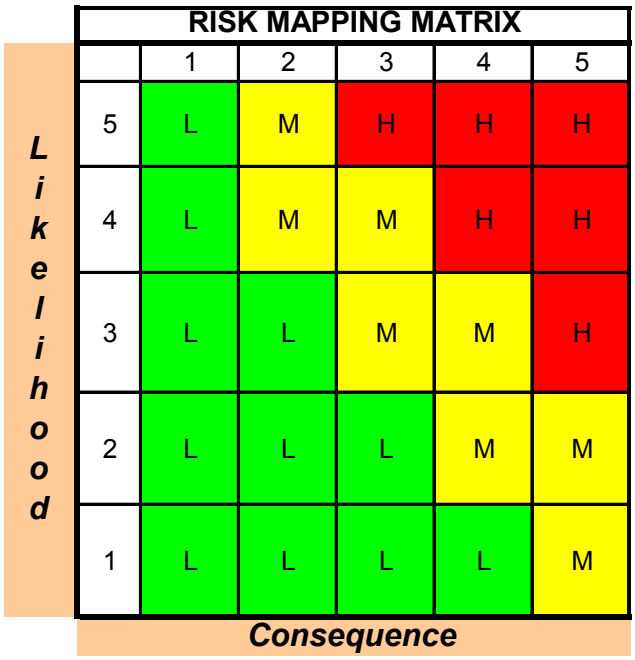

Figure 1 Risk Mapping Matrix - "Risk Cube "

Figure 2 indicates the Probability levels, descriptions, and ranges for the probability levels. Figure 3 shows the Cost Consequence levels, and their ranges. The consequences of risk items on the schedule and technical performance may be similarly constructed; usually, the Probability Table is the same. All of these tables can and should be customized for the program at hand.

Note that some programs explicitly elicit risk statements in the form of, "if this occurs, then the following consequence results," emphasizing the Probability - Consequence of risk and providing a direct link to the matrix.

Probability		
Level	Pf	Definition
1	0.0<P<= 0.2	Low likelihood
2	0.2<P<= 0.4	Low to medium likelihood
3	0.4<P<= 0.6	Medium
4	0.6<P<= 0.8	Medium to high likelihood
5	0.8<P<= 1.0	High likelihood

Figure 2 Probability Scale for Risk Assessment

Cost Consequence Scale	
Level	Cf
1	Min or No Impact 0%<C<=15%
2	15%<C<= 30%
3	30%<C<= 45%
4	45%<C<= 60%
5	C >60%

Figure 3 Cost Consequence Assessment

Steps in Cost Risk Determination

The steps to follow are as follows.

Specific domain experts identify risk items and estimate their Probability of occurring (Pf) and Consequence (Cf). The Risk Mapping Matrix, Probability, and Consequence on Cost (appropriately adjusted as necessary for the program) will be used to summarize and track all risks. The hardest part is estimating probabilities. However, domain experts, who are usually engineering staff, are more comfortable with this method than with other methods since it can be related to physical conditions, point designs, and point cost estimates.

- Risks are linked to the Work Breakdown Structure (WBS).
- Risk scoring is converted to a percentage, i.e., a probability with range 0 to 1.
- A Risk either occurs or it does not; therefore, there is a probability of occurring, which is considered a success, or not occurring, which is considered a failure. As in the Binomial Distribution such events are Bernoulli trials.
- For random variables (the Risks), the expected value of the sum of the variables equals the sum of the expected values and the variance of the sum is the sum of the variances for uncorrelated (statistically independent) variables. This means:
  - The Mean Value of any Risk = Pf x Cf,
  - The Total Risk = $\sum$ Pf x Cf, and
  - The Variance of any Risk = Pf x (1-Pf) x Cf.
- Assume the Pf for each Risk is Uniformly distributed over the range 0 to 1.0, then use Monte Carlo Simulation to combine the point cost estimate with cost risk impact:
  - IPE = Initial Point Estimate
  - If a single draw from the simulation yields a result $\leq$ Pf, then the Risk is applied, otherwise it is not applied.
- Risk dollars = IPE x Cf.

- Add the risk amount computed to the IPE for that element. Trace it to the WBS.
- The sum of all risk amounts is the amount of *contingency reserve* dollars to set aside to perform work on these *identified* risks *should it be necessary* to handle them *if they occur*.

EXAMPLE

As an example, assume there are four Risk Elements identified and traced to the WBS – A, B, C, D. Each Element has an associated computed cost – an Initial Point Estimate (IPE) – then a Probability of occurrence, Pf, and Consequence of occurrence, Cf are assessed, and these are shown in Table 1. Remember these are only Cost Risks.

RISK ELEMENT	Initial Point Estimate	Pf	Cf	Mean	Var
A	$ 100,000	0.75	0.40	0.30	0.075
B	$ 250,000	0.25	0.80	0.20	0.15
C	$ 375,000	0.80	0.60	0.48	0.096
D	$ 500,000	0.30	0.70	0.21	0.147
BASE AMOUNT	$ 1,225,000				

Next, a (50,000 run) Monte Carlo Simulation yields the results shown in Table 2.

ELEMENT	A	B	C	D		*Total*
Avg.(Median)	***$29,870***	***$49,555***	***$179,569***	***$105,823***	***$***	***364,816***
Max	$40,000	$200,000	$225,000	$350,000	***$***	***815,000***

The *Average* amount for any Element is less than its *Maximum Possible* amount. Note that the Maximum Risk Cost for any Element = Cf x IPE. This indicates that a likely amount to add to the Base Amount to account for the four identified risks is $364,816 - a moderate risk tolerance position. A very conservative program manager will add the summed maxima, $815,000, to the Base Amount to cover the risks.

Discussion

The ranges in a program specific Risk Cube may be used as a starting point to assign probabilities. If specific Pf and Cf cannot be elicited from the program personnel after careful questioning, the mid point of a range might be used. Another possibility is to bracket each item by using the top range value for Pf and the high and low of the range for Cf, but this means more computation uncertainty on top of uncertainty. Obviously, the more accurate and specific these values, the better the estimated risk reserve.

Summary and Conclusions

As a Risk Identification, Analysis, and Assessment must be performed for any program, it is natural to expect program personnel to be able to at least use the Risk Cube methodology, from which a cost risk analysis will lead to a reserve budget.

On the positive side, this method is engineering oriented and connects to the risk management process. On the negative side:

- Unknown unknowns are usually not included.
- Small risks are omitted. This becomes important if there are many small risks, which then add up to some sizeable amount.
- There could be bias or lack of familiarity with the program on the part of the estimators. *Program personnel tend to be optimistic*.
- Usually in the WBS, Program Management (PM) and Systems Engineering (SE) are level of effort tasks and each is grouped to manage the entire program, not individually allocated to each element. If the risk occurs, any *additional* PM/SE needed to cover the management of the risk will not be costed by this method.

These last four items indicate that the method tends to underestimate the added cost required for the risk.

[1] R.L. Coleman, J.R. Summerville, **A Survey of Cost Risk Methods for Project Management**, PMI Risk Special Interest Group Project Risk Symposium, 16 May 2004 (Briefing)