# BASELINE DEVELOPMENT USING THE CRITICAL DECISION AND DOE ORDER 413.3 FRAMEWORKS: A CASE STUDY

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## ABSTRACT

From 1943 through 1986, Battelle Memorial Institute performed nuclear research and development on behalf of various Federal government agencies, primarily for the U.S. Department of Energy (DOE) and its predecessor agencies. This work was performed in Battelle's privately owned facilities in Columbus, Ohio, and a research park located at an 11-acre facility 16 miles west of Columbus, in a rural area near the village of West Jefferson, Ohio. Under the Battelle Columbus Laboratories Decommissioning Project (BCLDP), Battelle is now engaged in cleaning up the West Jefferson site on a cost-sharing basis with the DOE. The BCLDP mission is to decontaminate Battelle facilities in a safe, environmentally sound, and cost-effective manner, returning the facilities to a condition suitable for use without radiological restriction.

The Columbus Environmental Management Project (CEMP), reporting to the DOE Ohio Field Office, is the DOE organization that is responsible for overseeing the BCLDP. CEMP requested preparation of a technical baseline, suitable for independent validation, establishing the scope, cost, and schedule for completing the project. Concurrent with this request, the DOE Office of Environmental Management issued DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets*, for review and, shortly thereafter, published the first drafts of companion documents titled *Program and Project Management Manual* and *Project Management Practices*. These two documents suggest or require the use of a variety of techniques and tools for planning and executing DOE cleanup programs. Accordingly, Battelle successfully developed a project baseline for obtaining approval of Critical Decision 2/3 (CD-2/3) in compliance with the requirements of DOE Order 413.3 and the technical approaches described in the companion documents. This paper addresses three fundamental questions:

1. What were the planned baseline development methodology and its implementation process?
2. What were the main reasons for success?
3. What were the important lessons learned?

Battelle's primary conclusions from this effort are that complying with DOE Order 413.3 requires (1) sustained commitment and attention by management and key technical staff, (2) the ability to shift technical resources in order to quickly develop data and analysis appropriate for the CD-level for which the baseline is being developed, (3) carefully planned and organized resources, and (4) repeated adjustment of the methodologies and process.

## INTRODUCTION

On April 16, 1943, Battelle was contracted by the Manhattan Engineering District to perform atomic energy research and development. Since that time, Battelle has continuously performed research and development work under contract at its facilities for the U.S. Department of Energy (DOE) and its predecessor agencies. The facilities used for these activities are located at Battelle's Columbus Laboratories King Avenue Site in Columbus, Ohio, and at its West Jefferson (WJ) Site in West Jefferson,

Ohio. As the result of these activities, 15 buildings (in part or as a whole) and associated grounds became radioactively contaminated. Six of the buildings are at the WJ Site, which is approximately 16 miles west of Columbus, Ohio. The Battelle Columbus Laboratories Decommissioning Project (BCLDP) for the cleanup of the King Avenue and WJ Sites was established in 1986. Remedial decontamination and decommissioning (D&D) of the King Avenue Site has been completed. At the present time, D&D activities continue at WJ North, the former Nuclear Science Area, where there is confirmed transuranic, mixed fission product, and activation product contamination. Figure 1 shows the WJ Site with designation of the contaminated structures and associated areas.


**Figure 1. West Jefferson North Site**

The status of the WJ North cleanup work corresponds with Critical Decision 2/3 (CD-2/3) of the five-phase project life cycle and the critical decisions associated with each phase as defined in DOE Order 413.3. The five phases are:

- CD-0, Approve Mission Needs
- CD-1, Approve Preliminary Baseline Range
- CD-2, Approve Performance Baseline
- CD-3, Approve Start of Construction
- CD-4, Approve Start of Operations or Project Closeout

## PURPOSE

As mandated by DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets* (1), a validated or approved baseline through the DOE Office of Environmental Management's "Internal Project Review" (IPR) process is a prerequisite for starting D&D operations or continuing activities that are already under way, as is the case at the WJ Site. The approach applied in successfully developing the BCLDP baseline was specifically designed to comply with the requirements of DOE Order 413.3 and its two addenda or companion documents, *Program and Project Management Manual* (2) and *Program and Project Management Practices* (3). The purpose of this paper is to present the reasons for the success of this baseline development and the lessons learned that may contribute to improvements in future applications of DOE Order 413.3 at other DOE sites.

