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ACQUISTION RISK ANALYSIS INTEGRATED SYSTEM

By

HAMED KAMAL ELDIN

Oklahoma Sate University

Stillwater,Oklahoma 74078

ABSTRACT

Over the years, there has been continuing cost growth in weapon system acquisition programs. Studies have been conducted to explain the causes of this cost growth. Risk and uncertainty is a common factor in major programs and it has been indentified as a significant cause of cost growth. It is apparent that cost growth can be reduced and controlled by specifically allowing and considering the risk involved.

The purpose of this paper is to develop an no-going formal methodology for review and analysis to indentify and evaluate risks and uncertaintites in technical, schedule, cost, functional performance and other categories of uncertainty at the different phases of the acquisition process and their interrelationships.

1.INTRODUCTION

Since the late 1960's and early 70's the problem of cost growth and its relationship to risk and uncertainty has been recognized. There is a large body of knowledge concerning risk analysis of various techniques and their application to specific programs.(Appendixes A,B,C)

However, investigation revealed that this considerable knowledge concerning risk analysis is not widely recognized or known by most project managers. In making decisions these managers use subjective measures in evaluating risk. There is a need for a formal methodology,preferably more objective and more quantifiable to indentify and evaluate risk.

This paper discusses a systematic approach to develop this methodology.

II.SYSTEM FRAMEWORK

This program will be guided by the framework for Acquisition Risk Analysis Integrated System (Figure1) There are three parameters to be considered.

A. Acquisition Process Phases:

1. The Conceptual Phase. During this phase, the technical.military and economic bases are established, and management approach is formulated. The program decision following this phase determines subsequent system progression.

2. Validation Phase. During this phase, major program characteristics are validated and refined, and program risks and costs are assessed resolved, or minimized. A ratification decision is sought when the confidence of success and cost realism becomes high enough to warrant progression to the next phase or conversely, the confidence of failure becomes certain enough to warrant termination.

3. Full Scal Development Phase. During the third phase, the design, fabrication and testing are completed, and costs are assessed to ensure that the program is ready for the production phase.

4. Production and Deployment Phase. During this period, the system is produced and delivered as an effective, economical, and supportable system. Entering into the deployment phase signifies that the system has reached its operational ready state and is turned over to the user.

B. Major Categories of Uncertainty:

1. Target Uncertainty involves a lack of knowledge concerning what end items are desired and what criteria should be used to evaluate them; stated another way, it is the uncertainty associated with reducing users need to cost, schedule, and performance goals.

2. Technical Uncertainty involves solving technical problems; it addresses the question of whether a system can be developed at all or the degree of difficulty which will be involved in building it.

3. Internal Program Uncertainty involves how a program should be planned an managed; it is uncertainty inherent in selecting a particular managerial strategy of dealing with a given problem.

4. Process Uncertainty involves the program's interaction with the external environment and revolves around uncertainty over the availability of resources required to complete the program, and the criteria and thresholds employed in program approval.

C. Decision Making Situation:(Appendix A)

1. Decision Making Under Certainty(characterized by the complete knowledge of a system, and implies that there exists only one feasible state nature for each possible course of action). Once a decision is made, the outcome is known and stable as far as the decision maker is concerned.

2. Decision Making under Conflict. This situation occurs when the states of nature facing the decision maker are the potential courses of action for a competitor.

3. Decision Making under Risk(characterized by some knowledge of the system). Implies that for each course of action there is more than one possible resultant states of nature each of which can be assigned a likelhood (probability) of occurrence.

4. Decision Making under Uncertainty (characterized by imperfect knowledge of a system). Implies the existence of several states of nature for each possible course of action. Also implies the decision maker is unable to assing probabilities to the likelihood of occurrences of future events.

The main three parameters are assembled to produced a three dimensional cube. Every cell of the cube represents the subsystem for decision making within the three levels. For example, the shaded cell of Figure(1) represents the risk analysis of technical uncertainty in the conceptual phase of the acquisition process.

The cube represents the integrated system for acquisition risk and uncertainty analysis. The ultimate objective is to cover all the cells of the cube. These cubes represents the subsystems or modules of the more all-encomparing system for the acquisition process decision making system. The total system, consisting of all the modules and their interfaces, represents a requirement for a well-defined plan over a long term of consideration.

This cube concept also serves another purpose; by indentifying the models derived from previous studies and assigning to the different cubes, we can indentify the areas where more analysis is required for risk and uncertainty evaluation.

III. METHODOLOGY FOR EVALUATION OF RISK AND UNCERTAINTY

1. Form a risk analysis task force with appropriate expertise. Construct a program network and specify critical events.

2. Indentify problem areas: for each phase of the four acquisition process phases, indentify the areas of potential uncertainty and consequence of failure. Starting with the conceptual phase, indentify the uncertainty categories that would be candidates for assessment and evaluation . For example : Technical uncertainty is the conceptual phase.

