



Cost & Schedule Procedures For The BTeV Proposal

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This document details the cost and schedule procedures for the BTeV Proposal. Guidelines are provided for developing a work breakdown structure and for estimating the labor, materials and contingency costs.

For additional information, file templates & examples:
<http://www-ese.fnal.gov/btev/costing/costingprocedures.htm>

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1 Purpose of These Procedures

These procedures are intended to guide BTeV subsystem managers and coordinators in developing project costs and schedules for the BTeV Proposal. The purpose of these costing procedures is to provide a common approach and framework among the activities for which the BTeV subsystem managers and coordinators are responsible.

The costs and schedule need to be organized using a work breakdown structure (WBS) format. It is intended that each of the subsystem managers and coordinators supply the details of the WBS for their subsystem subject to a set of general guidelines.

The steps of the WBS and cost estimate development for the BTeV Proposal, described in the following sections, are:

- 1) Develop an outline of the WBS elements that constitute the work breakdown structure for each Level 2 (two-digit) WBS element
- 2) Complete all entries for each WBS element in the WBS dictionary
- 3) Estimate the personnel effort and material costs for each WBS element and enter that information into the cost estimate worksheet
- 4) Complete the contingency analysis worksheet
- 5) Complete the cost estimate summary by adding the contingency information to the cost estimate worksheet
- 6) Compile backup material
- 7) Complete supporting text and figures
- 8) Complete information on collaborating institutions (BTeV management)
- 9) Complete personnel 'loading' information (BTeV management)

These procedures are based on those developed by the SDC collaboration (see SDC document SDT-000009). They are currently being used for US CMS projects.

Section 3 explains these nine steps.

2 Work Breakdown Structure

2.1 Guidelines for WBS Development

Subsystem coordinators are asked to break down their subsystem components into a hierarchy of WBS elements. Rules for WBS development beyond the summary level are as follows:

2.1.1 *WBS Elements and Activities*

WBS elements are deliverables, and for the most part should be described as nouns. The engineering and design for a component are activities; the component is the deliverable, not the engineering and design activities. It is the component that constitutes the WBS element.

2.1.2 *WBS Numbers*

WBS elements should be numbered in the classical dotted decimal format. The first level of the WBS corresponds to the BTeV project; the second level to the major components of BTeV.

Although no limits on the WBS numbering scheme are being imposed, the resultant WBS will be more manageable if the number of levels is limited to less than ten. In practice, it is seldom necessary to exceed six or seven WBS levels. For the BTeV Proposal, WBS elements must go down to Level 5 (5-digits). If practical at this time, costing down to Level 6 (6-digits) is preferred in the BTeV Proposal (see BTeV draft WBS document).

2.1.3 *Project Management*

Project management includes the activities of technical leadership and administration of a large project. Project management activities are WBS elements because they have associated with them subordinate activities that cross most other WBS elements. Project management costs should be included in the cost estimate spreadsheet.

2.2 BTeV WBS Outline

The outline below lists the proposed first two levels (first three levels for triggers & software) of the BTeV Proposal Work Breakdown Structure.

- 1 BTeV
 - 1.1 Detector Magnet
 - 1.2 Pixel Detector
 - 1.3 RICH Detector
 - 1.4 EM Calorimeter Detector
 - 1.5 Muon Detector
 - 1.6 Forward Tracker Straw Detector
 - 1.7 Forward Tracker Strip Detector
 - 1.8 Luminosity Monitoring Systems
 - 1.9 Trigger System Electronics & Links
 - 1.9.1 Pixel Trigger
 - 1.9.2 Muon Trigger

- 1.9.3 Global Trigger/Trigger Supervisor
- 1.10 Data Acquisition Electronics & Links
- 1.11 Level 2/3 Online Processor Array & Storage
- 1.12 Offline Processor Array & Storage
- 1.13 Accelerator Timing & Distribution System
- 1.14 Timing, Controls & Monitoring System
- 1.15 Control Room Electronics
- 1.16 Other Infrastructure
- 1.17 Software
 - 1.17.1 Development & Test
 - 1.17.2 System
 - 1.17.3 Offline
- 1.18 Test Stands
- 1.19 IC Characterization System
- 1.20 System Integration, Testing & Commissioning
- 1.21 Project Management

3 Proposal Preparation Guidelines

3.1 Work Breakdown Structure

Each subproject coordinator is responsible for generating a WBS for his/her Level 2 and below WBS elements. Use the Level 2 numbers as shown in Section 2.2.