## METHODOLOGY AND IMPLEMENTATION PROCESS

A structured process, based on hierarchical decomposition, was used to identify, define, and analyze the functions needed to carry out D&D for each building and area within the WJ North site. The basic approach was to apply the F-R-A (functions-requirements-architecture) process for functional analysis. Functions (F) define what must be done; requirements (R) specify how well it must be done; and architecture (A) identifies the preferred architecture (or strategy) for accomplishing it. This step-wise, hierarchical approach reduced the complexities that the BCLDP would otherwise have faced when developing an integrated baseline by increasing understanding of what is needed in order to satisfy BCLDP's mission while complying with all applicable laws and regulations.

The functional analysis was led by a pair of facilitators with systems engineering expertise, who directed a multi-disciplinary team of BCLDP subject matter experts through the process: experts in waste management, radiological decontamination, radiological characterization, health physics, radiological sample analysis, regulatory concerns, and operational safety. As a first step in the functional analysis, the mission of the BCLDP was explicitly stated:

> *To decontaminate Battelle facilities in a safe, environmentally sound, and cost-effective manner, returning the facilities to a condition suitable for use without radiological restriction.*

The subject matter experts were then asked, "How can the mission be satisfied?" After much deliberation on alternative ways of satisfying the BCLDP mission, the experts reached consensus on a set of eight 2$^{nd}$-level functions that were determined to be both necessary and sufficient to satisfy the mission, and hence, represented the minimum amount of work that needed to be accomplished (see Figure 2).

Each of the eight 2$^{nd}$-level functions were further decomposed by team members until they reached a level of detail appropriate to a sufficiently comprehensive baseline. The experts eventually agreed that an "appropriate" level would be one that allowed a thorough description of what needed to be done (i.e., function description), how well it needed to be done (i.e., associated requirements), and what was the best way to do it (i.e., technical strategy). This was the level of detail that was used to estimate the necessary resources (manpower, time, supplies, and equipment) to perform the functions satisfactorily.

At this point data templates were prepared for each of the lowest level functions (e.g., the level 4 functions in Figure 2). These templates define the function; list the applicable requirements; describe the strategy selected by the experts for performing the function; list all important inputs to, and outputs from, the function; and list the necessary assumptions. A total of 323 data templates were prepared: one for each of the lowest-level operational functions (283) in the overall function hierarchy, and one for each of the necessary programmatic support functions (40). Table I shows an example of a completed data template.

Once the subject matter experts provided manpower estimates and durations for individual functions, the functions were scheduled by level-loading the estimated expenditures over the expected time to complete the entire project. This defined the draft baseline cost and schedule to completion.