3. Within each category of uncertainty, indentify the decision making level of uncertainty.
   For example: Risk analysis for technical uncertainty in the conceptual pahse.

4. Within each level of uncertainty, indentify methods of solution and the appropriate technique that can be utilized (Appendix B).

   a. Whenever appropriate, develop a mathematical model to include the factor affecting the decision.

   b. Collect the relevant data related to the relative frequencies and strengths of events and the outcomes of alternatives are assessed.

5.Evaluate the different alternative and make one or more choices among these alternatives. This will require tradeoffs between economic costs againts the costs of reducing risk. At this stage indentify:

a.Requirements versus tradeoffs.

b.Adequacy of acquisition time.

c.Sufficiency of appropriation.

d.Optimum allocation of funds.

6.Implement the decision and evaluate result. If results is not satisfactory, go back to step 3 above. This may ential the acquisition of more information, injection of new assumptions, or the use of judgment for assessing intangibles. This also may lead to the choice of a difficult method of solution. (Figure 2 shows the decision process cycle).

7.After the completion of the analysis for the concepual phase, the same procedure (setps 2 to 6) is followed for the other phases of the acquisition process; namely the validation phase followed by the full scale production phase and the production/deployment stage.

IV.POTENTIAL SAVINGS

This paper will apply to all weapon system acquistion programs. With a reasonable support of resources, saving could be substantial. Project managers and acquisition managers who must deal with risk are intended of the results of this paper.

