SUBJECT:	FERMI RESEARCH ALLIANCE PROCEDURES PROJECT MANAGEMENT	NUMBER:	12.PM-005
RESPONSIBILITY:	Office of Project Support Services	REVISION:	4.1
APPROVED BY:	Head, Office of Project Support Services	EFFECTIVE:	07/5/16
TITLE	Cost Estimating		

1.0 PURPOSE

This procedure establishes the methods for developing cost estimates and implementing the cost estimating requirements as defined in the FRA *Earned Value Management System Description* document.

2.0 SCOPE

This procedure establishes the methodology for developing cost estimates for FRA projects where DOE Order 413.3B, "*Program and Project Management for the Acquisition of Capital Assets*," is required, or on projects where an Earned Value Management System (EVMS) is deemed appropriate.

3.0 RESPONSIBILITIES

3.1 Project Manager (PM) is responsible for

- issuing estimate preparation guidance and instructions
- establishing the project's WBS and Control Account (CA) structure
- establishing the project baseline budget consistent with the technical and schedule portions of the project baseline
- approving time-phased CA budgets
- documenting the baseline budget information in the Project Execution Plan (PEP)
- establishing estimate type based on known scope, schedule, pricing basis, and customer or sponsor requirements
- implementing any additional baseline budget development processes, practices, or procedures imposed by the project or customer specific requirements or the PM's functional organization
- identifying the type of work and funding source in order to apply correct labor rates and indirect burdens of the resource estimates

3.2 Control Account Manager (CAM) is responsible for

- developing cost estimates and establishing time-phased control account budgets
- managing the opening and closing of chargeable task codes as appropriate to support currently active authorized work scope
- identifying and documenting risk and contingency estimates but CAMs should be aware that once the contingency has been established, they do not directly own or manage that contingency
- managing the execution of the work
- providing periodic status update information
- keeping the PM apprised of any changes to the estimated cost at completion
- preparing basis of estimate documentation

3.3 Work Package (WP) Manager

Control accounts can be divided into smaller, discrete scopes of work called Work Packages (WP) or Planning Packages, and a Work Package Manager (WPM) can be assigned to specific WP. When this occurs, CAMs can delegate responsibilities to the WPM and the WPM reports and answer to the CAM.

3.4 Functional Managers are responsible for

Providing estimates of labor and duration for activities within their area of responsibility.

3.5 Project Controls are responsible for

- Applying the most current burdening rates and escalation to direct costs
- Integrating individual element estimates into a complete project cost estimate
- After integration, review the estimate with CAMs to ensure data correctness and accuracy
- Advising CAMs and PM of FRA EVMS requirements to ensure the project is compliant

4.0 PROCEDURE

Cost estimates are prepared in a clear, consistent, comprehensive format that facilitates reviewing the details and assumptions throughout the cost estimate review process. Activities to be estimated are identified in sufficient detail to support the cost estimate methodology used. Cost estimates have backup documentation in a centrally located file that explains the assumptions and calculations on which the estimate is based.

The objectives of the cost estimating process are to:

1. Support the establishment of the Performance Measurement Baseline (PMB)
2. Serve as a basis for change control
3. Support the establishment of the Estimate at Completion (EAC)
4. Support the establishment of the Estimate to Complete (ETC)

4.1 Cost Estimating

Cost estimating is a key component of the project baseline budget development process. Estimates are developed and maintained from project initiation through project completion. Cost estimates are created with sufficient levels of detail to identify CA resources and to take into consideration schedule activity durations. The cost estimate is prepared at the lowest level of the WBS and is activity based, consistent with the schedule and technical elements of the baseline scope of work. Estimates may be prepared for planning purposes, to support hypothetical exercises, or to evaluate potential pricing changes.

Cost estimates are prepared using appropriate estimating methodologies with the issuance of guidance and instructions from the PM. Estimates should be consistent with DOE G 413.3-21, Cost Estimating Guide. This guide classifies estimates into one of five categories, based on the Association for the Advancement of Cost Engineering (AACE) Recommended Practice No. 18R-97. Generally, most cost estimates are classified as Class 5 (Order of Magnitude), Class 3 (Preliminary) or Class 1 (Definitive). These classifications, further described in Appendix C, help ensure that the quality of the cost estimate is considered when applying contingency for estimate uncertainty and other risks.

To effectively estimate project costs, it is necessary to have a thorough understanding of the project work scope. The level of detail and accuracy of the budget becomes more definitive as the project's scope is refined. Cost ranges are required at CD-0 and CD-1, while a point estimate is required for project baselining at CD-2. Periodic estimates of

remaining work are conducted during the execution phase to calculate EAC/ETC. Comprehensive bottom-up cost estimates are performed annually or at major phases of project evolution (e.g. at CD-2, at the completion of design, etc.).

Contingency estimates are identified outside the baseline budget and schedule and are based on likelihood and severity of the uncertainty. Contingency is derived from individual work elements (product and activities) regardless of funding type using appropriate development techniques.

Labor and non-labor costs are stated in current Fiscal Year (FY)) rates and include overhead rates to arrive at fully burdened dollars. Future year escalated rates are developed consistent with Fermilab Finance Section guidance and applied based on the time frame of the scheduled activities. Projects may elect alternatively to evaluate escalation in specific areas outside the given rates and document those in their project plans. Standard rates for performing organizations are used unless an alternative explanation is provided.

