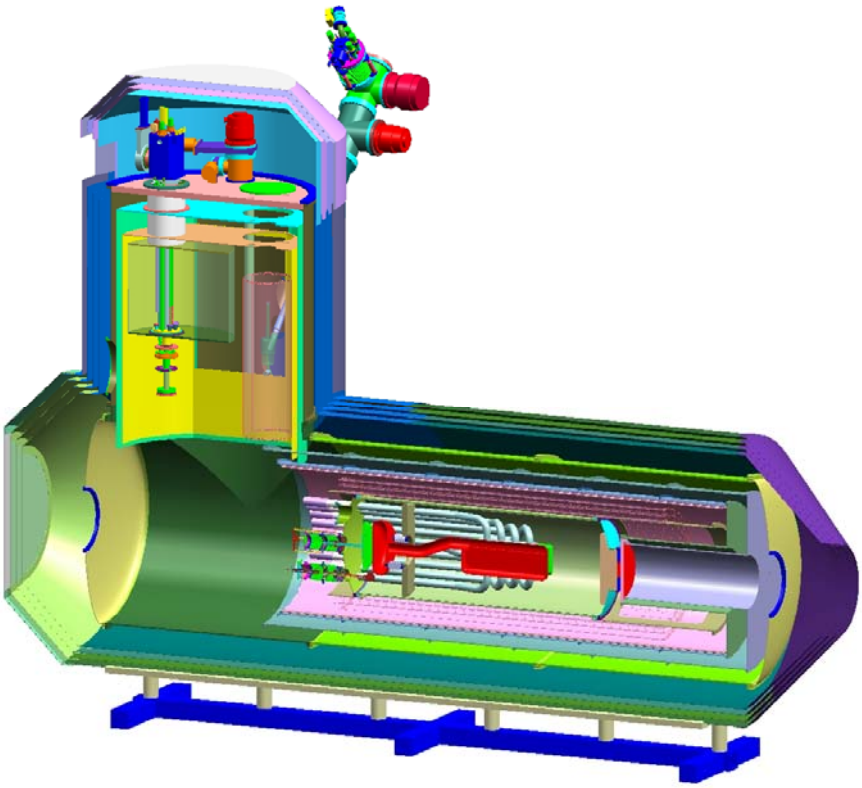
Project Controls Manual for the Electric Dipole Moment (EDM) of the Neutron Project



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List of Acronyms and Abbreviations

AC	actual cost
APP	advanced procurement plan
BA	budget authority
BAC	budget at completion
BCP	baseline change proposal
BO	budget outlay
CMP	configuration management plan
CPI	cost performance index
CPR	cost performance report
DCN	document change notice
DOE	U.S. Department of Energy
EAC	estimate at completion
ETC	estimate to complete
FIS	financial information system
FNBP	Fundamental Neutron Beam Line Project
FSR	financial status report
HQ	DOE headquarters
IPS	integrated project schedule
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
LOE	level of effort
M&S	materials & services
ML	milestone log
MSP	Microsoft Project™
MSSR	milestone schedule and status report
NNSA	National Nuclear Security Administration
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Office (of the DOE)
PBB	project budget baseline
PCR	project change request
PEP	project execution plan
PMB	performance-measurement baseline
PPEP	preliminary project execution plan
PV	planned value
R&D	research and development
RFP	request for proposal
SC-NP	Office of Science – Nuclear Physics Programs
SNS	Spallation Neutron Source
SPI	schedule performance index
TEC	total estimated cost
TPC	total project cost
WBS	work breakdown structure

1. Background and Introduction

1.1 Foundation for Proposed EDM Project Controls

The proposed EDM Project will be a complex scientific and organizational undertaking. From the proposed collaborative National Laboratory/University project organizational partnership; to the various scientific details and issues that will be addressed, the EDM Project will represent many unique challenges and opportunities for innovative performance. The EDM Preliminary Project Execution Plan (PPEP) will provide policy guidance for the overall planning and execution approach planned for the Project, and invokes this Project Controls Manual as the reference procedure for implementation of all estimating, budgeting, planning, and scheduling activities on the project.

The Project Controls processes, elements, and detailed methodologies defined within the body of this manual and the attached appendices are based on a wide variety of Department of Energy (DOE) policy and procedural guidance documents and the successful processes and methodologies utilized by other projects, such as the Spallation Neutron Source (SNS), and the Fundamental Neutron Beam Line Project (FNBP). Also reflected are various implementation practices already in place at the two National Laboratory partners and the proposed universities. In addition, the foundation of the overall Project Controls approach will continue to be refined to reflect the lessons learned provided by other DOE Projects as a result of Project Reviews. The EDM Project Controls philosophy and overall approach will focus on

- EDM Project Office leadership to ensure common-denominator planning and execution,
- organizational responsibility for performance and results by each project participant,
- an optimum balance of supporting processes and details,
- efficient reporting and performance measurement, and
- a clarity of focus on controlling project schedule and cost baseline “drivers.”

The EDM Project Controls program will evolve with different areas of emphasis as the project evolves through the various phases of project execution. Earned value measures, lower level schedule milestones, performance indicators, and performance reports and review meetings will be refined to suit the requirements of the project in various phases. A graded approach to project controls will be adhered to.

1.2 Lessons Learned on Other Projects

In addition to adopting successful practices from projects like the SNS and FNPB, an important ingredient in developing a successful Project Controls Program includes the evaluation and application of lessons learned from unsuccessful projects or programs. The proposed EDM Project team will be sensitive to the lessons learned on these projects and establish processes to prevent repeating past mistakes.

Many projects have failed for various technical and management reasons. As outlined in Appendix C, various references and studies compiled by the DOE and other reviewers document the deficiencies and errors that lead to failure. These include

- **Inadequate change-control processes and procedures**—This can lead to scope and schedule “creep” and result in large cost increases. Inadequate change-control procedures can also mask the reasons for cost growth from the original baseline. These problems can be greatly reduced by development and strict adherence to a change-control procedure.
- **Inadequate and inaccurate project-status reports**—Project managers must continuously assess and analyze the project status. This has been impossible on some past projects due to a lack of or improper reports from contractors and project participants. In addition, some reports have been found to contain inaccurate data, thereby resulting in incorrect analysis and assessment. Identifying early in the planning process what information is needed to assess and analyze the project properly and establishing a system for obtaining that information can minimize this problem.
- **Insufficient project reviews**—Both the frequency and the content of project reviews have been inadequate on many past projects. Ensuring that project-management personnel place the proper

emphasis on the review process can minimize this problem. Furthermore, establishing and using the Project Controls Program outlined within this manual will create a framework for success.

1.3 EDM Challenges

The proposed EDM Project collaboration of two National Laboratory partners and thirteen Universities provides a tremendous foundation of technical and management strength, capability, and flexibility to support a successful project. Intrinsic with this strength, however, is also the difficult challenge of managing the technical, cost, and schedule baselines while properly integrating the communication and interface coordination details of sixteen design and purchasing authorities. Figure 1-1 provides a summary depiction of the proposed principal EDM technical and management interface relationships at Work Breakdown Structure (WBS) Level 2 that must be managed to assure a comprehensive program is in place to support a successful project. The diagram illustrates the complexity of technical and management interfaces that must be dealt with very systematically to assure that communications are clear.

As depicted, the EDM Project Manager will be the focal point to provide the leadership and direction necessary to assure that cost estimate/budget and schedule planning, status reporting, performance measurement, and baseline change-control processes and methods are efficient and consistent. Working with the EDM Project Manager, the Project Controls Analyst will have the authority to assure that a sound basis and process exists across all partner organizations to support effective and timely compiling of project controls information on various reporting frequencies. Key examples of this will include

- a common project Work Breakdown Structure,
- a Master Schedule supported by a hierarchical scheduling structure,
- a common Work Package format,
- resource-loaded schedules at the activity level,
- periodic sampling-validation reviews of partner source information and processes,
- training required to assure a common-denominator process is understood and maintained, and
- participant feedback to refine the process as the project evolves from one phase to another.

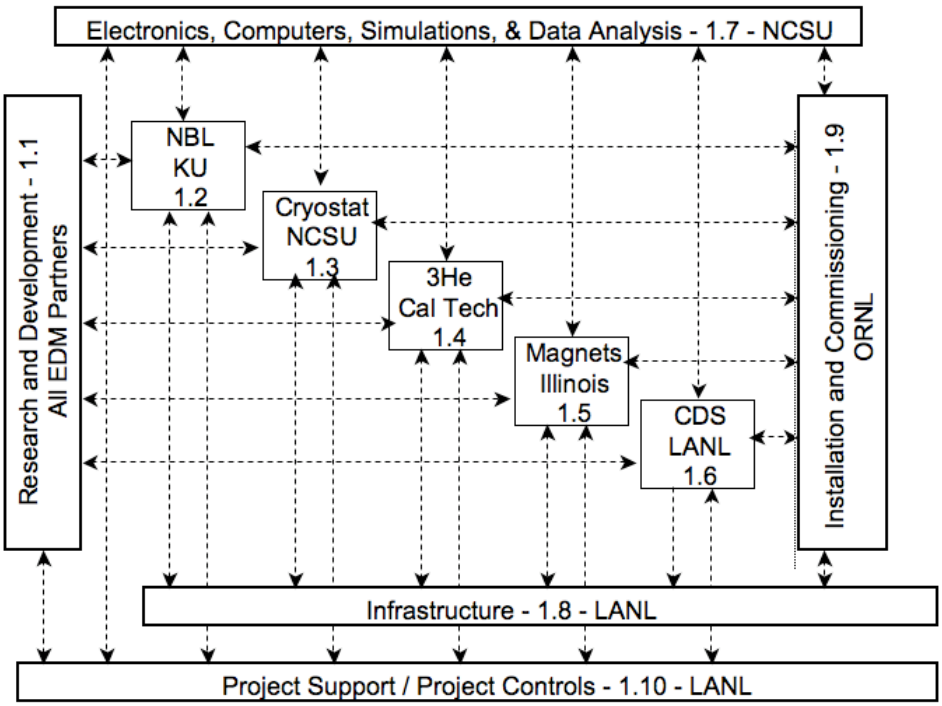

Figure 1-1. A summary depiction of the proposed principal EDM technical and management interface relationships at WBS Level 2.

1.4 Objectives of the EDM Project Controls System

The proposed EDM Project Controls System will be an integrated management control system for project planning, scope/schedule/cost integration, cost/schedule performance measurement, analysis, and reporting. Objectives of the EDM project controls system will be to

- establish consistent processes to assure that auditable bases exist to support the development of project-life-cycle cost/budget and schedule project baselines;
- provide mechanisms at each organization and at the EDM Project Office to objectively identify and communicate the status of the project;
- engage the Subsystem Managers and Work Package Managers in planning, execution, and performance as "owners" of their assigned WBS elements;
- reliably detect actual schedule or cost-performance variances from baselines; and
- reveal what must be done to recover from variances.

These objectives shall be satisfied by developing and using a system that provides

- a performance measurement based on the measurable value of work performed,
- variance analysis on major items (i.e., critical path or large dollar impacts),
- a change-control process, and
- organizational accountability for performance/accomplishments.

1.5 Document Purpose and Arrangement of Contents

The Project Controls Manual details the cost and schedule control systems that have been established to manage the EDM Project. The appendices are intended to be a "handbook" for day-to-day use by those involved in the processes of project management, administration, control, and status reporting. Also identified in Appendix C are the documents referenced and considered when developing the Project Controls Manual.

2. The Project-Control Process Overview

2.1 Organization

The proposed organization for the EDM Project will be established in the PPEP. The key staff involved in carrying out the daily planning, execution, and control of the project controls function are

- Federal Project Director,
- EDM Project Manager,
- Project Controls Analyst,
- Business Manager, and
- Subsystem Managers from each participating organization.

2.2 Functions, Responsibilities and Authority

Key positions in the project-controls function are the EDM Project Manager and the Project Controls Analyst. In addition, senior Project Management Advisors are actively involved in supporting the EDM Project Office and report to the EDM Project Manager. The EDM Project Manager may elect to employ a Deputy Project Manager if justified by work load.

The Project Controls Analyst is the focal point for the EDM Project Manager to provide leadership for coordinating overall EDM Project Controls activities. The Project Controls Analyst will provide systems and procedures for timely and accurate variance determination. These systems ensure that the processes across all partner organizations support effective and timely compiling of project controls information on various reporting frequencies. This involves close coordination and frequent communications with the EDM Project Manager, Subsystem Managers, and participant project-controls staffs.

The Subsystem Managers are responsible for executing the project and for overall performance and results of their assigned WBS elements. They will provide timely input to the Project Controls Analyst in the format described in the Project Controls Manual. A Business Manager is responsible for Financial Controls and portions of the budget-authorization process described in this document. Management of the procurement process is also the responsibility of the Business Manager. It must be emphasized that this team, working together, will provide the executive leadership of the EDM Project and the essential information for the timely and on budget completion of the project. Cooperation and teamwork are fundamental to success of the project-controls function.