ACQUISITION RISK ANALYSIS INTEGRATED SYSTEM

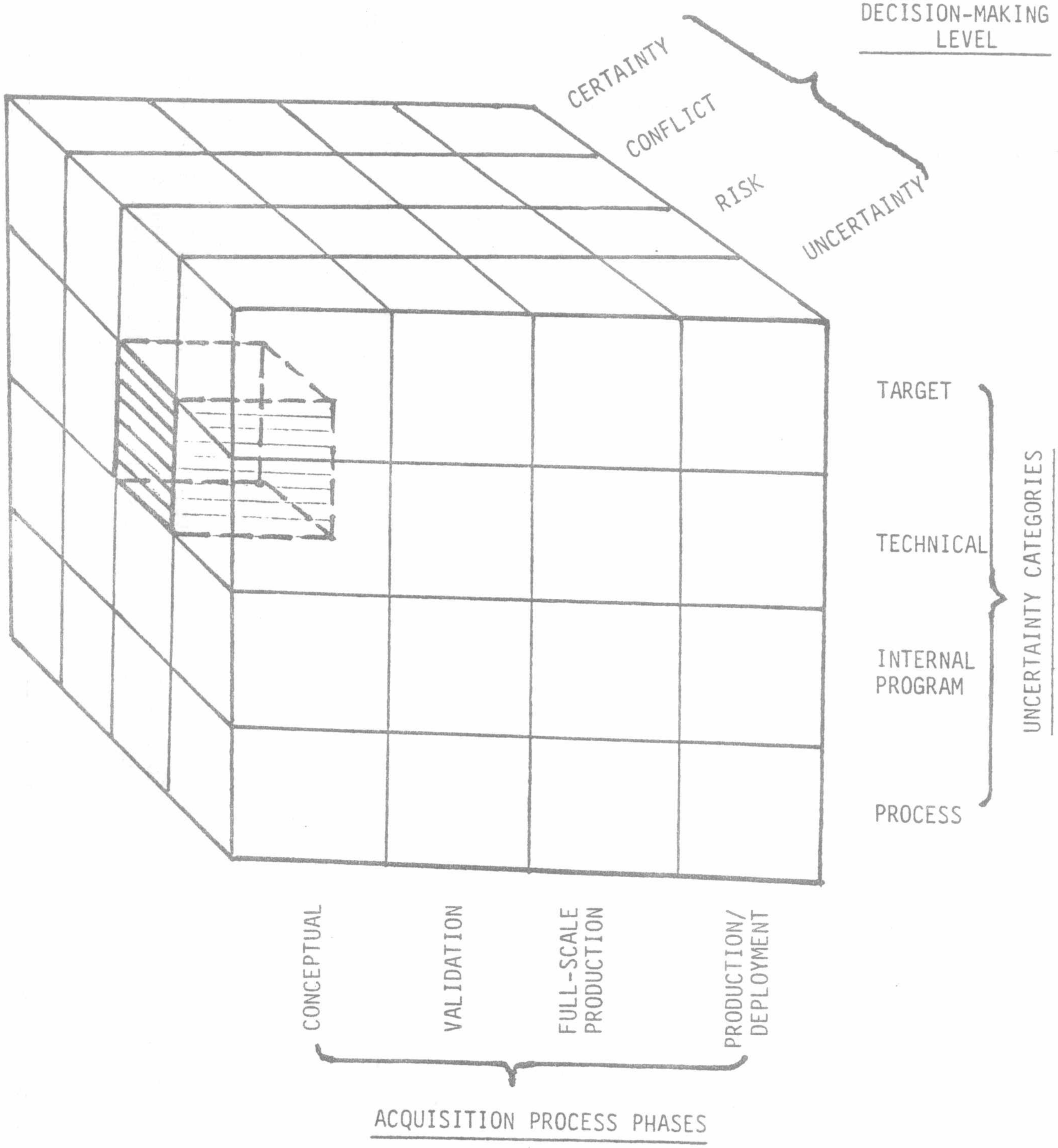
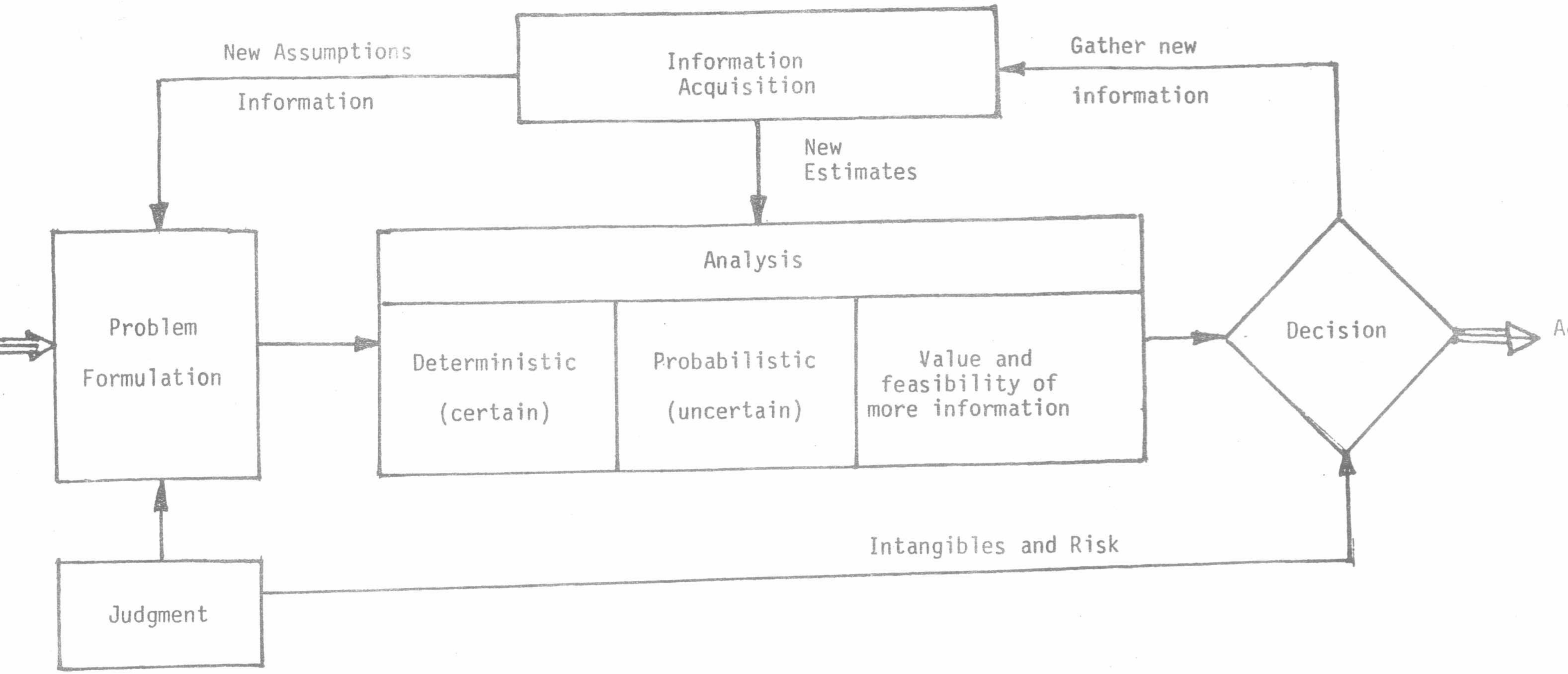


Figure - 1

SYSTEM FRAMEWORK

Figure (2) - Decision Process Cycle



- Assumptions
- Decision Tree
- Decision Matrix
  - States of Nature
  - Alternatives
  - Outcomes
- Structural Model

- Assign Values and Estimates
  - Constants
  - Uncertainties of States of Nature
- Computer Values of Outcomes
- Summarize Outcomes for each Alternative

- Cost/Benefit Assessment of Eliminating Uncertainty

- Combine Q - Analysis with Judgment
- Risk Aversion
- Impact of Intangibles

Appendix A

DECISION MAKING SITUATIONS

Decision - Making Situations, Solution Techniques

A. Decision making under Certainty (characterized by the complete knowledge of a system). Implies that there exists only one feasible state of nature for each possible course of action. Once a decision is made, the future is known, stable and is unalterable as far as the decision maker is concerned.