Contingency is derived at the activity level within the body of the estimate (but not retained within the WBS, CA, or WP). Fiscal year project/program management activities are estimated to the same level of detail as the project they support.

The development of the cost estimate is closely coordinated among the performing organizations. Concurrence by performing organizations is obtained for the performance of specified work scope as detailed in the schedule and cost estimates. Project cost estimates are prepared for the life cycle of the project and evolve as definitive design and construction information is established.

4.2 Cost Estimate Development

A consistent approach to cost estimating verifies that cost estimates meet all requirements, are based on standard requirements, are accurate, are traceable to technical requirements, and are consistent with generally accepted and sound industry cost estimating practices. Cost estimates also solidify the scope of work, providing a documented reference for identifying changes in scope and addressing future cost variances.

The GAO Cost Estimate and Assessment guide and DOE Cost Estimating Guide G 413.3-21 describe the following 12 steps to producing a quality cost estimate:

1. Define the estimate's purpose
2. Develop an estimating plan
3. Define the project characteristics
4. Determining the estimating structure (e.g. WBS)
5. Identify ground rules and assumptions
6. Obtain data
7. Develop point estimate and compare to an independent cost estimate
8. Conduct sensitivity analysis
9. Conduct risk and uncertainty analysis
10. Document the estimate
11. Present the estimate for management approval
12. Update the estimate to reflect actual costs and changes

The following section will describe the application of these 12 steps within the FRA EVMS. More detail is available in DOE G 413.3-21. In certain cases, specific guidance is

necessary to address special requirements. This guidance is determined by the CAM in consultation with the PM.

Step 1 - Define the estimate's purpose

Some potential uses of estimates include budgeting, alternatives analysis, value engineering, independent reviews, project baselining, and ETC/EAC. The estimate's purpose, audience, and scope will determine the level of detail required. Estimates become more refined as the project progresses. Comprehensive bottom-up cost estimates are performed annually or at major phases of project evolution (e.g. at CD-2, at the completion of design, etc.). Projects are officially baselined at CD-2 and therefore definitive, and accurate estimates are needed at this time. However, even pre-CD-0 estimates can have lasting effects on project budgets so even these early estimates should be prepared with care.

Step 2 - Develop an estimating plan

Preparation of a quality cost estimate requires the input of subject matter expert estimators. Therefore an estimating team needs to be identified. Normally detailed activity-based estimates are used for 413.3 projects and are required for a project's baseline, but other methods such as parametric techniques, analogies, or percentages (e.g. management as a percentage of construction cost) can be applied to early estimates for those categories of work where sufficient historical data exists. In any case, the approach needs to be identified before embarking on the exercise. A timeline for completion of the estimating exercise should be defined.

An activity based estimate has discrete, quantifiable units of work associated with each work element. Dividing estimate elements into discrete schedule activities provides the following benefits:

- The specific nature of the work can be better defined and understood
- Portions of the work can be assigned to individual, organizational elements
- Resources can be assigned using cost estimating relationships
- The work can be better planned and scheduled
- Changes to the cost estimate can be more easily incorporated

Step 3 - Define the project characteristics

Fundamental project characteristics such as the purpose, configuration, performance requirements, interfaces, technical risks, and acquisition strategies should be defined and documented, so the estimating team is clear on the scope to be estimated. As the project progresses, these items will be refined and documented in formal design reports, requirements and interface control documents, risk registers, acquisition strategies, and procurement plans.

Step 4 - Determining the estimating structure (e.g. WBS)

All estimates should be organized to ensure that there is no overlap, double counting, or missing elements. The most effective structure is a Work Breakdown Structure (WBS) as described in 12.PM-001. The WBS captures the project scope in its WBS dictionary, which defines the scope and boundaries of each WBS element.

In preparation for official baselining, project activities will be organized, into WPs and Planning Packages, using the WBS. For the purpose of this document WP and Planning

Packages will be used synonymously. Control Accounts (CA) and CAMs will also be established. CAMs are responsible for the development of cost estimates for WPs within the individual CAs. The development of the cost estimate follows the definition of the WP scope and the development of the initial schedule.

Step 5 - Identify ground rules and assumptions

A partial list of assumptions to consider and document include:

- Boundary conditions – what is included and what is not included in the estimate
- Base year of the estimate
- Escalation rates
- Definition of "fully burdened" rates
- Labor productivity and availability factors (e.g. #hours available per FTE)
- High-level schedule information
- Acquisition strategies
- Use of existing facilities
- Working conditions
- Key unknowns or missing information
- Assumptions about available technology
- Dependencies on events that are external to the project

Projects should document these ground rules and assumptions in a project "Key Assumptions" document. This description should be detailed enough to allow an individual not intimately involved with the project to understand the estimate's basis.

Step 6 - Obtain the data

Data for the estimates can be obtained from vendors, cost databases (e.g. RS Means), historical records, or expert judgment.

