PROGRAMMATIC RISK ASSESSMENT AT ROCKY FLATS: A TOOL FOR TECHNOLOGY DEPLOYMENT DECISIONS

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ABSTRACT

The Rocky Flats Environmental Technology Site (RFETS, or Site) is planned and managed under a performance-based contract that is structured to accelerate the schedule for safe clean-up and site closure. Kaiser-Hill undertook a site-wide programmatic risk assessment comprising all project activities in order to determine the sources and impacts of uncertainty in project schedules and costs. The risk assessment coupled with the project logic so that the uncertainties could be ranked in terms of their impact on successful completion of the project, on the critical path to closure of the Site, and thus on the overall closure schedule.

Risks, or uncertainties, were assessed activity-by-activity with respect to three parameters – technology, scope, and inter-site dependency – for their impact on the schedule for on-time completion of that activity. Monte Carlo simulations based on the total site critical path model for all project activities were thus able to produce a list of technology areas that represented the greatest need for risk reduction. To address the uncertainty in the baseline technologies associated with those key project activities, either the technology has to be qualified with more confidence or an alternative technology or technical approach has to be substituted. This is an on-going process since new problems present themselves as old problems are resolved. In general, multiple options or paths forward would be pursued until the point at which an optimal method is decided upon.

The performance incentive structure at RFETS means that innovative technologies are pursued aggressively as a means to achieving and improving upon the safety, cost, and schedule of closure operations. Each deployment of technology, being in essence a business decision, takes on these risks of performance. The programmatic risk assessment methodology is one way that RFETS takes a systems analytic approach to technical problem solving as the project bottlenecks are identified. The original closure schedule at RFETS has been reduced from 2060 to 2010, and most recently the risk assessment has served to help further accelerate the Site closure baseline to 2006.

INTRODUCTION

Rocky Flats is a former U.S. Department of Energy (DOE) production site comprising 6200 acres and 727 buildings and structures. The Site is located on the outskirts of the Denver metropolitan area, with a population of two and a half million people. Operations were mainly focused on plutonium components. Plutonium operations ceased in 1989, after which much of the plant and equipment was maintained in a readiness-to-restart mode. The mission of the Site was subsequently changed to closure, and in 1995 the Department of Energy contracted with

Kaiser-Hill to develop and execute a plan to clean up the Site and return it to an open space, prairie environment.

Original DOE estimates were that this task would take 65 years to accomplish and would cost approximately $37 billion. DOE undertook to incentivize Kaiser-Hill to find ways to reduce both the schedule and the cost, without compromising on the scope of the cleanup or the conditions of the end state, and to significantly improve upon the prevailing standards of safety for this type of work. Such a reengineering effort would require innovative technologies, both in planning and management, and in operations. This paper describes how one of those technologies, programmatic risk assessment, contributed to the selection of the many technologies that would be needed to improve upon the project operations.

At Rocky Flats, technology is pursued in the broadest sense -- not only a device or a process, as is commonly interpreted, but also information technology, management and business systems all contribute to increased productivity. Also, many times a problem is solved by developing an alternative technical approach rather than an alternative technology in its narrowly used sense. In summary, we want to reengineer the entire Site closure by looking at equipment, processes, software, information, work methods, and systems.

Developing the work plans for nuclear material safeguards and processing, radioactive and chemical decontamination and decommissioning, waste management, and environmental remediation was an iterative exercise. Alternatives were explored, integrated into an overall strategy, revised in conformance with resource/budget realities and the schedule requirements in the Rocky Flats Cleanup Agreement between DOE, EPA, and the State of Colorado, and ultimately refined to produce a Closure Project Baseline (CPB). Over time, as work was being accomplished, it was also being understood better and many innovations were made. The target date for closure was brought down to 2010, and most recently the plan for closure was further accelerated to 2006. (1) At each stage a schedule risk analysis was done.

Two important aspects of the planning and the work were evident throughout this period: there was considerable uncertainty in schedules and costs estimated for the complex work activities that would be required to clean up Rocky Flats; and, innovative technology would be needed to achieve the safety and productivity improvements required to accelerate closure. When the 2006 Closure Project Baseline was completed, it was audited for the DOE by Ernst & Young. In their report, Baseline Confidence Review (2006 CPB), Ernst & Young (2) perhaps summed up this situation best in two statements:

- "much of the RFETS cleanup work involves processes and technologies never before used on a large scale"
- "based on the successes of many projects that have already occurred and plans for others, the use of technology should continue to have positive impact on improved safety, schedules, and project costs."