Decision Procedures:

- Calculate outcomes
- Select action with largest outcome

Techniques:

- Maximization and minimization techniques
- Break even analysis
- Depreciation models
- Certain inventory models

B. Decision Making under Conflict. This situation occurs when the states of nature facing the decision maker are potential courses of action for a competitor.

Decision Procedure:

- Calculate outcomes for each "Action response" combination
- Assume competitor will take most damaging response
- Select action with largest minimum outcome MAXIMUM

Techniques:

- Game theory; primary objective is the development of a national criterion for selecting a strategy or plan of action.

C. Decision Making under Risk. (characterized by some knowledge of the system). Implies that for each course of action there is more than one possible resultant states of nature each of which can be assigned a likelihood (probability) of occurrence.

Decision Procedure:

- Calculate outcome for each "Action Nature" combination
- Assign probabilities to states of nature
- Compute expected value of each action
- Select action with maximum expected value

Techniques:

- Expected value analysis which is a weighted average of the measure of effectiveness of the possible outcomes of decision, is most commonly used.
- Bayes' theorem
- Decision trees
- Markov chains

D. Decision making under Uncertainty (characterized by imperfect knowledge of a system). Implies the existence of several states of nature for each possible course of action. Also implies the decision maker is unable to assign probabilities to the likelihood of occurrences of future events.

Decision Procedure:

- Calculate outcomes for each "Action Nature" combination
- Select action with outcome which is:

  MAXIMUM - Largest minimum

  MAXIMAX - Largest maximum

  MINIMAX - Least maximum loss

or convert to under risk by estimating state of nature probabilities.

Techniques:

When confronted with this situation, several criteria may be used, choice among which depends on the decision maker subjectivity.

1 - Criterion of optimism (MAXIMAX or MINIMUM)

2 - Criterion of pessimism (MAXIMUM or MINIMAX)

3 - Huriwicz criterion (MAXIMUM or MINIMUM)

4 - Criterion of insufficient reason (LAPLACE)

Appendix B

QUANTITATIVE TECHNIQUES FOR DECISION MAKING

Techniques	Decision Making Situations			
	Certainty	Conflict	Risk	Uncertainty
Maximization	X			X
Minimization	X			X
Break - Even	X			X
Trade Off	X	X	X	X
Game Theory		X		
Expected Value			X	X
Decision Trees			X	X
Bayes Theorem			X	X
Markov Chains			X	
MAXIMAX				X
MAXIMIN				X
Huriwicz Criterion				X
Laplace Criterion				X

Appendix C

Summary of other Quantitative Techniques

In addition to previously mentioned techniques, the following is a brief summary of techniques applies to risk analysis and uncertainty:

Technique	Application
Fault tree	Analyzing potential causes of deviations from plans such as cases of accidents and disturbances.
Cause Consequence	Analyzing the sequence of events which occur in an operating procedure.
Monte Carlo Simulation	Calculating of the consequences of probabilistic models - used when analytical solutions are not available.
Regression Analysis	Determining key parameter values in a model which accord best with available statistical data. Used in forecasting.
Sensitivity Analysis	Analyzing how much parameter variations affect the outcome.
Range method	Calculating the uncertainty in terms of a range between a maximum and a minimum.
Variance Method	Calculating standard deviation as an estimate of uncertainty.
Successive Estimating	Calculating the results of uncertain tasks as correct as possible with with least effort.
Bar/Gantt charts	Illustrating time schedules for activities.
Network Planning CPM	Calculating schedules time (Deterministic).
Network Planning PERT/GERI	Calculating schedules time (Stochastic).

PERT COST	Calculating Costs related to activities.
Crash Method	Calculating reduced time for additional cost.
Decision Networks	Examining several alternatives for a project.
Event Tree Method	Analyzing the possible consequences of failure in technical systems.
Hazard method	Analyzing technical risks of accidents in process plants.
Action Error Method	Analyzing human error in equipment operation
Human Error Reliability Prediction	Analyzing probability of failure in operation tasks.