A list of the resources and their associated unit prices is defined before resources are applied to activities in the schedule. Rates for labor and indirect costs by the institution and for escalation should be collected and documented for use uniformly across the project. Unit prices for labor include wages, taxes, insurance, fringe benefits, overtime, overheads, and shift differential when applicable. Unit prices for material include the material price, sales taxes, and shipping costs when applicable.

Step 7 - Develop point estimate and compare to an independent cost estimate

Assemble the data into a complete estimate structured by WBS. Identify activities and assign resources including the labor, material, equipment, services, and any other budget items required to perform a scope of work. The determination of the resources required to accomplish the defined scope within the timeframes scheduled is an iterative process that includes a preliminary Performance Measurement Baseline (PMB) and culminates with a final PMB.

Once estimate elements have been defined, units of measure identified, and quantities determined, resources are assigned to each schedule activity. One or more resources may be assigned to a schedule activity. To the extent possible, the resources assigned should correspond with the resources that will be used in completing the work. Unit rates are used to assign resources to estimate activities. Unit rates can be expressed as dollars per unit, as labor hours per unit, or as a percentage of an associated cost. Unit rates expressed as labor-

hours per unit require that the type of labor (carpenter, engineer, secretary, etc.) be identified by associating a labor type or crew with each unit rate.

Certain activities cannot be associated with quantifiable units of work. Instead, these activities are expressed as a defined level of effort over time.

Regardless of the method used to assign resources to a schedule activity, the following is true for each activity:

- All costs including labor and M&S are identified
- Labor hours, when applicable, are identified
- Labor type for all labor hours is identified
- Work output is measurable

All costs must be "fully burdened." If the burdening is applied using the standard FNAL resources and cost processor, this needs to be identified in the assumptions documentation. Otherwise, a description of what is included in the burdened rate should be included in the assumptions because the definition of "fully burdened" sometimes varies.

The development of Fermilab indirect rates is the responsibility of the Fermilab Finance Section. Indirect rates are evaluated and revised on a periodic basis as necessary, in accordance with Finance policies. If applicable, external collaborators will provide their indirect costs for inclusion in the project cost estimate.

Most cost estimating is done using current dollars and then escalated to the time when the work is expected to be performed. Escalation is the provision in a cost estimate for increases in the cost of equipment, material, labor, or other costs over time and is calculated using escalation rates or indexes. A base-year must also be established for the purposes of life-cycle cost estimating (see DOE G 413.3-21, *Cost Estimating Guide* for more on life-cycle cost estimating). Escalation has two main purposes:

1. **Convert historical costs to current costs.** This is usually accomplished by using indexes from recognized sources. The estimator ensures that the indexes used are applicable to the type of cost being updated.
2. **Project current costs into the future.** This is done using Fermilab's prescribed escalation rates or indexes. Escalation rates are evaluated by the project team for possible regional or economic differences.

The following sources provide escalation indexes that can be used to facilitate escalating historical cost data to current price levels. This list is not intended to be all-inclusive. The estimate preparer selects the indexes most appropriate for the intended use.

- "Means Construction Cost indexes" construction cost indexes on a quarterly basis
- The "Engineering News Record" historical construction cost indexes on a quarterly basis
- The "Means Construction Cost Data, The Annual Edition" historical construction costs indexes for 162 major U.S. and Canadian cities and includes formulas for calculation
- The "Bureau of Labor Statistics, Monthly Labor Review, Employment Cost Index Section" historical labor cost indexes
- Historical field data developed at Fermilab
- Escalation rates obtained from engineering and/or construction industry sources

The sum of estimates for all WBS elements is the project's point estimate. The results of the time phasing and WBS element summing should be reviewed by the entire estimating team to validate the results. The estimate should be compared to earlier estimates and/or estimates for similar work to provide a top down cross check.

Step 8 - Conduct sensitivity analysis

One method to test the integrity of the estimate is to test its sensitivity to varying assumptions, schedules, funding profiles, quantities, etc. These what-if exercises will also help to determine which elements and assumptions are cost and schedule drivers.

Step 9 - Conduct risk and uncertainty analysis

The project cost estimate is based on using the best available information to develop the expected cost, and then a risk analysis is performed to develop the risk-based contingency component budget based on risk probability and consequence. Characteristics include:

- Association with the specific project risk events or inherent uncertainty in element estimates
- Consideration of the varying degree of risk associated with a scope of work
- Not being used to avoid the effort required to prepare a properly detailed and documented cost estimate

The application of contingency for managing risk is considered in all estimates and is both prudent and necessary. Risk analysis takes into consideration budget, schedule, and technical risks as they apply to the project effort, underscoring the uncertainties that exist in each of the elements. The magnitude of the risk-contingency estimate will depend on the status of planning, design, procurement, and construction, and the complexities and uncertainties of the operation or component parts of the project element.

Contingency estimates are generally applied as a percentage of a particular cost or category of work to account for Estimate Uncertainty (EU) or as a discrete amount to account for risk events. Contingency is held outside the project WBS based on a review of each major cost category/activity.

One component of the EU is general estimate uncertainty associated with each element related to design maturity, technical requirements, and related experience. Guidelines for assigning this EU component are included in the tables in Appendix D for M&S, Labor, and Conventional Facilities. After determining the appropriate estimate type based on the description for the estimate from the right-hand column in the tables in Appendix D, a contingency value within the corresponding range listed in contingency column is chosen. A contingency value can be chosen outside of the stated ranges if approved by the project manager. In any case, the basis for selection of the contingency value should be documented in the Basis of Estimate (BOE) form (example in Appendix E).