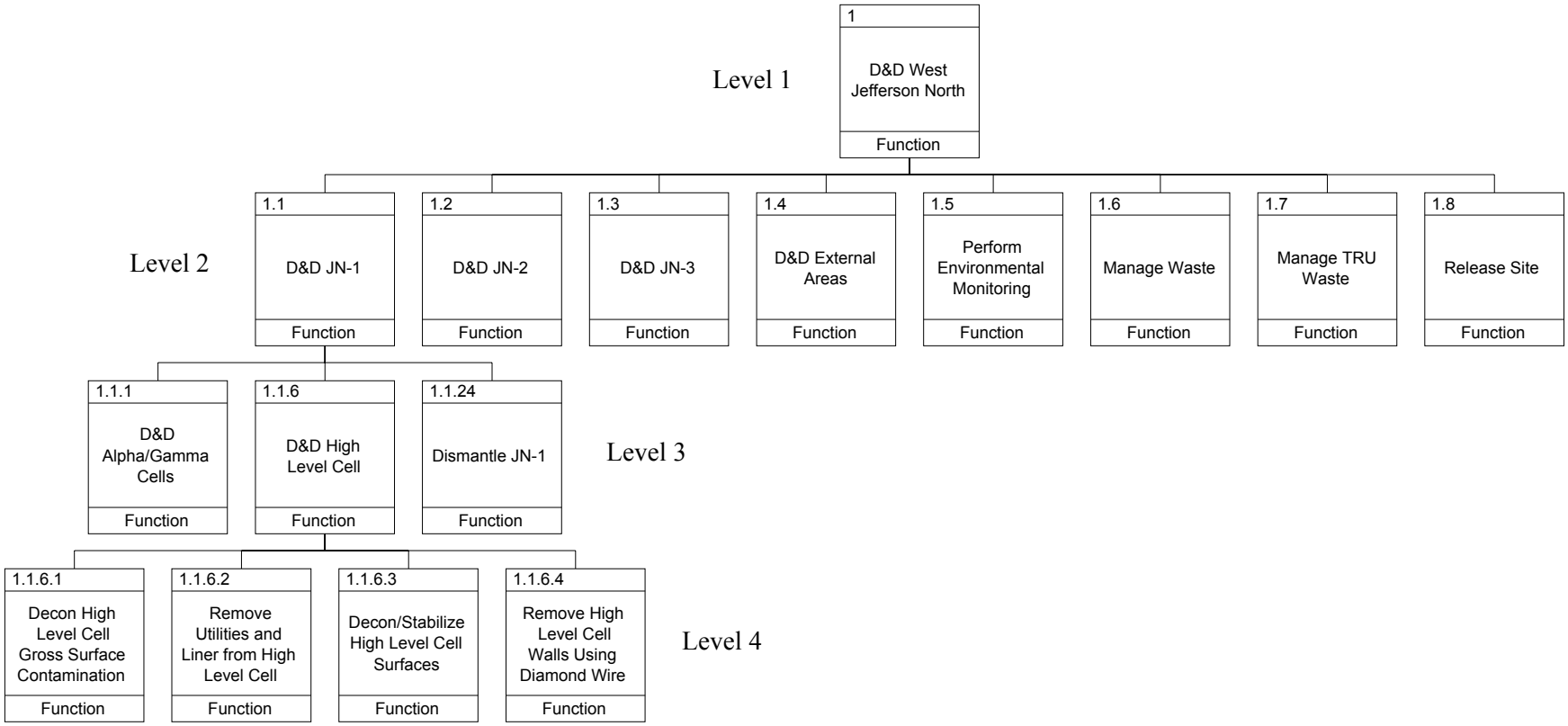


**Figure 2. Partial Hierarchy of Functions for Satisfying the BCLDP Mission**

**Table I. Example Data Template**

☒ **JN-1** ☐ **JN-2** ☐ **JN-3** ☐ **Ext. Area** ☐ **Env. Mtr** ☐ **TRU/Waste** ☐ **Release Site**

**Function No:** 1.1.6.3 **Activity No.:** C004 **Work Pkg. No.:**7C41-B03

**Function Name:** Decon/Stabilize High Level Cell Surfaces

**Component Name:** HLC

**Function Description:** Paint out and seal the surfaces of the HLC structure so there is no smearable contamination and minimal exposure for the HLC structural removal.

## Basis of Estimate

**Strategy for Accomplishing Function:** Generate a work instruction package to perform the decontamination and stabilization of the HLC structure. Paint and strip, if necessary, the HLC structure to lower smearable contamination and overall inventory. Seal the HLC structure in preparation for structure removal.

