

ROCKY FLATS CLOSURE PROJECT: PLANNING FOR UNCERTAINTY

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ABSTRACT

Traditional management tools used to represent project schedule and cost (e.g., Gantt Charts and Cost Estimate Profiles) do not adequately represent the leading-edge, environmental technology projects at the Rocky Flats Environmental Technology Site (RFETS). Traditional management tools do not provide insight into a project's cost and schedule challenges; therefore, they can easily convey a misleading sense of certainty with a project's schedule and estimated cost.

Traditional management methods often limit themselves to determining single point (i.e., deterministic) cost and schedule estimates for an activity. These estimates are then summarized to provide a planning level project cost and completion date. A deterministic planning approach is adequate for projects involving clearly defined, well documented activities such as standard construction projects, but some RFETS projects involve technical activities that have never been attempted on a large scale (e.g., plutonium residue stabilization, transuranic waste decontamination, and major Plutonium facility decommissioning and demolition). To provide a legitimate representation of these projects, management tools must also clearly convey a sense of cost and schedule uncertainty.

The Kaiser-Hill project planning process at RFETS classifies cost and schedule uncertainty as "programmatic risk" and quantifies each range of uncertainty with a customized probability distribution. Stochastic simulations (i.e., Monte Carlo simulations) using project critical path and cost models are conducted to develop insight into how each uncertainty can influence the overall project cost and schedule. Sensitivity analysis is conducted to understand how a variation in each uncertainty affects the total project cost and completion date. This information provides the basis for ranking project uncertainties in order of their influence on a project's cost and schedule (e.g., a Pareto chart format).

The RFETS programmatic risk identification and prioritization process provides each Project Manager with a Pareto chart of project cost and schedule uncertainties in two formats. One format provides the ranking of all uncertainties within the Project Manager's project; the other format provides an integrated ranking of all uncertainties among the 32 projects that makeup the RFETS site closure plan. These two rankings enable Project Managers to understand the influence each uncertainty can have within their individual project as well as within the overall RFETS closure plan. Armed with this information, Project Managers and senior management jointly focus attention on controlling the highest programmatic risk activities early in a project's development before negative cost or schedule variances develop.

This paper discusses how the Kaiser-Hill programmatic risk identification and prioritization process is conducted at the Rocky Flats Environmental Technology Site.

INTRODUCTION

The Rocky Flats site, constructed in the 1950's, developed into a major industrial complex consisting of more than 700 facilities and structures. The main production and support facilities occupy approximately 385 acres of the 6,200 acre site. Production of nuclear and non-nuclear weapons components contaminated many of the facilities and much of the equipment (e.g., furnaces, lathes, ventilation ducts, etc.) with radioactive and other hazardous materials. The site posed a risk to health and safety from the presence of large amounts of special nuclear material (SNM) in various forms. Rocky Flats currently stores approximately 12.9 metric tons of plutonium and over 6 metric tons of highly enriched Uranium. Much of this material has been stored in temporary packaging since 1989, following abrupt cessation of nuclear materials production activities.

The present mission at RFETS is to cleanup and close the site. Closing the site is extremely complex, because significant interplay between facilities is required to stabilize and ship SNM and to gather, package, and ship waste.

Much of the RFETS cleanup work involves processes and technologies never before used on a large scale; therefore, substantive cost and schedule uncertainties exist. Additionally, a major component of the RFETS cleanup strategy involves removal and transfer of contaminated materials to other DOE sites for disposal, processing, and/or storage. Consequently, the present cleanup schedule and cost estimate for the RFETS cleanup involves additional cost and schedule uncertainty due to the ongoing National Environmental Protection Act (NEPA) process.

Traditional management tools used to represent project cost and schedule (e.g., Gantt charts and Cost Estimate Profiles) do not adequately represent some of the more challenging cleanup projects at the RFETS. Without providing insight into cost and schedule challenges, the traditional Gantt chart and cost estimates can easily convey a misleading sense of certainty in schedule and estimated cost for the RFETS Closure Project.

The Kaiser-Hill project planning process at RFETS classifies cost and schedule uncertainty as "programmatic risk." A programmatic risk identification and prioritization process, described below, exists to provide management with appropriate insight and sufficient lead time to prevent unexpected and uncontrolled growth in project cost and schedule.