In the overall estimate, additional risk-based contingency amounts may be added to EU contingency for risk events and management judgment of overall risks.

After establishing the PMB, the distribution of contingency to CAs or WPs is controlled through a formal change control process.

Step 10 - Document the estimate

Estimates will be used not only by the estimating team but also by other project team members, management, independent reviewers, and others that are unfamiliar with the

estimate. Members of the estimating team itself may also change as the project progresses. Estimates will need to be updated periodically and will need to accommodate what-if analyses. For these reasons estimates must be well documented, traceable, auditable, and version controlled.

A peer review is a vital step in providing consistent, professionally prepared cost estimates and to verify estimate completeness. Competent and qualified personnel who have not been involved in preparing the estimate are involved in the review of cost estimates. This review provides an unbiased check of the assumptions, productivity, and cost data used to develop the estimate. The review is documented to indicate the name of the reviewer(s), the date of the review, and the reviewers' comments and comment disposition.

Step 11 - Present the estimate for management approval

A quality cost estimate will be able to be summarized at levels that are of interest to management (by WBS, control account, fiscal year, M&S vs. labor, direct vs. indirect, labor profiles, obligation profiles, etc.). The cost-estimate package is assembled in accordance with the direction and format provided by the PM in order to facilitate estimate rollup.

Step 12 - Update the estimate to reflect actual costs and changes

Estimates should be maintained to reflect the latest changes and progress. It is important that the latest cost and schedule information be included in the Estimate at Completion (EAC) or Estimate to Complete (ETC) to ensure accuracy. The EAC/ETC is updated during the EVM reporting phase of a project is described in 12.PM-006. Comprehensive bottom-up cost estimates are performed annually as part of the update to a capital project data sheet or at major phases of project evolution (e.g. at CD-2, at the completion of design, etc.).

4.3 Basis of Estimate Documentation

A well-documented estimate will withstand scrutiny. If rigorous documentation and estimate procedures are followed, the credibility of a cost estimate increases. It is important to document all steps of the cost estimating process described above in the project's BOE. Appendix E illustrates an Example Basis of Estimate Form and Appendix F illustrates an Example Basis of Estimate Spreadsheet. Use of either particular format is not required, but at a minimum, the documentation should contain the information shown.

Cost estimates support the development of the project's baseline budget and use a bottom-up, activity-based estimating methodology. In addition to reflecting the project's Total Project Cost (TPC), estimates must also include the following minimum requirements:

- Work scope description
- Explanation of the assumptions made to develop the budget
- Quantification of risk through the application of EU
- Labor hours
- Non-labor units
- Quantity and cost
- The basis for the estimate
- Type of estimate

The BOE provides a narrative explanation of the rationale behind the estimating and pricing of the work scope. It contains a documented summary of planning assumptions and resource requirements necessary to perform the project scope of work. For example, the BOE describes why a certain number of labor hours were assigned to a given task or why a certain dollar amount was assigned to specific non-labor costs.

In some cases, the estimator may simply rely on past experience of actual costs for similar work. In this case, there is a reference to the basis for selecting the number of labor hours or quantities of non-labor items based on estimator judgment and experience of prior tasks. An explanation is then provided to support the resources identified.

The use of a benchmark tool (RS Means, prior cost experience, estimating databases, etc.) is noted and modified to more adequately reflect the specific conditions for the estimate. These modifications could include adjustments for the following:

- Facility / facility component fit
- Geographic location
- Timeframe and escalation
- Market conditions
- Labor market
- Site conditions
- Project delivery options (fast track, phased construction)
- General requirements
- Ongoing operations
- Life-cycle costs
- Quality level
- Construction costs versus project costs
- Contingency allocation

The PM controls supporting documentation and ensures that it is retained by WBS element. The CAM forwards electronic copies of the documentation to the project database, where the file should be maintained under configuration management after the baseline is established. Proper care must be given to protect business-confidential and proprietary information from unauthorized disclosure.

Documents and records are generated in a manner suitable for reproduction. Documents, records, and work papers should include but are not limited to the following:

- Estimate spreadsheet
- Work papers, including vendor quotes, telephone records, material quantity measurements from design drawings, basis notes, calculations, etc.
- Analysis, such as contingencies, escalation application, and quantity discounts
- Estimating codes, such as labor disciplines and phase codes
- Application rates and associated application methodology

5.0 REFERENCES

DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*

DOE G 413.3-21, *Cost Estimating Guide*

Association for the Advancement of Cost Engineering (AACE) Recommended Practice No.18R-97

FRA Earned Value Management System Description

FRA EVMS Procedure 12.PM-001 *Project WBS, OBS and RAM*

FRA EVMS Procedure 12.PM-002 *Control Accounts, Work Packages, and Planning Packages*