2.3 Process

The purpose of the project-control system is to effectively control project execution. Goals are established, a plan is prepared, progress is measured and compared with the plan, variances from the plan are analyzed and alternative courses of corrective action evaluated, the best course of action is selected, and the plan is modified accordingly. Trends within each reporting segment are developed and analyzed (See Figure 2-1). Compliance with the WBS, cost and schedule control, and performance reporting provide the necessary assurance that the project leader has the basic data required for timely and meaningful management decisions. This system must produce standardized, timely, consistent, and accurate data.

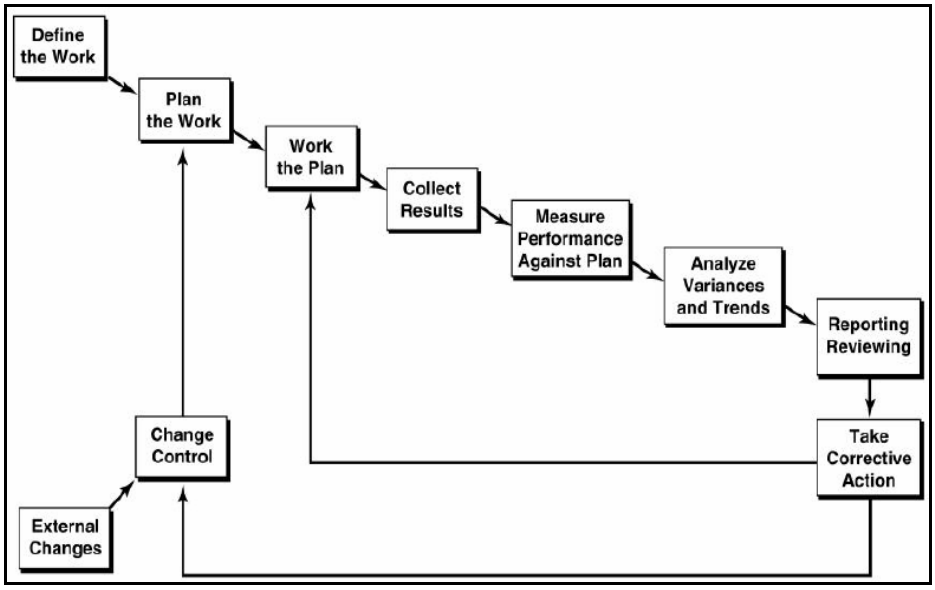

Figure 2-1. A flow chart of the project-control process.

3. Planning for Integrated Estimating, Budgeting, and Scheduling

The proposed planning and budgeting process for the EDM Project will include the scope definition, scheduling system, and the cost-planning system. A Cost Estimate Work Package template (Excel based) will be the repository for the basis of estimate for the Project's baselined budget. Each estimate will be assigned to a schedule activity and, as such, the estimate in Microsoft Project (MSP) will be time phased and appropriately burdened and escalated. As monthly reporting data is available (schedule, status, and actual costs), it will be imported into an Excel template, completing the final integration of all of the performance measurement components (schedule, performance, and actual costs).

3.1 Work Breakdown Structure

The WBS for the EDM Project (see Figure 3-1), identifies all elements of work within a framework that facilitates logical planning, budgeting, scheduling, assignment of responsibilities, cost tracking, performance

measurement, and reporting of status. The WBS also serves as a prime integrating tool for scope, schedule and cost. The project-specific WBS coding allows for the consistent roll-up and summarization of data for management and reporting purposes. Revisions to the WBS will be controlled (upon approval of CD-1), through a proposed change control process. A WBS Dictionary, will describe the scope content and boundaries of the individual WBS elements.

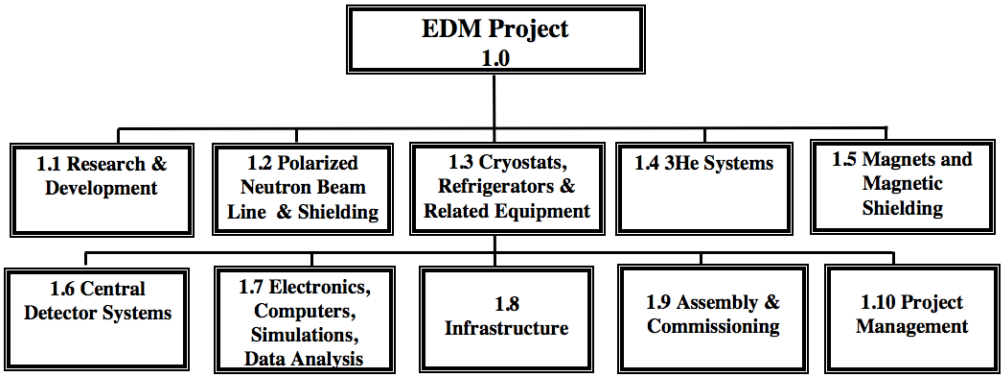

Figure 3-1. The WBS proposed for the EDM Project.

3.2 Estimating and Budget Development

Objectives of the budgeting process are to

- integrate the Project budget with the approved scope and schedule,
- establish a time-phased budget baseline in such a manner to facilitate cost/schedule performance measurement, and
- maintain the integrity of the time-phased budget baseline.

A budget represents the target cost for a particular scope of work and is based on the allocation of resources to scheduled activities. Integrating the budgeting process with the schedule assures that a Performance Measurement Baseline is properly established and maintained throughout the entire period of performance.

3.2.1 Procedure

The detailed Project cost estimates (and the subsequent estimate prepared with project change request or ETCs [estimate to complete]), will be developed and maintained under the guidance of the Subsystem Managers, as the primary data source in determining budget values. The EDM Project uses an activity-based-costing approach for estimating, where the resources required (labor, materials, services, etc.) are estimated for the activities in the schedule. Estimates will be prepared at the schedule activity level and in accordance with the requirements and guidelines in Appendix B. In addition, detailed work packages will be utilized across the project to capture the basis of estimate for each activity.

These work packages along with the associated guidelines allow standardization of data formats and estimating methods. Changes to the project cost baseline will only be through approved change requests.

3.2.1.1 Discrete Effort

Work is planned as discrete (measured effort with a final product) to the maximum extent practicable. Within a current planning year, activities should be of short duration and have definite scheduled start and completion dates. Whenever possible, activities longer than two to four months in duration should have intermediate milestones that provide interim performance measurement data.

3.2.1.2 Level of Effort

When a task cannot be measured as discrete, level-of-effort (LOE) planning will be used. LOE represents work that has no discrete measuring points such as administrative, financial, or project-management support. LOE

planning for the EDM Project should be kept to a minimum. LOE activities are measured the same as discrete tasks except that there is no schedule variance and earned value (EV) always equals planned value (PV).

3.2.2 Budget Baseline

The approved total project cost (TPC) as provided and approved by DOE in the PPEP is the total authorized budget for the project and the project budget baseline. The budget baseline is compiled for the total project period and time phased by fiscal year. As a minimum, the current fiscal year is further time-phased by month. The budget baseline is directly based on the cost estimates of the individual Work Packages.

3.2.2.1 Performance Measurement Baseline

The performance-measurement baseline (PMB) is the budget against which performance is measured and is synonymous with total estimated cost (TEC). It is developed by the integration of the cost estimate and schedule data. The PMB will reside in MSP as a controlled file. Changes to the performance measurement baseline occur only through approved Project Change Requests.

3.2.2.2 Project Budget Baseline

The project budget baseline (PBB) is equal to the sum of contingency and PMB and is synonymous with TPC.

3.3 Schedule Development

The objective of the schedule-control system is to ensure that EDM work is effectively planned and scheduled and to provide a mechanism for measuring progress against plans. The system also provides the identification of interface requirements among the partner organizations. Appendix C provides the scheduling requirements and procedures.

3.3.1 Scheduling Hierarchy and Management Milestones

The EDM Project schedules will be “tiered” from the Project Summary Schedule through intermediate schedules to the detail project schedule (which is at the level of greatest detail). The set of project schedules proposed for managing the EDM Project are described in Table 1. These include the Project Summary Schedule, the Integrated Project Schedule (IPS), and detailed project schedules.

The proposed Project baseline will be instituted at the Project Summary Schedule and driven down as progressively more detailed schedules are implemented. The detailed subproject schedules will initially be baselined at the detail level in April 08. Changes to this baseline will occur only through approved Project Change Requests. The Baseline Milestones in the Summary Schedule, their definitions and planned dates will be mutually developed by EDM and the DOE and will be documented in the Project Execution Plan (PEP). The EDM Project Office will track the status of these milestones. The actual and forecasted status will be reported each month by the Subsystem Manager. Schedule status will also be provided monthly by the Subsystem Manager. Schedule variances are calculated by comparing the statused dates to the approved baseline dates. Additional milestones at the IPS and activity levels will be used to provide visibility of other key events.

Table 3-1. Project Schedule

Schedule Document	Primary User	Purpose
Project Summary Schedule	DOE Headquarters	Show overall summary-level project baseline schedule, provide template for baseline dates in all lower level schedules; identify all DOE Schedule Milestones
Integrated Project Schedule	DOE-LASO and EDM Manager	Define project schedule strategy, identify assembly and commissioning strategy and critical path, monitor project-wide basis.
Detailed Project Schedules	Subsystem Managers	Plan and monitor progress of project scheduled activities; generate percent complete data; generate reports.

The partner organizations will be responsible for maintaining the detailed schedules. The EDM Project Office scheduler will be responsible for maintaining the Summary Schedule and the IPS, and overall

administration of the scheduling system. This includes horizontal and vertical integration of elements of the scheduling system, monthly critical-path analysis of the integrated schedule, maintenance of schedule baselines, reporting baseline schedule status to DOE, and providing enhancements to the scheduling system.

3.3.2 Schedule Implementation

Annual Budget Packages will be created from the detailed project schedule and developed by the responsible manager at each subsystem. They will be approved by the EDM Project Manager and agreed to by the Federal Project Director. The budget packages will summarize (at Level 3 and 2) the resource-loaded activities in the detailed schedules. These detailed schedules will be the lowest level schedules in the EDM performance measurement system. Longer, more summary activities represent the remaining out year work. The activities in any current 12-month window should average 1–3 months in duration with activities >1–3 months having intermediate milestones to the maximum extent practical. The intent is to have all discrete effort (a measurable final product) planned with frequent and measurable control points. Milestones are represented as zero-duration activities and are a part of the logic flow. Any effort that has no definable product or milestones will be planned as LOE. However, LOE planning will be kept to a minimum. In addition, LOE activities are to be scheduled to end at the end of each fiscal year.

Resources will be applied to schedule activities for the purpose of establishing planned value and determining performance measurement values within MSP. The EDM Project Office will integrate the subprojects' detailed schedules to provide a vehicle for total project critical path and "*what-if*" analyses. All technical components will be scheduled in detail from design through procurement, installation, and final testing. Schedules will be established and saved electronically utilizing MSP software. Specific guidelines for schedule development are included in Appendix C. The baseline schedules will be under configuration control.

3.3.3 Schedule Maintenance

All schedules will be maintained in and by the EDM Project Office. The assigned Project Controls Analyst/Scheduler will provide this service in direct support to the EDM Project Manager. The Controls Analyst/Scheduler will also provide support to the Subsystem Managers. Schedule maintenance involves maintaining the integrity and traceability of the schedule baseline and ensuring that all schedules are logical, are consistent with the WBS, are consistent with each other and are catalogued for historical purposes. The baseline schedule will have cradle-to-grave trace for the life of the project. Schedule maintenance also includes the timely incorporation of approved baseline changes (within 45 days of the approved change).

3.3.3.1 Progress and Status

Schedules will be statused monthly at the activity level with input from the responsible manager. Work will only be performed on authorized activities approved with the budget package or a subsequent project change request (PCR). Actual start and/or completion dates will be entered against the activities, producing a working schedule. Comparing the working dates to the baseline dates will facilitate variance analysis. Schedule logic will allow the impact of behind schedule activities on downstream events to be reported and summarized and the critical path to be analyzed. The responsible Subsystem Manager will review the schedule status, before submitting it to the EDM Project Office on the fifth working day of the next month. Upon receipt of the statused detail schedules (electronic MSP files), the EDM Project Office will integrate the schedules and analyze for impacts to the interproject links, project critical path, and Level 0–Level 3 milestones.

3.3.3.2 Baseline Revisions

Schedule variances of such magnitude as to make the authorized schedule baseline invalid *may* be addressed through the change-control process if conditions warrant and they cannot be brought back in line within the existing baseline. The criteria for rebaselining and the change-control process will be defined in a EDM Configuration Management Plan. Once approved, baseline changes will be incorporated into the schedule and future statusing will be compared to the revised baseline. It is the intent of the Integrated Project Team to avoid rebaseline situations.

3.3.3.3 Special Schedules

When problems of extended duration (more than several months) arise that present potential significant risks to project key schedule milestones or costs, recovery plans to include special schedules will be prepared. These schedules can be in any form, using whatever tool is the easiest. Simplicity will be encouraged as long as the level of detail ensures progress and the impact of delays can be accurately assessed. The schedules are to be reviewed by all involved managers on the project, including the EDM Project Manager and Federal Project Director and the EDM Project Office staff, and formally approved by the EDM Project Manager. Statused schedules will be provided, on an agreed to frequency based upon the severity of the problem, and discussed by the Subsystem Manager in the monthly EDM Project Office review meetings. Key milestones from these special schedules (e.g., go/no-go dates) will also be incorporated where appropriate into detailed subproject schedules. The milestone level for these milestones will be designated as "S" for easy tracking and evaluating impact on the total project.