PROGRAMMATIC RISK IDENTIFICATION

The purpose of the programmatic risk identification process is to provide each RFETS cleanup project organization an opportunity to identify areas of programmatic uncertainty (i.e., risks to cost and schedule). The major objective is to gain management control of these uncertainties as early as possible in the project development process. Programmatic risk is associated with a project's cost, schedule, and performance; it should not be confused with risk to the worker, public, and environment

Traditional methods of cost and schedule planning often limit themselves to determining single point (i.e., deterministic) estimates for an activity. These estimates are then summarized to provide a calculated project cost and completion date. The deterministic approach is adequate for projects involving clearly defined, well documented activities such as standard construction projects, but several Rocky Flats projects involve technical activities that have never been attempted on a large scale (e.g., plutonium residue stabilization, transuranic waste decontamination, and major Plutonium facility decommissioning and demolition). To be legitimate, the project schedule and cost estimate for these projects must also convey a sense of cost and schedule uncertainty contained within the project.

The Kaiser-Hill project planning process at Rocky Flats characterizes the source and nature of uncertainty contained within challenging projects by assigning customized probability density functions for schedule and cost uncertainties. The risk identification process starts with a detailed review of project historical performance for the past two years by focusing on project cost and schedule baseline changes. This historical comparison of “planned project cost and schedule” and “actual project cost and schedule” provides some measure of the project organization’s ability to plan and execute the project. This review is followed with an interview of the project management organization by a trained Programmatic Risk Assessor. The objective of the interview is to assess the technical basis for the project’s schedule and cost estimate and the associated range of uncertainty.

Cost and schedule information obtained from the historical project performance review and the project organization interview is integrated by the Programmatic Risk Assessor to produce an assessment of project’s future programmatic risk. In general, this assessment results in the assignment to project activities of one of the probability density functions illustrated in Figure 1 “Probability Density Functions For Cost / Schedule Uncertainty”. These probability density functions are described below:

BetaPERT Probability Density Function:

The BetaPERT Probability Density Function evolved from management principles initially developed in 1959 to manage large engineering projects within the Department of Defense. The original process, known as the Program Evaluation and Review Technique (PERT), was developed to manage complex projects that contained a significant amount of scheduling uncertainty.

With PERT, project parameters are described not with a single point estimate, but with a probability distribution that represents the level of uncertainty associated with that parameter. The BetaPERT probability distribution is produced from three estimates: optimistic estimate, most probable estimate, and a pessimistic estimate. Figure 1 illustrates the BetaPERT probability distribution for the duration of an activity with an optimistic duration estimate of 18 months, a most probable duration estimate of 21 months, and a pessimistic duration estimate of 29 months. The detailed shape of the distribution about these three values has been refined through the PERT process since 1959. In the past, the calculation complexity of the PERT process restricted its application to projects with significant computer resources; however, recent

gains in software development and desktop computer processing power permit the application of PERT process on a much broader basis.

Uniform Probability Density Function:

The Uniform Probability Density Function is similar to the BetaPERT distribution; however, it is applied to activities with greater uncertainty. Figure 1 also illustrates a probability density function for the duration of an activity that has an equal chance being completed anytime between 18 months and 29 months.

Customized Probability Density Function:

The Customized Probability Density Function is assigned to activities that are well known and have significantly detailed information to support the level of uncertainty projected by its customized distribution. Past history of cost or schedule performance must exist to support the development of a customized probability density function. Figure 1 also illustrates a sample customized probability distribution.

A summary of the major events that occur during the programmatic risk identification phase is provided in Table I.

Table I: Programmatic Risk Identification Events

Step	Event	Description
1	Interviewer selection and assignment	Interviewers must be selected from managers who possess experience in project management and are knowledgeable of the Rocky Flats Closure Project Baseline. Interviewers are assigned specific cost and schedule data collection objectives for individual projects.
2	Interviewer Training	Interviewers are trained in the information collection techniques used during the "expert opinion" interview process. Additionally, interviewers receive training in other topics, including sources of estimating inaccuracy, common sources of biases, and uncertainty probability density functions. Upon completion of training, interviewers are designated as Programmatic Risk Assessors.
3	Interview Preparation	Interview preparation by Programmatic Risk Assessors consists of a detailed review of the cost and schedule history of the project. This involves collecting and analyzing the historical information contained within the following Kaiser-Hill project performance data bases: • Baseline Change Proposal archives

		• “Planned vs. Actual” cost/schedule data base
4	Interview	Programmatic Risk Assessors collect specified cost and schedule information from key individuals in the project management organization. Initial interviews may identify additional individuals who should be interviewed. A data collection guide is provided to the Programmatic Risk Assessor specifying the data to be collected.
5	Activity Risk Identification	Each Programmatic Risk Assessor completes the data collection guide, including the data collection summary and the assignment of cost and schedule uncertainty. This information is forwarded to the Kaiser-Hill Risk Management Plan coordinator.