**Applicable Requirements/Procedures:**

DD-90-02; DD-93-04; DD-OP-075, 076; HS-AP-4.0, 5.0; HS-OP-001; HP-AP-1.0, 2.0, 5.0, 8.0; HP-OP-012; PR-AP-17.1; QD-AP-5.2, 6.1; RL-AP-1.0; SM-OP-001; TD-AP-2.0; WA-OP-020

**Input Descriptions:**

1. HLC ready for decontamination

**Output Descriptions**:

1. Approximately 20 cubic feet of secondary (PPE) waste
2. Approximately 20 cubic feet of stripped ALARA paint
3. The HLC structure is ready to be removed

**Assumptions**:

1. The HLC is essentially non-smearable and does not pose undue exposure risk to personnel.
2. Manpower, equipment, resources, and the area are available for this activity when scheduled
3. There are no RCRA constituents in the structure.
4. Production rates include 5 days to paint and strip, and 5 days to seal prior to cell structure removal
5. The work instruction and procedures are in place sufficiently early to perform this activity on schedule.

**Estimated Time to Plan the Work (Including Review and Approval):** this work is integrated into 1.1.6.2

### Estimated Resources Required to Plan the Work

*In the following table, for each appropriate labor type enter the # of Persons involved in planning the activity, the # of Days (full or partial) they will be involved, and the total # of person-Hours necessary to plan the work, e.g., 2/5/36*

**Table I. Example Data Template (continued)**

| Labor Type | Code | Persons/Days/Hours |
|---|---|---|
| Manager/Senior Staff | HBB | |
| Technical Advisors | HBTA | |
| Project Manager/HP Manager | HBPM | |
| Task Leader | HBTL | |
| Secretary/Clerical | HBS | |
| Support Professional | HBP | |
| Bartlett Health Physics | HRH | |

**Estimated Time to Perform the Work:** 10 Days

**Estimated Resources Required to Perform the Work**

*In the following table, for each appropriate labor type enter the # of Persons working on the activity, the # of Days (full or partial) they are involved, and the total # of Hours necessary to actually perform the work; the PPE/Laundry Group to be used during the performance of the work; and the Total # of Jumps; e.g., 4/20/640 Group 1 160*

| Labor Type | Code | Persons/Days/Hours | PPE/Laundry Group | Total Jumps |
|---|---|---|---|---|
| Program Manager | HBA | | | |
| Manager/Senior Staff | HBB | | | |
| Technical Advisors | HBTA | 1 / 10 / 10 | | |
| Project Manager/HP Manager | HBPM | 2 / 10 / 20 | | |
| Task Leader | HBTL | 1 / 10 / 80 | Group 0 | 10 |
| Battelle Technician | HBT | | | |
| Battelle Technician O/T | HBTO | | | |
| RAL Staff | HBL | | | |
| Support Professional | HBP | 1 / 10 / 8 | | |
| Secretary/Clerical | HBS | | | |
| Decon Ops Hourly | HBH | | | |
| BCO Support | HBCO | | | |
| BCO Skilled Laborer | HCE | | | |
| BCO Skilled Laborer O/T | HCEO | | | |
| BCO Facility Manager | HCF | | | |
| Bartlett Technician | HRD | 2/ 10 / 160 | Group 1 | 30 |
| Bartlett Maint Specialist | HRDS | 1 / 10 / 40 | Group 0 | 10 |
| Bartlett Health Physics | HRH | 1 / 10 / 80 | Group 1 | 15 |
| Bartlett Admin Support | HRA | | | |

**Subcontract/Purchased Service:** None

**Special Equipment/Material:** ALARA paint – 95 gallons = $9,644;
Epoxy Paint – 200 gallons = $11,730

**Comments/Explanations:** None

**Completed by:** C. Voth **Date:** 06/07/00 **Rev. No.**: 1

## REASONS FOR SUCCESS

The methodology and the implementation process described above resulted in a technical baseline that was recommended by the DOE Ohio Field Office for approval and funding. DOE Headquarters and other independent evaluators praised the techniques, tools, documentation of results, and the group-decision-making approach used in the baseline development. For example, the DOE IPR team assigned a grade of 96% to the technical scope portion of the draft BCLDP baseline. The review team acknowledged that the approach described in this paper resulted in a very well integrated baseline. They also concluded that the data templates were an effective means of documenting the results. The overall success of the effort can be attributed to the following factors.