A second form of special schedule is “working schedules, which are authorized for use by Subsystem Managers and Work Package Managers as supplemental to approved schedules. Working schedules often have utility in that they facilitate the understanding of necessary “work-arounds” and/or to accommodate efficiencies in the execution of the work. Working schedules are usually of short duration and are not used as replacements for authorized schedules.

4. Work Authorization & Budget Authority

4.1 Work Authorization

Work authorization ensures that all work performed on the project has been contractually authorized and properly planned before its execution. A project authorization to commence work cannot be officially initiated until the formal work/budget authorization and funding is received from DOE or another funding agency.

With the completion of the planning process for each work package within the subsystems, and following DOE approval of the project preliminary or final baseline, the responsible organization is ready to request authorization to proceed. The EDM Project Manager delegates work to the Subsystem Managers within the authority provided in the Budget Package (see Sections 4.2 & 4.3 below). The Budget Package includes the relationship to the WBS element and work packages, responsible organization identification, scope descriptions, schedule, and time-phased budget in dollars. Because DOE authorizes budget authority on an annual fiscal-year basis, the Budget Packages correspondingly are submitted and approved before the commencement of each Federal fiscal year. The work packages authorized by the Budget Package can only be changed with appropriate change approval.

The approved work package(s) is the EDM Project Manager’s vehicle to delegate responsibility for budget, schedule, and scope requirements to the Subsystem Manager. The approval of a Budget Package represents a multilateral commitment by all parties to authorize and manage the work within the budget and agreed-upon schedule.

4.2 Project Budget Authorization

It is assumed that with the passage of appropriating legislation for the DOE, Headquarters (HQ) will provide funds to the EDM Project Office through the normal financial plan process and authorization to perform work through the DOE work authorization system. The DOE financial plan will provide funds for the operating expense, and capital equipment portions of the project. Actual expenditures and commitments will be limited by the amount of funds authorized by DOE and the type of funds made available (operating expense, and capital equipment). At no time shall cost plus the outstanding commitment balance exceed the funds authorized by DOE.

In anticipation of the receipt of funds from DOE, agreements will be reached with each laboratory and university on the work scope, milestones, budgets, and type of funds for the ensuing fiscal year. Each organization will transmit Budget Packages to the EDM Project Office for review and acceptance by the EDM Project Manager. After acceptance by the EDM Project Manager and Federal Project Director, the Budget

Packages will become the official work scope for the coming year. If a DOE financial plan has not been received by the beginning of the fiscal year, the DOE-LASO EDM Project Office will issue directive authorization subject to receipt of the financial plan or availability of funds.

The LANL EDM Business Manager will prepare the necessary documents (i.e., procurement request) to authorize participating laboratories and universities to cost and commit funds. The Chief Financial Officer will sign the procurement request after the financial plan, the DOE work-authorization document, and the directive authorization are received/approved. The Business Manager will then submit the request to the Federal Project Director for approval. Once approved, the Federal Project Director will process the request to the LANL procurement office, where the procurement package is prepared and transmitted to DOE-LASO. Figure 4-1 shows the process just described. Official funding authorization will be provided to each laboratory via DOE Interoffice Work Order (B&R XX01), and university via university subcontracts. For EDM work to be performed by Los Alamos National Laboratory (LANL), budgets will be allocated internally based on approved budget packages and the availability of funds.

The DOE-LASO Budget Division is responsible for transmitting the procurement request to the affected DOE field offices (namely ORO). The DOE field offices will accept the procurement request and authorize participating laboratories to perform work consistent with the statement of work and funding limitations.

Each laboratory participant will be subject to home laboratory internal work authorization rules (e.g., purchase orders, subcontracts, work orders, etc.). Cost and commitments will be limited by the amount of funds allocated to each participant. The EDM Project Office reserves the right to incrementally fund approved budget packages.

The Business Manager will maintain the official file for authorizing documentation that will include

1. (1) DOE–LASO directive authorization,
2. (2) DOE work authorization documents,
3. (3) financial plan, and
4. (4) interoffice work order requests submitted to DOE-LASO.

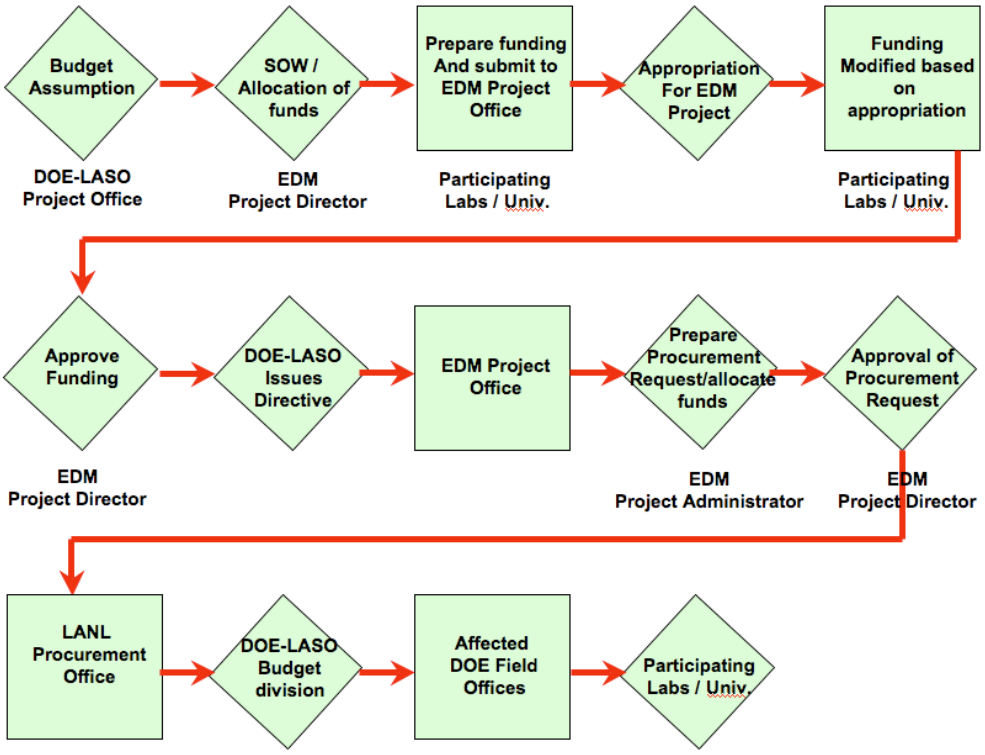

Figure 4-1. Budget Authorization

4.3 Annual Budget Packages

The Budget Package is the tool that will be used to request money. Budget Packages will be prepared by participating organizations based on their detailed schedule and submitted annually to the EDM Project Office for approval. The Budget Package summarizes the detailed resource loaded activities at WBS levels 4, 3, and 2. The Project's cost module (MSP) calculates the budget outlay (BO) profiles. Budget authority (BA) profiles are provided by the partners and should reflect the month that BA is needed for actual contract execution. A separate Budget Package is submitted for each Level 2 WBS element. The EDM Project Office will supply the specific format, but at a minimum the packages will include

1. narrative description of the scope of work,
2. budgeted cost of work scheduled (BCWS) profiles by month for each resource-loaded activity in MSP,
3. BA requirements by month at Level 2
4. BA requirements for the current year at Level 3 or 4,
5. detailed resource-loaded schedule of activities for the fiscal year, and
6. proposed performance-measurement methods for each resource-loaded activity.

Budget Packages may also be submitted to the EDM Project Office during the year in order to initiate new work as a result of approved change requests. All Budget Packages involve only one type of funding. By allowing only one type of funding (i.e., operating expense or capital equipment) per Budget Package, funding integrity will be maintained. Each Budget Package will identify the type of funds required to perform scheduled work activities.

When purchase orders are executed near the end of a fiscal year, deliveries and payments to suppliers may not occur until the next fiscal year. When this occurs, an outstanding commitment balance will exist at the conclusion of the year. Budget Package carryover funds will be used to make payments once the items are received in the new fiscal year. At the conclusion of each fiscal year, the Budget Package cost plus outstanding-commitment balance should provide for an effective use of funds and a smooth transition to the new fiscal year.

When a common scope of work is being performed by more than one organization, the Budget Package will identify the participants and include the BA and BO budgets with the corresponding profiles. Each performing organization will be responsible for preparing and submitting reports to the responsible Subsystem Manager. Again, the BO profiles will be extracted from MSP based upon the detailed schedules. The responsible Subsystem Manager will be responsible for validating this information before its approval in the Budget Package cycle. When work is performed at a performing organization that is not the responsible organization, the Subsystem Manager of the responsible organization must establish performance reporting procedures with the performing organization. Actual costs are submitted to the project office by each partner and reflect all work costed at that organization. The costs are reconciled with the official DOE Financial Information System and then integrated in the Project's cost module and disseminated out to all partners. The responsible organization will be responsible for comparing the actual cost (reported via the cost module) to the performance (reported by the performing organization) and analyzing variances where required

5. Baseline Change Control

5.1 Configuration Management Process

Appendix E describes the process and procedure for managing the approved Project baselines for the technical design basis, engineering approaches, interface design controls, and technical parameters for the Project. In addition, Appendix F describes the Project's contingency-management plan and quality-assurance process.

5.2 Change Control Responsibility

The Project Controls Analyst will be responsible for administrative operation and coordination of the overall baseline change-control system in support of all EDM Project participants, including processing all EDM project change requests (PCRs). This will begin upon receipt of a draft PCR from the responsible Subsystem Manager and continue through various reviews to the issue and distribution of approved PCRs or baseline change proposals (BCPs), which require DOE review and approval.

The Project Controls Analyst will be responsible for implementing approved cost/budget and schedule/milestone baseline changes to the official EDM Project baseline documents and files. Authorized baseline changes will be incorporated within 30 calendar days.

The Subsystem Managers will be responsible for implementing all approved baseline technical/design basis changes to the official EDM Project technical baseline documents and supporting technical design documents and files at all locations.

6. Performance Measurement and Analysis

This section describes how the performance-measurement system will be part of the closed-loop project-controls system described in Section 2.3. The EDM Project Office will develop the performance measurement and reporting system, maintains the system, generate project-wide reports, and distribute reports to appropriate personnel. The Subsystem Managers will generate performance data via the detail schedules, evaluate progress within MSP, generate reports, analyze variances and implement corrective actions if needed. The essential ingredient in measuring performance will be up front definition of what is to be measured.

6.1 Performance Measurement

6.1.1 Requirements

All work scope will be managed using tailored performance-measurement techniques. Planned value (PV), also known as BCWS, is the time-phased budget that represents the value of work to be accomplished during a given period of time. As work is completed, the budget associated with that work is “measured” as progress. The following guidelines should be followed in determination of measuring project progress:

- Performance measures are calculated using the method selected at the time of planning of the activity. That is, if a task is planned as a discrete measurable task, progress cannot be determined as though the task was LOE.
- Every scheduled activity within a Budget Package that has resources assigned to it must also be assigned an performance measurement (code).
- The selected measurement method does not change for the duration of the activity.
- Progress is determined in a manner that is consistent with the way PV is planned.
- Progress will be recorded at the end of each accounting period.
- Retroactive adjustments may not be made to progress reports previously reported.
- Performance measurement values can never exceed budget at completion (BAC).

The EDM Project Manager, assisted by the Project Controls Analyst and Subsystem Managers will agree on the performance-measurement method when authorizing Subsystem Managers to start work on each Budget Package. The following sections describe the recommended methods. The current performance measurement options for the project are

- **Percent complete.** The percent-complete method is intended to be used on short-duration tasks of no more than several months’ duration. The percent complete on the activity in the detail schedule is used to calculate earned value.
- **LOE.** The LOE method should be used sparingly, and only where there are no definable deliverables (milestones) or tasks and activities are repetitive in nature (PM, Title III, etc.). Progress on these activities is set as equal to actual costs.

In general, the percent-complete method is used primarily for short-duration activities (i.e., three months or less). Progress will be obtained by assessing the percent complete for a particular work package multiplied by the total amount required for the particular activity at the end of each reporting period. As discussed in Appendix F, the percent-complete approach can tend to hide problems that do not surface until it is too late to correct them.

In general, the milestone method should be used on all activities over two to four months long. Because resources (and therefore progress) cannot be associated with a milestone in MSP, one-day activities should substitute for milestones. Interim, one-day activities should be established in a logical, definitive manner. For example, if the task was to pour a large concrete foundation, it would be associated with several one-day activities, each having a particular percentage of the total value of the foundation estimate (e.g., excavation 20%, embedded materials installed 10%, and backfilling 10%). The total value of completing all interim activities equals the total cost of the larger activity. Progress is therefore obtained by completing the individual interim activities.

For material procurements, progress can be evaluated using two different methods in accordance with the nature of the procurement. The first method is used for procurements in which the vendor receives progress payments for reaching certain identifiable, pre-established milestones. Again, one-day activities, appropriately resource loaded, should be substituted for milestones to ensure correct performance-measurement reporting. Each of these one-day activities will be allocated a percentage of the total cost of the procurement during initial planning in an amount equal to the anticipated progress payment. Progress is earned only at the completion of these activities. Generally, this is the same period of time in which the actual costs for payment to the vendor are entered in the accounting system.