FRA EVMS Procedure 12.PM-004 *Project Scheduling*

FRA EVMS Procedure 12.PM-007 *Change Control*

6.0 APPENDICES

12.PM-005A: Appendix A: Signature Page and Revision History

12.PM-005B: Appendix B: Acronyms and Glossary

12.PM-005C: Appendix C: Cost Estimate Classifications

12.PM-005D: Appendix D: Estimate Types / Uncertainty Tables

12.PM-005E: Appendix E: Example Basis of Estimate Form

12.PM-005F: Appendix F: Example Basis of Estimate Spreadsheet

Appendix A
SIGNATURE PAGE AND REVISION HISTORY

This procedure approved by: _____ 7/5/2016
Marc Kaducak **DATE**
Head, Office of Project Support Services
Fermi National Accelerator Laboratory

TABLE OF REVISIONS

Author(s)	Description	Revision	Date
	Initial Version	0	10/17/08
E. McCluskey	Word Change: Policy to Guidance.	1	12/02/08
E. McCluskey	Word Change: contingency to contingency / management reserve	2	3/27-09
E McCluskey	Removed reference to OHEP Guidance document in Step 10; revised MR/Contingency wording; removed contingency from BOE form.	3	09/17/09
M. Kaducak	Updated all references to DOE O 413.3A to DOE O 413.3B and references to DOE Guide 430.1-1 to DOE G 413.3-21, *Cost Estimating Guide.* Updated usage of management reserve and contingency. General update to align procedure with DOE G 413.3-21	4	08/18/13
R. Marcum	Incorporated detail removed from FRA EVMS Description into this procedure. Added example of BOE Spreadsheet. Also, updated acronyms and made other minor corrections or updates.	4.1	07/05/16

Appendix B
ACRONYMS AND GLOSSARY

BOE — Basis of Estimate
CA — Control Account
CAM — Control Account Manager
CD — Critical Decision
DOE — Department of Energy
EAC — Estimate at Completion
ETC — Estimate to Completion
EVMS – Earned Value Management System
EU — Estimate Uncertainty
FTE — Full-Time Equivalent
FY — Fiscal Year
PB — Performance Baseline
PED — Project Engineering and Design
PEP — Project Execution Plan
PMB — Performance Measurement Baseline
PM — Project Management
TPC — Total Project Cost
WBS — Work Breakdown Structure
WP — Work Package
WPM — Work Package Manager

Collaborator – A university or laboratory partner who participates in a project by providing labor and/or materials through direct funding from the project, or through in-kind contributions.

Control Account (CA) - A key management control point located at the natural intersection point of the WBS and the OBS, where functional responsibility for work is assigned. It represents the point at which budgets (resource plans) and actual costs are accumulated and compared to earned value for management control purposes.

Control Account Manager (CAM) – The member of the project team responsible for the performance defined in a Control Account and for managing the resources authorized to accomplish the tasks.

Critical Decision (CD) – On DOE projects, a formal determination made by the Acquisition Executive and/or designated official at a specific point in a project life cycle that allows the project to proceed. Critical Decisions occur in the course of a project: at the determination of Mission Need (CD-0), at the completion of conceptual design (CD-1), at project baselining (CD-2), at the commencement of execution (CD-3), and at turnover (CD-4).

Functional Manager – Line manager whose responsibility includes assigning staff for matrix to projects

Project Controls – Project support staff for planning, baseline development, management system plan preparation, as well as for monitoring, assessing, controlling, and reporting progress against the project baseline.

Project Financial staff – Project support staff for preparing cost information for monthly reports, monitoring expenditures, tracking spending deviations from baseline plans, preparing the Project Accounting task structure, tracking requisitions, and developing interfaces for financial information from external entities such as other laboratories and universities.

Performance Measurement Baseline (PMB) - The collected key performance, scope, cost, and schedule parameters. The Performance Measurement Baseline defines the threshold and boundary conditions for a project. The PMB is modified in accordance with the change control process.

Total Estimated Cost (TEC) - DOE Order 413.3B defines Total Estimated Cost to include project costs incurred after CD-1 such as costs associated with the acquisition of land and land rights; engineering, design, and inspection; direct and indirect construction/fabrication; and the initial equipment necessary to place the plant or installation in operation.

Other Project Costs (OPC) - DOE Order 413.3B defines Other Project Costs to include all project costs that are not identified as Total Estimated Cost costs. Generally, Other Project Costs are costs incurred during the Initiation and Definition Phases for planning, conceptual design, research and development, and during the Execution Phase for startup and operation.

Total Project Cost (TPC) - DOE Order 413.3B defines Total Project Cost as the sum of the Total Estimated Cost (TEC) and Other Project Costs (OPC)

Work Breakdown Structure (WBS) - A product-oriented grouping of project elements that organizes and defines the total scope of the project. The WBS is a multilevel framework that organizes and graphically displays elements representing work to be accomplished in logical relationships. Each descending level represents an increasingly detailed definition of a project component. Project components may be products or services. It is the structure and code that integrates and relates all project work (technical, schedule, and cost) and is used throughout the life cycle of a project to identify and track specific work scopes.

Work Package (WP) – A task or set of tasks performed within a control account. The work package is the lowest level activity to which resources are assigned.

