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# Case Study of PMCS Implementation/Tools - Advanced LIGO

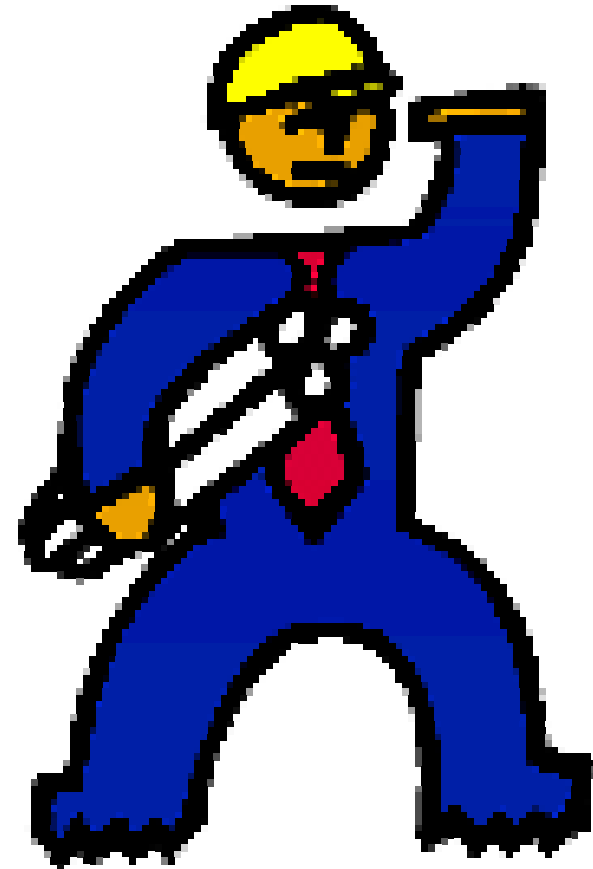
**An Example Of Implementation In Progress**

**Prepared by Thomas Frey, CCC, PMP**

# Presentation Outline

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- Introduction
- Value to Stakeholders
- PMCS Implementation  
General Practice
  - » Model System
  - » Tools
  - » LIGO Lab Criteria
- Why CPM
  - » A Case Study of Scheduling Tools
    - MS Project vs. Primavera Project Planner
- Real World Example of Tool Use
- Conclusion
- References





# Introduction

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- My Background.
- Focus of the Presentation.
- Not the Focus of the Presentation.
- Topic Definition





# Speaker Background

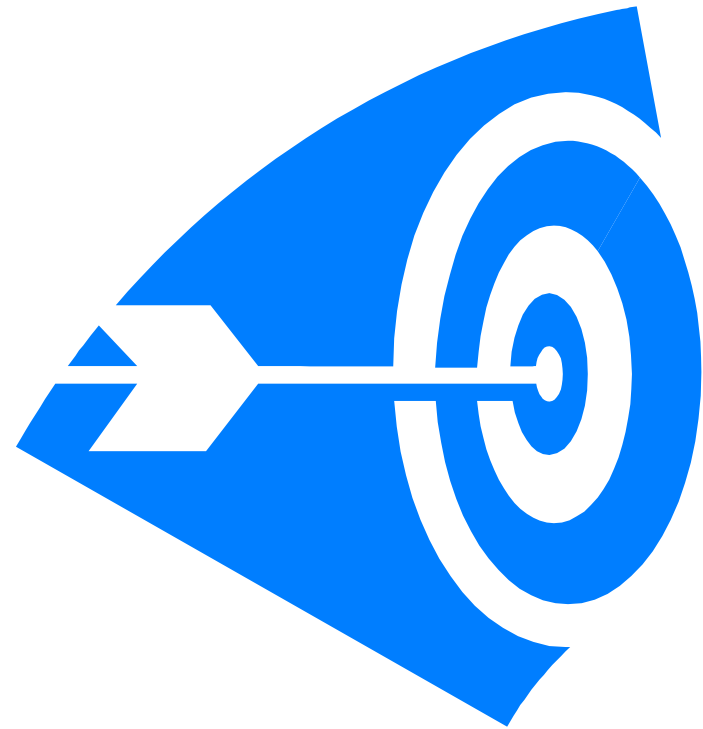
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- Thomas L. Frey, CCC, PMP
- Experience : 12 Yrs. Work Experience in Project Control Systems.
- Education : BS Degree Project Mgmt. Purdue University at West Lafayette, IN.
- Present : Working at LIGO Lab out of the Business Office.
- Comments & Additional Info.: [TFrey@ligo.caltech.edu](mailto:TFrey@ligo.caltech.edu) ; [www.ligo.caltech.edu/~tfrey/](http://www.ligo.caltech.edu/~tfrey/)

# Focus of Presentation

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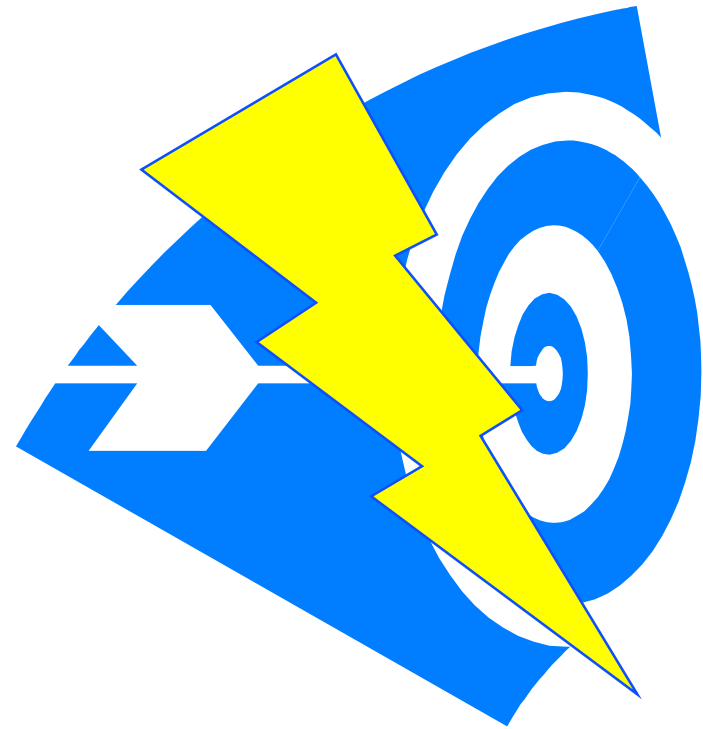
- Focus of this presentation is:
  - » to explain the elements of the implementation process.
  - » to explain the why it is best to choose CPM tools.
  - » to outline the tools being used by LIGO.
  - » to present the project structure being used by LIGO.
  - » to present a real world example of how the tools benefited LIGO and a collaborator.
  - » To discuss some future / proposed tool selections by LIGO.



# FOCUS of Presentation is NOT...

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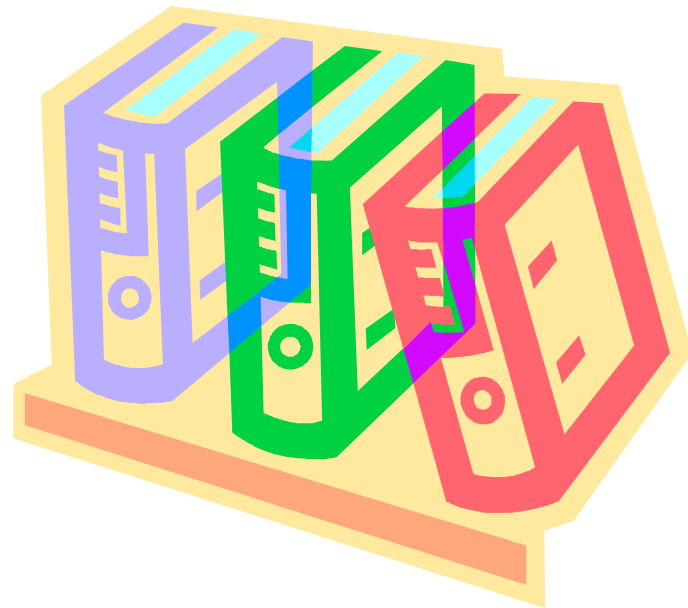
- The focus of this presentation is not:
  - » to discuss the pros and cons or history of CSC Criteria.
  - » to discuss the origin of EV Analysis.
  - » to suggest that EV Analysis / Reporting is a panacea.
  - » to dictate specific means or methods.
  - » to imply that EV Analysis has to be implemented on all projects.
  - » To suggest that the tools LIGO uses, are the only options.



# Topic Definition

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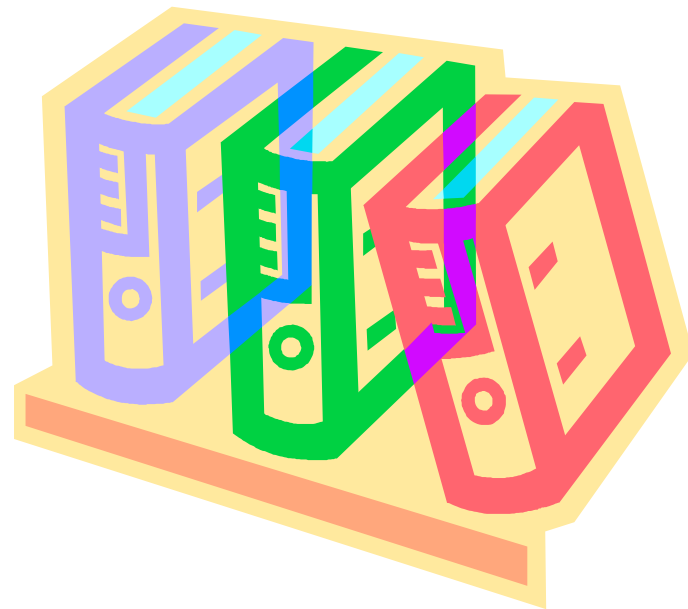
- What is implementation?
  - » **CARRY OUT, ACCOMPLISH**; *especially* : to give practical effect to and ensure of actual fulfillment by concrete measures
  - » to provide instruments or means of expression for.



# Topic Definition Con't

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- What is an Project Management Control System? A M.I.S. that...
  - » Determines project status.
  - » Makes a comparison of project status to planning.
  - » Provides information regarding corrective action.
  - » Manages the change process.
  - » May or may not implement Earned Value Analysis.







# Topic Definition Con't

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- What is Implementation of a Project Management Control System? A M.I.S. that...
  - » To give practical effect...
    - PMCS that provides useful information.
  - » Actual fulfillment by concrete measures....
    - PMCS that provides quantifiable benefit to project.
  - » Provide instruments or means of expression
    - PMCS that has meaningful output.



# Topic Definition Con't

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- **Still a form of Estimating!**
  - » This is a combination of cost estimation and time estimation. Both come with inaccuracies in the form of allowable variances. Allowable has to be defined by the management team and accepted. Variances will always be directly proportional to the quality and quantity of data available.

# Value to Stakeholders

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- Define Stakeholders
- Define the Value of PMCS.
- Objections / Misconceptions



# Value to Stakeholders

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- Who are the stakeholders?
  - » Anyone associated with the project or a benefactor of the project.
  - » “Product of the Project”
- Need to have stakeholders at the highest levels in the organization that recognize the value of project controls.



# Value to Stakeholders

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- What kind of stakeholders?
  - » Anyone that works in a project environment.
  - » Product independent.
  - » Any process (Industry) can be accommodated.



# Value to Stakeholders

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## ● Value?

- » Better decision making regarding corrective actions.
- » Better Resource Analysis.
- » Better Cost / Schedule Risk Analysis.
- » Can use for justifying schedule and cost impact due to changes.



# Value to Stakeholders

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- Objections / Misconceptions?
  - » Too complicated.
  - » Makes us look bad. (Shoot the Messenger)
  - » Micro Management.
  - » We don't need to control costs and resources. (?) (Ostrich Management Style)
  - » Can't afford the expertise.



# Value to Stakeholders

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- Value? (Bottom Line)
  - » Better Project Control, Better Budget Use!
  - » Better Project Value.







**LIGO**

# PMCS Implementation General Practice

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- Implementation Process
- Basic System Elements
- Criteria of LIGO Lab
  - » Program Model

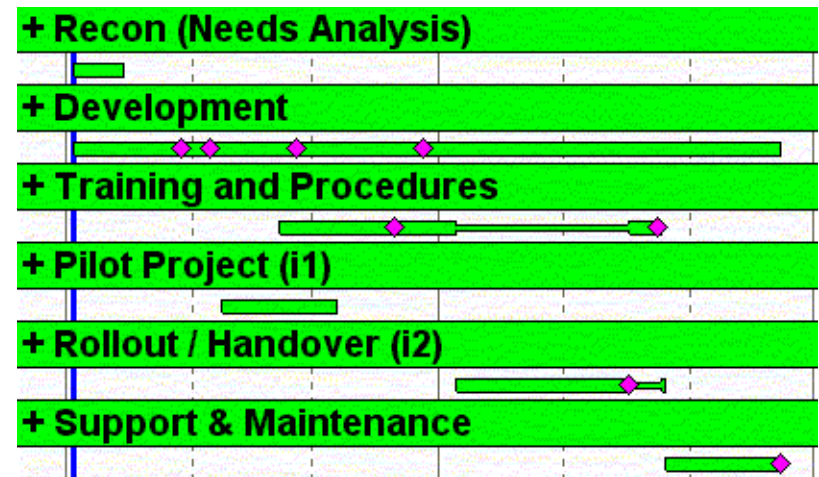




# General Practices – Implementation

- SDLC (System Development Life Cycle)

- » Recon (Needs Analysis)
  - The process of learning your customers unique business processes and determining how you can apply your knowledge of software tools to improve the management of those processes.
- » Development
  - The process designing and creating the solution for the customer.
- » Training and Procedures
  - The process of teaching your customers champions and staff how to use the developed solution and documenting how to use it.
- » Pilot Project (i1)
  - This is the preliminary phase of implementation and is a test of how well the developed solution will meet the expectations of the customers and users.
- » Rollout / Handover (i2)
  - This is the final phase of implementation and is a process of incorporating the changes to meet the expectations of the customers and users; and handing the system over to the customer.



- » Support & Maintenance
  - The process of tech support, continued education, continued improvement, and follow through.



# General Practices – System Elements

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## ● Elements of the PMCS

- » WBS, tailored for effective management control.
- » OBS, define the organizational elements in which work will be planned and controlled.
- » Provide for integration with accounting systems.
- » Schedule methodology used should describe sequence of scope and identify sequencing that meets the requirements of the program.
- » Establish budgets for the scope and identify significant cost elements as needed for management control.
- » Establish and maintain a budget loaded baseline schedule, against which program performance can be measured.