The second method for evaluating progress for material involves procurements with no intermediate payments. For these procurements, the entire value of the procurement is scheduled on the anticipated delivery date. Performance credit is earned in full upon delivery and acceptance by the EDM Project. In general, an invoice is also issued with delivery and receipt of material at the same time as the actual costs are booked in the accounting system. However, if a lag between these two actions is expected, an accrual for the invoice will be completed.

The milestone method (one-day activities) should be used as often as possible to determine the actual progress of activities.

The LOE method should be used as little as possible and only when measuring tasks that lack definable, objective milestones or tasks that are repetitive in nature (project management, Title III support, some research and development [R&D] tasks, etc.). Progess = Actual Costs for this method. Materials & services (M&S) activities should be treated as LOE when the resources for these M&S activities are spread linearly across time.

6.2 Estimate to Complete/Estimate at Complete

A comprehensive “bottom-up” re-evaluation of the resource requirements to complete remaining scope of work may be initiated at any time at the discretion of the Subsystem Manager or as requested by the EDM Project Office or DOE. However, the project is proposing a phased estimate-to-complete (ETC) approach based on the percentage of remaining work for each subproject. In general, every subproject will be required to review their remaining work once they have passed the 50% complete stage. Another ETC is required at the 80% stage if 12 months have elapsed since the last ETC. PCRs will be prepared as required and the BAC adjusted to reflect approved baseline changes. Rebaselining as a result of an approved ETC may or may not include the elimination of variances by setting Progress = PV = Actual Costs.

6.3 Variance Analysis

6.3.1 Requirements

The following activities will be used to determine cost and schedule variances:

- Status will be determined on a monthly basis for all activities.

- Actual Costs data will be obtained directly from the laboratories and universities as an extract from the financial system and will be reconciled with a Financial Status Report (FSR) to ensure that the data is consistent and reconciled to the DOE Financial Information System (FIS). If necessary, university costs will be collected using an Excel-based report.
- Current-month and cumulative-to-date cost and schedule variances will be calculated and reported to the EDM Project Office as specified in Section 7.1.
- At-completion variances will be calculated based on performance to date and the EDM Project's cost for work to be performed taking into account corrective actions, forecasted increases/decreases, and scope changes.
- Cost and schedule variances that exceed the established thresholds will be analyzed, variance analysis reports prepared and reported in a cost performance report (CPR) at the designated levels.
- Correction action plans will be prepared by the Subsystem Managers and tracked through to close-out by the Subsystem Manager.

6.3.2 Variance Analysis Reporting

Variance analysis will be performed to identify whether cost or schedule problems exist, whether they are improving or getting worse (i.e., the trend analysis described below in Section 6.4), who is responsible for the work associated with the difficulty, what overall impact the problem may have on the project and what may be done to recover from or mitigate the impacts of the difficulty. Therefore, it will be necessary to analyze schedule and cost variances by WBS and participant and to identify variance contributions associated with overhead and LOE cost elements.

Cost and schedule performance variance thresholds will be established at the EDM Project level and at DOE WBS reporting levels. These thresholds are expressed as ±% and ±$ variances. When cost and schedule variances are in excess of both the percent and dollar thresholds, a variance analysis will be required in the monthly progress report. The thresholds for variance reporting are shown in Section 7.0. It will be the responsibility of the Subsystem Manager to provide performance reports to their own management, and the EDM Project Manager.

The variance-analysis sections of the monthly reports should contain the Subsystem Manager's description of the problem, an explanation of the cause of the problem, its impact on the immediate task and on the total project, and a description of the corrective action taken or planned. Whenever the analysis indicates that a cost variance will be sustained or increased, the estimate at completion (EAC) must be re-evaluated to ensure that it reflects the actual conditions. The methods for calculating variances are as shown below.

- **Cost Variance**—Cost performance is measured by comparing work accomplished (progress) to actual cost (AC). Cost variances (CVs) are expressed as
  - CV = – AC.
  - Percent Cost Variance= $\frac{\text{Progress- AC}}{\text{EV}} \times 100$.

  Positive variances indicate a cost under run while negative variances indicate a cost overrun condition. Examples of causes for cost variances include poor initial estimates, technical difficulties requiring the application of additional resources and cost of labor or materials different than planned.

  A Cost Performance Index (CPI) will also be utilized where

  $$\text{CPI} = \frac{\text{Progress}}{\text{AC}}.$$

  CPI values less than 1.0 represent "cost overrun" condition and values greater than 1.0 represent "cost under run" condition.

- **Schedule Variance**—Schedule performance is measured by comparing work accomplished with work scheduled (PV). Schedule variances (SVs) are expressed as
  - SV = Progress – PV

- Percent Schedule Variance $= \frac{\text{Progress} - \text{PV}}{\text{PV}} \times 100.$

Positive variances indicate an ahead-of-schedule condition while negative variances indicate a behind schedule condition. Examples of causes for negative schedule variances include an uncompleted constraining task, resources not available and work completed later than planned.

A Schedule Performance Index (SPI) will also be used where

$$\text{SPI} = \frac{\text{Progress}}{\text{PV}}.$$

SPI values less than 1.0 represent "behind schedule" condition and values greater than 1.0 represent "ahead of schedule" condition.

6.3.3 Corrective-Action Monitoring

It will be the Subsystem Manager's responsibility to monitor and report corrective actions through resolution and to highlight the current status of the corrective actions in progress reports until the variance is resolved. The EDM Project Manager will review the status of corrective-action plans during routine reviews with the Subsystem Manager.

6.4 Evaluating Trends

In the sections above, various performance measures were discussed and the proposed method of calculating each is defined. It will also be necessary to plot these on a continuing basis to track the Project trends and more precisely trends on individual elements of the WBS and major tasks.

In addition, other performance measures and analyses will be used for monitoring project status and assessing trends. Performance measures and reports will change as appropriate to ensure they are relevant to the goals and objectives of the different phases of the project.

6.5 Responsibilities

The PPEP identifies the roles and responsibilities for the DOE, the EDM Project Office and the partner institutions as related to the performance-measurement system.

7. Risk Management

7.1 Introduction

The EDM Project uses a formal, systematic process for the management of risk and will do so throughout the project life-cycle. Risk management is a core process within the overall project-management process that is designed to achieve scope, schedule, and cost results. Both of these processes are compliant with the intent of DOE Order 413.3 and recognized best practices.

7.2 Risk Control

Risk management is an integral part of project management on the EDM Project. Risk is closely coupled to project scope, schedule, and cost, both in terms of planning and the execution to the project baseline. Risk is also an important consideration in project decision-making and contingency determination. The risk-control mechanisms selected by the EDM Project are designed to be practical, useable, and produce risk information that can be used for management purposes, reporting, and decision-making. In these ways, the EDM risk process is "graded" to the needs of the project, type of project (science), and to the size of the project.

7.3 Risk Management Plan

The risk controls and processes used on the EDM Project are described in detail in the EDM Project Risk Management Plan maintained in the EDM Project Office.

8. Reports, Meetings, and Reviews

8.1 Performance Reporting

Reporting will be an integral part of the EDM Project team's Performance Measurement System, with the Monthly Progress Report being one of the key reports. Monthly status reporting will be provided by the Subsystem Managers to the EDM Project Office utilizing standard report formats that will be developed by the EDM Project Office. The EDM Project Office will summarize the data provided by the Subsystem Managers and prepare a monthly report for DOE. Included in the report will be a CPR and variance analysis. Other project-management reports may also be used as the project progresses into different phases.

8.2 Meetings and Reviews

In addition to performance measurement and reports, the EDM Project will rely heavily upon regularly scheduled meetings and reviews to manage Project technical, schedule, and cost status. These meetings will provide early indications of developing trends and problems, which will be revealed later in the report data. They will also provide a forum for resolving emerging problems.

Use of the EDM Collaboration Meetings will also be used to ensure effective communication with the Executive Committee and, when necessary, resolve issues.

In addition, formal design reviews, including preliminary and final designs will be peer reviewed for technical specifications, interface issues, and any other potential risk areas for each major subsystem.

8.2.1 Performance-Review Meetings

Routine meetings will be held to review the status of tasks from the viewpoint of cost, schedule, and scope. The EDM Project Manager or his designee will chair the meetings. The status-meeting format will be simple, straightforward, and concise. Utilizing trend charts for cost and schedule performance, the Subsystem Manager will present task status including

- accomplishments,
- schedule and cost status,
- management estimate of EAC,
- procurement status (if applicable),
- staffing status (if applicable),
- top issues,
- key activities in the next 60 days, and
- risks.

It should be noted that the focus will primarily be on the most recent period—the upcoming few months and the previous months. It is anticipated that each presentation and discussion following this format will be completed in no more than one hour. Use of video teleconferences, and other electronic web-based tools will be employed.

9. Value Engineering Assessment/Study

Value management is recognized as a key technique in a process that supports reaching the lowest-cost alternative. The EDM Project has placed management emphasis on and adhered to value-management principles in the post CD-0 phase by rigorous R&D analysis and review of design options conducted by the collaborating national laboratories and universities.

All relevant options have been investigated for technical viability as well as cost and schedule considerations. The EDM Project has pursued competing alternative design concepts to determine the feasibility of each alternative. Review of any alternatives has been a central focus of the Project R&D activities.

The primary selection criterion is a integrated design that meets the technical performance requirements specified by the Office of Science – Nuclear Physics Programs (SC-NP) for the EDM Project.

For the post CD-1 design period leading to CD-2/3 and the execution phase, the EDM Project will continue to emphasize design and engineering choices that represent cost and safety consciousness. Subsystem Managers will consider the cost alternatives relative to engineered items, and select those options that represent best-value to the Government. The EDM Project Office will oversee and challenge the value proposition of proposed selected courses of action to ensure they represent the best alternative to achieving the approved project technical objectives and baseline parameters for the lowest possible cost.

For these reasons, the EDM Project does not intend to conduct a formal value engineering study unless so directed by SC-NP (reference DOE M 413.3-1, pages 2–5).

Appendix A

Definitions

A1 Definitions

Accounting accrual—Expenses or an estimate of expenses that have been incurred and posted in the cost accounting systems, but have not actually been paid.

Activity—A unique work task, approximately 4–6 months duration, identified in the schedule **.**

Activity Code—An alphanumeric identifier assigned to each project activity (in Primavera) to add information for updating, analyzing, reporting, plotting, summarizing, and grouping activities. Must contain the WBS element ID.

Activity ID Code—Unique number assigned to an activity (in Primavera) much like a serial

number.

AC— Actual cost incurred as reported through laboratory cost accounting systems including accruals.

Actual Progress to-date—The sum of the cumulative EV to-date for WBS elements. The percentage is calculated by dividing the sum of the cumulative EV to-date by the Budget at Completion for WBS elements.

BAC—Budget at completion is the total budget estimate for the project, or for a subsystem or work package (excludes contingency).

Budget Authority (BA)—Total authorized funding available (including carryover funds) to cover both cost and commitments.

Budget Outlays (BO)—Funds required to cover estimated cost, typically PV.

Capital Equipment Not Related to Construction—Capital items projected to cost $25,000 or more and have a service life of greater than 2 years and to be used in conducting LANL research and development.

Charge Code—an optional code used to identify the account to which cost will accrue for a resource or an activity. This code should be the same as the code in the financial system used to collect charges.

Commitments—Funds allocated to subcontractors where the work has been authorized but not yet expensed.

Completion variance—Completion Variance = BAC minus EAC (a negative result is unfavorable, cost overrun).

Construction and Fabrication Activities (Capital Funded)—Construction and fabrication activities generally include the design and engineering for a specific project or for the components of a project after the ideas or conceptual design are crystallized; the procurement, fabrication, erection, and installation of all materials and equipment constituting the project; models built for size and spacing in connection with preliminary (Title I) and final (Title II) design work; the preparation of operating manuals; and the preoperational testing of the project components.

Contingency—An amount budgeted to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties. The amount of contingency will depend on the status of and the complexity and uncertainties of the sub-projects of the program. Contingency is not to be used to avoid making an accurate assessment of expected cost.

Cost Performance Index (CPI)—Represents the relationship between the actual cost expended and the value of the physical work performed. CPI = EV/AC.

Cost-reimbursement subcontract—Type of subcontract that (1) establishes an estimate of the total cost of performance for the purpose of committing funds and specifying a ceiling that the subcontractor cannot exceed (except at its own risk) without the approval of the laboratory; (2) requires the periodic reimbursement of the subcontractor's costs during performance; and (3) does not involve an enforceable promise by the subcontractor to complete the work with estimated funds, but only a commitment to use its best efforts to do so.

Cost Variance Percent (CV%)—The cost variance as a percent of the performance value. CV% = CV/EV.

Commissioning Costs—Costs associated with authorizing equipment to operate.

Cost Account—Defines the functional (WBS) responsibility for a block of work, PV, and EV; provides the cost collection point for AC. May contain one or more charge codes.