SCHEDULE RISK ANALYSIS

The initial focus of schedule risk analysis is on the Rocky Flats Expanded Management Summary Schedule. This schedule identifies the critical path and near critical path activities for the Rocky Flats Closure Project. Individual projects activities are identified and examined for schedule duration uncertainties. Long duration activities are disassembled into smaller, tangible activities that are more easily envisioned from a duration perspective. When this is accomplished, a range of values and a probability distribution for the duration estimate is developed. Schedule Risk Analysis is conducted with a three step process:

Step 1: Schedule Risk Identification

- 1) Identify all critical path and near critical path activities. Schedule risk analysis is modeled from the RFETS Closure Project Baseline's critical path and near critical path presented in the RFETS Closure Project Baseline (CPB).
- 2) Convert single point estimates for task duration into a duration range based on the Programmatic Risk Assessor's estimates for optimistic, most probable, and pessimistic duration as illustrated in Figure 2, "Schedule Risk Identification".
- 3) Assign a probability density function to the duration range.

Step 2: Schedule Risk Analysis:

- 1) Conduct critical path analysis to calculate the project completion date using the duration ranges rather than the single point estimates. Monte Carlo simulations are conducted using project critical path and near critical path model as illustrated in Figure 3, "Monte Carlo Simulation and Schedule Risk Prioritization".
- 2) Results of project schedule analysis are presented in two forms:
 - (a) Probability density function for the project completion date, and
 - (b) Cumulative probability distribution for the project completion date.

Step 3: Schedule Risk Prioritization:

Sensitivity analysis is conducted on the project's critical path (and near critical path) uncertainties to identify the influence each uncertainty has on the project completion date. Sensitivity analysis permits the ranking of project uncertainties in a Pareto chart format (i.e., ranking uncertainties in order of their affect on the project's cost and schedule).

COST RISK ANALYSIS

Cost risk analysis is similar to the schedule risk analysis process. It is modeled from the project's work breakdown structure (WBS). The initial focus of cost risk analysis is to disassemble the work elements into small, tangible activities that are more easily envisioned from a cost estimating perspective. When this is accomplished, a range of costs and a probability distribution for the cost estimates are developed with a three step process:

Step 1: Cost Risk Identification

- 1) Identify all cost elements contained within the project's work breakdown structure. Cost elements are analyzed on an annual basis within the lifecycle of the project.
- 2) Convert the single point estimate for activity cost into a range based on the Programmatic Risk Assessor's estimates for optimistic, most probable, and pessimistic cost as illustrated in Figure 4, "Cost Risk Analysis".
- 3) Assign a probability density function to the cost range. This process is similar to the schedule assessment process illustrated in Figure 2.

Step 2: Cost Risk Analysis:

- 1) Using the project's cost breakdown structure, calculate the uncertainty range for total project cost.
- 2) Cost risk analysis uses the probability distributions for each element of the cost breakdown structure, rather than a single point "deterministic" estimate. Monte Carlo simulations are conducted using the WBS Cost Model as illustrated in Figure 4. When the analysis is complete, cost results are presented in two forms:
 - a) Probability distribution for total project cost
 - b) Probability distribution for the project cost for each year. This information takes the form of a funding profile with a cost range extending from 5% probability (high cost risk) to 95% probability (low cost risk).

Step 3: Cost Risk Prioritization:

- 1) Conduct a sensitivity analysis on the cost elements that makeup total project cost to identify the influence each activity has on total project cost.
- 2) Illustrate the results of the sensitivity analysis in a Pareto chart to identify, in the order of influence, contributors to overall cost risk.

PROGRAMMATIC RISK MANAGEMENT

To be useful, the Programmatic Risk Identification and Prioritization process must provide practical information to the project manager and senior RFETS management. Without useful

information and insight into the overall programmatic risk situation within the RFETS Closure Project, the risk identification process remains an academic, computer simulation exercise.

The RFETS programmatic risk identification and prioritization process provides each Project Manager with the systematically determined ranking of project uncertainties in two formats. One format provides the relative ranking of all uncertainties with the Project Manager's project; the other format provides the relative ranking of all uncertainties among the 32 projects that makeup the RFETS site closure plan. These two tools enable the Project Manager to understand the influence each project uncertainties has within the individual project as well as within the overall site closure plan.

Armed with this information, the project manager and senior management can jointly focus their attention on the highest risk activities early in a project's development before a negative cost or schedule variance develops. This joint involvement includes:

- 1) Being proactive during early project planning to ensure high risk activities benefit from the experience and knowledge of corporate and national experts.
- 2) Identifying appropriate levels of cost and schedule contingency to minimize distractions and resource commitments to support future baseline change proposals
- 3) Recognizing and communicating a project's cost and schedule challenges to the entire management organization
- 4) Focusing corporate talent on events that present the largest obstacles to completing the project on schedule and at cost.

References:

Throughout this paper, significant and frequent reference is made to the information contained within the Kaiser-Hill Programmatic Risk Management Plan.