# General Practices – System Elements

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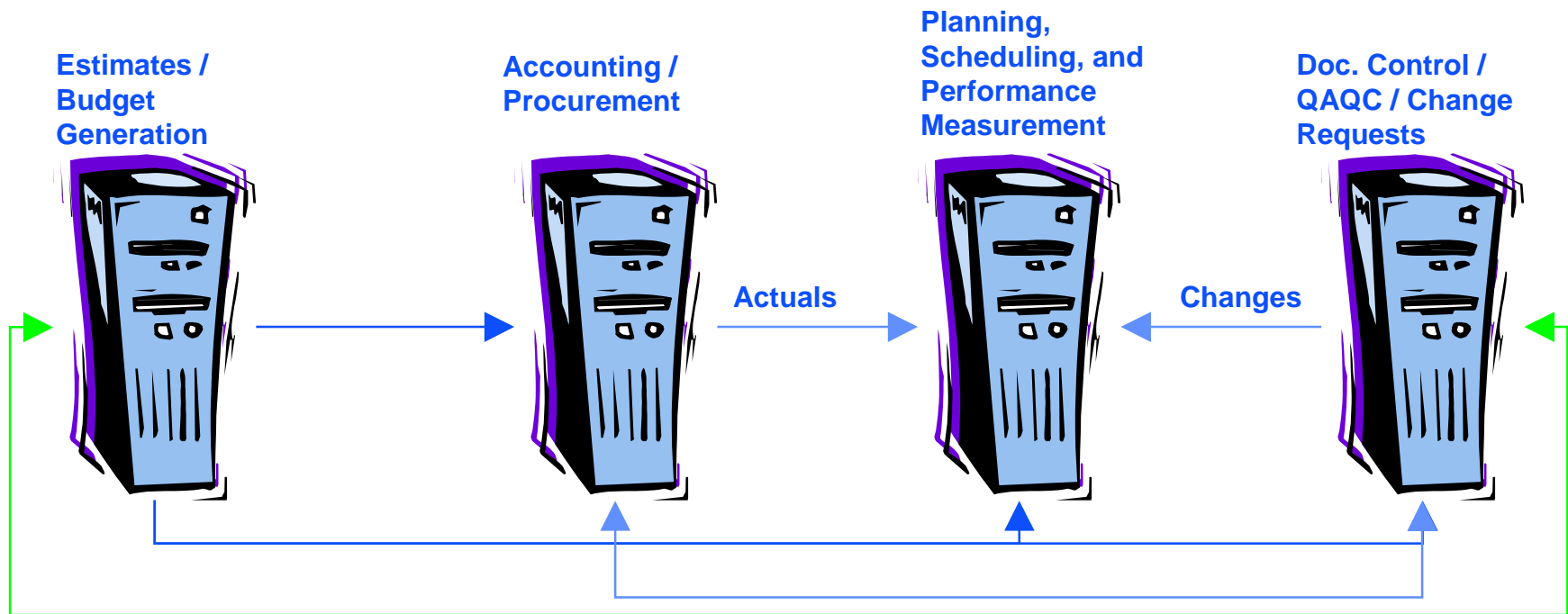
## ● Elements of the PMCS

- » At least on a monthly basis, reconcile any deviations that are not performance related.
- » At least on a monthly basis, generate Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the schedule variance
- » At least on a monthly basis, generate comparison of the amount of the budget earned and the actual direct costs for the same work. This comparison provides the cost variance
- » At least on a monthly basis, generate the significant differences between both planned and actual schedule performance and planned and actual cost performance, and provide the reasons for the variances.



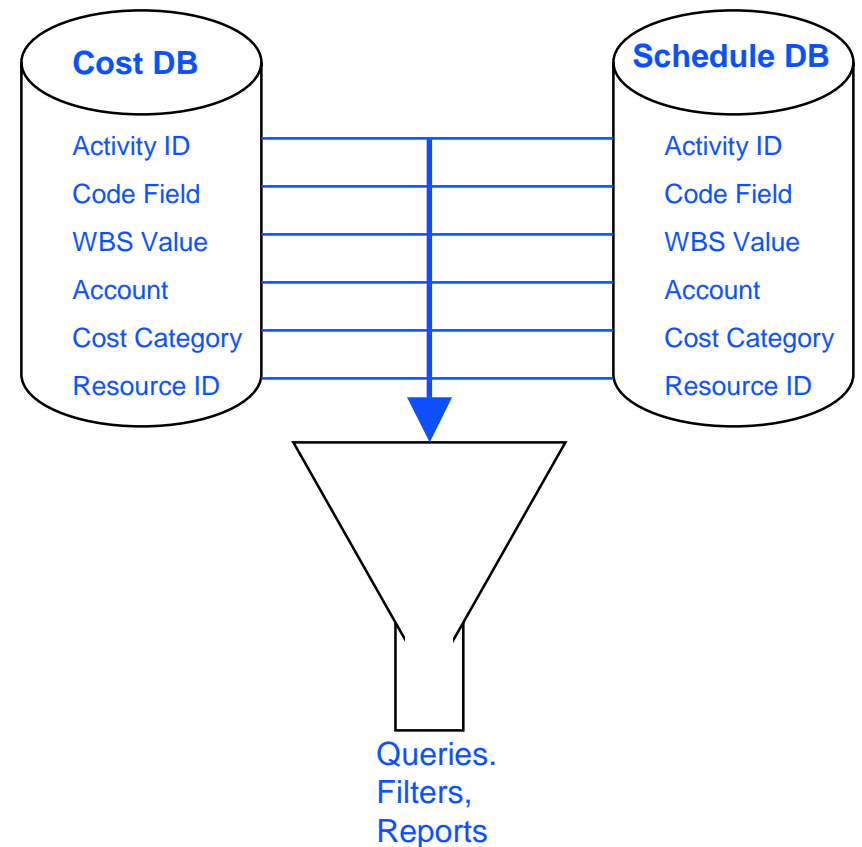
# General Practices – System Elements

- Elements of the PMCS (EVMS)



# General Practices – System Elements

- Tools and software work on a database concept. To make data integrate, common field values must exist to join data. For example:
  - » Activity IDs
  - » Code Fields
  - » WBS Values
  - » Cost Accounts
  - » Cost Categories
  - » Resource IDs





## Criteria for LIGO Lab

---

- Use of a Traditional WBS (Work Break Down Structure)
- Follow a defined project life cycle and structure.
- Cost Codes that are linked to a WBS
- Resource planning by Discipline. –
  - » Resource Pool Listing by Discipline
- Cost and Schedule Integration. –
  - » LIGO II Cost Book Tool
    - Cost Estimating Plan
    - Cost Estimating Tool User Procedure
- Reporting capability at any level within the WBS
  - » Schedule Development
  - » Example reports for pilot projects
    - LASTI
    - 40-Meter
- Earned Value Analysis - AKA Variance Analysis. –
  - » Program Model Output from P3 (Primavera Project Planner)



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## LIGO.2 LIGO Laboratory Operations

### LIGO.2.01 Laboratory Caltech Site Operations

LIGO.2.01.1 Director's Office (DIR)

LIGO.2.01.2 Business Office (BUS)

LIGO.2.01.3 Technical and Engineering Support (TEC)

LIGO.2.01.4 Detector Support (DET)

LIGO.2.01.5 Data Analysis and Computing (COMP)

LIGO.2.01.5.1 Data Analysis (REC)

LIGO.2.01.5.2 Modeling & Simulation (REC)

LIGO.2.01.5.3 Data Analysis - General Comp

LIGO.2.01.6 Campus Research Facilities (CAM)

LIGO.2.01.6.1 40 Meter Interferometer Upgrade

LIGO.2.01.6.1.1 FAC

LIGO.2.01.6.1.1.1 Lab Expansion

LIGO.2.01.6.1.1.2 Vacuum Envelope

LIGO.2.01.6.1.1.3 Vacuum Controls

LIGO.2.01.6.1.2 SEI

LIGO.2.01.6.1.2.1 Output Chamber Stack

LIGO.2.01.6.1.2.2 Cavity Optics Isolation

LIGO.2.01.6.1.2.3 Open

LIGO.2.01.6.1.2.4 Active Isolators

LIGO.2.01.6.1.3 SUS

LIGO.2.01.6.1.3.1 Large Optic Suspensions

LIGO.2.01.6.1.3.2 Small Optic Suspensions

LIGO.2.01.6.1.4 PSL

LIGO.2.01.6.1.4.1 Laser

LIGO.2.01.6.1.4.2 PSL

## LIGO.4 Advanced LIGO Construction

### LIGO.4.01 Facility Modifications (FAC)

LIGO.4.01.1 FAC Vacuum Equipment

LIGO.4.01.1.1 2K to 4K Conversion

LIGO.4.01.1.2 Clean Room Systems

LIGO.4.01.1.3 Vacuum Equipment Bakeout and Preparation

LIGO.4.01.2 FAC Beam Tube

LIGO.4.01.3 FAC Conventional Facilities

LIGO.4.01.3.1 Livingston Staging Building

LIGO.4.01.3.2 Staging Building Cranes

### LIGO.4.02 Seismic Isolation (SEI)

LIGO.4.02.1 SEI Subsystem Management

LIGO.4.02.2 SEI R&D

LIGO.4.02.2.1 Seismic Isolation R&D - Caltech (SEI)

LIGO.4.02.2.2 Stochastic Noise R&D - MIT (STO)

LIGO.4.02.2.3 Seismic Isolation R&D - LSU

LIGO.4.02.2.4 Seismic Isolation R&D - Stanford

LIGO.4.02.2.5 Seismic Isolation R&D - JILA

LIGO.4.02.3 SEI Design

LIGO.4.02.3.1 SEI Conceptual Design/Requirements

LIGO.4.02.3.2 SEI Preliminary Design

LIGO.4.02.3.2.1 ETF Prototype Unit

LIGO.4.02.3.2.1.1 Design

LIGO.4.02.3.2.1.1.1 Requirements Definition

LIGO.4.02.3.2.1.1.2 Mechanical Design

LIGO.4.02.3.2.1.1.3 Electrical Design

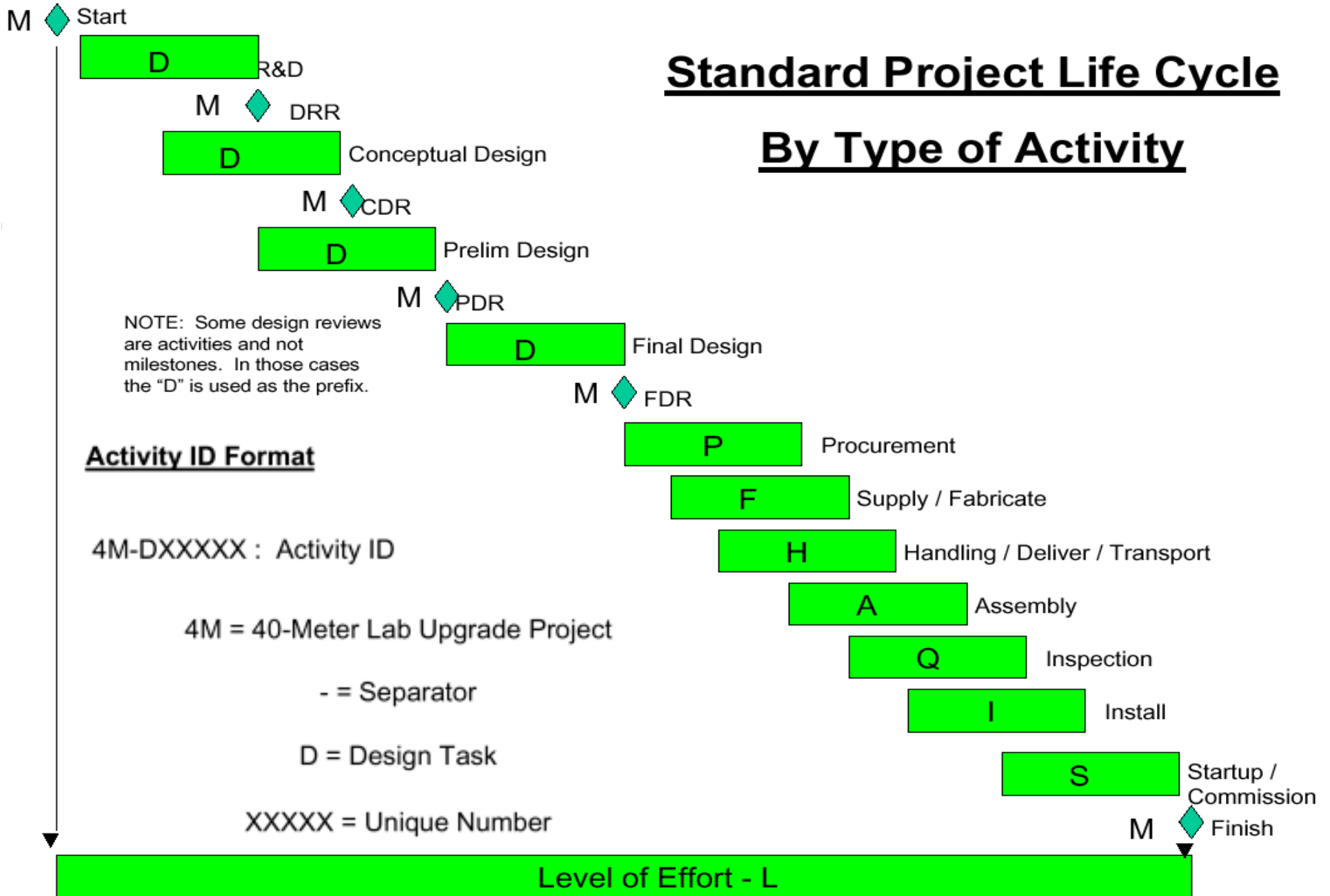


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# Standard Project Life Cycle By Type of Activity





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Cost Code	Description	Location	Project	Task	Award
<b>Operations</b>					
08-2011-11	Director's Office (DIR)	ON	LIGO.00008	2011	NSFLIGO.000011
08-2012-11	Business Office (BUS)	ON	LIGO.00008	2012	NSFLIGO.000011
08-2013-11	Technical and Engineering Support (TEC)	ON	LIGO.00008	2013	NSFLIGO.000011
08-2014-11	Detector Support (DET)	ON	LIGO.00008	2014	NSFLIGO.000011
08-20151-11	Data Analysis (REC)	ON	LIGO.00008	20151	NSFLIGO.000011
08-20152-11	Modeling & Simulation (REC)	ON	LIGO.00008	20152	NSFLIGO.000011
08-20153-11	Data Analysis - General Comp	ON	LIGO.00008	20153	NSFLIGO.000011
08-20161-11	40 Meter Interferometer Upgrade	ON	LIGO.00008	20161	NSFLIGO.000011

Note: the value "2011" is common.

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  - LIGO.2.01.6.1 40 Meter Interferometer Upgrade

Advanced LIGO					
09-40111-12	2K to 4K Conversion	CAP	LIGO.00009	40111	NSFLIGO.000012
09-40112-12	Clean Room Systems	CAP	LIGO.00009	40112	NSFLIGO.000012
09-40113-12	Vacuum Equipment Bakeout and Preparation	CAP	LIGO.00009	40113	NSFLIGO.000012
09-4012-12	FAC Beam Tube	CAP	LIGO.00009	4012	NSFLIGO.000012
09-40131-12	Livingston Staging Building	CAP	LIGO.00009	40131	NSFLIGO.000012
09-40132-12	Staging Building Cranes	CAP	LIGO.00009	40132	NSFLIGO.000012
09-4021-12	SEI Subsystem Management	ON	LIGO.00009	4021	NSFLIGO.000012

Note: the value "40111" is common.

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# Resouce Pool - LIGO II Planning

Status: Known Status

Discipline: Engineer

NSF Code:

Organization:

NAME	RES ID	Relation to Proj.	Percentage Availability
Abbott, Richard	ENB2CT02	LIGO Lab	100.00%
Armandula, Helena	ENB2CT04	LIGO Lab	100.00%
Barnes, Maria	ENB2CT08	LIGO Lab	100.00%
Billingsly, Garilynn	ENB2CT10	LIGO Lab	100.00%
Ding, Hongyu	ENB2CT14	LIGO Lab	100.00%
Duncan, Kris	ENB2CT16	LIGO Lab	100.00%
Eherns, Philip	ENB2CT18	LIGO Lab	100.00%
Frey, Thomas	ENB2CT55	LIGO Lab	100.00%
Hu, Grace	ENB2CT58	LIGO Lab	100.00%

This value is used as a unique resource ID and populates the resource dictionary for planning.

This value is used as a FTE value for making head counts and evaluating resource usage.





# Resource Database

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- Resource ID is as follows:
  - » EN = Engineer
  - » B2 = NSF Code for Technical Staff. We are changing this to be a specialty code and will move the NSF code to a data field.
  - » CT = Organization Code for Caltech.
  - » 02 = Unique Counter
- Resource database also performs the following solutions for LIGO:
  - » OBS – Organizational Breakdown
  - » Live data link that drives the LIGO Roster and LSC roster on the Web.
  - » We are creating an Email / Reporting Utility on the web that will allow managers to generate email lists and resource reports. Resource reports can be run by department, supervisor, discipline, and / or specialty.