Cost Estimate—A documented statement of costs estimated to be incurred to complete the project. Cost estimates provide baselines against which cost comparisons are made during the life of a project.

Cost variance—current period and cumulative CV = Progress – AC (a negative result is unfavorable, cost overrun).

Critical Path—A sequential path of activities in a network schedule, which determines the necessary duration of a project. Any slippage of the tasks in the critical path will increase the duration and the planned completion date of a project.

Data Date—The data date is the "AS OF" date. The date status has been included in the schedule.

Division—An optional activity code that may be used to identify a particular division of an organization that will perform the activity.

Directive—A programmatic document issued to LANL by the Department of Energy (DOE), which authorizes the commitment and expenditure of funds for specific projects or major activities.

Estimate at Completion (EAC)— Forecast final cost of a scope of work based on the current AC plus a management assessment of the cost to complete the remaining scope of work.

ETC—estimate to complete is the latest estimate of budget required to finish the work remaining.

Field Work Proposal (FWP)—A basic work support document used to provide information for program planning or budget formulation (operating, expense and capital equipment not related to construction).

Financial Plan—A financial document issued to LANL by DOE, which legally authorizes the commitment and expenditure of funds in total for budgeted programs and activities.

Fixed-price subcontract—Type of subcontract that requires the subcontractor to deliver acceptable supplies or perform acceptable services as a precondition to receiving payment of the price.

Indirect Costs—Costs incurred by an organization for common or joint objectives, and which cannot be identified specifically with a particular activity or project (e.g., laboratory overhead).

Inter-project Link (IPL)—A logical link between a milestone in one subproject and another milestone in a different subproject affecting the start or completion of an activity.

Master Project Schedule—The top-level schedule for the project which integrates and rolls up key activities and milestones for DOE review.

Milestone—An activity representing a significant schedule occurrence/key event at a point in time. Milestones by definition have zero duration.

New budget authority—BA provided in the current fiscal year.

Obligation Plan—Time-phased plan of how each organization plans to commit their Allocated BA. Labor and materials and supplies are typically time-phased as expended, while procurements are typically time-phased at award of contract plus award of any contract options.

Other Project Cost (OPC)—Fund "types" (Operating Expense and Capital Equipment) supporting, but not directly contributing to a LI construction project, generally include research and development and pre-operation activities.

Performance Measurement Baseline—The time-phased budget plan against which project performance is measured.

Planned Progress to-date—The sum of the cumulative PV to-date for WBS elements. The percentage is calculated by dividing the sum of the cumulative PV to-date by the Budget at Completion for WBS elements.

Project Authorization Package—Tool used to request funding for a fiscal year. A basic building block used to identify the scope of work, the schedule, and the budget for the work planned in a fiscal year

Project Management—Covers those services provided to the DOE on a specific project, beginning at the start of design and continuing through the completion, for planning, organizing, directing, controlling, and reporting on the status of the project. It includes developing and maintaining the project management plan; managing project resources; establishing and implementing management systems, including performance measurement systems; and approving and implementing changes to the project baseline

Project Office—When used in this document, the term "Project Office" means the Program Integration Office in ADWP that provides project management functions for all subprojects.

Project Phase—An optional activity code that defines the type, such as design, procurement, fabrication, installation, testing, etc., of the activity.

PV—Planned Value is the cost plan based on the budgeted value of a scope of work, time-phased based on the schedule for the scope of work.

Research and Development Activities (Operating Expense Funded*)*— Research and development activities include the development of conceptual designs, origination of ideas, and investigations to obtain scientific and engineering data, as well as activities directed toward the investigation and development of technical improvements in such projects, processes, systems, or components during the project period.

Report Code—An optional activity code that may be used for sorting project activities.

Schedule Performance Index (SPI)—Represents the relationship between the value of the initial planned schedule and the value of the physical work performed, or progress. SPI = Progress/PV.

Schedule variance—SV = Progess – PV (a negative result is unfavorable, behind schedule).

Schedule Variance Percent (SV%)—The schedule variance as a percent of the performance baseline. SV% = SV/PV.

Subproject—Each major schedule group within the overall ADWP Program Plan is defined as a subproject (i.e., Boost, Advanced Radiography, Thermonuclear Experiments, etc).

Total Estimated Cost (TEC)—The anticipated capital costs directly associated with design and construction of a facility. The TEC includes design, construction, equipment and its installation and associated management, contingency, and escalation. These typically require project specific congressional authorization.

Total Project Cost (TPC)—Consists of all the costs included in the TEC of a construction project plus the pre-construction costs such as conceptual design and R&D, plus the costs associated with the preoperational phase such as training and startup costs.

Unburdened Cost—Cost calculated from listings of materials or equipment and quantities, man-hours needed and labor rates, or other fundamental cost estimating techniques but not including overhead costs. Where costs are quoted from equipment suppliers or construction contractors, the cost quoted can be used as unburdened cost - there is no need to separately obtain indirect or overhead costs from suppliers or construction contractors.

Undistributed budget—part of the Performance Budget Baseline that has not been distributed to a specific WBS element or organizational element.

Variance—The difference between the expected/budgeted/planned and the actual results.

Variance at completion (VAC)—The algebraic difference between budget at completion and estimate at completion (VAC = BAC/EAC).

Vendor Submittals/Quotes—Documents provided by vendors on their equipment and materials. These documents are used to determine whether or not the equipment meets the specifications of the purchase order.

Work authorization document—The document provided by DOE that authorizes the performance of work by LANL on receipt of funding in the official DOE-LASO/LANL financial plan.

Work Breakdown Structure (WBS)—A breakdown of a project into those sub elements that define a project. The WBS provides a consistent organization framework throughout the project.

WBS Level 2 Rollup—A required activity code that reflects level 2 of the WBS.

WBS Level 3 Rollup—A required activity code that reflects level 3 of the WBS.

WBS Level 4 Rollup—A required activity code that reflects level 4 of the WBS.

Appendix B

Cost Estimating

B1 Purpose and Objectives

This appendix provides requirements and guidance for generating, documenting and maintaining the project cost estimate in a verifiable form. It includes requirements for all aspects of generating a cost estimate, including the application of overhead and other burdens as related to the ETC (or any estimate change that affects the project baseline). It is recognized that Technical personnel will deal almost exclusively with determining labor hours required for tasks and equipment supplier quotes for procured equipment. Scheduling software, such as MSP or planning tools like the LANL *EDM Work Package Tool* will apply appropriate overhead rates to calculate burdened costs. Scope should be accomplished for as low a cost as possible. Thus, as a rule cost estimates should be:

- Near the realistic or low end of the range for meeting requirements and specifications, performing reliably and allowing cost-effective operations.
- "Bare Bones," or not accommodate unnecessary features. They should not be so low as to be unbelievable, nor so high that managers feel fully confident of success.
- Include credibly optimistic assumptions for any quantity discounts and manufacturing or assembly economies.
- Initial estimates should not include "contingency".
- Estimates should generally assume that planned R&D will be successful.

B2. Generating a Cost Estimate

B2.1 Definition of the Deliverable

Burdened or unburdened cost estimates should be provided to EDM project controls staff for input into MSP. Data can be provided using the *EDM Work Package Tool* or though any other means that breaks down costs in a clear and concise manner. For future years, project controls staff will use official DOE escalation rates as provided by LANL CFO.

B2.2 Level of Detail

Estimates may be based on either labor hours or FTEs. However, the project leader should identify the salary level or category for each labor resource to perform work. Estimates for contract labor should list the labor hours for each, technician, or other labor type used. They should also attach any vendor quotes to the extent practicable. Other backup material may also be provided, such as catalog cuts, detailed listings and other data that clearly illustrates the basis of the estimate.

B2.3 Scope of Work

The initial proposed baseline will form the basis for all estimates to complete. The defined scope, WBS descriptors and technical parameters will be defined in an *EDM requirements document*.

B2.4 Contingency Analysis

A risk based process will be used to identify uncertainties within the current estimate. See Appendix F for a full discussion of the EDM contingency development and management processes.

Appendix C

Reference List of Good Practice

C1 Guidelines and Lessons Learned

1. DOE Order 4700.1, Project Management (no longer in effect)
2. Improving Project Management in the Department of Energy, National Academy Press, 1999
3. SNS Lessons Learned, 2004
4. DOE Good Practice Guides
   - GPG-FM-001 Project Management Overview
   - GPG-FM-002 Critical Decision Criteria
   - GPG-FM-005 Test and Evaluation
   - GPG-FM-006 Performance Analysis and Reporting
   - GPG-FM-007 Risk Analysis and Management
   - GPG-FM-008 Work Scope Planning
   - GPG-FM-009 Baseline Change Control
   - GPG-FM-010 Project Execution and Engineering Management Planning
   - GPG-FM-012 Configuration and Data Management
   - GPG-FM-014 Program/Project Relationships
   - GPG-FM-015 Project Reviews
   - GPG-FM-016 Baseline Development
   - GPG-FM-019 Project Budget Process
   - GPG-FM-020 Contracting Options/Acquisition Resource Planning/Application of
5. Performance Measures
   - GPG-FM-022 Public Participation
   - GPG-FM-026 Project Closeout
   - GPG-FM-030 Prioritization
   - GPG-FM-001 Life-Cycle Cost, 1953 KB
6. U.S Department of Energy, Program and Project Management Practices, 8/14/00
7. DOE O 413.1, Program and Project Management for the Acquisition of Capital Assets
8. GAO Report to the Committee on Science, House of Representatives, National Ignition Facility, Management and Oversight Failures Caused Major Cost Overruns and Schedule Delays
   - GAO/RCED-00-141, August 2000

Appendix D

Performance Measurement -Approach Tutorial

D1 Introduction

The Earned Value Method was first developed over 30 years ago by the United States Department of Defense to reduce risks of project cost growth. The Department of Defense refers to it as the Cost/Schedule Control Systems Criteria. The method is an early warning project management tool that enables Project Managers to identify and control problems before they become formidable. The process does not prevent cost overruns and schedule slippage. It allows the EDM Project Manager to take necessary corrective action to change the trend.

Traditional cost and funding management looks at cost and schedule separately and sometimes makes wrong assumptions from the data. A project may appear to be on schedule and under budget when it is actually over budget and/or behind schedule. The Earned Value method is an enhancement over traditional accounting progress measures. Older methods focus on planned accomplishment (expenditures) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. It also provides more accurate estimates for projected completion costs. With a clearer picture, managers can create risk mitigation plans based on the actual cost, schedule, and technical progress of the work.

Early warning is important because cost overruns tend not to correct themselves over time. In fact, studies have shown they worsen, if not realized early. Research shows that projects that are over budget when only 15 percent finished usually post overruns at completion. Similarly, research shows that actual completion costs will not improve by more than 10% of the current percentage overrun. This is caused by the fact that in most cases is that managers don't know they have a cost overrun early enough in the project. The Earned Value method gives the early indicators that help alleviate this problem – indicators that can be used as early as the 15 to 20 percent point of completion.

The EDM Project will employ a graded-approach to measuring progress, that is consistent with the needs of a $15-24M project. However, in order to understand the intent of a performance measurement system, the application of earned value is discussed here.

D2. Definition

Earned Value reflects the integration of cost, schedule, and technical work into one common view to establish a project plan. It uses progress against previously defined work plans to forecast such important concerns as estimated completion costs, finish dates, and the effectiveness of corrective action plans. Earned Value is the measurement of what you physically got for what you actually spent, or the value of work accomplished. "Earned Value" is a term that is often referred to as

Budgeted Cost of Work Performed. Simply put, it is a project management technique that uses "work in progress" to indicate what will happen to work in the future.

In a graphical representation of the Earned Value approach, the cumulative Planned Value is the baseline for the project. The Actual Cost is the cost as a function of time. The Earned Value is a dollar representation of what it should have cost to do the work already accomplished. From this information, it is easy to calculate the cost variance and the schedule variance of the project at any point in time. It allows us to use cost and schedule together to determine where we are instead of using them separately and missing the total picture. Figure D2-1 shows the graphical representation of the data collected using this process.

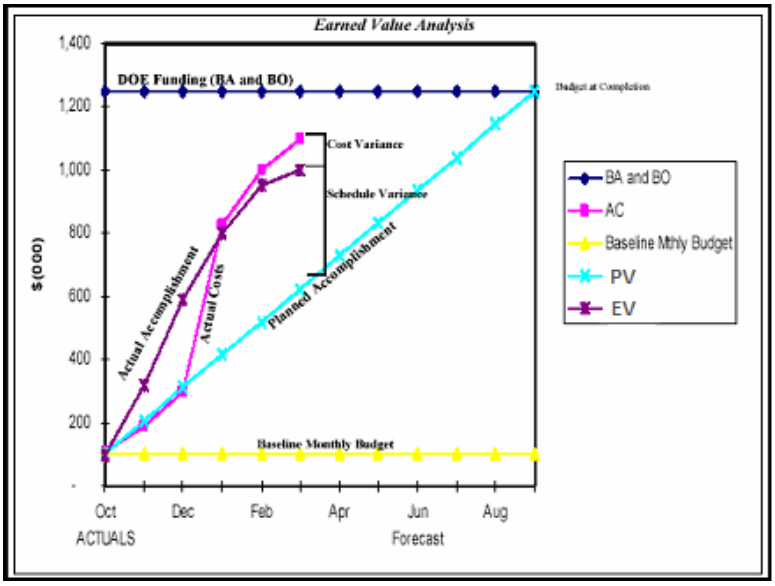

Figure D2-1. Data Needed for Earned Value Determination

D3. Assessing Project Performance

The primary performance measures for the Earned Value method are the Cost Performance Index and the Schedule Performance Index. The Cost Performance Index is the ratio between Earned Value and actual costs while the Scheduled Performance Index is the ratio between Earned Value and planned work (budgeted costs). The formulas are shown below:

Cost Performance Index (CPI) = Earned Value/Actual Cost = EV/AC

Schedule Performance Index (SPI) = Earned Value/Planned Value = EV/PV

If CPI = 1.0, then performance is on target.