### Management Support

Arguably, the most important reason for success was the sustained and frequently emphasized support for the effort by both BCLDP and DOE Columbus Environmental Management Project (CEMP) management. Active participation in and contribution to the effort were explicitly included as performance measures in all participants' annual performance review. Without the support of top management, both DOE and contractor, any baseline development effort is doomed to failure.

### CEMP Involvement

The active involvement of CEMP management and senior technical staff helped to avoid later controversies. All important assumptions and decisions were discussed openly among both BCLDP and CEMP experts. The uncertainties in contamination levels, the need for additional data, the identification of alternative technologies, and the selection of a preferred D&D technical strategy were resolved "real-time," insuring full cognizance of and approval by CEMP. As a result, the prolonged delays often encountered in explaining the bases for technical baselines were avoided. By being involved throughout the entire effort, CEMP became a stakeholder in the process and was better able to understand and defend the results. This helped to reduce the overall time to recommend approval of the baseline.

### Prepare – Review – Resolve

As a result of the detailed and open discussions during the baseline development, differences in technical opinion between BCLDP and CEMP staff were minimal, but they did occur. In such cases, BCLDP typically proceeded on the basis of their own judgments. Subsequently, when a draft baseline was submitted by BCLDP for formal review, CEMP was aware of, and well-informed of, any potentially controversial issues. The CEMP adopted a rigorous three-step review process: (1) preparation of comments by CEMP, (2) review of CEMP's comments by BCLDP, and (3) resolution of comments. Because of CEMP's involvement in the process, they were able to collect, organize, and resolve most of the contradictory external comments before they were provided to BCLDP. When necessary, comment resolution occurred in meetings attended by technical staff from both organizations. This process ensured efficiency in time and cost. More importantly, however, it allowed integration of comment resolutions immediately into the baseline.

### Logical and Consistent Methodology

A logical, consistent process, relying on experienced technical staff and managers to provide expert knowledge, was used to establish a firm foundation for the BCLDP project's draft baseline. The process identified 323 specific work activities that are necessary to successfully satisfy the BCLDP mission. Requirements specifying how well each of these activities had to be performed and the technical strategies for accomplishing the activities were openly discussed. Moreover, the relationships among the

activities and the impact of those relationships on cost, schedule, and BCLDP's ability to accomplish its mission were transparent and open to analytical scrutiny and examination. The approach applied to the development of the BCLDP baseline was specifically designed to comply with the requirements of DOE Order 413.3 and its two addenda, *Program and Project Management Manual* (2) and *Program and Project Management Practices* (3).

**Early Recognition of Data Needs**

Early recognition of the data necessary to support analyses and decisions during the development of the technical baseline is important to maintain the desired schedule. The F-R-A approach is especially useful in identifying specific data needs early in the process. The two most important data estimates were the amounts of legacy waste and the additional waste that would be generated during decontamination. Waste type and waste volume were the primary variables for determining the scope of individual activities, their durations, and the preferred D&D strategies and technologies. Since all the data that would be necessary for supporting a CD-2/3 decision were not immediately available, the methodology was useful in timely identification of data-gaps which resulted in immediately initiating additional data collection and analysis activities without delaying the baseline development process.

**Experienced Facilitators**

There are two aspects to the development of a technical baseline: technical content and process. The baseline was developed in working sessions composed of a multi-disciplinary team of subject matter experts who provided the technical content and a pair of facilitators experienced in applying the F-R-A methodology. The experts were responsible for providing the in-depth knowledge needed to decompose the mission into a necessary and sufficient set of functions to satisfy it, to specify all applicable requirements, and to select preferred technical strategies from among feasible alternatives. The facilitators were responsible for guiding the thought process of the experts, mediating their deliberations, resolving the problems that typically occur in small groups, and achieving consensus. The facilitators' experience in applying the F-R-A methodology allowed them to anticipate discomfort and anxiety on the part of the subject matter experts, who were accustomed to thinking in terms of things, rather than functions.