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# Requirements

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- What Classification of Estimate:
  - » Conceptual
    - Based on some form of technical capability roughly defined. Rough sketch of system.
    - Variance +50% to +100%
  - » ROM (Rough Order of Magnitude)
    - Similar to a conceptual estimate and usually based upon some historical factors from a similar system.
    - Variance +25% to +75%
  - » Unit Cost Estimate
    - Based upon historical cost and known units.
    - Variance -5% to +25%
  - » Bottoms Up (Detailed Estimate)
    - This is the process of developing cost by counting units and quantifying labor.
    - Variance -5% to +20%



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  - Contract Labor
  - Travel
  - Equipment
  - Subcontract
  - Material/Publications/Consultants/Computer Services
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(choose from list, then press Edit) Edit
- Edit WBS Dictionary
 

(choose from list, then press Edit) Edit
- Edit Activity Sheet
 

(choose from list, then press Edit) Edit

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  - 4.05 Input Optics Detail (233KB)
  - 4.06 Core Optics Detail (199KB)
  - 4.07 Auxiliary Optics Detail (179KB)
- Reports by WBS (select a WBS)
 

[Dropdown]

Browse Activities WBS Detail WBS Summary

Labor Resources Nonlabor Resources Dictionary
- Reports by System (select a system)
 

[Dropdown]

Browse Activities System Summary

Labor Resources Nonlabor Resources
- Estimator Summary Report (select a name)
 

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- Total Cost for LIGO 4

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- Reports by WBS (select a WBS)
  - LIGO 4.06.3.2.2 -- Fixture/Handling Design
  - LIGO 4.06.3.2.3 -- Cleaning Process Design
  - LIGO 4.06.3.2.4 -- Metrology Design
  - LIGO 4.06.3.2.5 -- Mechanical Tests Design
  - LIGO 4.06.3.3 -- COC Final Design
  - LIGO 4.06.3.3.1 -- Optics Design
  - LIGO 4.06.3.3.2 -- Fixture/Handling Design
  - LIGO 4.06.3.3.3 -- Cleaning Process Design
  - LIGO 4.06.3.3.4 -- Metrology Design
  - LIGO 4.06.3.3.5 -- Mechanical Tests Design
  - LIGO 4.06.4 -- COC Fabrication
  - LIGO 4.06.4.1 -- Pathfinder**
  - LIGO 4.06.4.2 -- Metrology Fabrication
  - LIGO 4.06.4.3 -- Substrate Blanks
  - LIGO 4.06.4.4 -- Polishing
  - LIGO 4.06.4.5 -- Coating
  - LIGO 4.06.4.6 -- Cleaning Process Equipment
  - LIGO 4.06.4.7 -- Metrology Testing/Qualification
  - LIGO 4.06.4.8 -- Fixture/Handling Fabrication
  - LIGO 4.07 -- Auxiliary Optics (AOS)
  - LIGO 4.07.1 -- AOS Subsystem Management
  - LIGO 4.07.2 -- AOS R&D
    - LIGO 4.07.2.1 -- Active Optics Compensation R&D - MIT (AOP)
    - LIGO 4.07.2.2 -- Active Optics Compensation R&D - Stanford
    - LIGO 4.07.2.3 -- Active Optics Compensation R&D - ACIGA
    - LIGO 4.07.2.4 -- Photon Drive R&D - CIT
    - LIGO 4.07.2.5 -- Photon Drive R&D - MIT
    - LIGO 4.07.2.6 -- Photon Drive R&D - GEO
    - LIGO 4.07.3 -- AOS Design
    - LIGO 4.07.3.1 -- AOS Conceptual Design/Requirements

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    - Browse Activities
    - WBS Detail
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**LIGO II CostBook Activity Sheet Summary for a WBS - Microsoft Internet Explorer**

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Address [http://admdbsrv.ligo.caltech.edu/costbook/report\\_wbsSummary.htm?rtype=wbs&callingform=sum&wbs:](http://admdbsrv.ligo.caltech.edu/costbook/report_wbsSummary.htm?rtype=wbs&callingform=sum&wbs:) Go Links >>

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**CostBook Activity Sheet Summary**  
 for WBS Number LIGO.4.06.4.1 -- Pathfinder  
 (Amounts Include Staff Benefits, GRA Benefits, and Indirect Cost)

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WBSNo: LIGO.4.06.4.1 - Pathfinder

<a href="#">COF40641A</a> - EST: Pathfinder SPF	\$490,276.25
<a href="#">COF40641B</a> - EST: Pathfinder LPF	\$833,015.50
<b>WBS Total: \$1,323,291.75</b>	
<b>Report Total: \$1,323,291.75</b>	
<b>Report Contingency at 63.40%: \$839,007.79</b>	
<b>Total Plus Contingency: \$2,162,299.54</b>	

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**LIGO II Costbook Activity Sheet Detail - Microsoft Internet Explorer**

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Address [http://admdbsrv.ligo.caltech.edu/costbook/report\\_sheetDetail.htm?sheet=COF40641A&wbsstring=LIGO.4.06.4.1%2APathfinder&rtype=wbs&callingform=sum](http://admdbsrv.ligo.caltech.edu/costbook/report_sheetDetail.htm?sheet=COF40641A&wbsstring=LIGO.4.06.4.1%2APathfinder&rtype=wbs&callingform=sum) Go Links >>

### Costbook Activity Sheet Detail

WBSNo:LIGO.4.06.4.1 - Pathfinder  
 Activity:COF40641A - EST: Pathfinder SPF  
 Duration:365 days  
 Estimator:G. Billingsley on 05/02/2001

Item Code	Cost Category	Resource Description	Comments or Vendor	Cost Basis	Cost Code	Quantity	Unit Cost	Item Amount
B2	Labor	EN	Engineer	EE	12-40641-14 CP	507	\$45.00	\$22,815.00
B2	Labor	OT	Other	EE	12-40641-14 CP	179	\$50.00	\$8,950.00
B2	Labor	SC	Scientist	EE	12-40641-14 CP	108	\$40.00	\$4,320.00
D2	Equip.	D2	Small Pathfinder blank cost - rollup of 6	HD	12-40641-14 CP	1	\$43,010.00	\$43,010.00
E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications	HD	12-40641-14 CP	1	\$2,075.00	\$2,075.00
G5	Contract	G5	Coat 5 types of mirrors	EE	12-40641-14 CP	1	\$200,000.00	\$200,000.00
G5	Contract	G5	Polish 3 Mode cleaner mirrors	VQ	12-40641-14 CP	1	\$68,445.00	\$68,445.00
G5	Contract	G5	polish 3 optics	VQ	12-40641-14 CP	1	\$129,640.00	\$129,640.00
G5	Contract	G5	Shipping	HD	12-40641-14 CP	1	\$2,000.00	\$2,000.00
							<b>Subtotal:</b>	<b>\$481,255.00</b>
							<b>Staff Benefits:</b>	<b>\$9,021.25</b>
							<b>GRA Benefits:</b>	<b>\$0.00</b>
							<b>Indirect Cost:</b>	<b>\$0.00</b>
							<b>Total Cost:</b>	<b>\$490,276.25</b>
							( Cost: 6x1.00% + Sched: 4x1.00% + Tech: 8x4.00%) <b>Contingency @ 42.00%:</b>	<b>\$205,916.02</b>
							<b>Cost Plus Contingency:</b>	<b>\$696,192.27</b>

[Return to WBS Summary page](#)

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Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Late Start	Late Finish	Total Float	Budgeted Cost	2001	2002	2003	2004	2005	
<b>LIGO</b>														
<b>LIGO.4 Advanced LIGO Construction</b>														
Subtotal		762	18OCT00	03NOV03		12OCT01	20MAR07	641	2,162,299.54					
<b>LIGO.4.06 Core Optics Components (COC)</b>														
<b>LIGO.4.06.4 COC Fabrication</b>														
<b>LIGO.4.06.4.1 Pathfinder</b>														
CO-F40641A	EST: Pathfinder SPF	654*	18OCT00	02JUN03		29SEP05	20MAR07	949	696,192.27					EST: Pathfinder SPF
CO-F40641B	EST: Pathfinder LPF	742*	15NOV00	03NOV03		12OCT01	03NOV03	0	1,466,107.27					EST: Pathfinder LPF
CO-D50540	Small Pathfinder-Prepare Blank specifications	10	18OCT00	31OCT00		29SEP05	12OCT05	1,238	0.00					Small Pathfinder-Prepare Blank specifications
CO-P50550	SPF-Order Blanks	5	02JAN02*	08JAN02		13OCT05	19OCT05	949	0.00					SPF-Order Blanks
CO-P50560	SPF - Polishing RFP	20	18OCT00	14NOV00		21FEB06	20MAR06	1,333	0.00					SPF - Polishing RFP
CO-P50570	SPF - Polish Proposal prep at vendor	20	15NOV00	14DEC00		21MAR06	17APR06	1,333	0.00					SPF - Polish Proposal prep at vendor
CO-P50580	SPF-Polishing Proposal Evaluation	10	15DEC00	02JAN01		18APR06	01MAY06	1,333	0.00					SPF-Polishing Proposal Evaluation
CO-P50590	SPF-Let Polishing Contract	10	03JAN01	17JAN01		02MAY06	15MAY06	1,333	0.00					SPF-Let Polishing Contract
CO-P50600	SPF- Coating RFP	10	18OCT00	31OCT00		31AUG06	14SEP06	1,468	0.00					SPF- Coating RFP
CO-P50610	SPF - Coating Proposal prep at vendor	20	01NOV00	30NOV00		15SEP06	12OCT06	1,468	0.00					SPF - Coating Proposal prep at vendor
CO-P50620	SPF-Coating Proposal Evaluation	10	01DEC00	14DEC00		13OCT06	26OCT06	1,468	0.00					SPF-Coating Proposal Evaluation
CO-P50630	SPF-Let Coating Contract	5	15DEC00	21DEC00		27OCT06	02NOV06	1,468	0.00					SPF-Let Coating Contract
CO-T50640	SPF-Coating Set Up	20	22DEC00	24JAN01		03NOV06	04DEC06	1,468	0.00					SPF-Coating Set Up
CO-F50650	SPF-Fabricate Blanks, Half size	100	09JAN02	31MAY02		20OCT05	20MAR06	949	0.00					SPF-Fabricate Blanks, Half size
CO-Q50660	SPF-Absorb Testing	20	03JUN02	28JUN02		21MAR06	17APR06	949	0.00					SPF-Absorb Testing
CO-Q50670	SPF-Homogeneity Measurement	20	01JUL02	29JUL02		18APR06	15MAY06	949	0.00					SPF-Homogeneity Measurement
CO-F50680	SPF-PF-Polishing	120	30JUL02	23JAN03		16MAY06	02NOV06	949	0.00					SPF-PF-Polishing
CO-Q50690	SPF- Uncoated Metrology	20	24JAN03	21FEB03		03NOV06	04DEC06	949	0.00					SPF- Uncoated Metrology
CO-T50700	SPF-Coating	40	24FEB03	18APR03		05DEC06	05FEB07	949	0.00					SPF-Coating
CO-Q50710	SPF-Coated Metrology	20	21APR03	16MAY03		06FEB07	06MAR07	949	0.00					SPF-Coated Metrology
CO-H50720	SPF-Deliver to UWA	10	19MAY03	02JUN03		07MAR07	20MAR07	949	0.00					SPF-Deliver to UWA
CO-D50740	LPF-Prepare Blank specifications Full size	10	15NOV00	30NOV00		12OCT01	25OCT01	227	0.00					LPF-Prepare Blank specifications Full size
CO-P50750	LPF-Order Blanks - Pathfinder full size	10	01DEC00	14DEC00		26OCT01	08NOV01	227	0.00					LPF-Order Blanks - Pathfinder full size
CO-P50760	LPF- Polishing RFP	10	11DEC02	26DEC02		11DEC02	26DEC02	0	0.00					LPF- Polishing RFP
CO-P50770	LPF - Polish Proposal prep at vendor	10	27DEC02	13JAN03		27DEC02	13JAN03	0	0.00					LPF - Polish Proposal prep at vendor
CO-P50780	LPF-Let Polishing Contract	10	14JAN03	28JAN03		14JAN03	28JAN03	0	0.00					LPF-Let Polishing Contract
CO-P50790	LPF- Coating RFP	10	11DEC02	26DEC02		10APR03	23APR03	80	0.00					LPF- Coating RFP
CO-P50800	LPF - Coating Proposal prep at vendor	10	27DEC02	13JAN03		24APR03	07MAY03	80	0.00					LPF - Coating Proposal prep at vendor
CO-P50810	LPF-Let Coating Contract	5	14JAN03	21JAN03		08MAY03	14MAY03	80	0.00					LPF-Let Coating Contract
CO-T50820	LPF-Coating Set Up	20	22JAN03	19FEB03		15MAY03	12JUN03	80	0.00					LPF-Coating Set Up
CO-F50830	LPF-Fabricate Blanks, Full size	260	09NOV01*	22NOV02		09NOV01	22NOV02	0	0.00					LPF-Fabricate Blanks, Full size
CO-Q50840	LPF-Absorb Testing	20	25NOV02	26DEC02		25NOV02	26DEC02	0	0.00					LPF-Absorb Testing
CO-Q50850	LPF-Homogeneity Measurement	20	27DEC02	28JAN03		27DEC02	28JAN03	0	0.00					LPF-Homogeneity Measurement
CO-F50860	LPF-Polishing	80	29JAN03	21MAY03		29JAN03	21MAY03	0	0.00					LPF-Polishing
CO-Q50870	LPF- Uncoated Metrology	15	22MAY03	12JUN03		22MAY03	12JUN03	0	0.00					LPF- Uncoated Metrology
CO-F50880	LPF-Coating	80	13JUN03	06OCT03		13JUN03	06OCT03	0	0.00					LPF-Coating
CO-Q50890	LPF-Coated Metrology	20	07OCT03	03NOV03		07OCT03	03NOV03	0	0.00					LPF-Coated Metrology
CO-H50900	Deliver LPF ETM to LASTI	0		03NOV03			03NOV03	0	0.00					Deliver LPF ETM to LASTI
CO-H50930	Deliver LPF ITM to LASTI	0		03NOV03			03NOV03	0	0.00					Deliver LPF ITM to LASTI





Cost										
-   +   -   D2*										
Resource	D2*	E1*	EN*	G5*	OT*	SC*	Z-RISK	Z-RISK	Z-RISK	Z-RISK
Cost Acct/Category	12-40641-14E	12-40641-14I	12-40641-14L	12-40641-14C	12-40641-14L	12-40641-14L	12-40641-14C	12-40641-14E	12-40641-14I	12-40641-14L
Driving	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Curve										
Budgeted cost	43010.00	2075.00	28518.75	400085.00	11187.50	5400.00	168035.70	18064.20	871.50	18944.62
Actual this period	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Actual to date	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent expended	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent complete										
Earned value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cost to complete	43010.00	2075.00	28518.75	400085.00	11187.50	5400.00	168035.70	18064.20	871.50	18944.62
At completion	43010.00	2075.00	28518.75	400085.00	11187.50	5400.00	168035.70	18064.20	871.50	18944.62
Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Budget Summary				
-   +   -   D2*				
Resource	Cost Acct/Category	Driving	Curve	
D2*	12-40641-14E	<input type="checkbox"/>		
E1*	12-40641-14I	<input type="checkbox"/>		
EN*	12-40641-14L	<input type="checkbox"/>		
G5*	12-40641-14C	<input type="checkbox"/>		

	Units	Cost	Total Units	Total Cost
Units per day	0.00			
Res Lag/Duration	0			
% Complete/Expended		0.0	0.0	0.0
Budgeted amount	1.00	43010.00	800.00	696192.27
Planned value	0.00	0.00	0.00	0.00
Earned value	0.00	0.00	0.00	0.00
Actual to date	0.00	0.00	0.00	0.00
To complete	1.00	43010.00	800.00	696192.27
At completion	1.00	43010.00	800.00	696192.27
Variance	0.00	0.00	0.00	0.00