Appendix C

Cost Estimate Classifications

Cost Estimate Classification	Primary Characteristics	
	Level of Definition (% of Complete Definition)	Cost Estimating Description (Techniques)
Class 5, Concept Screening	0% to 2%	Stochastic, most parametric, judgment (parametric, specific analogy, expert opinion, trend analysis)
Class 4, Study or Feasibility	1% to 15%	Various, more parametric (parametric, specific analogy, expert opinion, trend analysis)
Class 3, Preliminary, Budget Authorization	10% to 40%	Various, including combinations (detailed, unit-cost, or activity-based; parametric; specific analogy; expert opinion; trend analysis)
Class 2, Control or Bid/Tender	30% to 70%	Various, more definitive (detailed, unit-cost, or activity-based; expert opinion; learning curve)
Class 1, Check Estimate or Bid/Tender	50% to 100%	Deterministic, most definitive (detailed, unit-cost, or activity-based; expert opinion; learning curve)

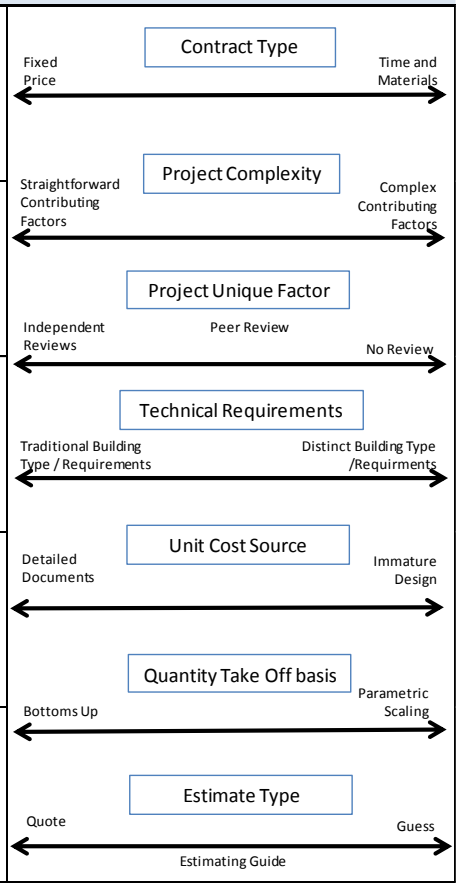
Critical Decision	Suggested Estimate	AACEI Estimate Classification
CD-0	Cost estimate range	Class 5
	Estimate of costs to be incurred prior to CD-1	Class 3
CD-1	Estimate of near term preliminary design cost	Class 3
	LCC of likely alternatives that are being considered	Class 5
	TPC range	Class 4
CD-2	Single point estimate representing entire project:	
	Low risk projects	Class 3
	High risk projects	Class 2
CD-3	Cost estimate based on Final Design [or sufficiently mature to start construction]:	
	Low risk and final design complete	Class 1
	Low risk and final design not complete	Class 2
	High risk (final design or not)	Class 2
CD-4		N/A

Appendix D. Estimate Types / Uncertainty Tables for M&S, Labor, Conventional Facilities

Code	Type of Estimate	Contingency %	Description
M&S Guidelines			
M1	Existing Purchase Order	0%	Items that have been completed or obligated. (Note: Contact Change Orders are considered a Risk and should not be included as estimate uncertainty contingency)
M2	Procurements for LOE / Oversight work	0%-20%	M&S items such as travel, software purchases and upgrades, computers, etc. estimated to support LOE efforts and other work activities.
M3	Advanced	10%-20%	Items for which there is a catalog price or recent vendor quote based on a completed or nearly completed design or an existing design with little or no modifications and for which the costs are documented.
M4	Preliminary	20%-40%	Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design belongs here.
M5	Conceptual	40%-60%	Items with a documented conceptual level of design; items adapted from existing designs but with extensive modifications, which have documented costs from past projects
M6	Pre-Conceptual - Common work	60%-80%	Items that do not have a documented conceptual design, but do have documented costs from past projects. Use of this estimate type indicates little confidence in the estimate. Its use should be minimized when completing the final estimate.
M7	Pre-Conceptual - Uncommon work	80%-100%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Its use should be minimized when completing the final estimate.
M8	Beyond state of the art	>100%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Technical requirements are beyond the state of the art.

Code	Type of Estimate	Contingency %	Description
LABOR Guidelines			
L1	Actual	0%	Actual costs incurred on activities completed to date.
L2	Level of Effort Tasks	0%-20%	Support type activities that must be done to support other work activities or the entire project effort, where estimated effort is based on the duration of the activities it is supporting.
L3	Advanced	10%-25%	Based on experience with documented identical or nearly identical work. Development of activities, resource requirements, and schedule constraints are highly mature. Technical requirements are very straightforward to achieve.
L4	Preliminary	25%-40%	Based on direct experience with similar work. Development of activities, resource requirements, and schedule constraints are defined at a preliminary (beyond conceptual) design level. Technical requirements are achievable and with some precedent.
L5	Conceptual	40%-60%	Based on expert judgment using some experience as a reference. Development of activities, resource requirements, and schedule constraints are defined at a conceptual level. Technical requirements are moderately challenging.
L6	Pre-conceptual	60%-80%	Based only on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints are defined at a pre-conceptual level. Technical requirements are moderately challenging.
L7	Rough Estimate	80%-100%	Based only on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints is largely incomplete. Technical requirements are challenging.
L8	Beyond state of the art	>100%	No experience available for reference. Activities, resource requirements, and schedule constraints are completely undeveloped. Technical requirements are beyond the state of the art.