If CPI > 1.0, then performance is exceptional.

If CPI < 1.0, then performance is substandard.

The same is true for Schedule Performance Index. Note that a Cost Performance Index of 0.85 means that for every dollar that was spent, only $0.85 in physical work was accomplished. A Schedule Performance Index of 0.90 means that for every dollar of physical work the project had planned to accomplish, only $0.90 was completed.

There are other factors that can be used to assess the performance of projects. These measures include Cost Variance, Schedule Variance, Percent Variance, Variance at Completion, and To Complete Performance Index. In many cases, the Cost and Schedule Variances are more meaningful to upper management who may not fully understand the indices. An illustration of cost and schedule variance is seen in Figure D3-1 and in the following illustration.

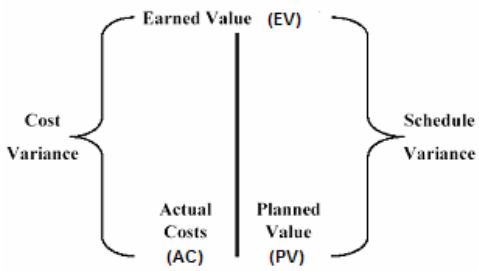

Figure D3-1. Cost and schedule variance

D4. Estimating Future Cost and Completion Dates

Because we have cost and schedule indices, we can then estimate the approximate cost at completion of the project and the time that it will take to complete it. For cost, we can calculate the Estimate at Completion within a given range of values. The calculations are as follows:

Estimate at Completion (EAC) min = (BAC – EV) + AC

Estimate at Completion (EAC) max = ((BAC – EV) / (CPI x SPI)) + AC

(Note that there are a number of different Estimates at Completion equations that can be used.)

The estimated time to complete the project can also be calculated by taking the projects planned completion in months and dividing it by the Scheduled Performance Index. Therefore:

Estimated Time to Complete (ETC) = Planned Completion / SPI

D5. Monitoring Performance

Performance must be monitored at the lowest level of the Work Breakdown Structure where distinct work packages are created, budgeted, and scheduled. This gives the greatest confidence in determining specific deliverables and the ability to estimate the Earned Value for work performed. However, the final indices and measures are reported overall as a roll-up of the Work

Breakdown Structure elements ~~tasks~~.

The schedule of tasks and a method for measuring the use of resources are needed in order to calculate Earned Value. The metrics used can vary and should be determined based on availability of data, type of project task, and appropriateness. The various types of metrics include:

D5.1 Weighted Milestones

Weighted milestones work well for work packages that are three or more months in length. Each milestone is given a budget value that will be earned on completion of the event. Thus, the total work package budget is divided up based on a weighted value assigned to each milestone, as shown in the following table.

Table D5-1. Weighted Value Assigned to Each Work Package Milestone

	Item	Jan	Feb	Mar	Apr	May	Jun	BAC
Weighted Milestones	Planned	30	70	70	30	30		230
	Earned							
	Actual							

This method is a preferred one used in performance measurement, but it is also the most difficult to plan and administer. Why? Because it requires a close working relationship between the work package managers, scheduling people, and resource estimating people in order to establish meaningful milestones.

D5.2 Fixed Formula by Task: 0/100; 25/75; 50/50

This method is perhaps the best one when applied to short-span work packages whose duration is only one, two, or possibly even three months. For instance, 0/100 method is best applied to those work packages that start and end within one accounting month. Nothing is earned when the task begins, but 100 percent of the budget is earned when completed.

Similarly, the 50/50 technique is used for work packages whose duration usually spans two accounting months. Fifty percent of the planned value is earned when the task starts and the balance is earned when it ends.

Cost account managers may use other variations of this method to set in advance the percentage values they wish to use, e.g., 25/75, 20/80, etc.

D5.3 Percent Complete

Typically this method relies strictly on one's "subjective" estimate of the percentage of work completed and is provided by the individual in charge of the work package. However, written guidelines have been used to assist in assigning a percent complete value based on completed work, e.g., drawings issued, lines of software code tested, parts received, etc.

The percent complete method is the easiest to administer, but is most subject to individual bias and optimism. One technique used to address the optimism factor is to set a maximum ceiling amount for any work package until it is 100 percent complete. For example, with an 80 percent ceiling, a work package may only earn up to 80 percent of the manager's estimate until the task is 100 percent complete.

Subjective estimates only work well if checks and balances exist to challenge poor or overly optimistic estimates.

D5.4 Equivalent Completed Units

This approach places a planned value for each unit completed and is used for managing repetitive-type work. For instance, a project's goal is to construct ten homes valued at $100,000 per unit. Costs for each site excavation and unit foundation are estimated to be ten percent of each house. At the end of the first month, the project completed excavation and unit foundations for all ten homes. Therefore, the Earned Value for the first month would be $100,000, or the equivalent of one home.

Typically laboratory projects are not repetitive enough for this approach to be useful.

D5.5 Level of Effort … NOT Recommended!

Level of effort activities are those driven by time vs.task (e.g. administration, finance, project controls, etc.). The principal problem with level of effort activities is that whatever is authorized as the planned value actually becomes the Earned Value regardless of what actual work takes place. In other words, Earned Value always matches planned value.

The use of level of effort methods is not recommended.

D6. Limitations on Earned Value

Earned Value measurement works well with direct labor and corresponding indirect labor rates applied to direct labor costs. However, with materials, subcontracts, and other direct costs whose charges may take time to arrive, the problem arises with the early or delayed recording of actual costs. This will obviously affect the Earned Value performance being measured! Some care is required to compare comparable costs; the results will not be comparable if there is a significant difference between project reporting times and financial accounting times.

It may be possible to improve the accuracy of reporting by using Actual plus Committed costs to obtain Earned Value. Whenever this is used, it should be highlighted in reports to avoid confusion.

D7. References

1. American Graduate University, (1999), Performance Measurement and Analysis (Performance Measurement Using Earned Value Concepts*);* Technical Program Management Course.
2. CMS Information Services, Inc. (March 1999), Web Page

3. Hess, Michael M. (September 1998). Earned Value Project Management: What is it? And how can we effectively use it? White Paper, Sandia National Laboratories
4. Kerzner, Harold. (1998), Project Management: A Systems Approach to Planning, Scheduling, and Controlling.

Appendix E

Configuration Management

E1 Engineering Approach

The coordination of all engineering in the EDM project is the responsibility of the Chief Engineer. The Chief engineer works closely with the EDM Project Manager and the Technical Coordinator. When a Subsystem Manager needs engineering, a request is placed for resources with the project office. The Chief Engineer finds the resources best matched to the needs of the subsystem. Co-location with the scientific team becomes a consideration when two engineering sources are deemed appropriate.

The Chief Engineer currently has five sources of engineers from the following institutions:

1. The P-25 group at LANL;
2. North Carolina State University;
3. Affiliates of the University of Illinois;
4. MIT Bates Laboratory;
5. Quantum Technology, a private firm specializing in low temperature equipment.

All engineering will be done with modern 3D-modeling programs such as Unigraphics, Pro-Engineer, etc. that have been used to develop the conceptual design of the EDM experiment. CAD tools are approved by the Chief Engineer. Communication between different products will be made by step translation, a proven technique. The official version of the reference design will be part of a Unigraphics model.

A computer program, Teamcenter, will be used to coordinate the disparate sources of engineering. Teamcenter is analogous to a code management system in software development. The project is broken into relatively small pieces. When an engineer wishes to do design on a piece, the relevant piece is checked out from Teamcenter. While it is checked out, no other engineer can have a changeable copy of the same piece of the model. Reference copies are allowed. When the design is complete, the engineer returns the completed piece of the model to Teamcenter, making it available to anyone else who needs it. It is the responsibility of the Chief Engineer to verify that the completed design matches the other parts of the project and is properly registered in Teamcenter. The Technical Coordinator consults as needed on scientific issues, especially in the area of subsystem conflicts. In this way, the Chief Engineer and the Technical Coordinator manage the integration of the EDM experiment.

One area of special note is the heat budget. The difficulty of a cool-down/warm-up cycle and remotely diagnosing heat leaks makes adherence to the heat budget crucial. When the pieces of the experiment are assembled, any one subsystem can cause the entire project to be delayed significantly if the heat budget is not kept. Hence, the integration of the cryogenic components needs special attention. Acceptance tests that convey a high sense of reliability will be conducted by subsystem workers before any subsystem is integrated into the full apparatus. Cryogenic operation of a detector with this volume in the 500 mK range is outside the normal experience of most members of the nuclear physics community. The Technical Coordinator is a cryogenics specialist with experience in most other technical areas of the project. Mechanical, cryogenic and scientific integration of all parts of the subsystem is a requirement to pass a quality assurance review of an acceptance test.

When pieces of the project are converted to shop drawings for the manufacture of parts, these drawings are to be archived in the SNS electronic drawing-archive system. The SNS has agreed to accept EDM drawings, and the EDM project will adhere to SNS drawing and identification standards. It is currently believed that the PDF format will have the greatest longevity. The Chief Engineer will check that engineers keep the archive up to date. In this way, as-built drawings of the apparatus will remain available to the collaboration for the duration of the project and ensuing scientific program.

Appendix F

Contingency Development

F1 Contingency Development

Project contingency is determined based on risk, as assessed by the EDM Project Team. The EDM Project Manager and the Subsystem Managers work as a team to determine and validate contingency estimates. Applicable DOE Orders and Guidelines are utilized as well as DOE lessons learned from similar projects of a scientific R&D nature.

To ensure contingency realism and adequacy, EDM project contingency is developed using both a bottom-up and top-down process. Initial contingency analysis, based on risk, is made from the bottom-up, at the Activity level within the Work Package and Subsystem(s). Following this calculation, a final overall determination, also based on risk, is made. The contingency development process is described below.

The initial contingency estimate is developed by the Subsystem managers by using the EDM Work Package Development Tool. Please also see the EDM Work Package Tools instructions for additional information on the project contingency assessment and management process. The key contingency provision is that:

"The development of the project's initial ***cost contingency estimate*** is predicated on the factors identified at the activity level by the subsystem managers using"…..risk factor tables (See Tables F-1 and F-2 [also shown below]). The key provisions of this process are:

1. Each WBS element ***(Activity)*** is assigned a contingency.
2. The contingency for each WBS element is a sum of three different risk contributions: *Technical*, *Cost,* and *Schedule*.
3. Each risk contribution is calculated as a product of a *Risk Weight* and a *Risk Factor*, values for which are shown in the Tables F-1 and F-2, respectively (below).

The sum of the technical ,cost, and schedule contributions is the total contingency used to determine **cost contingency** (Note: for clarity the activity cost sheets request the individual risk weights and factors – the calculation of the total contingency is done by the spreadsheet itself).

Schedule contingency is also determined at the activity level and is compiled using the sum of the technical and schedule risk factors and weights (excludes cost), as described above. Schedule contingency is initially compiled as a percentage that is applied to the estimated duration of the activity; the schedule contingency is then derived and expressed as work days.

The sum of all schedule contingency values for all activities with identified contingency is rolled-up to the total project-level and then included in the Project Summary schedule.

Table F-1. Technical, Cost, and Schedule Risk Factors

Technical	Cost	Schedule	Risk Factor
Existing design and off-the-shelf hardware	Off-the-shelf or catalog item		1%
Minor modifications to an existing design	Vendor quote from the established drawings	No schedule impact on any item	2%
Extensive modifications to an existing design	Vendor quote with some design sketches		3%
New design, nothing exotic	In-house estimate based on previous similar experience	Delays completion of non-critical path subsystem item	4%
New design, different from establishing designs or existing technology	In-house estimate for item with minimal experience but related to existing capabilities		6%
New design, requires some R&D but does not advance to state-of-the-art	In-house estimate for item with minimal experience and minimal in-house capability	Delays completion of critical path subsystem item	8%
New design, development of new technology which advances state-of–the-art	Top-down estimate from analogous program		10%
New design, far beyond the current state-of-the-art	Engineering judgment		15%

Table F-2. Technical, Cost, and Schedule Risk Weights

Technical	Cost	Schedule	Risk Weight
—	Material cost *or* labor rate	Same for all	1
Design or manufacturing	Material cost *and* labor rate		2
Design *and* manufacturing			4

Instructions to accompany Table F-1 and F-2:

1. Each activity is assigned a contingency.
2. The contingency for each activity is a sum of three different risk contributions: *Technical*, *Cost,* and *Schedule*.
3. Each risk contribution is calculated as a product of a *Risk Weight* and a *Risk Factor*, values for which are shown in Tables F-1 and F-2, respectively.
4. To calculate the total contingency for a particular WBS element, first evaluate the technical risk of your cost estimate from the left-hand column of Table F-2 and assign the appropriate *Risk Factor* (1%–15%). Then determine whether that element involves design and/or manufacturing and assign the appropriate *Risk Weight* (2 or 4, From Table F-1). You then multiply these numbers. You would similarly calculate the contingency associated with the cost and schedule risk of the WBS element

from the middle and right-hand columns of Tables F-1 and F-2. The sum of these contributions is the total contingency.