**Advanced LIGO Cost Estimate Summary**

WBS LIGO-4 Advanced LIGO Construction

WBSNo	Description	Direct Labor Total		Contract Labor Total		Equipment Total (\$)	Travel Cost (\$)	Material Total (\$)	Subcontracts Total (\$)	Indirect Cost (\$)	SubTotal Cost (\$)	Contingency		Total Cost (\$)
		Hours	(\$)	Hours	(\$)							%	(\$)	
LIGO-4.02	Seismic Isolation (SEI)	36,502	1,780,120			18,269,739	42,300		180,000	543,243	20,815,402	20.23%	4,211,442	25,026,844
LIGO-4.03	Suspension (SUS)	84,857	3,836,655			11,667,605	462,000	27,500	271,200	2,274,139	18,539,999	26.15%	4,848,983	23,388,982
LIGO-4.04	Prestabilized Laser (PSL)	41,520	2,365,375			8,989,894	235,000		128,000	1,710,392	13,408,660	23.30%	3,123,842	16,532,502
LIGO-4.05	Input Optics (IO)	18,272	987,638			2,048,808	66,450		1,156,131	474,788	4,707,785	26.14%	1,236,566	5,938,349
LIGO-4.06	Core Optics Components (COC)	10,999	625,300			4,724,287	53,275		5,656,305	95,734	11,148,901	41.30%	4,604,296	15,753,197
LIGO-4.07	Auxiliary Optics (AOS)	19,794	1,029,081				27,600	1,091,360		381,825	2,529,866	20.80%	526,139	3,056,005
		211,944	10,604,369			45,680,332	881,525	1,118,860	7,385,636	5,480,089	71,150,612	26.08%	18,545,267	89,695,879

Advanced LIGO Cost Estimate Detail

WBS Number	0.001.006.4.1
WBS Description	Polisher
Activity	COF4064A
Description	EST: Polisher SFF
Location	Capital Project
Cost Code	12-0041-14

Duration	605 days
Estimated By	G. Billingsley
Last Modified On	07/12/2001

Line	WSP Item Code	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference		
							Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)				
1	B2	Labor	EN	Engineer	EE	507	45	22,815											22,815	CO10202-80		
2	B2	Labor	OT	Other	EE	179	50	8,950											8,950	CO10202-80		
3	B2	Labor	SC	Scientist	EE	108	40	4,320											4,320	CO10202-80		
4	D2	Equip.	B2	Small Polisher Blank cost - sub-p of 6	EE	1					43,000	43,000							43,000	CO10202-80		
5	E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications	EE	1							2,075	2,075					2,075	CO10202-80		
6	G5	Contract	G5	polish 3 optics	CSBD	VQ	1								129,640	129,640			129,640	CO10202-81		
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Wave Precision	VQ	1								68,445	68,445			68,445	CO10202-80		
8	G5	Contract	G5	Shipping	Tauo Trans	EE	1								2,800	2,800			2,800			
9	G5	Contract	G5	Cost 5 types of mirrors	7 Virgo-Lyon	EE	1								200,000	200,000			200,000			
<b>Subtotal COF4064A EST: Polisher SFF</b>																						
								6,035		280,061		43,000		2,075				400,685		481,255		

Staff Summary (Direct Labor plus Contract Labor)

-- AA --													-- B1 --			-- B2 --			-- B3 --			-- B4 --			-- B5 --		
Key/Fac		Post/Doc		Mgmt		Sr/Sr		Sr		Sr/Eng		Eng		Tech		Other		Total		Grad		UGrad		Admin			
Hours						100		507		179		794															
Person Years						0.7		0.3		0.1		0.9															

Risk Factors		Risk Multipliers		Calculated Contingency	
Technical	5	4.00%		42.00%	
Cost	5	1.00%			
Schedule	4	1.00%			
Estimator Override					

Staff Benefits at	25.00%	5,821
(G4) GR4 Benefits at	18.00%	0
Indirect Cost at	8.00%	0
Total Cost		480,276
Contingency at	42.00%	201,916
Cost Plus Contingency		682,192

**WBS Definition**

In addition to serving as a summary WBS element for all COC fabrication (other than the fabrication associated with the R&D elements), the Polisher-II effort is also covered under this WBS element. The purpose of the Polisher-II program is to demonstrate the ability of industrial partners to achieve the requirements for:

- Supply blanks in the large sizes required for LIGO-II with required homogeneity and low bulk absorption at 1064 microns. Although supply material development is covered under WBS elements 0.4.6.2.2 and 0.4.6.2.4 these efforts are focused on small samples and enabling research to be able to attempt production of large blanks meeting LIGO-II requirements. The cost for the large scale blanks is to be covered under this WBS element, as a proof of capability and the first step in the Polisher program.
- Supply polishing to the LIGO-II surface figure and surface smoothness requirements in the large sizes required. Initially polishing will be attempted on small samples of supplies, provided by WBS elements 0.4.6.2.2 and 0.4.6.2.4. Later the full scale blanks processed under this WBS element, will be polished to demonstrate the capability meet LIGO-II requirements on full scale optics.
- Coating on large diameter optics to equal or better than the LIGO-I requirement for absorption in the high reflectance coatings. The purpose of this WBS element is the qualification of a new coating vendor and possibly a new coating prescription (for lower absorption) at full scale size, whether on fused silica or sapphire. The small scale coating research (WBS element 0.4.6.2.4) is to define a suitable coating for sapphire substrates and a coating prescription for a lower absorption high reflectance coating on fused silica. The results of this small scale coating research are applied under this WBS element at full scale in a production facility.

**Basis of Estimate**

Based on Material cost quoted by vendor as follows:

- 40 Kg sapphire mirror 2 ITM, 4ITM spare, \$97,985 ea.
- 2 ITM, 4 ITM spare \$97,985 ea.
- Graph OAA fused silica PEM and 2 spares at \$22,075 ea.
- 1 SRM and 2 spares at \$22,075 ea.
- Graph 311 SV fused silica
- 1 BS and 2 spares at \$142,291 ea.

Travel:

- Konane 2 trips to 311SV vendor (Germany)
- Konane 1 trips RAA vendor (NY)
- Konane 2 trips to Sapphire vendor (Boston)

Shipping:

- US to ship each optic from vendor to Caltech. Based on verbal estimate from shipping clerk.

Labor:

- Based upon LIGO I experience.

**Task List**

Task No	Description	Duration
CO-P50500	SFF - Polishing RFP	20
CO-P50600	SFF - Coating RFP	10
CO-D50540	Small Polisher-Prepare Blank specifications	10
CO-P50650	SFF - Coating Proposal prep of vendor	20
CO-P50530	SFF - Polish Proposal prep of vendor	20
CO-P50620	SFF-Coating Proposal Evaluation	10
CO-P50580	SFF-Polishing Proposal Evaluation	10
CO-P50630	SFF-Let Coating Contract	5
CO-T50640	SFF-Coating Set Up	20
CO-P50590	SFF-Let Polishing Contract	10
CO-P50550	SFF-Order Blanks	5
CO-F50650	SFF-Fabricate Blanks, Half size	500
CO-G50660	SFF-Absorb Testing	20
CO-G50570	SFF-Homogeneity Measurement	20
CO-F50680	SFF-PP Polishing	120
CO-G50590	SFF-Uncoated Metrology	20
CO-T50700	SFF-Coating	40
CO-G50710	SFF-Coated Metrology	20
CO-H50720	SFF-Deliver to UWA	10

Advanced LIGO Cost Estimate Detail

WBS Number	LIGO.4.06.4.1
WBS Description	Pathfinder
Activity	COF40641A
Description	EST: Pathfinder SPF
Location	Capital Project
Cost Code	12-40641-14

Duration	365 days
Estimated By	G. Billingsley
Last Modified On	07/12/2001

Line	Item Code	Cost Category	Description	Units or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference
							Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)		
1	B2	Labor				507	45	22,815											22,815	CO10202-80
2	B2	Labor						8,950											8,950	CO10202-80
3	B2	Labor																	4,320	CO10202-80
4	B2	Equip.									41,000								41,000	CO10202-80
5	E1	Int Travel										2,875							2,875	CO10202-80
6	G5	Contract	G5													129,640	129,640		129,640	CO10202-81
7	G5	Contract	G5													68,445	68,445		68,445	CO10005-80
8	G5	Contract	G5																	
9	G5	Contract	G5																	

Activity Sheet Header

Advanced LIGO Cost Estimate Detail

WBS Number	LIGO.4.06.4.1
WBS Description	Pathfinder
Activity	COF40641A
Description	EST: Pathfinder SPF
Location	Capital Project
Cost Code	12-40641-14

Duration	365 days
Estimated By	G. Billingsley
Last Modified On	07/12/2001

Labor Summary (Direct Labor plus...)

AA	BS	CS	D1	D2	E1	E2	G1	G2	G3	G4	G5	SS
Key/Fac	Post/Doc											
Hours												
Person Years												

WBS Description

In addition to serving as a summary WBS element, this WBS element is used to track the cost of the Pathfinder industrial partners to achieve the requirements for...  
 - Supplies blanks in the large sizes required for low bulk absorption at 1064 microns. Although small scale WBS elements 0.4.6.2.2 and 0.4.6.2.4 have a small scale coating research to be able to attempt production of requirements. The cost for the large scale blanks is to be proof of capability and the first step in the Pathfinder project.  
 - Supplies polishing to the LIGO1 surface figure in the large sizes required. Initially polishing will be attempted by WBS elements 0.4.6.2.2 and 0.4.6.2.4. Later, this WBS element, will be polished to demonstrate the capability to meet the requirements for full scale optics.  
 - Coating on large diameter optics to equal or better than the LIGO-1 requirement for absorption in the high-reflectance coatings. The purpose of this WBS element is the qualification of a new coating vendor and possibly a new coating prescription (for lower absorption) at full scale size, whether on fused silica or sapphire. The small scale coating research (WBS element 0.4.6.2.4) is to define a suitable coating for sapphire substrates and a coating prescription for a lower absorption high reflectance coating on fused silica. The results of this small scale coating research are applied under this WBS element at full scale in a production facility.

Trip:	CO-F5060	SPF-Get Polishing Contract	10
Contract 2 trips to 311SV vendor (Germany)	CO-F5065	SPF-Order Blanks	5
Contract 1 trips to RAA vendor (NY)	CO-F5060	SPF-Fabricate Blanks, Half size	500
Contract 2 trips to Sapphire vendor (Boston)	CO-G5060	SPF-Absorb Testing	20
	CO-G5070	SPF-Homogeneity Measurement	20
Shipping:	CO-F5060	SPF-PP Polishing	120
	CO-G5060	SPF-Uncoated Metrology	20
	CO-T5070	SPF-Coating	40
ISO to ship each optic from vendor to Caltech. Based on verbal estimate from shipping clerk.	CO-G5070	SPF-Coated Metrology	20
Labor:	CO-H5070	SPF-Deliver to UWA	10
Based upon LIGO 1 experience.			

Advanced LIGO Cost Estimate Detail

WBS Number	0.001.406.4.1	Duration	655 days
WBS Description	Pathfinder	Estimated By	E. Billingsley
Activity	0.0140641A	Last Modified On	07/12/2001
Description	EST: Pathfinder SPT		
Location	Capital Project		
Cost Code	12-86041-14		

Line	NSF Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Ea)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)		
1	B2	Labor	EN	Engineer		EE	507	45	22,815											22,815	C010202-80
2	B2	Labor	OT	Other		EE	179	50	8,950											8,950	C010202-80
3	B2	Labor	SC	Scientist		EE	108	40	4,320											4,320	C010202-80
4	D2	Equip.	D2	Small Pathfinder blank cost - rollup of 6		HD	1					43,000	43,000							43,010	C010202-80
5	E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications		HD	1						2,075	2,075						2,075	C010202-80
6	G5	Contract	G5	polish 3 optics	CSIRO	VQ	1										129,640	129,640	129,640	129,640	C010202-81
7	G5	Contract	G5	Polish 3 Mode cleaner mirrors	Wave Precision	VQ	1										68,445	68,445	68,445	68,445	C010202-80
8	G5	Contract	G5	Shipping	Time Trax	HD	1										2,800	2,800	2,800	2,800	
9	G5	Contract	G5	Coat 5 types of mirrors	? Virgo-Lyon	EE	1										200,000	200,000	200,000	200,000	
									16,035		280,061		43,000		2,075			400,685		481,255	

Staff Benefits at	25.00%	9,821
(G4) GR&A Benefits at	18.00%	0
Indirect Cost at	8.00%	0
<b>Total Cost</b>		<b>490,276</b>

Labor Summary (0)

Person Years

WBS Description

In addition to serving as a fabrication associated with this WBS element, the pathfinder partners to achieve:

- Supply blanks in the low bulk absorption at 1064 nm under WBS elements 0.4.6.2, enabling research to be able to requirements. The cost for the purchase of capability and the first a
- Supply polishing to the 1, the large size required, initially provided by WBS elements 0.4.6.2, this WBS element, will be polished on full scale optics.
- Coating on large diameter optics absorption in the high-reflection coating qualification of a new coating vendor an absorption) at full scale size, whether on research (WBS element 0.4.6.2.4) is to do coating prescription for a lower absorption of this small scale coating research an application facility.

**Activity Sheet Takeoff Area**

Line	NSF Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Ea)
1	B2	Labor	EN	Engineer		EE	507
2	B2	Labor	OT	Other		EE	179
3	B2	Labor	SC	Scientist		EE	108
4	D2	Equip.	D2	Small Pathfinder blank cost - rollup of 6		HD	1
5	E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications		HD	1
6	G5	Contract	G5	polish 3 optics	CSIRO	VQ	1
7	G5	Contract	G5	Polish 3 Mode cleaner mirrors	Wave Precision	VQ	1
8	G5	Contract	G5	Shipping	Time Trax	HD	1
9	G5	Contract	G5	Coat 5 types of mirrors	? Virgo-Lyon	EE	1

Advanced LIGO Cost Estimate Detail

WBS Number	0.001.006.4.1	Duration	605 days
WBS Description	Pulsar	Estimated By	G. Billingsley
Activity	E-0140641A	Last Modified On	07/12/2001
Description	EST: Pulsar SP7		
Location	Capital Project		
Cost Code	12-0041-14		

Line	Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, B1-B6)		Contract Labor (G5)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (G5)		Total Cost (\$)	Reference																	
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)																			
1	B2	Labor	EN	Engineer		EE	507	45	22,815											22,815	C010202-80																	
2	B2	Labor	OT	Other		EE	179	50	8,950											8,950	C010202-80																	
3	B2	Labor	SC	Scientist		EE	108	40	4,320											4,320	C010202-80																	
4	D2	Equip.	B2	Small Pulsarlike Blank cost - set-up of 6		ED	1					43,010								43,010	C010202-80																	
5	E1	Int Travel	E1	Dulcor Mission to UWA, review specifications		ED	1						2,075	2,075						2,075	C010202-80																	
6	G5	Contract	G5	polish 3 optics	CSBD	VQ											129,640	129,640		129,640	C010202-81																	
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Wave Precision	VO											68,445	68,445		68,445	C010168-80																	
8	G5	Contract	G5	Shipping	Tauo Trans												2,000	2,000		2,000																		
9	G5	Contract	G5	Cost 5 types of mirrors	7 Virgo-Lyon												200,000	200,000		200,000																		
Subtotal: C0F00641A - EST: Pulsar																			480,885	481,255																	9,821	

Labor Summary (Direct Labor plus Contract Labor)

AA	B1	B6
Key/Fac	Post/Doc	Mgr
Hours		
Person Years		

WBS Description

In addition to serving as a summary WBS of fabrication associated with the R&D during this WBS element. The purpose of the Pulsar subelement is to achieve the requirements:

- Supply blanks in the large size required for absorption at 1064 microns. Also under WBS elements 0.0.0.2.2 and 0.0.0.2.3 enabling research to be able to attempt proof requirements. The cost for the large scale R&D proof of capability and the first step in the P
- Supply polishing to the LIGO on the large size required. Initially polishing provided by WBS elements 0.0.0.2.2 and 0.0.0.2.3 WBS element, will be polished to done on full scale optics.
- Coating on large diameter optics to a absorption in the high-reflection coatings, qualification of a new coating vendor and a proof of capability at full scale size, whether on the research (WBS element 0.0.0.2.4) is to do coating prescription for a lower absorption of this small scale coating research on appl production facility.