In the process of their 2006 CPB validation, Kaiser-Hill's programmatic risk assessment was also reviewed. (3)

GENERAL APPROACH TO TECHNOLOGY

Technology pursuit at Rocky Flats is production oriented; i.e., how do we use technology to get things done better?...better in terms of safety, schedule, and cost. The effort to exploit technology is centered principally in two areas: planning -- both strategic and project planning; and, integration -- incorporation into project operations. The approach is to work with operations (the line organizations) at the management and project levels to develop the closure strategy for the Site and to integrate the individual project plans into an overall Closure Project Baseline. Capitalizing on this then involves working with the line program and project managers to package and integrate innovative technology/technical approaches in their project activities.

For planning projects, a systems approach is used to explore multiple alternatives, with risk assessment being one of the tools. The Kaiser-Hill approach incorporates all of the principles of the recent National Academy of Sciences report (4) recommending how technology should be selected at the DOE sites; namely, systems engineering analysis, development of multiple options, initial state characterization, and end state focus -- all with planning being the key to successful deployment.

For executing projects, the key to exploiting technology is to integrate it with all other aspects of the project, some aspects being technical and some not, at the detailed activity level. This involves screening, qualifying, repackaging, and rendering the technology into a procurable service on commercial, performance terms. Each project activity has its unique technical specifications and criteria. As stated above, much of the work at Rocky Flats is being done for the first time anywhere, and the characteristics or conditions tend to differ from project to project.

The Rocky Flats Site was "projectized" at an early stage in the closure planning. That is, all of the challenges at the Site have been rendered into well-defined, tractable projects, each with defined objectives or products, distinct project management plans, resources, schedules, and budgets. The Work Breakdown Structure (WBS) has been taken to a detailed level, and over 12,000 activities are tracked using the P3 project planning/management system. Logic and resources for the individual projects are integrated in the overall site plan, or Closure Project Baseline.

Technology planning at Rocky Flats thus means that technology is factored into the closure strategy, and then built into the project designs and execution plans in a consistent, deliberate way. Yet considerable uncertainty is inherent in the process, not the least of which is whether a particular innovative technology or project technical approach will deliver it's intended results. Another feature of the work at Rocky Flats is that the "rolling wave" method of project execution is used. Projects are initiated before all details are known, and the work has to be adapted in real time as the characteristics and conditions unfold. While this violation of the rule of initial state characterization clearly presents risks, the lesson from the Superfund program has been that little gets accomplished if we continue to wait for complete scope definition.

There are three basic tools that Kaiser-Hill employs for planning and making technology deployment decisions within this project management environment:

- "What If" Scenario Evaluation (WISE) Model - This model is designed to run sensitivity studies on the 2006 CPB. Assumed advantages and outcomes associated with various alternative technologies and technical approaches can be captured and explored for the advantages that would be afforded to simultaneous and subsequent projects. Technology "what if" scenarios are run to see how life cycle costs, resource allocations, schedules, and other aspects of a technical innovation would affect the Site closure critical path, the overall closure schedule, and each of the program and project budgets. This model helps determine where the promising "breakthrough" opportunities are.

- Project Planning and Integration - Individual project plans are prepared by the line organizations and then scrubbed in a peer review exercise for scope, WBS logic, schedule, cost, and technology. One of the most effective ways to integrate and exploit technology is to build it into projects; and, the earlier in the project that this can be done the better. The project plans are then interrelated for consistency and completeness as to overall Site scope, schedule, and budget. None of these is deterministic. There is considerable uncertainty in each and the risks of these need to be taken into account.

- Programmatic Risk Assessment - The probability and impact of an uncertainty with respect to technology, scope, and external factors is modeled to learn about its likely effect on overall Site closure. Assessments are conducted at the detailed activity level to identify those activities with technical, scope, and thus cost and schedule uncertainty, and to isolate those activities that could become bottlenecks. Where an improved technology is needed or foreseen, planning and project managers can develop a path forward and engage potential vendors and service providers. Multiple options and paths forward are often pursued until the point at which an optimal technical approach can be decided upon.