Appendix D Continued

Code	Type of Estimate (Desing Maturity)	Contingency %	Description	Contributing Factors
Conventional Facilities				
C1	Contract Award	0-5%	Contract Award	
C2	Final Design	5-20%	Bid Docs Complete	
C3	Preliminary	10-30%	30% design complete	
C4	Conceptual	20-40%	10-15% design complete	
C5	Project Definition	40-100%	Scope Developed	

Appendix E
Example Basis of Estimate Form

Mu2e **BASIS of ESTIMATE (BoE)**	**Date of Estimate:** 5 / 29 / 2013 **Prepared by:** R. Ray **Docdb #:** xxxx
WBS number: 475.01.03.01	**WBS Title:** Design Phase Management

WBS Dictionary Definition:
Management of the Project during the design phase from CD-1 to CD-3. This includes all activities related to the management, administration, quality assurance and safety, change control, document control, cost/schedule reporting and control systems, configuration management, systems engineering, and general computing infrastructure.

Supporting Documents (including but not limited to):
see Electronic docdb file referenced above for supporting documentation.

P6 schedule spreadsheet corresponding to this BOE (Excel)

Quality Control Process Applied: by date

Assumptions: Assume CD2/3 approval at the end of FY14.

- BOE only covers activities from FY14 onward. Activities prior to FT14 are entered into the schedule as actuals with 0% contingency.
- Costs are in 2014 dollars.
- 1 FTE = 1768 hours for an average year. P6 uses the actual calendar for each year with the exact number of work days.
- Project Management labor is a level of effort. Estimates based on assigned personnel and estimated effort.
- Simulation infrastructure is included in Project Management because it is a general service made available to the entire Project. Support for simulations goes away after designs are complete, and we are in the construction phase of the Project.

Details of the Base Estimate (explanation of the Work, Contingency, and Duration)

All activities related to the Management of the Project during the design phase from CD-1 to CD-3. Labor is all level-of-effort for each fiscal year. Labor estimates are based on assigned personnel and scope of work. Actuals from FY13 are incorporated into FTE estimates.

Currently Assigned Personnel

- Project Manager – R. Ray
- Deputy Project Manager – D. Glenzinski
- Project Mechanical Engineer – K. Krempetz – Also serving as Head of PPD Mechanical Engineering Department.
- Project Electrical Engineer – K. Larwill – Also serving as Head of PPD Electrical Engineering Department.
- Project Financial Officer – D. Knapp – Assigned full time.
- Project Controls – 2 FTE of contract labor.
- Project Controls – M. Gardner – Assigned full time
- Project Controls – H. Brown – Currently assigned 50% as she transitions off of NOvA. Becomes 100% in FY14.
- ES&H Coordinator – D. Hahn – Primary responsibility is to coordinate between Project and off-Project ES&H specialists. Has several other responsibilities outside of Mu2e.
- Risk Manager – M. Dinnon – Assigned at 25% per agreement with LBNE.
- Procurement Manager – S. Gaugel – Highest priority is Mu2e but participates in other procurement activities when time permits. Uncosted resource.

M&S Base Estimate:

Project Management M&S includes Project Office travel, computers for Project Office staff, software and training, visitor support. M&S base estimate is extrapolated from FY13 actuals.

M&S Actuals for FY13

Item	Actual Cost ($k)
Computers, Software, Licenses	0
Visitor Support	$20.7
Travel	$2.2
Misc.	$4.0
Total	26.9

Project Management LOE FY14 (M&S) – 47501.3.1.001240

Item	Cost ($k)	Contingency	Contingency Rule	Comments
Computers, Software, Licenses	$5	30%	3	Assume need to replace 1 - 2 computers per year. The cost of computers is well-known.
Visitor Support	$20	30%	3	Same level of support as in FY13
Travel	$10.0	30%	3	More travel in FY14 due to site visits to solenoid vendors.
Misc.	$4.0	50%	4	Assume similar to FY13, but with large uncertainty.
Total	**39.0**	**32%**		

M&S Contingency:

The overall contingency of 32% based primarily on extrapolation from FY13 actuals. See table above.

M&S Duration

Fiscal year task – 1-year duration.

Labor Base Estimate:
Project Management labor is a level of effort. Estimates based on assigned personnel and estimated effort. Estimates for FY14 based on actuals from FY13.

Project Management Labor Actuals for FY13

Resource	FY13 Actuals	Comments
Project Manager	1.00	Assigned Full-time
Deputy Project Manager	0.66	Spends time on CDF wrap-up and Mu2e @ Project X
ES&H Manager	0.08	The effort is relatively flat over the year.
Project Mechanical Engineer	0.50	Activity ramped up as year progressed as integration and installation planning activities increased
Project Electrical Engineer	0.51	The effort is relatively flat over the year.
Finance	1.00	Assigned Full-time
Project Controls	1.74	Gardner (100%) + ramp up of Brown
Project Controls – Contract Labor	1.80	Leeb (80%) and Nordhoff (100%)
Risk Manager	0.15	Activities ramped up as the year progressed as we got into risk evaluation and costing for CD-2.