Cost Extension Area													Total Cost (\$)	Reference
Direct Labor (AA, B1-B6)		Contract Labor (G5)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (G5)				
Unit Cost	Total (\$)	Unit Cost	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)			
45	22,815											22,815	C010202-00	
50	8,950											8,950	C010202-00	
40	4,320											4,320	C010202-00	
				43,010	43,010							43,010	C010202-00	
							2,075	2,075				2,075	C010202-00	
									129,640	129,640		129,640	C010202-01	
									68,445	68,445		68,445	C010168-00	
									2,000	2,000		2,000		
									200,000	200,000		200,000		
36,085		400,085		43,010		2,075				400,085		481,255		

Advanced LIGO Cost Estimate Detail

WBS Number	0300-406-4-1	Duration	655 days
WBS Description	Pulsar	Estimated By	E. Billingsley
Activity	COF40641A	Last Modified On	07/12/2001
Description	EST: Pulsar SPF		
Location	Capital Project		
Cost Code	12-8041-14		

Line	Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)		
1	B2	Labor	EN	Engineer		EE	507	45	22,815											22,815	CO10202-80
2	B2	Labor	OT	Other		EE	179	50	8,950											8,950	CO10202-80
3	B2	Labor	SC	Scientist		EE	108	40	4,320											4,320	CO10202-80
4	B2	Equip.	B2	Small Pulsar Mask cost - sublet of 6		EE	1					43,000	43,000							43,000	CO10202-80
5	E1	Int Travel	E1	Deliver Minutes to UWA, review specifications		EE	1						2,075	2,075						2,075	CO10202-80
6	G5	Contract	G5	polish 3 optics	CSBD	VQ	1										129,640	129,640	129,640	CO10202-81	
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Wave Precision	VQ	1										68,445	68,445	68,445	CO10202-81	
8	G5	Contract	G5	Shipping	Tauo Trans	EE	1										2,800	2,800	2,800		
9	G5	Contract	G5	Cost 5 types of mission	7 Virgo-Lyon	EE	1										200,000	200,000	200,000		
Subtotal: COF40641A EST: Pulsar SPF										16,035	280,061		43,000		2,075			400,985	481,255		

Labor Summary (Direct Labor plus Contract Labor)

AA	B1	B2	B3	B4	B5							
KeyFac	PostDoc	Mgmt	GrSci	Sci	GrEng	Eng	Tech	Other	TOTAL	Grad	UGrad	Admin
Hours				108	507		179	179	794			
Person Years				0.3	0.3		0.1	0.4				

WBS Definition  
 In addition to serving as a summary WBS element for all COC (Contract, Other, and...) fabrication associated with the R&D element, the R&D element also serves as the WBS element. The purpose of this WBS element is to provide a summary of the R&D element.

Staff Benefits at	25.00%	9,021
(G6) GRA Benefits at	58.00%	0
Indirect Cost at	0.00%	0
<b>Total Cost</b>		<b>490,276</b>
Contingency at	42.00%	205,916
<b>Cost Plus Contingency</b>		<b>696,192</b>

<b>Risk Factors</b>	<b>Risk Multipliers</b>	<b>Calculated Contingency</b>	<b>Estimator Override</b>
Technical	8	4.00%	
Cost	6	1.00%	
Schedule	4	1.00%	
			42.00%

Advanced LIGO Cost Estimate Detail

WBS Number	G02040641	Duration	65 days
WBS Description	Polisher	Estimated By	E. Billingsley
Activity	G0140641A	Last Modified On	07/12/2001
Description	EST: Polisher SPF		
Location	Capital Project		
Cost Code	12-06041-14		

Line	WBS Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, B5-B8)		Contract Labor (C2)		Equipment (D1, D7)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (J2)		Total Cost (\$)	Reference
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)		
1	B2	Labor	EN	Engineer		EE	507	45	22,815											22,815	C010202-80
2	B2	Labor	OT	Other		EE	179	50	8,950											8,950	C010202-80
3	B2	Labor	SC	Scientist		EE	108	40	4,320											4,320	C010202-80
4	B2	Equip.	B2	Small Polisher Blank cost - sub-p of 6		EE	1					43,000	43,000							43,000	C010202-80
5	E1	Int Travel	E1	Deliver Mirror to UWA, review specifications		EE	1						2,075	2,075						2,075	C010202-80
6	G5	Contract	G5	polish 3 optics	CSBD	VQ	1										129,640	129,640	129,640	129,640	C010202-81
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Ward Precision	VQ	1										68,445	68,445	68,445	68,445	C010202-81
8	G5	Contract	G5	Shipping	Tauo Trans	EE	1										2,800	2,800	2,800	2,800	
9	G5	Contract	G5	Cost 5 types of mirror	7 Virgo-Lyon	EE	1										200,000	200,000	200,000	200,000	
Subtotal: C0140641A EST: Polisher SPF										16,035	280,061		43,000		2,075			400,085	481,215		

Labor Summary (Direct Labor plus Contract Labor)

Key/Fac	PostDoc	Mgmt	SrSci	Sci	SrEngr	Engr	Tech	Other	Total
Hours			108		507				794
Person Years			0.1		0.3				0.4

Risk Factors and Multipliers

Technical	5	4.00%
Cost	5	1.00%
	3	1.00%
Calculated Contingency	42.00%	
Estimator Override		

Cost Summary

Staff Benefits at 25.00%	5,821
(G4) GR&A Benefits at 28.00%	0
Indirect Cost at 8.00%	0
Total Cost	496,276
Contingency at 42.00%	209,516
Cost Plus Contingency	705,792

WBS Definition

In addition to serving as a summary WBS, this WBS also serves as a summary WBS for the fabrication associated with the 3.0m mirrors for this WBS element. The...  
 - 5 -

Task List

Task No	Description	Duration
	SPF - Polisher RFP	20
	Polisher RFP	10
	Secure Blank specifications	10
	Review of vendor	20
	Vendor	20
	Ion	10
	ation	10
		5
		20
		10
		5
		100
		20
		20
		120
		20
		40
		20
		10

Labor Summary (FTEs)

Labor Summary (Direct Labor plus Contract Labor)

Key/Fac	PostDoc	Mgmt	SrSci	Sci	SrEngr	Engr	Tech	Other	Total	Grad	UGrad	Admin
Hours			108		507			179	794			
Person Years			0.1		0.3			0.1	0.4			



Advanced LIGO Cost Estimate Detail

WBS Number	0.4.6.2.4.1	Duration	65 days
WBS Description	Pathfinder	Estimated By	E. Billingsley
Activity	COF4041A	Last Modified On	07/12/2002
Description	EST: Pathfinder SPT		
Location	Capital Project		
Cost Code	12-0041-14		

Line	WSP Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, BS-00)		Contract Labor (00)		Equipment (01, 02)		Travel (01, 02)		Material (02, 04)		Subcontracts (00)		Total Cost (\$)	Reference
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)		
1	B2	Labor	EN	Engineer		EE	507	45	22,815											22,815	CO10202-80
2	B2	Labor	OT	Other		EE	179	50	8,950											8,950	CO10202-80
3	B2	Labor	SC	Scientist		EE	108	40	4,320											4,320	CO10202-80
4	B2	Equip.	B2	Small Pathfinder Blank cost - 100g of 6		EE	1					43,000	43,000							43,000	CO10202-80
5	B1	Int Travel	B1	Deliver Mirrors to UWA, review specifications																2,875	CO10202-80
6	G5	Contract	G5	polish 3 optics																320,680	CO10202-81
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors																68,445	CO10005-80
8	G5	Contract	G5	Shipping																2,800	
9	G5	Contract	G5	Cost 5 types of mirrors																200,800	
<b>Subtotal</b>																				<b>481,255</b>	
<b>Labor Summary (Direct Labor plus Contract Labor)</b>																				<b>9,821</b>	
<b>Hours</b>																				<b>0</b>	
<b>Person Years</b>																				<b>0</b>	

Labor Summary (Direct Labor plus Contract Labor)				
	AA	BT		
	KeyFac	PostDoc	Mgmt	OT
Hours				
Person Years				

**WBS Definition**

In addition to serving as a summary WBS element for all COC fabrication (other than the fabrication associated with the R&D elements), the Pathfinder-II effort is also covered under this WBS element. The purpose of the Pathfinder-II program is to demonstrate the ability of industrial partners to achieve the requirements for:

- Sapphire blanks: in the large sizes required for LIGO-II with required homogeneity and low bulk absorption at 1064 microns. Although sapphire material development is covered under WBS elements 0.4.6.2.2 and 0.4.6.2.4 these efforts are focused on small samples and enabling research to be able to attempt production of large blanks meeting LIGO-II requirements. The cost for the large scale blanks is to be covered under this WBS element, as a proof of capability and the first step in the Pathfinder program.
- Sapphire polishing: to the LIGO-II surface figure and micro-smoothness requirements in the large sizes required. Initially polishing will be attempted on small samples of sapphire, provided by WBS elements 0.4.6.2.2 and 0.4.6.2.4. Later the full scale blanks procured under this WBS element, will be polished to demonstrate the capability meet LIGO-II requirements on full scale optics.
- Coating: on large diameter optics to equal or better than the LIGO-I requirement for absorption in the high-reflectance coatings. The purpose of this WBS element is the qualification of a new coating vendor and possibly a new coating prescription (for lower absorption) at full scale size, whether on fused silica or sapphire. The small scale coating research (WBS element 0.4.6.2.4) is to define a suitable coating for sapphire substrates and a coating prescription for a lower absorption high reflectance coating on fused silica. The results of this small scale coating research are applied under this WBS element at full scale in a production facility.

### WBS Definition

In addition to serving as a summary WBS element for all COC fabrication (other than the fabrication associated with the R&D elements), the Pathfinder-II effort is also covered under this WBS element. The purpose of the Pathfinder-II program is to demonstrate the ability of industrial partners to achieve the requirements for:

- Sapphire blanks: in the large sizes required for LIGO-II with required homogeneity and low bulk absorption at 1064 microns. Although sapphire material development is covered under WBS elements 0.4.6.2.2 and 0.4.6.2.4 these efforts are focused on small samples and enabling research to be able to attempt production of large blanks meeting LIGO-II requirements. The cost for the large scale blanks is to be covered under this WBS element, as a proof of capability and the first step in the Pathfinder program.
- Sapphire polishing: to the LIGO-II surface figure and micro-smoothness requirements in the large sizes required. Initially polishing will be attempted on small samples of sapphire, provided by WBS elements 0.4.6.2.2 and 0.4.6.2.4. Later the full scale blanks procured under this WBS element, will be polished to demonstrate the capability meet LIGO-II requirements on full scale optics.
- Coating: on large diameter optics to equal or better than the LIGO-I requirement for absorption in the high-reflectance coatings. The purpose of this WBS element is the qualification of a new coating vendor and possibly a new coating prescription (for lower absorption) at full scale size, whether on fused silica or sapphire. The small scale coating research (WBS element 0.4.6.2.4) is to define a suitable coating for sapphire substrates and a coating prescription for a lower absorption high reflectance coating on fused silica. The results of this small scale coating research are applied under this WBS element at full scale in a production facility.

Duration	20
	10
	10
	20
	20
	10
	10
	5
	20
	10
	5
	500
	20
	20
	100
	20
	20
	10

Advanced LIGO Cost Estimate Detail

WBS Number	0.001.006.4.1
WBS Description	Pulsar
Activity	0.01.004.1
Description	EST: Pulsar SPT
Location	Capital Project
Cost Code	12-0041-14

Duration	605 days
Estimated By	E. Billingsley
Last Modified On	07/12/2001

Line	WBS Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Eq)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference									
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)											
1	BS	Labor	EN	Engineer		EE	507	45	22,815											22,815	C010202-80									
2	BS	Labor	OT	Other		EE	179	50	8,950											8,950	C010202-80									
3	BS	Labor	SC	Scientist		EE	108	40	4,320											4,320	C010202-80									
4	BS	Equip.	BS	Small Pulsar Blank cost - setup of 6		EB	1					43,000	43,000							43,000	C010202-80									
5	E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications		EB	1						2,075	2,075						2,075	C010202-80									
6	G5	Contract	G5	polish 3 optics	CSBD	VQ	1										129,640	129,640	129,640	129,640	C010202-80									
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Wave Precision	VQ	1										68,445	68,445	68,445	68,445	C010202-80									
8	G5	Contract	G5	Shipping	Time Trans	EB	1										2,800	2,800	2,800	2,800										
9	G5	Contract	G5	Cost 5 types of mirrors	TV Optics	EB	1										200,000	200,000	200,000	200,000										
																			480,885	481,255										

Labor Summary (Direct Labor plus Contract Labor)

AA	BS	CS	D1	D2	E1	E2
Key/Fac	Post/Doc	Mgmt	St/Sc			
Hours						
Person Years						

**WBS Description**

In addition to serving as a summary WBS element for a fabrication associated with the R&D element, the Pulsar WBS element. The purpose of the Pulsar-01 project is to fabricate and test the requirements for:

- Supply blanks in the large sizes required for L3 low bulk absorption at 1964 microns. Although supply under WBS elements 0.0.6.2.2 and 0.0.6.2.4 those of our enabling research is to be able to attempt production of 1st requirements. The cost for the large scale blanks is to be proof of capability and the first step in the Pulsar-01 project.
- Supply polishing to the LIGO1 surface figure. The large sizes required. Initially polishing will be done provided by WBS elements 0.0.6.2.2 and 0.0.6.2.4. This WBS element, will be polished to demonstrate the on full scale optics.
- Coating on large diameter optics to equal or better absorption in the high-reflection coatings. The purpose qualification of a new coating vendor and possibly a new absorption at full scale size, whether on fused silica or research (WBS element 0.0.6.2.4) is to define a suitable coating prescription for a lower absorption high reflectors of this small scale coating research are applied under the production facility.

### Basis of Estimate

Based on Material costs quoted by vendors as follows:

- 40 Kg sapphire masses 2 ITMs, 4ITM spares, \$97,986 ea.
- 2 ETMs, 4 ETM spares \$97,986 ea
- Grade 0AA fused silica 1 PRM and 2 spares at \$22,076 ea
- 1 SRM and 2 spares at \$22,076 ea
- Grade 311 SV fused silica
- 1 BS and 2 spares at \$142,291 ea

**Travel:**  
Assume 2 trips to 311SV vendor (Germany)

Assume 1 trip to 0AA vendor (NY)

Assume 2 trips to Sapphire vendor (Boston)

**Shipping:**  
190 to ship each optic from vendor to Caltech. Based on verbal estimate from shipping clerk.

**Labor:**  
Based upon LIGO 1 experience.

Staff Benefits at	25.00%	9,821
(G4) GR&A Benefits at	18.00%	0
Indirect Cost at	8.00%	0
<b>Total Cost</b>		<b>480,276</b>
Contingency at	42.00%	203,916
<b>Cost Plus Contingency</b>		<b>684,192</b>

Activity	Duration
ing RFP	20
ig RFP	10
nder-Prepare Blank specifications	10
ng Proposal prep of vendor	20
h Proposal prep of vendor	20
g Proposal Evaluation	10
ng Proposal Evaluation	10
ing Contract	5
g Set Up	20
ining Contract	10
Blanks	5
ole Blanks, Half size	500
o Testing	20
ometry Measurement	20
ining	120
ist Metrology	20
g	40
Metrology	20
to UWA	10

Advanced LIGO Cost Estimate Detail

WBS Number	0.001.406.4.1	Duration	605 days
WBS Description	Pathfinder	Estimated By	E. Billingsley
Activity	CO-P50641A	Last Modified On	07/12/2001
Description	EST: Pathfinder SPF		
Location	Capital Project		
Cost Code	12-86041-14		

Line	WBS Item Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Bash	Quantity (Hrs/Eq)	Direct Labor (AA, BS-BS)		Contract Labor (CS)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (SS)		Total Cost (\$)	Reference		
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)				
1	B2	Labor	EN	Engineer			507	45	22,815											22,815	CO10202-80		
2	B2	Labor	OT	Other			179	50	8,950											8,950	CO10202-80		
3	B2	Labor	SC	Scientist			108	40	4,320											4,320	CO10202-80		
4	D2	Equip.	B2	Small Pathfinder Blank cost - sub-p of 6			1					43,000	43,000							43,000	CO10202-80		
5	E1	Int Travel	E1	Deliver Mirrors to UWA, review specifications			1						2,075	2,075						2,075	CO10202-80		
6	G5	Contract	G5	polish 3 optics	CSBD		1										129,640	129,640	129,640	129,640	CO10202-81		
7	G5	Contract	G5	Polish 7 Mode cleaner mirrors	Wave Precision		1										68,445	68,445	68,445	68,445	CO10202-81		
8	G5	Contract	G5	Shims	Env-Tech		1										2,000	2,000	2,000	2,000			
9	G5	Contract	G5														200,000	200,000	200,000	200,000			
																			480,885	481,255			

Labor Summary (Direct Labor plus...)