3.2 WBS Dictionary

Each subproject coordinator is responsible for generating a WBS Dictionary for each WBS element in his/her Level 2 subproject. A WBS Dictionary template and WBS Dictionary element example are available on the web.

A WBS Dictionary element consists of the following six items:

- 1) WBS Element Number
- 2) WBS Element Name
- 3) WBS Element Description
- 4) Ground Rules & Assumptions
- 5) Estimate Source
- 6) Basis of Estimate

3.2.1 WBS Element Description

The text contained in this entry of a WBS Dictionary element should explain, with reasonable detail, what item or items constitute the WBS Element Name. Key technical issues should also be included.

3.2.2 Ground Rules & Assumptions

This text helps BTeV Proposal reviews fully understand such things as:

- 1) Why is the work being done
- 2) Who are the groups working on this work
- 3) What are the deliverables and how many of each
- 4) What are the rough schedules for these deliverables
- 5) Any other pertinent information to assist the reviewers in their understanding of the WBS element

3.2.3 Estimate Source

This 'Estimate Source' indicates the source of the cost estimate of the WBS element. For example, if budgetary or other quotes are available from a manufacturer for the WBS element, this should be stated as the 'Estimate Source' for that element. These quotes should also be included in the backup material for this WBS element. Including a reliable source for your costing adds credibility to your cost estimates. Some other sources for cost estimates include:

- 1) Summary element (cost from roll up)

- 2) Vendor estimate
- 3) Bottoms-up analysis
- 4) Manufacturing analysis or standards
- 5) Historical reference
- 6) Parametric estimate
- 7) Top-down analogy
- 8) Engineering judgment
- 9) Other (specify)

3.2.4 Basis of Estimate

The 'Basis of Estimate' is a brief description of how the estimate was made and what labor classifications have been used. Some examples items that could be used to form a credible 'Basis of Estimate' include:

- 1) Purchase order(s) and/or quotation(s)
- 2) Past experience doing similar work
- 3) Knowledge of other similar work
- 4) Other (specify)

3.3 Cost Estimate Spreadsheet

Cost estimates will be in FY2000 US dollars. A Cost Estimate spreadsheet template file is available on the web. The following are notes pertaining to the Cost Estimate spreadsheet:

- 1) The spreadsheet cells contain helpful comments. Please read them.
- 2) The personnel time estimates are based on 250 working days per year, 8 hours per day.
- 3) PH.D, EN.D & TE.D are for personnel time estimates of physicists, engineers (and engineering associates) & technicians, respectively for the development and testing of prototype WBS element items.
- 4) PH.M, EN.M & TE.M are for personnel time estimates of physicists, engineers (and engineering associates) & technicians, respectively for the manufacturing, subsystem assembly, testing, installing & commissioning of all production WBS elements. Note that, for the BTeV Proposal, there are two areas of WBS elements for *.M category people time estimates, both of which deal with testing at the experiment site. For example, *.M people time estimates within the Pixel Detector WBS elements include production and testing-at-the-experiment people time estimates for the Pixel Detector. There is also a separate Level 2 WBS element for system integration testing and commissioning at the experiment site. This WBS element is intended for cost estimating the integration testing and commissioning of the entire BTeV project.
- 5) PH.D & PH.M personnel time estimates are not included in labor costs.

3.3.1 Labor Rates

For the purposes of the BTeV Proposal, all labor costs will use Fermilab rates in their calculations. These labor rates used should be fully burdened with all associated costs. Typically, a burdened labor rate includes direct labor, fringes, overhead, and general and administrative costs.

3.3.2 Calendar and Time Units

A standard calendar of 250 days/year, based on 8 hours/day, 5 days/week, 10 holidays/year, which equates to 2000 hours/year, should be used for all estimates. The standard unit of time will be the day.

