THE RELATIVE RISK WEIGHTING PROCESS

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Abstract:
The Relative Risk Weighting (RRW) is a technique for translating technical risks into cost impacts. RRW is part of the Cost-Risk Identification and Management System (CRIMS). In RRW process three technical risk profiles (Pessimistic, Most Likely and Optimistic) of a Work Breakdown Structure element are 'scored' and the scores used to develop ratios that are applied to the point cost estimate as multipliers to generate the high and low ends cost of a triangular distribution.

Key words: *risk, risk management, cost estimate, relative risk weighting*

JEL classification: *C51, D24*

Risk is defined in ISO 31000[1] as *the effect of uncertainty on objectives* (whether positive or negative). **Risk management** can therefore be considered the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Risks can come from uncertainty in financial markets, project failures, legal liabilities, credit risk, accidents, natural causes and disasters as well as deliberate attacks from an adversary. Several risk management standards have been developed including the National Institute of Science and Technology of USA, actuarial societies and ISO standards. Methods, definitions and goals vary widely according to whether the risk management method is in the context of project management, security, engineering, industrial processes, financial portfolios, actuarial assessments, or public health and safety.

The strategies to manage risk include transferring the risk to another party, avoiding the risk, reducing the negative effect of the risk, and accepting some or all of the consequences of a particular risk.

Certain aspects of many of the risk management standards have come under criticism for having no measurable improvement on risk even though the confidence in estimates and decisions increase.

The **Relative Risk Weighting** (RRW) is part of the *Cost-Risk Identification and Management System* (CRIMS). The main point to CRIMS is expressed by the acronym 'ITS' - Identify, Track and Store:

- Identify cost-risk with the *Relative Risk Weighting* Process;
- Track cost-risk with the *Risk Feedback Management Strategy;*
- Store cost-risk with *Cost Risk Database.*

[1] **ISO 31000** is intended to be a family of standards relating to risk management codified by the International Organization for Standardization. The purpose of ISO 31000:2009 is to provide principles and generic guidelines on risk management. ISO 31000 seeks to provide a universally recognized paradigm for practitioners and companies employing risk management processes to replace the myriad of existing standards, methodologies and paradigms that differed between industries, subject matters and regions. Currently, the ISO 31000 family is expected to include:

- ISO 31000: Principles and Guidelines on Implementation
- IEC 31010: Risk Management - Risk Assessment Techniques
- ISO/IEC 73: Risk Management - Vocabulary

The preferred methodology for identification within CRIMS is the Relative Risk Weighting process where three technical risk profiles of a Work Breakdown Structure (WBS) element are 'scored' and the scores used to develop ratios that are applied to the point estimate as multipliers to generate the high and low ends of a triangular distribution. Monte Carlo simulation is used to combine these distributions into a summary distribution from which a cost is selected for budgeting at some confidence level. After contract award, the government and contractor work together in managing the cost-risk with the help of the earned value management system of the contractor. After the contract is over, initial estimates are compared with actual cost results and lessons learned are stored in a database for future evaluation and projections.

The Relative Risk Weighting (RRW) technique was developed from an earlier attempt to integrate the Maxwell Risk Criteria Matrix (MRCM) with the Analytical Hierarchy Process (AHP) performed at the Air Force Space and Missile Systems Center (SMC) of USA to quantify cost-risk due to technical and schedule drivers. The RRW improves on the two basic deficiencies of the MRCM-based approach: of a lack of definitions for the risk categories and level of risk and a rather arbitrary method of establishing scales which quantified the relative magnitude of each risk category.

Much of the end-of-contract cost impact due to risk-driven forces has already been captured by the cost estimate itself. The *cost estimate* is a projection from end-of-contract costs ('actuals'), already containing end-of-contract, risk-driven cost growth. Risk-driven cost growth on the proposed WBS element is likely to be similar to, but not exactly like, that experienced in the past.

The application of RRW process transforms a point cost estimate (excluding expected cost change) into a risk-adjusted cost estimate (including expected cost change) based on an analysis of technical and schedule uncertainties in the form of cost-risk drivers. The analysis is based on an evolved method of relative risk weighting which is based on the Analytical Hierarchy Process (AHP) and which utilizes a matrix of risk drivers. The identifying part of the process depends on establishing and weighting cost-risk driver categories. In acquisition applications, the categories may be established based on acquisition guidelines. Weighting can be aided by pair wise comparisons, aided by computerized decision support software (e.g., Expert Choice).

RRW operate thus:

- The RRW attempts to capture the *incremental* technical cost-risk in a WBS element over-and-above, and under-or-below, that technical cost-risk already captured by the cost estimate;
- The risk-driven cost embedded in the cost estimate is adjusted for the unique technical characteristics of the proposed WBS element;
- This *incremental* or 'marginal' cost-risk exists due to the planned WBS element's characteristics not present in any previous instances of like-WBS elements that are in the database underlying the cost model;
- Relates the worst and best case possibilities to a most likely possibility in terms of riskiness;
- Scenarios should be explicitly described for each case: Pessimistic, Optimistic and Most Likely (Reference) (see Table 1);
- The worst case scenario, the 'Pessimistic Profile', reflects everything that could go wrong actually going wrong, and reflects pessimistic assumptions about achieving the desired specifications;
- The best case scenario, the 'Optimistic Profile', reflects getting lucky on all the things that could go wrong and, as credibly as possibly, assumes that achieving difficult specifications will be relatively easy;