Because the rolling wave method of project execution has been adopted at Rocky Flats, all of these tools for technology decisionmaking are employed in a continuing process of iteration. As we get into each project, the uncertainties may either increase or decrease as will the need for alternative approaches. At the same time, given the performance incentive nature of the DOE contract with Kaiser-Hill, innovations that will improve safety and productivity are continuously and aggressively sought.

ROCKY FLATS PROGRAMMATIC RISK ASSESSMENT

Kaiser-Hill Risk Management Plan

Uncertainty in the planned schedule and budget for the cleanup and closure of Rocky Flats is taken into account for each of the individual projects by considering:
- how well the scope is defined to realize the project objectives or products,
- how well the technical approach and the technologies are expected to work, and
- whether certain events or decisions are achieved at other sites upon which RFETS depends.

These unknowns were identified, their likelihood of occurrence was estimated, and the range of uncertainty quantified as best as possible at the time, for each project activity.

Initially, Kaiser-Hill focused on the uncertainty factors inherent in those activities that were on the Site CPB critical path or near critical path, taking as a simplifying or "starter" assumption that this would point to some opportunities for "quick fixes" that would yield some sure returns for the effort. These schedule uncertainties for individual projects were then propagated through the P3 schedule model to see what the probable effects would be on the overall schedule, and where to focus some early efforts to make improvements. Recognizing that it is the project whole -- not simply the technology component of the project -- that gets work done, it is nevertheless important to know which projects and activities to look at.

The next step was to concentrate on the consequences or impacts of the uncertainties. The probability that an activity would be on the critical path and the expected range of the duration and cost of that activity needed to be coupled with the impact that would have on other projects. In this way, we could make trade-offs, prioritize our resources, and bring alternative technology approaches to bear on the problem. Such prioritization is essential in deciding when and where to make the best technology moves, and what we want to achieve in each case. For example, we may decide to invest for potentially large cost and schedule savings on an activity with already relatively low technology risk versus a potentially lower savings on an activity with a relatively high technology risk.

Risk Assessment Methodology

For each project activity, uncertainties are evaluated in terms of three variables: work scope definition, technology performance, and inter-site dependency. Regarding technology, the term refers to the total ensemble of equipment, methods, and systems that must function together to get the job done. The technology component of an activity typically comprises dozens of such elements, and a judgement is made as to the expected performance of entire integrated component. Regarding inter-site dependency, typical examples include the ability to send TRU/mixed waste to WIPP, nuclear materials to Savannah River, and low level/mixed wastes to NTS and commercial sites, since Rocky Flats has no disposal facilities. Regulatory approvals, on the other hand, are often treated as project assumptions rather than analyzed probabilistically.

- Interviews: The Kaiser-Hill project managers with their designated assistants are interviewed by the planning and integration team trained for the risk assessment study. For each variable, the project uncertainties are scored on a 1 through 5 scale. The scores for each variable are defined in Table I. Based on the uncertainties, the project team estimates the most optimistic, the most pessimistic, and the most likely outcomes in schedule and cost. Different probability distributions were investigated, based on whether the estimates were derived from historical performance, industry standards, project manager forecasts, or expert opinion. In the end, the triangular probability distribution was used, except where the uniform distribution was clearly more appropriate.

- Analysis: The range and probability distribution was substituted for each single point (deterministic) activity duration in the P3 schedule. Monte Carlo simulations were run on the overall Site schedule/work logic. This consists of some 12,000 activities, of which about 350 are critical path and 550 are near critical path activities in the 2006 CPB. The calculation gave us the range of possible site closure dates and the cumulative probability of closure on any particular date. Of greater interest and use, however, was the information about which projects - and more specifically, which project activities - were most influential on the outcome. Therefore we needed to know which activities not on the P3 (i.e., deterministic) critical path were statistically critical.