**Accelerated Closure**

Anticipated or pre-established annual budget levels are often a limiting factor that must be considered during baseline development. Project schedules normally cannot be optimized under constant budget constraints, which therefore result in longer schedules and increased overall project cost. Because the BCLDP is identified as an Accelerated Closure Site, the 2006 Congressionally-mandated closure date eliminated the annual budgetary constraint and permitted development of an optimized baseline. This one element alone resulted in an estimated reduction of $25 million in the final baseline compared to a previous version that was constrained at $16 million per year.

## LESSONS LEARNED

BCLDP is a relatively small DOE environmental cleanup project. Its scope and technical challenges are fairly well understood and manageable. For example, the volumes, types, and locations of legacy waste are well known compared to other DOE sites; there are no layers or divisions of institutional responsibilities in the form of multiple contractors and subcontractors; and there are no major stakeholder concerns and controversies that often delay programmatic and technical decisions at other DOE sites. No doubt, such a relatively simple context contributed to the overall effectiveness in applying the methodology. However, in retrospect, the development of BCLDP's baseline in accordance with DOE

Order 413.3 addressed nearly all the potential difficulties typical of a far more complex cleanup program. The lessons learned from this application have universal implications in that they apply to all DOE cleanup programs, regardless of their size, scope, complexity, and programmatic configuration.

**Baseline Development within an Ongoing Program**

When beginning a comprehensive baseline development effort within an ongoing program, management is often torn between using the best available subject matter experts (thus risking disruption of the ongoing work) or using less knowledgeable technical staff (thus perhaps sacrificing the quality of the baseline). Two unique challenges involved in implementing a baseline development process within ongoing programs are (1) the availability of key technical project personnel who have to balance the demands of their daily work assignments with the needs of an intense baseline development effort and (2) diverting additional technical staff from ongoing work to develop new data and analyses that are judged necessary to support the baseline development effort. The more critical challenge, however, is related to parochial attitudes and technical opinions ─ "we've always done it this way" ─ that come to be accepted as the norm and engender both overt and subtle resistance to new and different ways of viewing technical and programmatic issues in ongoing programs. These opinions are often left unquestioned over time. They represent a particular disciplinary bent or bias in such matters as likely levels of contaminants on a site, tradeoffs between acceptable risk levels and additional site characterization, and the applicability of various technical approaches and technologies to D&D. The methodology applied herein allows, in fact promotes, the introduction and discussion of new ideas and in a structured way, facilitating consensus and a common understanding among various technical disciplines and organizational elements involved in a cleanup program.

*We believe that due to the challenges involved, the schedule and cost of developing a technical baseline within an ongoing program will turn out to be at least 50% greater than originally anticipated. Fifty percent is a minimum adder recommended in planning similar efforts*.

**Value of New Information**

Critical technical decisions must be made throughout the technical baseline development process. Often, the data and results of analyses to support these decisions are not available. In these situations, the question is whether to collect new data and conduct additional analyses or to base decisions on old information. Data collection can be time consuming and expensive and should not be undertaken without understanding the value that will be derived. For example, reducing the uncertainty in the estimates of existing contamination levels is not reason enough to collect new information; determining what technology is best suited to the specific decontamination is. Occasionally, additional data will be needed to support specific CD-level analyses, to reduce the uncertainty associated with the estimated cost and schedule, or to respond to specific review comments. As stated earlier, in developing the BCLDP baseline the need for new data and analyses was anticipated and the implementation process was designed to accommodate it. We expect that the need for additional data and analyses increases with the technical complexities of the cleanup (e.g., applicability of existing technologies) and the expected duration of the program (i.e., availability of new technologies).

*Regardless of how long a program has been ongoing, the technical staff will claim they lack enough data and analyses. Do not be fooled. Ask them what decisions are to be supported with any new information they say they need.*

**Multiple Reviews**

The BCLDP baseline development process was planned and managed to satisfy an eventual IPR by the DOE Office of Environmental Management, including resolution of comments from that review. However, as shown in Table II, there were several additional, unanticipated reviews. These reviews were carried out for a variety of reasons, none of which was related to the methodology or its implementation, and probably should have been anticipated. Obviously, the additional review cycles extended the schedule and increased the cost of the overall baseline development effort.