Simulation Infrastructure Labor Actuals for FY13

Resource	FY13 Actuals	Comments
Engineering Physicist	0.57	The effort is relatively flat over the year.
Applic Dev & Sys Analyst	0.55	The effort is relatively flat over the year.
Comp Science Researcher	0.24	The effort is relatively flat over the year.
Computational Physics Dev	0.75	The effort is relatively flat over the year.

Simulations Infrastructure LOE FY14 – 47501.3.1.001260

Resource	FY14 Estimate (FTEs)	Contingency	Contingency Rule	Comments
Engineering Physicist	0.50	30%	3	Extrapolated from increasing effort in FY13. Contingency rule 3 applies because the effort is based on previous effort.
Applic Dev & Sys Analyst	0.50	30%	3	Extrapolated from increasing effort in FY13. Contingency rule 3 applies because the effort is based on previous effort.
Comp Science Researcher	0.25	30%	3	Extrapolated from increasing effort in FY13. Contingency rule 3 applies because the effort is based on previous effort.
Computational Physics Dev	0.75	30%	3	Extrapolated from increasing effort in FY13. Contingency rule 3 applies because the effort is based on previous effort.

Project Management LOE FY14 – 47501.3.1.001220

Resource	FY14 Estimate (FTEs)	Contingency	Contingency Rule	Comments
Project Manager	1.00	0%	NA	Assigned full-time. No contingency on a full-time assignment. Risk registry contains risks associated with additional effort in Project Office.
Deputy Project Manager	0.90	10%	NA	Spends ~ 10% of the time on Project X physics. 10% contingency allows for full-time effort. Risk registry contains risks associated with additional Project effort.
Project Support	0.25	50%	4	Project support for change control, monthly reports. Contingency rule 4 is used because the effort is not extrapolated from previous Mu2e effort.
Project Mechanical Engineer	0.75	30%	3	Extrapolated from increasing effort in FY13. Contingency rule 3 applies because the effort is based on previous effort.
Project Electrical Engineer	0.50	30%	3	Same effort as FY13. Contingency rule 3 applies because the effort is based on previous effort.
Finance	1.00	0%	NA	Assigned full-time. No contingency on a full-time assignment. Risk registry contains risks associated with additional effort in Project Office.
Project Controls	2.00	0%	NA	Brown and Gardner assigned full time. No contingency on a full-time assignment. Risk registry contains risks associated with additional effort in Project Office.
Project Controls – Contract Labor	1.80	10%	NA	Leeb (80%) and Nordhoff (100%). 10% contingency allows for full-time effort. Risk registry contains risks associated with additional Project effort.
Risk Manager	0.25	0%	NA	Negotiated fraction of Dinnon with LBNE. Adequate to do the job based on FY13 effort. No contingency because 0.25 FTE is full allocated allotment. Risk registry contains risks associated with additional effort in Project Office.
QA manager	0.10	50%	4	Setup and coordination of QA across project. Actual QA activities are accounted for in appropriate subsystem WBS. Contingency rule 4 is used because the effort is not extrapolated from previous Mu2e effort.
Procurement Manager (uncosted)	0.75	30%	3	Ramp up from FY13 based on significant procurements of solenoids and detector hall. Contingency rule 3 applies because effort is based on previous effort.

Labor Contingency:

The overall contingency of 29% based on extrapolation from FY13 actuals. See table above.

Labor Duration

Fiscal year task – 1-year duration.

Appendix F
Example Basis of Estimate Spreadsheet

Basis of Estimate (BoE)

Project or FNAL Logo may go here

Document ID: Doc-DB-xxxx
Prepared by:
Updated:

Placing a good Estimate description in Excel cells can be difficult, especially if well defined. This limitation produces a tendency to oversimplify the process used to establish the rational/methodology for the BOE development. We suggest using a word document with pertinent text, to eliminate tendency to simplify continent. However, if using Excel add cells for different purposes and merge cells to provide more usable format (as demonstrated).

WBS Component	
WBS Number:	
WBS Name:	

WBS Dictionary Description:
This WBS element includes

Assumptions:
Include rational for exclusions such as the scope of work does not include installation.
Standard labor rate for....

Rational or Methodology used:
Estimates are based on

Supporting Documents		
1	Schedule	Doc-DB-
2	Quote	Doc-DB-
3	Historical Cost	Doc-DB-
4	Basis for Analogy	Doc-DB-
5		

Examples of possible document

Estimate Categories	
	Option A - Expert Opinion
	Option B - Analogy
	Option C - Parametric Estimating
	Option D - Engineering Build-up (Includes Quote)
	Option E - Extrapolate from Actuals (averages, learning curves, estimates at completion)

Activity ID	Activity Description	Duration (days)	Resource Name	Resource Type (M&S or Labor)	Cost Estimate Direct Dollars	Fermilab Labor base estimate (Hours)	University Labor base estimate (Hours)	Estimate Uncertainty Type	Estimate Uncertainty %	Estimate Category (One per Activity)	Funding Agency (DOE, NSF, etc)	Escalated Costs	Contingency	Total w/ contingency
				SubTotals	0	0	0					0.00	0.00	0.00

Total Labor Cost
Total M&S Cost
Contingency
Total Cost