3.3.3 Material Costs

Material costs include the purchase of raw materials for fabrication and the procurement of components, subassemblies, and tooling from outside sources, or items estimated in such a way that only a total dollar amount can be identified. It includes detector hardware, equipment, fixtures, tooling, utilities, test and assembly equipment, computer hardware and software, raw materials, and procurement processing. Travel is considered a material cost. The Cost Book should indicate the basis for arriving at the materials cost estimate.

Material estimates should be included as part of the Cost Book when used to arrive at material or procurement costs. The basis of estimate should also identify how the estimate was arrived at, and reference the vendor estimate if applicable. If the vendor's name is identified on the estimate, it is advisable to obtain their permission before publishing the estimate. If the vendor objects, simply identify the source as "Vendor A".

3.3.4 Supporting Documentation

The cost estimate should include all direct and indirect labor costs. The methodology behind developing the labor estimates should be included in the Cost Book as part of the basis of estimate. The methodology may range from engineering judgment, performance on historical projects, or detailed manufacturing estimates based on process plans or industrial engineering standards. The level of detail required is dictated by the total labor contribution to that element.

Manufacturing analyses performed to arrive at the labor estimate need to be spelled out. Analyses should be done to a level that ensures a high degree of confidence in the total effort estimated. For example, if thousands of like items are to be assembled in a high volume production setting, the credibility of the labor estimate will have to be very high or else a small change in the estimate will result in a rather large change in the total cost.

Labor estimates will also be affected by the manufacturing process assumptions made. Total labor will vary based on the level of automation assumed. University shops may be very labor intensive, while laboratory or industry settings may use automation to greatly reduce the labor required to assemble an item. There is a trade-off between labor-intensive operations at lower labor rates versus automated tooling resulting in less labor required but at a higher rate. The quality assurance program will also be affected by the assumptions made. The labor strategy needs to be clearly identified in the basis of estimate in the subsystem cost book by each subsystem cost coordinator.

3.4 Contingency Analysis & Spreadsheet

A Contingency spreadsheet template file is available on the web. Its contents need to be copied and pasted into the appropriate cells of the Cost Estimate spreadsheet.

The methodology for developing a contingency for a WBS element is given in the following subsections.

3.4.1 Risk Analysis

Risk analysis is to be performed for each WBS element. Results of this analysis will be related to a contingency that will be listed for each WBS element. The goal is to make the method of cost estimation and contingency determination uniform across all BTeV WBS elements.

3.4.2 Procedures

3.4.2.1 Base Cost Estimate

The base cost estimate is the estimated cost of doing things correctly the first time, unless from past experience you are fairly certain that it will take more than once. In other words, contingency should not be included in the base cost.

3.4.2.2 Cost Contingency

Cost contingency is the amount of additional money, above and beyond the base cost, that is required to ensure the project's success. This money is to be used only for omissions and the unexpected difficulties that may arise. Contingency would be held entirely by BTeV project management and not by individual subsystem managers or coordinators. Contingency costs are explicitly part of the total cost estimate.

3.4.2.3 Contingency Estimation

The procedure for estimating cost contingency is to:

- 1) Compare the conceptual state of the element with Table 1 to determine risk factors;
- 2) Compare the potential risk within an element with Table 2 to determine the appropriate weighting factors;
- 3) Multiply the individual risk factors by the corresponding weighting factors, and then sum them to determine the composite contingency percentage;
- 4) Do this for each element at a chosen level, preferably Level 5 or 6 of the WBS;
- 5) Calculate the dollar amount of contingency for an element by multiplying the base cost by the calculated contingency.