AA	BS	CS	D1	D2	E1	E2	G1	G2	G3	G4	G5	SS
Key/Fac	Person/Doc											
Hours												
Person Years												

WBS Description

In addition to serving as a summer fabrication associated with the R&D this WBS element. The purpose of industrial partners to achieve the following:

- Supply blanks in the large low bulk absorption at 1064 micron under WBS elements 0.4.2.2 and enabling research to be able to do proof of capability and the first step
- Supply polishing to the 13 the large size required. Initially provided by WBS elements 0.4.4, this WBS element, will be polished on full scale optics.
- Coating on large diameter of absorption in the high-reflection qualification of a new coating was absorption at full scale size, when research (WBS element 0.4.2.4) coating prescription for a lower ab of this small scale coating research production facility.

### Task List

Task No	Description	Duration
CO-P50560	SPF- Polishing RFP	20
CO-P50600	SPF- Coating RFP	10
CO-D50540	Small Pathfinder-Prepare Blank specifications	10
CO-P50610	SPF - Coating Proposal prep at vendor	20
CO-P50570	SPF - Polish Proposal prep at vendor	20
CO-P50620	SPF-Coating Proposal Evaluation	10
CO-P50580	SPF-Polishing Proposal Evaluation	10
CO-P50630	SPF-Let Coating Contract	5
CO-T50640	SPF-Coating Set Up	20
CO-P50590	SPF-Let Polishing Contract	10
CO-P50550	SPF-Order Blanks	5
CO-F50650	SPF-Fabricate Blanks, Half size	100
CO-Q50660	SPF-Absorb Testing	20
CO-Q50670	SPF-Homogeneity Measurement	20
CO-F50680	SPF-PF-Polishing	120
CO-Q50690	SPF- Uncoated Metrology	20
CO-T50700	SPF-Coating	40
CO-Q50710	SPF-Coated Metrology	20
CO-H50720	SPF-Deliver to UWA	10

Staff Benefits at 25.00%	9,821
GRS Benefits at 18.00%	0
Indirect Cost at 8.00%	0
<b>Total Cost</b>	<b>480,276</b>
Agency at 42.00%	202,916
<b>Agency</b>	<b>683,192</b>



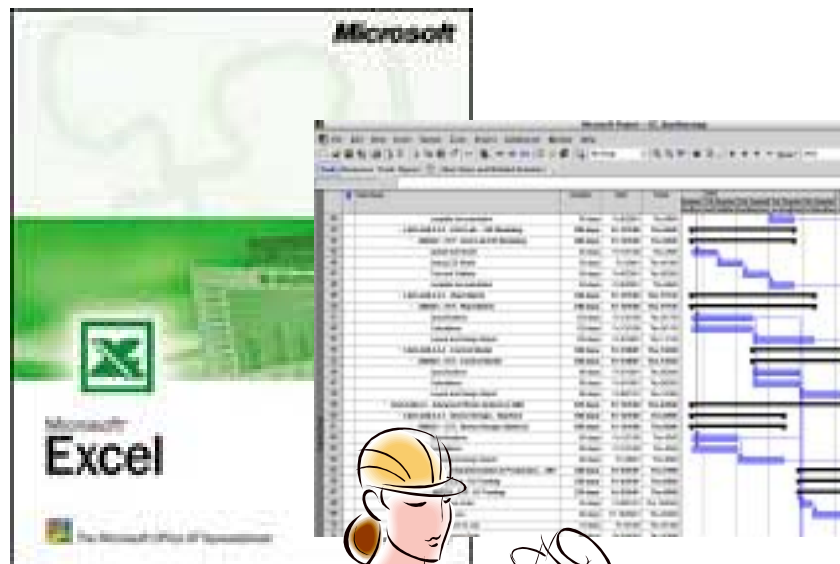
## Criteria for LIGO Lab

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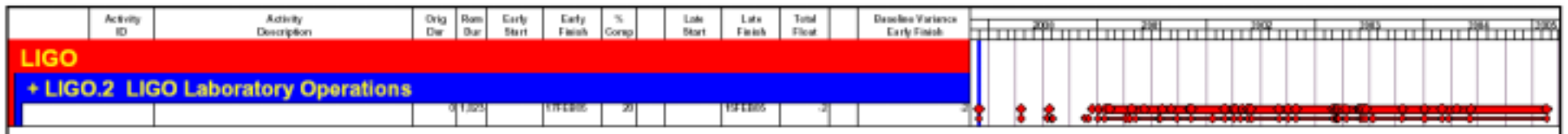
- Use of a Traditional WBS (Work Break Down Structure)
- Follow a defined project life cycle and structure.
- Cost Codes that are linked to a WBS
- Resource planning by Discipline. –
  - » Resource Pool Listing by Discipline
- Cost and Schedule Integration. –
  - » LIGO II Cost Book Tool
    - Cost Estimating Plan
    - Cost Estimating Tool User Procedure
- **Reporting capability at any level within the WBS**
  - » **Schedule Development**
  - » **Example reports for pilot projects**
    - **LASTI**
    - **40-Meter**
- Earned Value Analysis - AKA Variance Analysis. –
  - » Program Model Output from P3 (Primavera Project Planner)

# Schedule Development

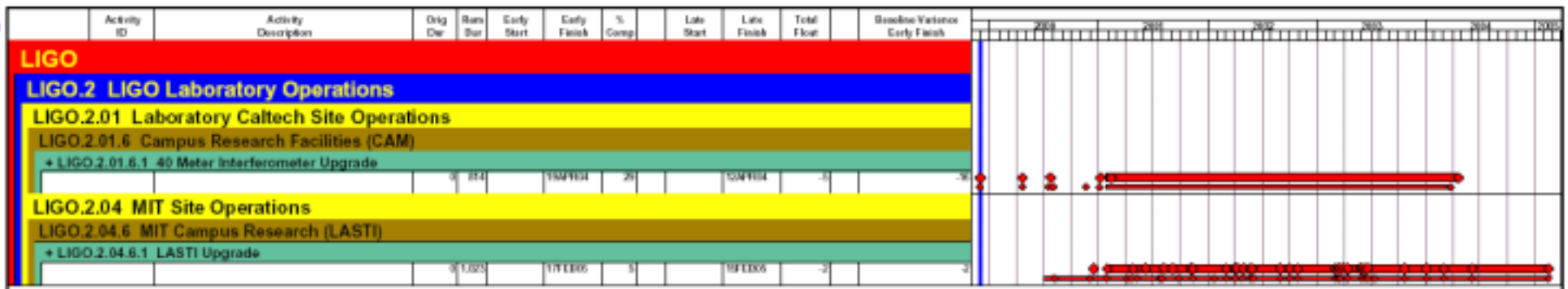
- Data collection done using what ever method it takes.
- Tools used by scientists and engineers:
  - » MS Project (98, 2000, 2002, and ver. 4 for MAC)
    - NOTE: MS Project 98 and ver. 4 for MAC are not backward compatible with 2000 or 2002.
  - » Excel Spreadsheets
  - » Text Files
  - » Sketches on Paper
  - » I do them.