- Prioritization: The risk assessment model produced a Pareto chart, exhibiting in order the activity that had the largest impact on overall closure uncertainty, the activity posing the next largest risk, and so on. Figure 1 is a typical Pareto chart showing a clear break in the pattern of confidence, and thus identifying which activities need reengineering. The next question is when to provide that reengineering. By comparing the P3 schedule with a probabilistic schedule we can move backwards from a risk event through the work precedence to see where the divergence from plan begins to appear. To avoid a potential "trainwreck," the fix has to be introduced at the time of a certain precusor activity. Moreover, this fix may call for a different technology than the later risk would suggest. Figure 2 shows schematically that an activity may have to be done a different way today to effectively deal with a high risk identified on the Pareto chart for a year from now. As an example, we might not need a particular certification method at a future date if we start much earlier to process or package the material differently

- Carry-through: As described above, this is a continuing process at Rocky Flats. The first risk assessment was performed early in FY99 on the then Path to Closure with a target closure date of 2010. The first preliminary results were used to point out ways in which the closure schedule could be further accelerated. The new DOE/Kaiser-Hill contract specifies that a rebaselining of the 2006 closure plan will be completed in June, 2000. With reference to Figures 1 and 2, remember that the Pareto chart prioritizes project activities, but not the technical component of the activity. The record for each activity can be easily consulted to determine whether and how the technology risk plays a role in that activity. Independently, a table or graph could be generated from the same data base to rank the activities having the highest technology uncertainty, the next highest, and so forth. But this does not necessarily translate directly into impact on Site closure.

Results

For purposes of making technology deployment decisions, we are looking for innovations that will improve upon safety, cost, and schedule, as well as human resource requirements. In addition to these productivity factors, there are cases where new technology or a new technical approach is needed to enable a project that has no feasible path forward. With these objectives in mind, we can say what the risk assessment tool helps us to accomplish:

- prioritize our efforts on those activities most in need of alternative technology to improve upon the safety, cost and schedule for Site closure. "80% of the risk is driven by 20% of the activities."
- schedule our efforts to have the needed technical services ready when the innovation is needed. "Window of opportunity."
- support scenario development and alternative technology sensitivity analysis efforts using Kaiser-Hill's WISE Model. "Bottom line impact."

Table I: Programmatic Risk Categories and Scoring System

Risk Scores	Technological	Work Scope Definition	Inter-Site Dependency
5 (high)	• The technology required to accomplish the planned activity does not exist.	• Project endstate is not determined or supported by stakeholders • Waste/material quantities and characteristics are unknown • Process operations are not identified or supported by stakeholders • Final disposition location for waste/material has not been identified	• Activity involves multiple sites • No concurrence has been reached between sites • Stakeholders are opposed to RFETS involvement in the activity
4	• Development of the technology is only at the laboratory level.	• Project endstate is determined but may be controversial to stakeholders • Process operations are identified but may be controversial to stakeholders • Final disposition location for waste/material has not been identified and approved.	• Activity involves multiple sites, site concurrence has been verbally reached • The Waste Acceptance Criteria (WAC) has not been resolved • No funding has been identified and no schedule for receipt or treatment of the waste/material exists • RFETS involvement may be controversial to stakeholders
3	• Technology is in full scale development and demonstration.	• Project endstate is determined and is expected to be acceptable to stakeholders • Waste/material quantities and characteristics are broadly known • Process operations are identified and expected to be acceptable to stakeholders • Final disposition location for waste/material has been identified and an EIS is being prepared	• Activity impacts another site, site concurrence has been verbally reached • Receiving facility is reviewing characterization data to determine WAC acceptability • Funding has been identified but no schedule for receipt or treatment of the waste/material exists • RFETS involvement is expected to be acceptable to stakeholders
2	• The required technology has been fully developed and demonstrated at another site with a similar waste/material type.	• Project endstate is determined and supported by stakeholders • Waste/material quantities and characteristics are well known • Process operations are identified and supported by stakeholders • Final disposition location for waste/material has been identified and an EIS ROD is prepared	• Activity doesn't impact another site or site concurrence has been documented if multiple sites are impacted • Receiving facility has verified WAC acceptability • Funding has been identified but no schedule for receipt or treatment of the waste/material exists • RFETS involvement is supported by stakeholders
1 (low)	• Technology has been demonstrated at RFETS on some actual waste/materials and is operationally ready.	• Project endstate is determined and supported by stakeholders • Waste/material quantities and characteristics are well known • Process operations are identified and supported by stakeholders • Final disposition location for waste/material has been identified and an EIS ROD is pending	• Activity doesn't impact another site or site concurrence has been documented if multiple sites are involved • Receiving facility has verified WAC acceptability • Funding is identified in an approved PBS and facility is ready to receive the waste/material • RFETS involvement is supported by stakeholders