Table 1
Technical, Cost, and Schedule Risk Factors

<u>Technical</u>	<u>Cost</u>	<u>Schedule</u>	<u>Risk Factor</u>
Existing design and off the shelf hardware	Off the shelf or catalog item	Not used	1 %
Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item	2 %
Extensive modifications to an existing design	Vendor quote with some design sketches	Not used	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 established designs or existing technology	In-house estimate for item with minimal experience but related to existing capabilities	Not used	6 %
New design, requires some R&D but does not advance the state-of-the-art	In-house estimate for item with minimal experience and minimal in-house capability	Delays completion of critical subsystem item	8 %
New design, development of new technology which advances state-of-the-art	Top-down estimate from analogous programs	Not used	10 %
New design, way beyond the current state-of-the-art	Engineering judgment	Not used	15 %

**Table 1
Technical, Cost, and Schedule Risk Weights**

<u>Technical</u>	<u>Cost</u>	<u>Schedule</u>	<u>Risk Weight</u>
Not used	Material cost OR Labor rate	Same for all	1
Design OR Manufacturing	Material cost AND Labor rate	Not used	2
Design AND Manufacturing	Not used	Not used	4

3.4.3 Input Format

Using the Contingency spreadsheet template, create a copy of your WBS. Pick a level at which you will do detailed contingency analysis, and include the following additional columns:

<u>WBS #</u>	<u>Elem. Desc.</u>	<u>Tech Risk</u>	<u>Cost Risk</u>	<u>Sched. Risk</u>	<u>Tech Wt.</u>	<u>Cost Wt.</u>	<u>Sched. Wt.</u>	<u>Comp. Risk %</u>
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Input all information following the procedure outlined above.

3.4.4 Contingency Backup Information

Keep all supporting information used in deriving risk factors. Most of the backup information will be the above spreadsheet itself. A copy of this information should be included in the 'Backup Material' (see Section 3.5).

3.5 Cost Book Backup Material

All backup material used for completing any of the above sections should be included in a Cost Book for the entire BTeV Proposal (see Section 3.8). The backup section of this book should be sub-sectioned by WBS Level 2 elements and sub-sectioned by the area of backup material (e.g., WBS Dictionary, Cost estimate, Contingency estimate, etc.).

Backup material such as cost quotations and data sheets on new technology items is strongly recommended as it adds credibility to cost estimates and technology choices, respectively. Other backup material as necessary and/or helpful to Proposal reviewers should be included as well.

3.6 Cost Book Supporting Text & Figures

Supporting text and figures are very important to the reviewer's understanding of the BTeV project and all its subprojects. This information should be fairly detailed, including explanatory figures wherever appropriate and/or helpful. There should be explanatory text and figures, for example, such that the technical features and work involved with completing each WBS element of a Level 2 subproject can be easily understood.

This information is part of the Cost Book (see Section 3.8). The supporting material section of this book should be sub-sectioned by WBS Level 2 elements.

3.7 BTeV Management Items

3.7.1 Collaborating Institutions

To the extent possible at the Proposal stage, BTeV management should provide estimates of outside collaborator contributions to the project. Collaborator information for which there are entries in the cost estimate spreadsheet template should be included both there and in the template provided for this section. Using the appropriately highest WBS level for each subproject on which a collaborating institution will work, the following information should be provided:

- 1) The subproject's WBS number
- 2) For each collaborating institution on the subproject:
 - a) The type and number of people and for how long
 - b) The amount of money to be contributed
 - c) If deliverables other than funds are expected, state clearly these deliverables and their schedule
 - d) Other pertinent information to aid the Proposal reviewers

3.7.2 Project Personnel Loading

To the extent possible at the Proposal stage, BTeV management should provide estimates of the number of physicists, engineers (including engineering associates) and technicians needed at the start of the project and a profile of each of their uses during the course of the project. The estimates should clearly indicate which fraction of each of these personnel categories are Fermilab personnel.

3.7.3 Overall BTeV Schedule Estimates

To the extent possible at the Proposal stage, BTeV management should provide schedule estimates for the completion of all the major components of the project. Schedule estimates for completion of subsystem assemblies, installation at the detector and commissioning of the subsystems and the overall BTeV project should also be included. For example, development and manufacturing schedule for all WBS Level 2 elements should be included. Major technical, personnel and/or funding issues that can affect the estimated schedule should be clearly indicated.

3.8 Cost Book

This book is a compilation of all the items requested for the Proposal in this document. It should contain:

- 1) WBS Dictionary
- 2) Cost & contingency spreadsheets
- 3) Backup & supporting material
- 4) Collaborating institution material
- 5) Project loading material
- 6) Overall BTeV schedule material

All sections of the Cost Book should be clearly indicated.