5. Note: for clarity the cost sheets request the individual risk weights and factors—the calculation of the total contingency is done by the sheet itself.

Final overall contingency determination is determined for each Subsystem based on multiple factors, the above calculations, lessons learned, DOE Guidance, and effects on risk from related Subsystems. The final Subsystem determination is made jointly by the EDM Project Manager and the Subsystem Managers. The Project Controls Analyst and the Senior Project Management Advisors contribute to the assessment. Table F-3, below, provides the standard model used for final contingency applications.

Table F-3. Standard Model for Final Contingency Applications

Overall Risk Level for Subsystem	Percentage Contingency Applied
High	50%
Medium	40%
Low	30%

Contingency Management. Cost and schedule contingency are managed and controlled by the EDM Project Office. The basic management principles used are shown below:

- The EDM Project Manager reviews and validates the subsystem contingency calculations through reviews with the Subsystem Managers. An overall cost and schedule contingency determination is made in this way for each Subsystem.
- To derive the project Total Estimated Cost, the EDM Project Office applies the cost contingencies to the project base cost estimate.
- The Project Summary Schedule includes contingency as an identifiable segment of times at the activity level, and is then “rolled-up” and added as a block duration to the project schedule.
- Cost and schedule contingency will not be used to mask performance variances.
- The application/use of cost/budget contingency will require a formal project change request (PCR) from the Subsystem Manager to the EDM Project Manager. The EDM Project Manager has cost change authority up to $200K per request. The application of budget contingency in amounts greater than $200K require the approval of the DOE.
- Schedule contingency will be closely monitored as based on close management of any schedule variances.

F1-1. Quality Assurance

Quality assurance is the responsibility of the EDM Project Manager. As each activity in the WBS is completed, the EDM Project Manager must consider whether it meets specifications consistent with the ultimate goal of the project. In most cases, the judgment of the EDM Project Manager is sufficient.

When a milestone is met, the EDM Project Manager will use internal peer review to evaluate the quality of the work. The EDM Project Manager may choose to call an internal review of any work, but the following events automatically trigger a peer review: commencement of R&D, completion of R&D, completion of preliminary engineering, completion of final engineering, and completion of acceptance testing of a piece of apparatus.

The peer review will normally be a report to the collaboration at one of its regular meetings. The event meets the quality assurance standards if there is consensus amongst the collaboration members. The EDM Project Manager may choose to appoint an official committee at more important junctures, charging them to

focus on an evaluation of the work in question. The collaboration has expertise in a wide variety of skills that can be brought to bear on any work.

The EDM Project Manager will keep the Federal Project Director apprised of progress, and quality assurance will be a topic at the monthly teleconferences with DOE headquarters. DOE plans to conduct reviews associated with each critical decision plus annual reviews at their discretion. The EDM Project Manager will update DOE at each of their reviews on whether progress is consistent with the specifications of the project.

Appendix G

Pre-CD-1 Work Package Instructions

G1 Pre-CD-1 Work Package Instructions

G1.1 Purpose, Objectives, and Overview

This document provides guidance for generating, documenting and maintaining the initial EDM project plan in a verifiable form necessary for supporting the Conceptual Design.

This guidance is consistent with the processes that will be utilized in the EDM Fast Start, tentatively scheduled for May 23-24th at ORNL in conjunction with the collaboration meeting that follows. By completing these actions, you will be helping to generate the project schedule and cost estimate needed for CD-1 as well as help support the development of the Conceptual Design Report (CDR) and the Preliminary Project Execution Plan (PEP). You have already received a request for the 5-15 page technical description of your subsystem for the CDR.

The expectation for the Fast Start is that each subsystem manager plus the technical coordinator/ORNL operations manager will make presentations of roughly ½-hour duration on the project plan they have developed for their subsystem following this guidance. Your plan will receive constructive criticism from the project office and the other subsystem managers. The second day will be spent on inter-connects between the subsystems. Following the Fast Start, subsystem managers will have until June 9 to make improvements. In this latter period, subsystem managers will be offered the services of a project controls professional if they request assistance. *If you would like assistance from the project office either prior or after the Fast Start, someone will be available to travel to your institution for 1-2 days. Please inform the project office as soon as possible if you are interested in receiving such help.*

The schedule requires us to be properly prepared for an extensive dress rehearsal in mid-July and an office of nuclear physics review in August. It will be important for everyone to do their best to hold to it. You should request the participation from others in the collaboration to prepare both the technical description and subsystem plan, especially those you envision to be future work package leaders. In order for the project office to monitor your progress, please provide a preliminary copy of your WBS by the 5th of May.

G1.2. Establish the Project Scope

EDM Project Manager (PM), Martin Cooper, has completed a preliminary scope statement and preliminary project metrics (see attachment 2.1). The metrics table includes both the minimal performance acceptable for passing CD-4 as well as the optimum specification. It also lists the collaboration member responsible for providing feedback on each metric.

Please review the attached scope statement and metrics table and provide your feedback to Martin Cooper by April 7th. The performance metrics will be put under change control at this point, and will be managed accordingly.

G1.3. Refine the Existing WBS

The initial EDM WBS is in the process of being reorganized to match the subsystems and the Microsoft Project file will be sent to you by April 14th. Using this preliminary WBS as a starting point, each subsystem manager should refine their section of the WBS by adding sufficient detail to your WBS elements to enable you to successfully manage your part of the project. This elaboration can be done by either breaking tasks into parallel ones or by adding lower level elements, modifying task descriptions, etc. In doing so, make sure that all lower level elements necessary to complete the subsystem have been adequately represented in the WBS. Figure G1-1 provides an example of how the WBS can be organized to the point of generating work packages.

(***Additional guidelines for refining the WBS are also contained in attachment 2.2)***.

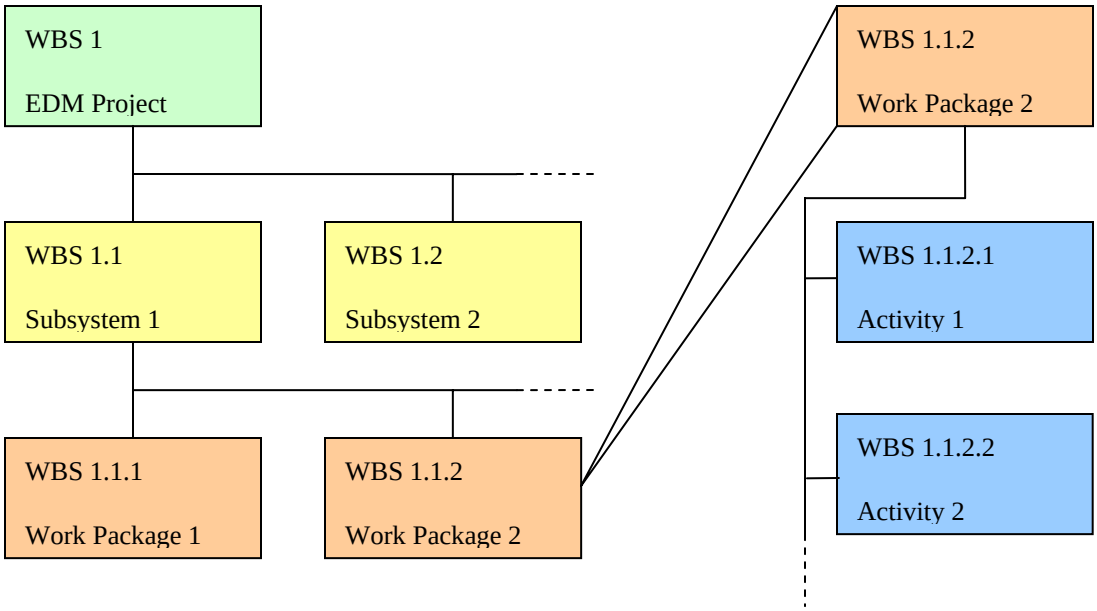

Figure G1-1. An example of how the WBS can be organized to the point of generating work packages.

G1.4. Refine the Existing Schedule

Because of its ease-of-use and relatively low cost, EDM will utilize Microsoft Project as its scheduling tool. You should therefore purchase an inexpensive copy of MS Project 2000 or greater for reading and editing project schedules. When you add activities to the project schedule, uncheck the "effort driven" box on the "Advanced" tab of the Task Information dialog box. This will prevent your task durations from changing when you add resources to the schedule later. Microsoft Project only works well in a PC environment.

Those of you who are new to Microsoft Project can obtain some help in using it from the project office. The normal arrangement is a table to the left and a Gantt chart to the right. In the table, there is a column called Task Name. If you highlight a task name and type Insert, a new task will appear above the old one. If you double click on the task name, it will open a dialogue box where you can enter useful information.

Using the initial schedule as a guide, each subsystem manager should arrange the tasks and milestones within the WBS. Although tasks within the WBS can be ordered in different ways, the project to this point has followed a subsystem, component, phase methodology that, if followed by all WBS managers, will result in a consistent schedule across subsystems.

Once you have arranged the tasks, add realistic durations to each task (i.e. neither aggressive nor slow). Lag (float) and lead times, if necessary, will be added later by the project office so that the PM is able to manage schedule contingency. Avoid constraining the schedule wherever possible by forcing tasks to end on a particular date. End dates will be determined once the logic is added to the schedule. The duration is one of the inputs on the general tab obtained by double clicking on a task.

Finally, add logic (linkage) to your subsystem schedule by adding the relationships between tasks. Most often, tasks follow a finish-to-start pattern in which a predecessor task must finish before its successor can begin. Other relationship types include start-to-start and start-to-finish. Figure G1-2 identifies the scheduling approach that will be employed. *(Control Account is equivalent to Subsystems)*

Links may be added in two ways: Click on the predecessor task, hold the control button down, click on the successor task, and click on the link symbol on the tool bar. The other method is to double click on a task

name. When the dialogue box appears, select the predecessor tab and enter the line number of the predecessor task.

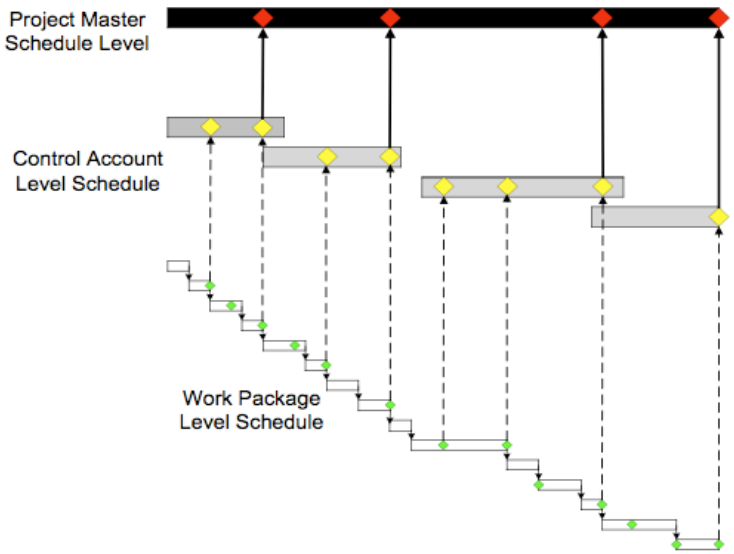

Figure G1-2. The scheduling approach that will be employed.

G1.5. Resource-Load the Schedule

For each activity or task, estimate the number of hours required by each undergraduate student, graduate student, postdoc, staff member, faculty member, technician or engineer. Be sure to consider any M&S expenditures, equipment purchases or major procurements necessary for completion of the task. To add milestones, add tasks with zero duration.

Resources may be added by double clicking on the task name and selecting the resource tab. Enter the name or category of employee. The units should be hours of work. People should be identified as "institution – type of worker – name if available". "LANL – Staff Member – Martin Cooper" would be an example.

G1.6. Formulate Work Packages

Once the WBS and schedule have been completed, arrange the tasks into logical work packages, or sets of tasks that will be managed by a work package manager. Work packages can be at either level 3 or level 4 of the project WBS, depending on the detail required for your WBS element. You should identify work package leaders, where possible. The work package leaders should also provide input on the WBS and schedule. In the following steps, you will formalize the work packages and the activities that constitute them.

You will be asked to report on the work packages you have identified for your sub system at the Fast Start meeting on May 23rd – 24th.

G1.7. Estimate Costs

Loaded cost estimates will be obtained by estimating costs outside of project and then transferring the loaded costs into MS Project. EDM will employ an easy-to-use Excel costing template. You will enter the total cost for each activity into the schedule's cost column. This process will ensure uniformity in the project's basis of estimate and will allow reviewers to quickly identify the assumptions that went into developing the cost for a particular activity. The EDM Cost Estimating Workbook, which is still being revised, will be sent to you by April 14th along with instructions.