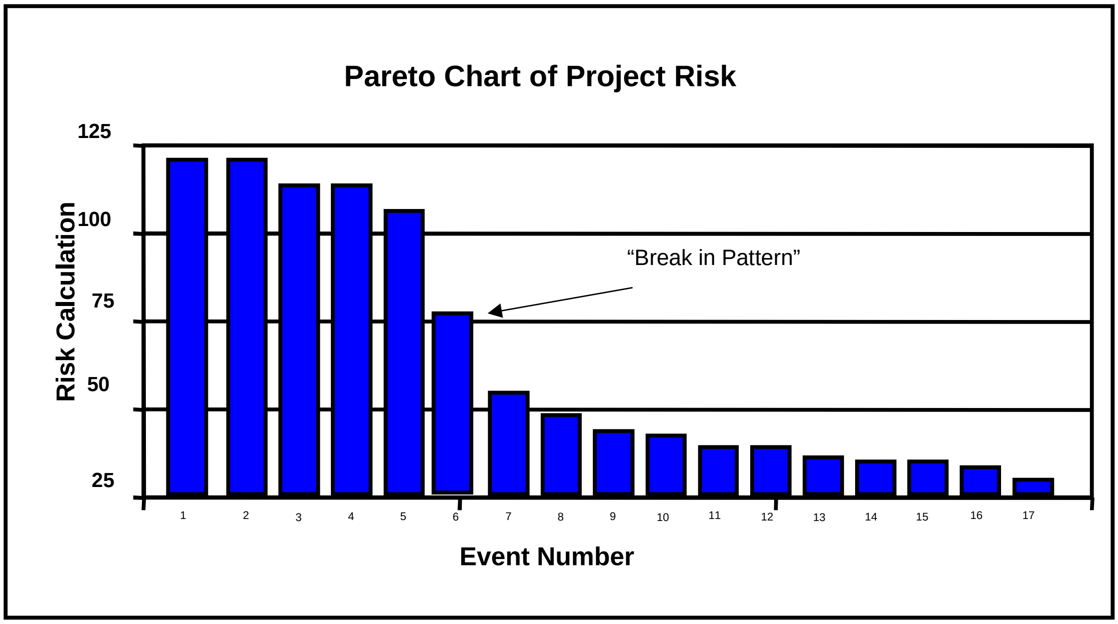

Figure 1. Calculation Outcome Showing High Risk Project Activity Events

Activity ID	Activity Description	Rem Dur	Early Start	Early Finish
C0D37111P1	B707 Dry Oper. IDC301 Graphite Shapes	37	04OCT99A	20FEB00
C0D70700P4	B707 Dry Opr IDC480 Lght Mtls	106	21FEB00*	12AUG00
C0D37101P5	B707 Dry Oper. IDC197 Tant. Targ.	38	13AUG00*	14OCT00
C0D70700P8	B707 Dry Oper IDC370 LECO's K-Mod	172	20DEC99	12JUL00
C0D37111P4	B707 Dry Oper. IDC442 Leached	20	14OCT00	16NOV00
C0D37100P3	B707 Dry Oper. IDC371 Firebrick	36	16NOV00	18JAN01
C0D7760014	IDC300,300,312,377 Graphite Shapes	57	18JAN01	18APR01
C0D7070013	B707 TRU IDC301 Graphite Shapes	58	19APR01	22JUL01
C0D70700P6	B707 Dry Repack Operations Complete	0		26JUL01
D2RSNM0201	SNM Holdup Removal/Deact - MOD D	56	26JUL01*	14MAY02
D2RSNM0203	SNM Holdup Removal/Deact - Module D	95	14MAY02	23NOV02