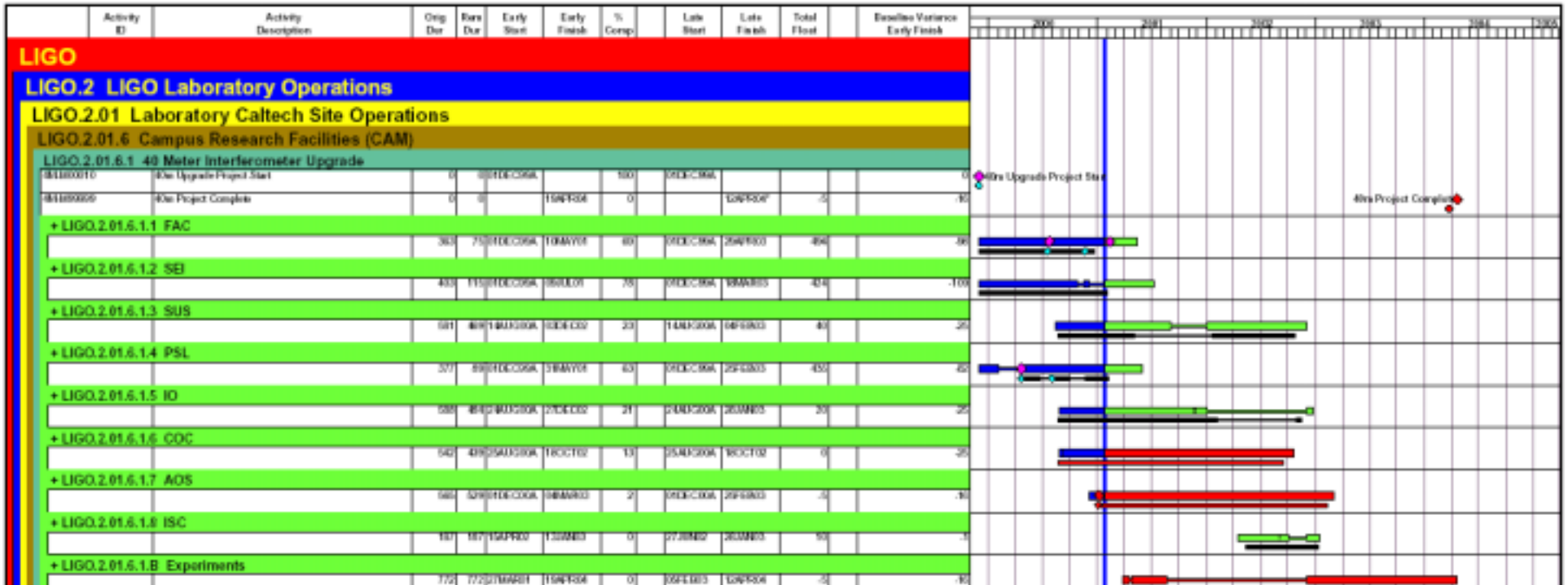
# Level 1



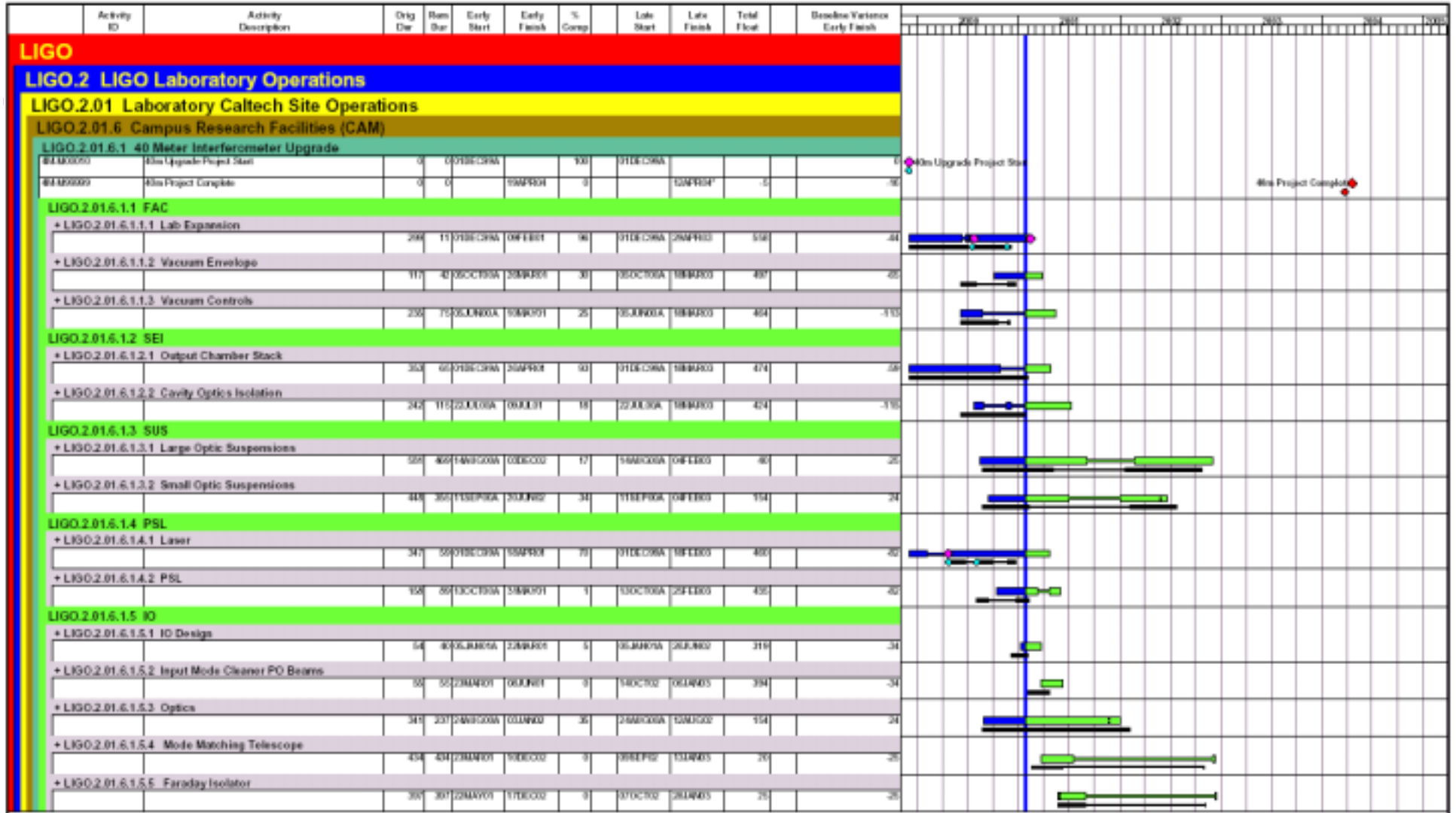
# Level 2



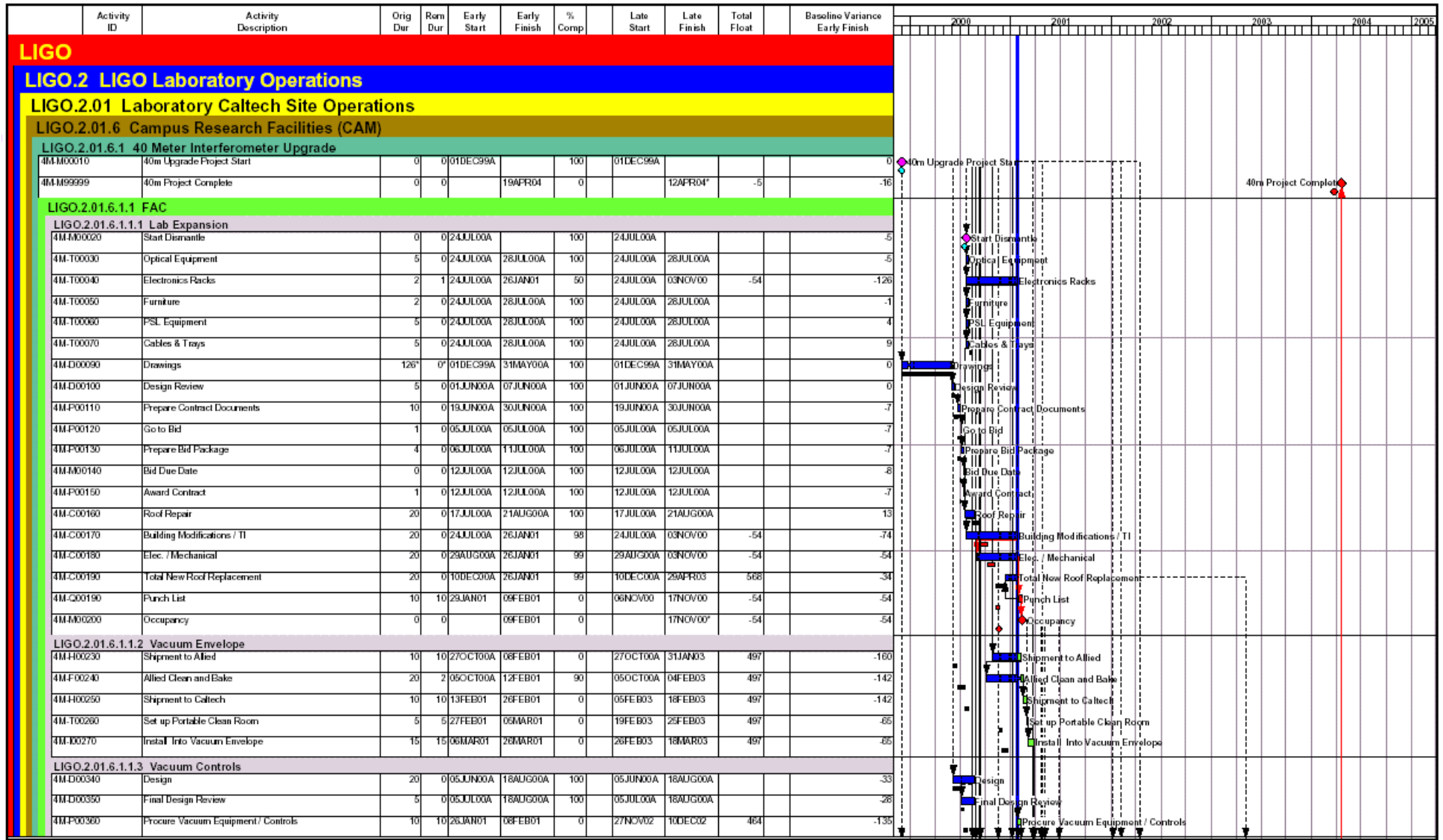
# Level 3



# Level 4



# Level 5







## Criteria for LIGO Lab

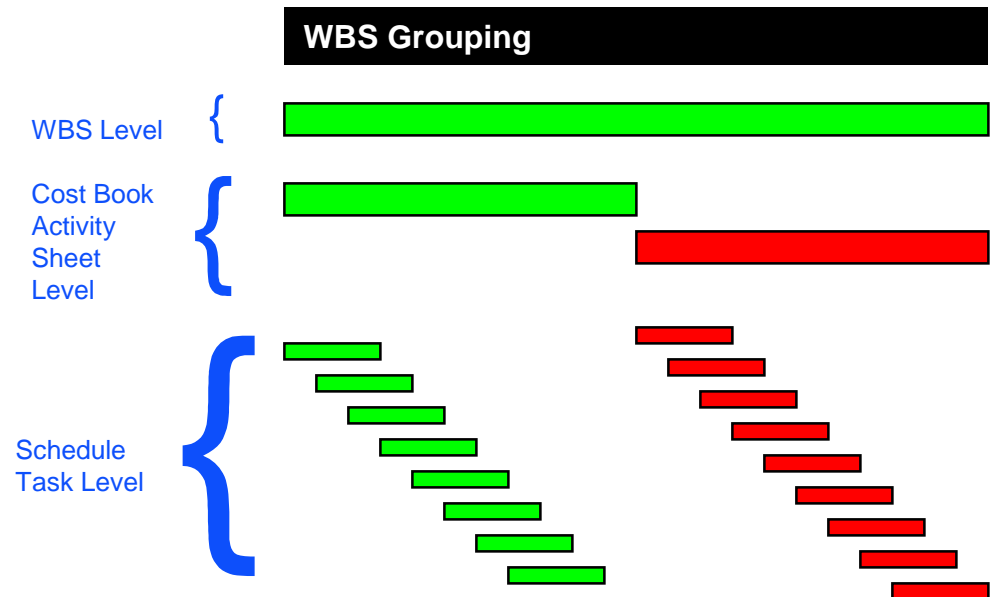
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- Use of a Traditional WBS (Work Break Down Structure)
- Follow a defined project life cycle and structure.
- Cost Codes that are linked to a WBS
- Resource planning by Discipline. –
  - » Resource Pool Listing by Discipline
- Cost and Schedule Integration. –
  - » LIGO II Cost Book Tool
    - Cost Estimating Plan
    - Cost Estimating Tool User Procedure
- Reporting capability at any level within the WBS
  - » Schedule Development
  - » Example reports for pilot projects
    - LASTI
    - 40-Meter
- **Earned Value Analysis - AKA Variance Analysis. –**
  - » **Program Model Output from P3 (Primavera Project Planner)**



# Planning for Performance Measurement

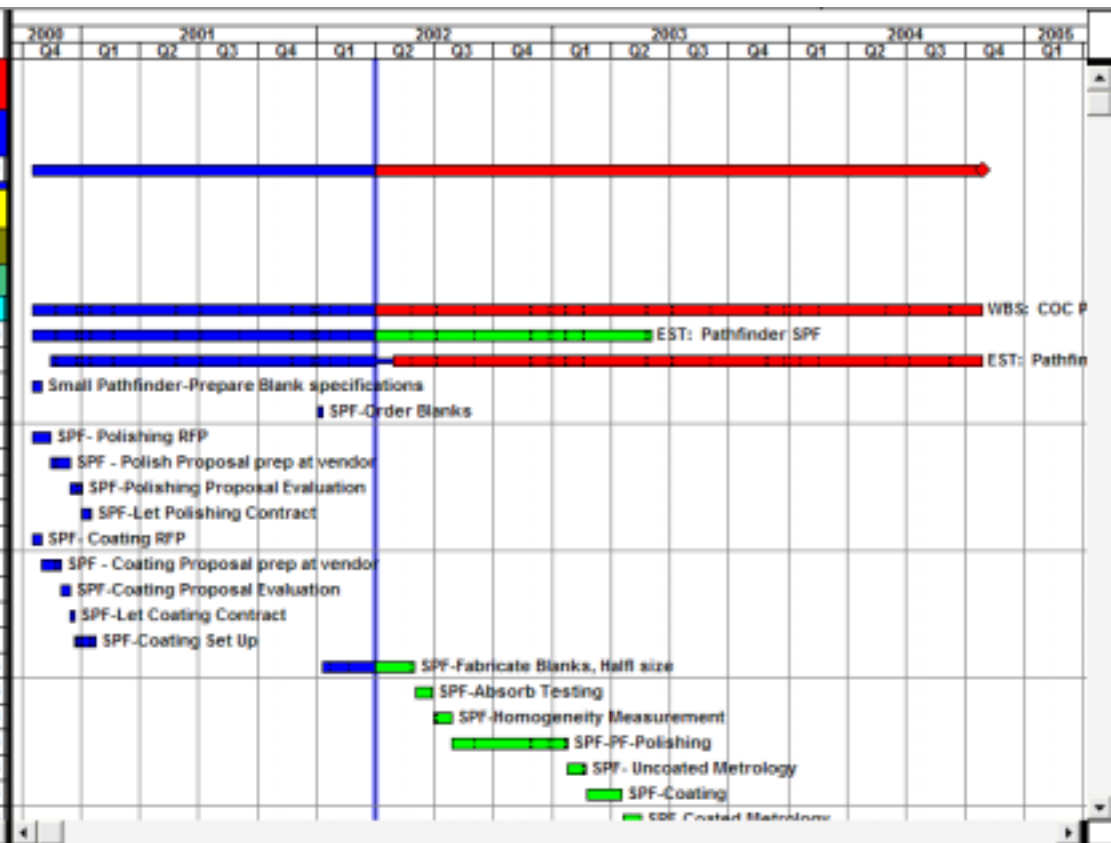
- At what level do you cost load the schedule?
  - » WBS Level is where we collect actual cost.
  - » Cost Book Activity Sheet is where we load the estimate.
  - » Schedule Activity level is where we measure progress that determines the earned value.
- Performance Evaluation is executed at the rollup level for the WBS.
  - » ACWP
  - » BCWS
  - » BCWP
  - » Schedule Variance
  - » Cost Variance



Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	Budgeted Cost	% Comp	2001	2002	2003	2004	2005	2006	2007
<b>LIGO</b>														
<b>LIGO.4 Advanced LIGO Construction</b>														
Subtotal		1,006	18OCT00A	25OCT04	0	2,162,299.54	37							
<b>LIGO.4.06 Core Optics Components (COC)</b>														
<b>LIGO.4.06.4 COC Fabrication</b>														
<b>LIGO.4.06.4.1 Pathfinder</b>														
CO-VI40841	WBS: COC Pathfinder	1,006	18OCT00A	25OCT04	0	0.00	36							
CO-F40641A	EST: Pathfinder SPF	654	18OCT00A	02JUN03	108	696,192.27	55							
CO-F40641B	EST: Pathfinder LPF	986	15NOV00A	25OCT04	-244	1,466,107.27	37							
CO-D50548	Small Pathfinder-Prepare Blank specifications	10	18OCT00A	31OCT00A		0.00	100	■ Small Pathfinder-Prepare Blank specifications						
CO-P50550	SPF-Order Blanks	5	02JAN02A	08JAN02A		0.00	100	■ SPF-Order Blanks						
CO-P50560	SPF- Polishing RFP	20	18OCT00A	14NOV00A		0.00	100	■ SPF- Polishing RFP						
CO-P50570	SPF - Polish Proposal prep at vendor	20	15NOV00A	14DEC00A		0.00	100	■ SPF - Polish Proposal prep at vendor						
CO-P50580	SPF-Polishing Proposal Evaluation	10	15DEC00A	02JAN01A		0.00	100	■ SPF-Polishing Proposal Evaluation						
CO-P50590	SPF-Let Polishing Contract	10	03JAN01A	17JAN01A		0.00	100	■ SPF-Let Polishing Contract						
CO-P50600	SPF- Coating RFP	10	18OCT00A	31OCT00A		0.00	100	■ SPF- Coating RFP						
CO-P50610	SPF - Coating Proposal prep at vendor	20	01NOV00A	30NOV00A		0.00	100	■ SPF - Coating Proposal prep at vendor						
CO-P50620	SPF-Coating Proposal Evaluation	10	01DEC00A	14DEC00A		0.00	100	■ SPF-Coating Proposal Evaluation						
CO-P50630	SPF-Let Coating Contract	5	15DEC00A	21DEC00A		0.00	100	■ SPF-Let Coating Contract						
CO-T50640	SPF-Coating Set Up	20	22DEC00A	24JAN01A		0.00	100	■ SPF-Coating Set Up						
CO-F50650	SPF-Fabricate Blanks, Half size	100	09JAN02A	31MAY02	108	0.00	57	■ SPF-Fabricate Blanks, Half size						
CO-Q50660	SPF-Absorb Testing	20	03JUN02	28JUN02	108	0.00	0	■ SPF-Absorb Testing						
CO-Q50670	SPF-Homogeneity Measurement	20	01JUL02	29JUL02	108	0.00	0	■ SPF-Homogeneity Measurement						
CO-F50680	SPF-PF-Polishing	120	30JUL02	23JAN03	108	0.00	0	■ SPF-PF-Polishing						
CO-Q50690	SPF- Uncoated Metrology	20	24JAN03	21FEB03	108	0.00	0	■ SPF- Uncoated Metrology						
CO-T50700	SPF-Coating	40	24FEB03	16APR03	108	0.00	0	■ SPF-Coating						
CO-Q50710	SPF-Coated Metrology	20	21APR03	16MAY03	108	0.00	0	■ SPF-Coated Metrology						
CO-H50720	SPF-Deliver to UWA	10	19MAY03	02JUN03	108	0.00	0	■ SPF-Deliver to UWA						
CO-D50740	LPF-Prepare Blank specifications Full size	10	15NOV00A	30NOV00A		0.00	100	■ LPF-Prepare Blank specifications Full size						
CO-P50750	LPF-Order Blanks - Pathfinder full size	10	01DEC00A	14DEC00A		0.00	100	■ LPF-Order Blanks - Pathfinder full size						
CO-P50760	LPF- Polishing RFP	10	03DEC03	16DEC03	-244	0.00	0	■ LPF- Polishing RFP						
CO-P50770	LPF - Polish Proposal prep at vendor	10	17DEC03	05JAN04	-244	0.00	0	■ LPF - Polish Proposal prep at vendor						
CO-P50780	LPF-Let Polishing Contract	10	06JAN04	20JAN04	-244	0.00	0	■ LPF-Let Polishing Contract						
CO-P50790	LPF- Coating RFP	10	03DEC03	16DEC03	-164	0.00	0	■ LPF- Coating RFP						
CO-P50800	LPF - Coating Proposal prep at vendor	10	17DEC03	05JAN04	-164	0.00	0	■ LPF - Coating Proposal prep at vendor						
CO-P50810	LPF-Let Coating Contract	5	06JAN04	12JAN04	-164	0.00	0	■ LPF-Let Coating Contract						
CO-T50820	LPF-Coating Set Up	20	13JAN04	10FEB04	-164	0.00	0	■ LPF-Coating Set Up						
CO-F50830	LPF-Fabricate Blanks, Full size	260	09NOV01A	26DEC02	-20	0.00	36	■ LPF-Fabricate Blanks, Full size						
CO-Q50840	LPF-Absorb Testing	20	27DEC02	28JAN03	-20	0.00	0	■ LPF-Absorb Testing						
CO-Q50850	LPF-Homogeneity Measurement	20	29JAN03	26FEB03	-20	0.00	0	■ LPF-Homogeneity Measurement						
CO-F50860	LPF-Polishing	80	21JAN04	12MAY04	-244	0.00	0	■ LPF-Polishing						
CO-Q50870	LPF- Uncoated Metrology	15	13MAY04	03JUN04	-244	0.00	0	■ LPF- Uncoated Metrology						
CO-F50880	LPF-Coating	80	04JUN04	27SEP04	-244	0.00	0	■ LPF-Coating						
CO-Q50890	LPF-Coated Metrology	20	28SEP04	25OCT04	-244	0.00	0	■ LPF-Coated Metrology						
CO-H50900	Deliver LPF ETM to LASTI	0		25OCT04	-244	0.00	0	◆ Deliver LPF ETM to LASTI						