- The most likely case scenario, the 'Most Likely Profile', reflects the achievement of the desired specifications without everything either going all right or all wrong and assumes that some of the specifications will be harder than the initial expectations while others will be easier. The Most Likely case is the only profile estimated for cost. The Most Likely case is also rated with respect to risk. The RRW captures the Most Likely Profile in the risk dimension with a risk 'score' from the weighted risk category matrix. The Most Likely profile is the 'common denominator' between risk and cost, allowing worst and best *cost* cases to be derived through worst and best *technical risk* cases through RRW-derived ratio-factors

Table 1.
Rate WBS Profiles

	TECHNOLOGY	**ENGINEERING**	**COMPLEXITY**	**SCHEDULE**	**TOTAL**
Pessimistic Profile	High	Very High	Very High	High	'SCORE'
Most Likely (Reference) Profile	Moderate	Moderate	Moderate	Moderate	'SCORE'
Optimistic Profile	Low	Moderate Low	Moderate	Moderate	'SCORE'

The RRW technique rates three program profiles (the most likely outcome, a worst-case pessimistic outcome, and best-case optimistic outcome) for each WBS element estimated. Scores are generated from the three rated profiles for the WBS elements by applying the AHP rating scale as ratios to the profile point estimate. This combination derives the "low end" and "high end" estimates without the need of deriving these estimates using the analyst's estimating method (e.g., Cost Estimating Relationships, analogy). The three estimates may be positioned on a triangular-shaped probability density function for each WBS element estimated. Other distributions could be used, but the triangular distribution is relatively easy to analyze and provides a sufficient degree of accuracy.

Simplified RRW approach without the AHP:

- STEP 1: Choose risk categories and *directly* assign weights of relative importance;
- STEP 2: *Directly* assign values for rating intensities in each risk category rating scale;
- STEP 3: Using scale values, rate the WBS's three profiles against risk categories;
- STEP 4: Develop the cost-risk factors (ratios) between Pessimistic/Reference and Optimistic/Reference Risk Scores to apply to the Reference cost estimate.

Example: A new aircraft has to be evaluated for cost-risk

- ***Step 1:*** Work with engineers to assign weights, that sum to 1.0, to each example risk category:
  - TECHNOLOGY 0.35
  - ENGINEERING 0.25
  - COMPLEXITY 0.2
  - SCHEDULE 0.2

    1.0

- ***Step 2:*** Work with engineers to assign weights to rating intensities for each scale by risk category:

	TECHNOLOGY	**ENGINEERING**	**COMPLEXITY**	**SCHEDULE**
Very Low	0.8	0.7	0.9	0.6
Low	1	1	1	1
Moderate Low	2	2.5	2	1.5
Moderate	3	3.5	2.7	2.2
Moderate High	4	4.5	4	3.8
High	5	6	5.5	5.3
Very High	6.5	7.5	6	6.3

- ***Step 3:*** A risk category matrix is developed utilizing risk categories and weighted:

	TECHNOLOGY 0.35	**ENGINEERING** 0.25	**COMPLEXITY** 0.2	**SCHEDULE** 0.2	**TOTAL** RISK SCORE
Pessimistic Profile	High 5	Very High 7.5	Very High 6	High 5.3	**5.9**
Most Likely (Reference) Profile	Moderate 3	Moderate 3.5	Moderate 2.7	Moderate 2.2	**2.9**
Optimistic Profile	Low 1	Moderate Low 2.5	Moderate 2.7	Moderate 2.2	**2**

Reference Profile Calculation: *(0.35)(3) + (0.25)(3.5) + (0.2)(2.7) + (0.2)(2.2) = 2.9*

- ***Step 4:*** Build Pessimistic/Reference Profile and Optimistic/Reference Profile Ratios:
  Pessimistic/Reference = 5.9/2.9 = 2.0 high end risk factor for aircraft
  Optimistic/Reference = 2.0/2.9 = 0.7 low end risk factor for aircraft

A triangular distribution was chosen due to limited amount of information available. Information is only available to precisely specify a triangular distribution, whereas other distributions (e.g., beta, log-normal, etc.) would have to be approximated by secondary calculations.

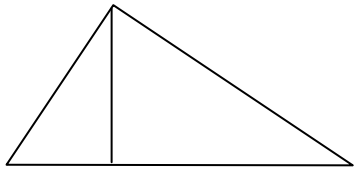

Figure 1. The triangular distribution to obtain the "Low and High end" Costs

The development of the low and high ends of the triangle is the result of factors applied to the point cost estimate (PCE).

Three profiles of the WBS element are rated against the weighted risk categories using the weighted scales and three risk 'scores' are generated representing how risky

each is perceived to be by the raters, mostly engineers. Two ratios are developed from these three risk scores and used as factors on the point cost estimate (assumed to be the most likely in the triangle) to generate the low and high ends of the triangular distribution.

Since the project specifications are rated for the Reference Profile and result in the Reference Profile risk score and the project specifications result in the Reference Point cost estimate for that WBS element, there is an implied *equivalency* between the Reference Profile risk score and the Reference Point cost estimate. In other words, the Reference Profile risk score represents the WBS in qualitative, technical risk form. The Reference Point cost estimate represents the WBS in cost form. It is this equivalency that justifies the application of the ratios to the point cost estimate that generates the upper and lower bounds of the cost-risk triangle.

Why this risk weighting is "relative"? Because:

- Risk in the proposed WBS is relative to the instances of like-WBS's that have been developed before;
- Pessimistic and Optimistic profiles are relative to what is expected, that is, to the 'Reference' profile;
- The RRW process takes both relativities into account;
- All profiles are rated relative to the project specifications or some other technical description;
- Once all three profiles are rated and a risk 'score' is obtained for each, ratios are developed between the Pessimistic and Optimistic scores and the Reference score;
- These ratios become factors applied to the Reference cost to derive the low and high ends of a triangular distribution.

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