**Table II. Timeline of Baseline Development Activities**

| MILESTONE OR ACTIVITY | DATE |
|---|---|
| Draft BCLDP Revision 3 Baseline | September 2000 |
| DOE Independent Project Review | November 2000 |
| Internal Battelle Corporate Review | February 2001 |
| Independent Challenge Team Review | May 2001 |
| Draft Final BCLDP Revision 3 Baseline | July 2001 |
| DOE Independent Cost Estimate Review | November 2001 |
| Final BCLDP Revision 3 Baseline | June 2002 |
| CEMP recommendation for approval | July 2002 |

*Multistage reviews by multiple reviewers should be considered in planning the development of baselines in accordance with DOE Order 413.3. We believe that the possibility of additional reviews increases as a D&D program progresses through its critical decisions.*

**Baseline as the Representative of the Whole Project**

DOE Order 413.3 and the Manual (2) address all elements of environmental restoration, D&D, and facility disposition in terms of five critical decision levels of a program life cycle. In addition to a technical baseline, the program elements that are either directly or indirectly addressed include risk management program, cost and schedule contingencies, stakeholder involvement program, requirements management program, technical work procedures, and others. These elements are expected to be at various degrees of completion at the end of each critical decision level. Because of interdependencies among various program elements, a technical baseline reflects, or represents, the status of such other elements. Consequently, evaluation of a baseline invariably requires evaluation of other elements and often the whole program. For example, the DOE IPR identified the need for a comprehensive (i.e., CD-2/3 compliant) risk management program, along with the results of a more robust risk-based approach to estimating cost and schedule contingencies than used in the reviewed version of the baseline, as important to ultimately achieving an approved baseline.

*Development and implementation of any one of program elements addressed in DOE 413.3 Order and the Manual should be undertaken with a clear, and well articulated, understanding of all other elements of a cleanup program. This approach is especially important in developing a baseline. The baseline is the program node or product where the most fundamental strategic assumptions, tactical or operational*

*approaches, and results from technical analysis are translated into measurable and concrete measures of money and time. Therefore, cost and schedule estimates in a baseline should reflect a cohesive and integrated program configuration, all aspects of which comply with the DOE Order 413.3 Order requirements applicable to a critical decision level.*

**Choice of Simulation and Modeling Methods**

DOE Order 413.3 and the Manual (2) recommend the use of systematic and quantitative methods for the development of cost and schedule contingencies. The Manual discusses the "flat rate contingency" and Monte Carlo simulation methods; in terms of rigor of results, ease of application, and resource requirements, these two methods represent the two extremes of a continuum, in which the more rigorous methods require more resources and time for their application. Clearly, cost and schedule risk assessments have value and provide insights for the management of a cleanup program, and using a more rigorous method provides for better and more reliable insights. However, it is often difficult to justify the additional cost and time associated with a sophisticated method if the results of a contingency analysis have little or no bearing on actual contingency funding decisions (i.e., contractual commitment by DOE and contractors regarding management, availability, and disbursement of those funds). Moreover, without an explicit contractual linkage between risk and contingency funding decisions, the effectiveness of the risk assessment process and the use of its results (contingency costs) would depend solely upon an individual advocate in a cleanup program, which is often not sustainable over the full lifecycle of a program.

*Whenever possible, the results from a cost and schedule risk assessment should be linked with funding decisions and action, regardless of what methodology may be used. Once such a link is established, the methodology can be selected on the basis of desired analytical rigor, ability to examine tradeoffs between rigor and cost of application of a methodology, quality and quantity of historical and available data, and/or other criteria appropriate to the site.*

## REFERENCES

1. DOE Order 413.3, "Program and Project Management for the Acquisition of Capital Assets", October 13, 2000, Draft
2. DOE Order 413.3, "Program and Project Management Manual", October 2000, Draft
3. DOE Order 413.3, "Program and Project Management Practices", October 2000, Draft