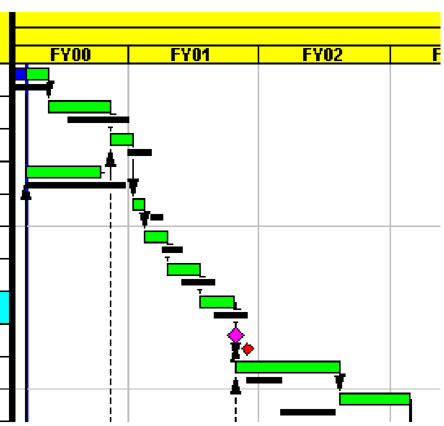

Figure 2. Schedule Segment Comparing P3 (black) and Risk-Based (color) Scheduling

Programmatic risk assessment as used here does not describe the risk that a technology will or will not perform as designed, but rather addresses how significantly that fact or occurrence will affect Site closure. The former is of course a commercial contracting matter, but the business decision to deploy that technology does depend on the results of the programmatic risk assessment.

After the first, preliminary rounds of the risk assessment were completed, we had a better knowledge of when to fund and start what activities. We also had a better sense of what activities that were not considered critical had a certain probability of being on the critical path. Some of the immediate and concrete results of our initial risk assessment were that the decontamination and decommissioning (D&D) of one of our major plutonium processing buildings was rescheduled in detail and our workforce was shifted accordingly. We began shifting our resources toward processing and shipping special nuclear material ahead of the then current schedule. We changed our strategy and plans for the temporary storage of TRU waste and ER waste. These actions were taken even as we were still reworking the risk assessment to achieve a further acceleration of the schedule. These refinements have further clarified which work needs to be accelerated, and in which buildings work can be deferred. Regarding technology, we are making a priority of moving towards remote operated tools for handling, cutting, and packaging radioactively contaminated process equipment. Risk-based scheduling tells us when the windows of opportunity will come and go to prepare for these long lead time technologies. We are also pursuing improved instrumentation and information systems geared toward characterization and measurement in several areas; e.g., work planning and monitoring for the D&D of equipment and buildings, and for the environmental restoration of soil and groundwater; nuclear material and waste container sampling, assay, and certification; and, release of uncontaminated property from the Site.

Technology deployments have already played an important part in cost savings and schedule reduction at Rocky Flats, and are expected to play an even greater role as we seek to bring the schedule and cost down from 65 years and $37 billion to our new targets of 7 years and $4 billion starting this month.

CONCLUSIONS, CHALLENGES, ISSUES

Programmatic risk assessment has proven to be a useful tool in helping to make technology deployment decisions. Yet there are some clear limitations to our potential further applications of the model. A considerable amount of judgement is required in assigning a risk score to the technology component of a project activity. As stated earlier, this component often comprises dozens of elements of equipment, methods, and systems to accomplish a given activity. The project manager has to make a judgement of the composite technical risk for each project activity. Yet, in the case of technology, the weakest link may cause an entire system of reliable technologies to fail. Once that is identified and improved upon, the next weakest link governs. For this reason, solutions have to be pursued not individually, but using a systems approach.

Another complication is that the three variables of scope, technology, and inter-site dependence are interrelated. For example, the use of an alternative technology might overcome a hurdle with the waste acceptance criteria at another site, and/or it might make it possible to redefine the project. Also there is an inter-dependency in that the solution to one activity might open the way for a subsequent solution to other activities. Yet the interdependencies of these three variables and of potential project-to-project solutions do not appear in the P3 logic.

Nevertheless, use of the model interactively as we have done to date has yielded many important results. It as served as a guide, pointing to those project activities that need priority attention. And, since alternative technical scenarios will continue to be evaluated, schedule and cost risk assessments should continue to be useful tools.

ACKNOWLEDGEMENTS

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REFERENCES

1. Kaiser-Hill Company LLC, “Rocky Flats 2006 Closure Project Baseline, Revision 3a,” June, 1999.

2. Ernst & Young LLP, “Baseline Confidence Review – 2006 Rocky Flats Closure Project Plan,” U.S. Department of Energy, Rocky Flats Field Office, 1999.

3. Kaiser-Hill Company LLC, “Rocky Flats Closure Project Baseline Risk Analysis – An Analysis of Schedule Uncertainties Within the Rocky Flats Closure Project Baseline (2006) and Their Potential Impact on the Site Closure Date,” June, 1999.

4. National Academy of Sciences, “An End State Methodology for Identifying Technology Needs for Environmental Management, with an Example from the Hanford Site Tanks,” National Academy Press, 1999.