A sample of the proposed activity sheet is shown as attachment 2.3. Shaded locations are calculated by the spread sheet. The project office will use the work package template during the execution of the project. Detailed instructions will accompany the template.

Because the template contains macros, it works best in a PC environment. You will also need to enable the macros when prompted or by adjusting your security setting to medium or low (Tools > Options > Security > Macro Security). The template is a close analogy to the FNPB template used by EDM prior to CD-0. The primary advantage is that the rates and burdens by institution that have been provided by the institutional principal investigator have already been entered into the data base of the spread sheet.

Once you have estimated the labor hours for the resources in MS Project, open a copy of the EDM costing template (approximately one per work package) and enter the activity names and WBS numbers at the top of each sheet. Next, complete the labor section of the template by entering the names of the individuals that will perform work on the activity, if known, and that person's resource type and hours. Next, enter miscellaneous small purchases in the other direct cost section to the left and major purchases over $25k in the table to the right. Finally, document assumptions, risks, and constraints for the activity in the box provided. These will later be collected into a risk planning document for the entire EDM project.

The template is currently limited to 20 activity sheets. However, if you have a work package with more than 20 activities, open up a separate workbook rather than attempting to modify the template.

Other guidance for estimating EDM project costs include the following:

- Whenever possible, obtain vendor quote for procurements over $50k. Additional information that can help to substantiate the cost estimate, assumptions, or risks can also be included with the work package.
- Estimates should be in the realistic range for meeting requirements and specifications, performing reliably, and allowing cost-effective operations.
- Estimates should not accommodate unnecessary features and not be so low as to be unbelievable. They should not be so high that the customer questions whether the project is overpriced. The subsystem managers can expect push back from the audience at the Fast Start if the estimates are either too optimistic or look padded.
- Estimates should include credibly optimistic assumptions for any quantity discounts and/or manufacturing/assembly economies, and be based on the most cost-effective strategy for accomplishing the work
- Estimates should generally assume that planned R&D will be successful.

You will be asked to provide the first draft of a completed set of activity sheets and an overall cost projection at the Fast Start on May 23rd.- 24th.

G1.8. Formalize Work Packages

The EDM template is still being refined by the project office and will be circulated to the subsystem managers on April 14 with more detailed instructions. A sample work package sheet is shown as attachment 2.4. The following indicates what it is designed to do.

The EDM costing template is set up so that activity sheets automatically roll up to a summary tab. This sheet constitutes the work package for the activities entered in the workbook. In addition to the listing of activities and costs, you will need to provide a summary of the work scope to be accomplished within the work package. You will also need to enter milestones, the work package manager, and the WBS number for the work package.

When entering milestones, you will need to enter a target completion date. This date together with the target start and finish dates you entered in the activity sheets, are for planning purposes only and are subject to change as linkages between subsystems and funding constraints are considered by the project office. You will also need to select the appropriate level for each milestone. This determination will determine the amount of visibility and tracking afforded to it. The following guidance applies to milestone levels:

- **Level 1** – Highest level of deliverables or deadlines within the EDM project. These will be tracked nationally by DOE and NSF and will determine the success of the project. Critical Decisions (CDs) 1-4 are the most notable level 1 milestones, but others may be included in the schedule at the request of DOE.
- **Level 2 –** Major project deliverables for which performance is tracked nationally by DOE and NSF. Unlike Level 1 milestones that reflect performance on the entire project, Level 2 milestones are defined within

the subsystems or major WBS elements. Level 2 milestones also reflect regulatory milestones, such as NEPA Determination, etc.

- **Level 3** – Important deliverables or decision points that are not monitored outside of the project and are instead tracked internally by the project manager. Although Level 3 milestones are not reportable to outside customers, they should exist in sufficient quantity throughout the project schedule to allow the project manager and WBS managers to objectively gauge performance on the project.
- **Level 4** – Aids to allow WBS managers monitor progress within their own WBS element. These milestones are not tracked outside of the WBS element, nor will the project manager hold WBS managers accountable for their completion. However, the status of Level 4 milestones is often a good indication of progress towards higher level milestones or goals.

You will be asked to provide a completed set of preliminary work packages at the Fast Start on May 23rd – 24th.

G1.9. Contingency

EDM will use the same method of calculating contingency as the FNPB, which is the same as was used for the LANL CD-0 review. The tables for estimating contingency as a percentage of your cost estimate is shown in attachment 2.5. You will be asked to enter each of the factors you determine onto the cost sheets for each activity. The worksheet will give the final overall contingency for this activity. As a result, the work sheet will produce a base cost and total cost for that activity.

G1.10. Risks

The risks associated with the EDM project will be part of the criteria that the committee will be charged to evaluate before recommending in favor of CD-1. For each significant risk, the EDM project will need a description and mitigation approach.

While creating the schedule and work packages, you will have identified a number of risks and opportunities that could potentially impact your WBS element. In the evaluation of the contingency, you also calculated an overall risk factor, i.e. the contingency percentage. If you identified a technical, schedule or cost contingency, you should have a corresponding risk(s) that you would enter into Section VI. And the Risk Log.

Relative to the Risk Log, the intent is that you analyze the risk in terms of its likelihood and impact (if it does occur), select a strategy and assign an overall risk rating, and the specify plans for addressing the risk. One paragraph for risk and strategy descriptions each will suffice. Below are three of the more common risk strategies, though others such as mitigation and strategies for opportunities exist:

- **Acceptance** – If you understand the risk and have sufficient information to address the potential impacts, the project can choose to accept the risk by:
  - *Increasing the amount of contingency allocated to a budget*
  - *Increasing the amount of time allocated to complete a task*

- **Avoidance** – Take an action that prevents the risk from being realized
  - *Technology development plans or prototyping*
  - *Insure against the risk*

- **Transfer** – Move the risk burden to another entity
  - *Use a fixed price procurement strategy*
  - *Use programmatic R&D focused on de-scoped elements of the project to clarify the technical outcome in a timely manner and reduce the risk sufficiently to accept the scope back into the project*

G1.11 Submit Schedule and Work Packages

After you have completed your schedule and work packages, submit them to the project controls analyst for integration into the EDM master schedule and work package book. Be sure to provide the analyst with

information regarding any linkages to activities external to your WBS. The links between subsystems will be a major agenda item at the Fast Start.

During or shortly following the Fast Start meeting, you will need to provide electronic copies of all of your planning files to the EDM Project Controls Analyst for inclusion in the overall project plan. A deadline of June 9 has been established for your submission.

G1.12 Analyze and Refine the Initial Integrated Baseline

Once all WBS managers have submitted their resource-loaded schedules and work packages, the PM and project controls analyst (PCA) will perform a quality check of the data. The PM will then compare the revised schedule and TPC to the schedule and cost targets in the project charter and provide you with feedback. You should expect communication with the project office following your submission.

G1.13 Establish the Initial Project Baseline, Critical Path, and Milestones

After completing the initial comparisons of the project's scope, cost, and schedule to the project charter and modifying each as appropriate, the PCA will establish the "initial" project baseline.

G2. ATTACHMENTS

G2.1 Project Goal Statement and Metrics

G2.1.1 Overarching Goal

The overarching goal of the EDM project is to construct an apparatus that will search for a neutron EDM with a statistical sensitivity and systematic uncertainty of 10^{-28} e•cm (95% CL). The collaboration has selected the cryogenic method of Golub and Lamoreaux and sited the experiment on the UCN beam line of the FNPB at ORNL.

Table G2-1. Principal Specifications

Description	Minimal Performance	Optimal Performance	Responsible Manager
Operating Temperature (mK)	300-550	300–550	Huffman
Wall Loss Time (s)	200	2000	Ito
Capture Signal/Electron Background	0.5	50	Ito
^{3}He-Spin Relaxation Time (s)	200	30,000	Williamson
^{3}He Polarization (%)	80	99	Williamson
SQUID Noise ($\mu\phi_0$)	20	1	Ito
Magnetic Field (B_0) Uniformity	2×10^{-3}	2×10^{-5}	Filippone
Electric Field (kV/cm)	25	50	Ito
UCN Production Rate (/cm^3/s/cell)	0.08	0.3	TBD (Huffman)

Table G2-2. Supporting Specifications

Description	Minimal Performance	Optimal Performance	Responsible Manager
Construction Time CD-0 to CD-4 (yr)	8	5	Cooper
Construction Cost ($M)	18.3	13.0	Cooper
Total Experiment Live Time (yr)	0.3	1	Huffman
Total Cooling Power at 450 mK (mW)	25	50	Haase
Cool Down Time (d)	28	14	Haase
Polarized ^{3}He Loading Time (s)	1000	100	Williamson
Injection ^{3}He Polarization (%)	90	99.5	Williamson
Maximum ^{4}He Purity (10^{12} atoms/cm^3)	10	1	Williamson
Valve Lifetime (cycles)	5000	10^5	Williamson
Mean Number of Photoelectrons/Event	12	40	Ito
Particle Identification Rejection	1	50	Ito
Magnetic Shielding Factor	10^4	10^5	Filippone
Eddy Current Heating (mW)	1000	100	Filippone
Uniformities of Other Magnetic Fields	5×10^{-3}	10^{-3}	Filippone
Coil Power Supply Ripple	10^{-6}	10^{-7}	Filippone
Coil Winding Precision (mm)	5	1	Filippone
Alignment of *E* and *B* Fields (mrad)	3	0.5	Ito
Electric Field Spark Rate (/yr)	0.5	0.1	Ito
Electric Field Uniformity	10^{-2}	10^{-3}	Ito
Personnel Radiation Field (mR)	0.2	0.2	TBD (Huffman)

G2.2 WBS Guidance

G2.2.1 Refining the WBS

Some tasks have become vestigial as the project has developed and should be eliminated while some new tasks will need to be added. Examples of taking tasks to the next level of detail include the following:

An example of breaking up a component into its major subcomponents:

^{3}He Spin-Holding Coil → ^{3}He Spin Coil Support Structure
^{3}He Spin Coil Windings

Examples of the process for constructing a major component or subassembly:

Design →	Developmental Tests Preliminary Design Final Design Drawing Production
Procurement →	Write specifications Identify and qualify vendors Place order Vendor performs Acceptance tests
Install →	Pre-fit subassemblies In-field modifications Assemble the device Test the device More in-field modifications Final acceptance test

A sufficient number of internal milestones need to be identified throughout the project to monitor progress. The project office will identify the high level milestones.

G2.3 Sample Activity Sheet

I. Activity Information

Activity Title:					WBS Number:	
Estimated Duration in Days:		Anticipated Start Date:			Anticipated End Date:	
Technical Contingency:	5%	Technical Contingency Weight:	4	Weighted Technical Contingency:		20%
Cost Contingency:	5%	Cost Contingency Weight:	2	Weighted Cost Technical Contingency:		10%
Schedule Contingency:	5%	Schedule Contingency Weight:	1	Weighted Schedule Contingency:		5%

II. Labor Charges

Name (Optional)	Labor Type or Discipline	Home Institution	Fractional Time	Hours	Base Labor Rate	Base Labor Cost	Org Support	Facility Cost (LANL)	G&A Overhead	Loaded Cost
Total										

III. Miscellaneous Charges

M&S Type	Base Estimate	Purchasing Institution	Loaded Total
ODC Base Total			

IV. Major Purchases >$25k (Attach backup documentation)

Purchase Description	Date Required	Base Estimate	Purchasing Institution	G&A	Loaded Total
Total					

V. Activity Summary

Unloaded Labor Total	
Loaded Labor Total	
Miscellaneous Charges Unloaded Total	
Miscellaneous Charges Loaded Total	
Major Purchases >$25k Unloaded Total	
Major Purchases >$25k Loaded Total	
Sales Tax on Materials @ 8%	
Subtotal	-
Contingency @ 35%	-
Total Estimated Cost for Activity	-

VI. Risks, Constraints and Dependencies (Transfer to Risk Listing Form)

1	
2	
3	
4	
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7	
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9	
10	

G2.4 Sample Work Package Sheet

EDM Construction Project

Project Work Package

Work Package Title:	

WBS Number:		Work Package Manager:		Subsystem Manager:	
Date:		Revision:		Start Date:	End Date:

FY07 Planned Budget (BCWS) ($K)	Future Planned Budget (BCWS) ($K)				
FY07	FY08	FY09	FY10	FY11	FY12

Work Scope Description:

WBS Number	Milestone Level	Project Milestone Description	Completion Date or Quarter

WBS Number	Activity Title	Start Date	End Date	Labor Estiamte	Misc. Estimate	Major Purchases	Conting.	TEC
Total								

Main Assumptions:

G2.5 Risk Listing and Analysis Form

EDM Construction Project

Risk Listing and Analysis Form

Subsystem: | Subsystem Manager:

Work Package Title: | Work Package Manager:

Risk Evaluation							Risk Planning	
WBS Number	Risk Type	Risk Description	Probability (%)	Impact ($k) or Days)	Schedule Exposure	Budget Exposure	Strategy Type	Strategy	Follow Up Date