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	Budgeted Cost	% Comp	RC % Expended	Cost to Date (ACWP)	Planned value cost (BCWS)	Earned value cost (BCWP)	Cost at Completion	Sched Var (BCWP - BCWS)	Cost Variance (BCWP - ACWP)
<b>LIGO</b>														
<b>LIGO.4 Advanced LIGO Construction</b>														
Subtotal		1,006	18OCT00A	25OCT04	0	2,162,299.54	37	69	1,500,000.00	1,656,066.66	920,893.41	2,162,299.54	-137,173.25	-579,106.59
<b>LIGO.4.06 Core Optics Components (COC)</b>														
<b>LIGO.4.06.4 COC Fabrication</b>														
<b>LIGO.4.06.4.1 Pathfinder</b>														
CO-VV40641	WBS: COC Pathfinder	1,006	18OCT00A	25OCT04	0	0.00	36	0	1,500,000.00	0.00	0.00	2,162,299.54	0.00	-1,500,000.00
CO-F40641A	EST: Pathfinder SPF	654	18OCT00A	02JUN03	108	696,192.27	55	0	0.00	384,289.61	384,296.14	0.00	8.53	384,296.14
CO-F40641B	EST: Pathfinder LPF	866	15NOV00A	25OCT04	-244	1,466,107.27	37	0	0.00	673,777.05	536,596.27	0.00	-137,181.78	536,596.27
CO-D50540	Small Pathfinder-Prepare Blank specifications	10	18OCT00A	31OCT00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50550	SPF-Order Blanks	5	02JAN02A	08JAN02A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50560	SPF- Polishing RFP	20	18OCT00A	14NOV00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50570	SPF - Polish Proposal prep at vendor	20	15NOV00A	14DEC00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50580	SPF-Polishing Proposal Evaluation	10	15DEC00A	02JAN01A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50590	SPF-Let Polishing Contract	10	03JAN01A	17JAN01A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50600	SPF- Coating RFP	10	18OCT00A	31OCT00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50610	SPF - Coating Proposal prep at vendor	20	01NOV00A	30NOV00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50620	SPF-Coating Proposal Evaluation	10	01DEC00A	14DEC00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50630	SPF-Let Coating Contract	5	15DEC00A	21DEC00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-T50640	SPF-Coating Set Up	20	22DEC00A	24JAN01A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-F50650	SPF-Fabricate Blanks, Half size	100	09JAN02A	31MAY02	108	0.00	57	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50660	SPF-Absorb Testing	20	03JUN02	28JUN02	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50670	SPF-Homogeneity Measurement	20	01JUL02	29JUL02	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50680	SPF-PP-Polishing	120	30JUL02	23JAN03	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50690	SPF- Uncoated Metrology	20	24JAN03	21FEB03	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-T50700	SPF-Coating	40	24FEB03	18APR03	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50710	SPF-Coated Metrology	20	21APR03	16MAY03	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-H50720	SPF-Deliver to UWA	10	19MAY03	02JUN03	108	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-D50740	LPF-Prepare Blank specifications Full size	10	15NOV00A	30NOV00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50750	LPF-Order Blanks - Pathfinder full size	10	01DEC00A	14DEC00A		0.00	100	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50760	LPF- Polishing RFP	10	03DEC03	16DEC03	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50770	LPF - Polish Proposal prep at vendor	10	17DEC03	05JAN04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50780	LPF-Let Polishing Contract	10	06JAN04	20JAN04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50790	LPF- Coating RFP	10	03DEC03	16DEC03	-164	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50800	LPF - Coating Proposal prep at vendor	10	17DEC03	05JAN04	-164	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50810	LPF-Let Coating Contract	5	06JAN04	12JAN04	-164	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-T50820	LPF-Coating Set Up	20	13JAN04	10FEB04	-164	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-F50830	LPF-Fabricate Blanks, Full size	260	09NOV01A	26DEC02	-20	0.00	36	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50840	LPF-Absorb Testing	20	27DEC02	28JAN03	-20	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50850	LPF-Homogeneity Measurement	20	29JAN03	28FEB03	-20	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-F50860	LPF-Polishing	80	21JAN04	12MAY04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50870	LPF- Uncoated Metrology	15	13MAY04	03JUN04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-P50880	LPF-Coating	80	04JUN04	27SEP04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-Q50890	LPF-Coated Metrology	20	28SEP04	25OCT04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
CO-H50900	Deliver LPF ETM to LASTI	0		25OCT04	-244	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00

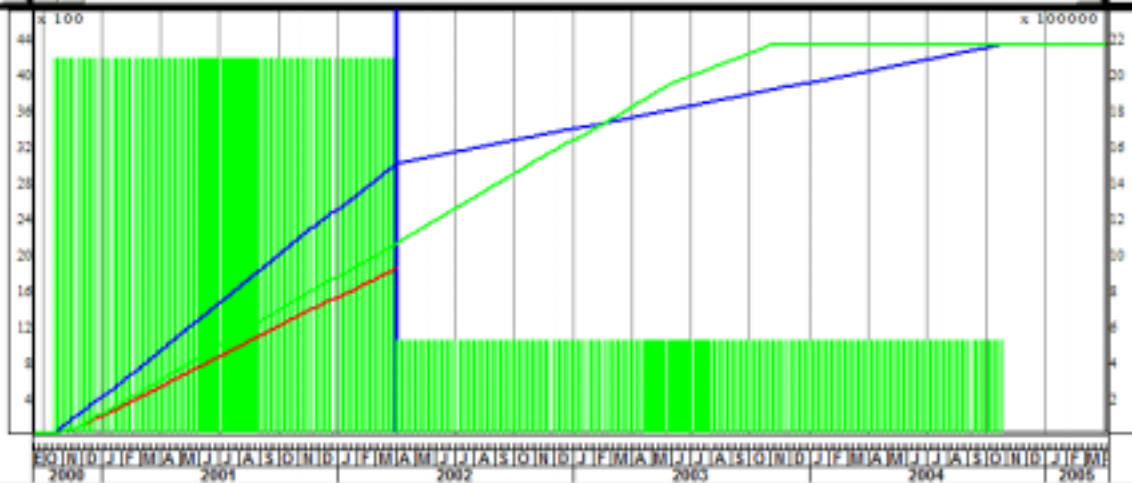
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
<b>LIGO</b>					
<b>LIGO.4 Advanced LIGO Construction</b>					
Subtotal		1,006	18OCT00A	25OCT04	0
<b>LIGO.4.06 Core Optics Components (COC)</b>					
<b>LIGO.4.06.4 COC Fabrication</b>					
<b>LIGO.4.06.4.1 Pathfinder</b>					
CO-W49641	WBS: COC Pathfinder	1,006	18OCT00A	25OCT04	0
CO-F40641A	EST: Pathfinder SPF	654*	18OCT00A	02JUN03	108
CO-F40641B	EST: Pathfinder LPF	986*	15NOV00A	25OCT04	-244
CO-D50540	Small Pathfinder-Prepare Blank specifications	10	18OCT00A	31OCT00A	
CO-P50550	SPF-Order Blanks	5	02JAN02A	08JAN02A	
CO-P50560	SPF- Polishing RFP	20	18OCT00A	14NOV00A	
CO-P50570	SPF - Polish Proposal prep at vendor	20	15NOV00A	14DEC00A	
CO-P50580	SPF-Polishing Proposal Evaluation	10	15DEC00A	02JAN01A	
CO-P50590	SPF-Let Polishing Contract	10	03JAN01A	17JAN01A	
CO-P50600	SPF- Coating RFP	10	18OCT00A	31OCT00A	
CO-P50610	SPF - Coating Proposal prep at vendor	20	01NOV00A	30NOV00A	
CO-P50620	SPF-Coating Proposal Evaluation	10	01DEC00A	14DEC00A	
CO-P50630	SPF-Let Coating Contract	5	15DEC00A	21DEC00A	
CO-T50640	SPF-Coating Set Up	20	22DEC00A	24JAN01A	
CO-F50650	SPF-Fabricate Blanks, Half size	100	09JAN02A	31MAY02	108
CO-Q50660	SPF-Absorb Testing	20	03JUN02	28JUN02	108
CO-Q50670	SPF-Homogeneity Measurement	20	01JUL02	29JUL02	108
CO-F50680	SPF-PF-Polishing	120	30JUL02	23JAN03	108
CO-Q50690	SPF- Uncoated Metrology	20	24JAN03	21FEB03	108
CO-T50700	SPF-Coating	40	24FEB03	18APR03	108
CO-Q50710	SPF-Coated Metrology	20	15APR03	18MAY03	108



Resource Profile/Table

Select... Resources: Total

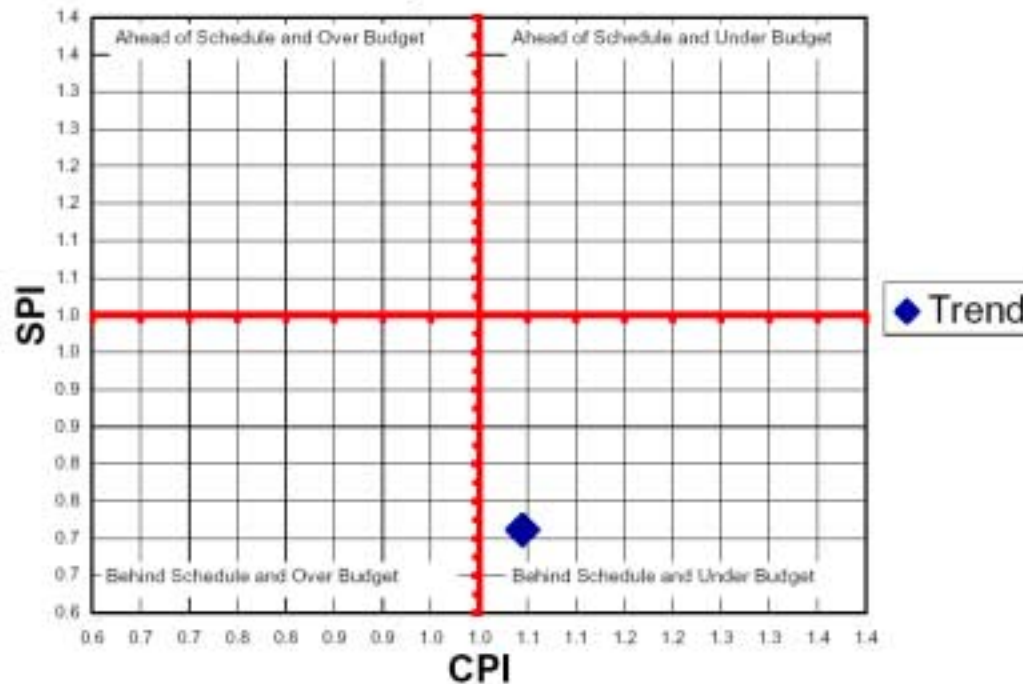
Display... Previous Next





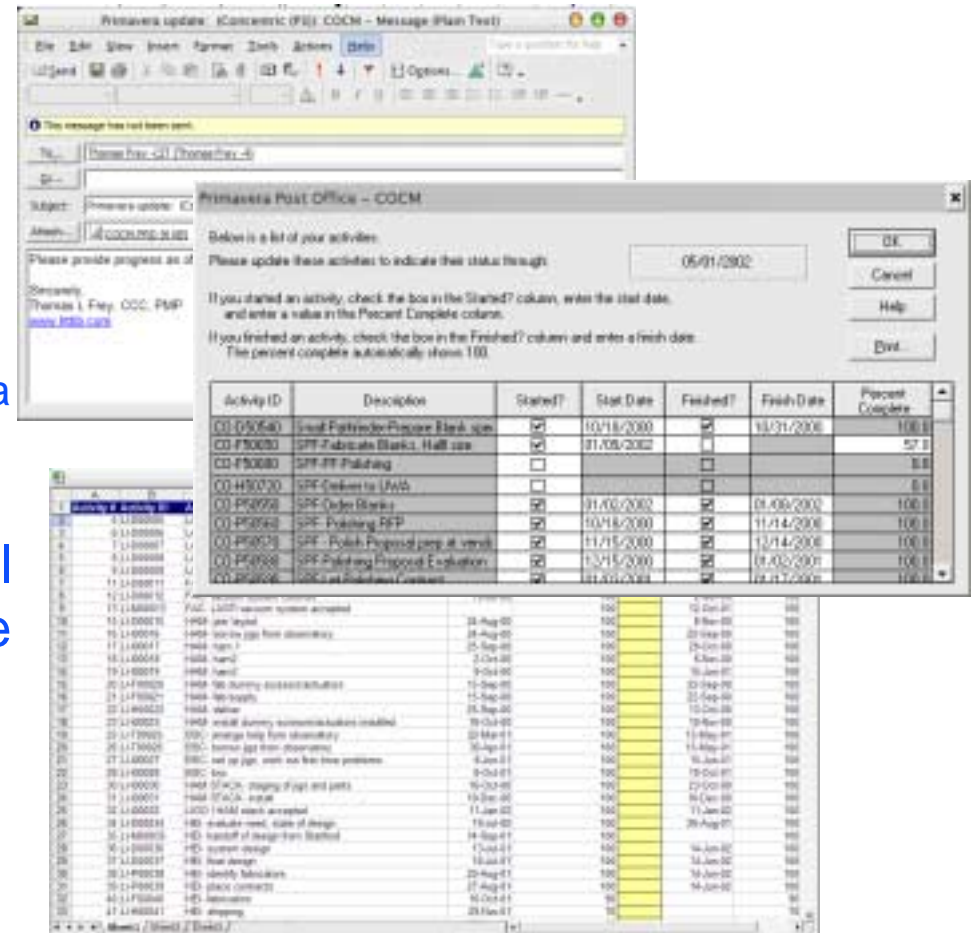
COST ACCOUNT	PCT COM	CUMULATIV ACWP	CUMULATIV BCWP	CUMULATIV BCWS	COST VARIANCE	SCHEDULE VARIANCE	BUDGETED COST	COST AT COMPLETIO	CAC VARIANCE
07-4131-04	100	75000	90000	90000	15000	0	90000	75000	15000
07-4133-04	37	235250	238125	385938	2875	-147812	637500	735150	-97650
07-4134-04	39	234375	234375	435385	0	-201010	600000	837000	-237000
07-4135-04	0	0	0	0	0	0	225000	225000	0
07-4136-04	69	392000	416250	464423	24250	-48173	600000	850000	-250000
07-4137-04	0	0	0	0	0	0	112500	112500	0
		<b>936625</b>	<b>978750</b>	<b>1375745</b>	<b>42125</b>	<b>-396995</b>	<b>2265000</b>	<b>2834650</b>	<b>-569650</b>

### Trend Analysis LIGO II Model



# Progress Data Collection

- Primavera Project Planner comes with a built in free ware program called Post Office.
  - » Using a built in feature within the application you can create a mail attachment that contains the activities to be updated.
- Another option is using Excel spreadsheets. These can be easily imported.



The screenshot shows the 'Primavera Post Office - COCM' window. It contains a table of activities with the following columns: Activity ID, Description, Started?, Start Date, Finished?, Finish Date, and Percent Complete. The table lists several activities, some with checked boxes in the 'Started?' and 'Finished?' columns, indicating their status.

Activity ID	Description	Started?	Start Date	Finished?	Finish Date	Percent Complete
CO-D00540	Install Primavera-Project Blank.spc	<input checked="" type="checkbox"/>	10/18/2000	<input checked="" type="checkbox"/>	10/31/2000	100.0
CO-F30000	SPE-Fabricate Blanks, Half size	<input checked="" type="checkbox"/>	01/08/2002	<input type="checkbox"/>		57.8
CO-F30000	SPE-PT Fabricating	<input type="checkbox"/>		<input type="checkbox"/>		0.0
CO-H30020	SPE-Order to LWB	<input type="checkbox"/>		<input type="checkbox"/>		0.0
CO-P50000	SPE-Order Blanks	<input checked="" type="checkbox"/>	01/02/2002	<input checked="" type="checkbox"/>	01/02/2002	100.0
CO-P50002	SPE-Processing RFP	<input checked="" type="checkbox"/>	10/18/2000	<input checked="" type="checkbox"/>	11/14/2000	100.0
CO-P50020	SPE-Polish Proposed Joints, 48" diam	<input checked="" type="checkbox"/>	11/15/2000	<input checked="" type="checkbox"/>	12/14/2000	100.0
CO-P50000	SPE-Processing Proposed Evolution	<input checked="" type="checkbox"/>	11/15/2000	<input checked="" type="checkbox"/>	01/02/2001	100.0
CO-P50000	SPE-Processing Proposed Evolution	<input checked="" type="checkbox"/>	01/02/2001	<input checked="" type="checkbox"/>	02/01/2001	100.0





## Criteria for LIGO Lab – The Tools

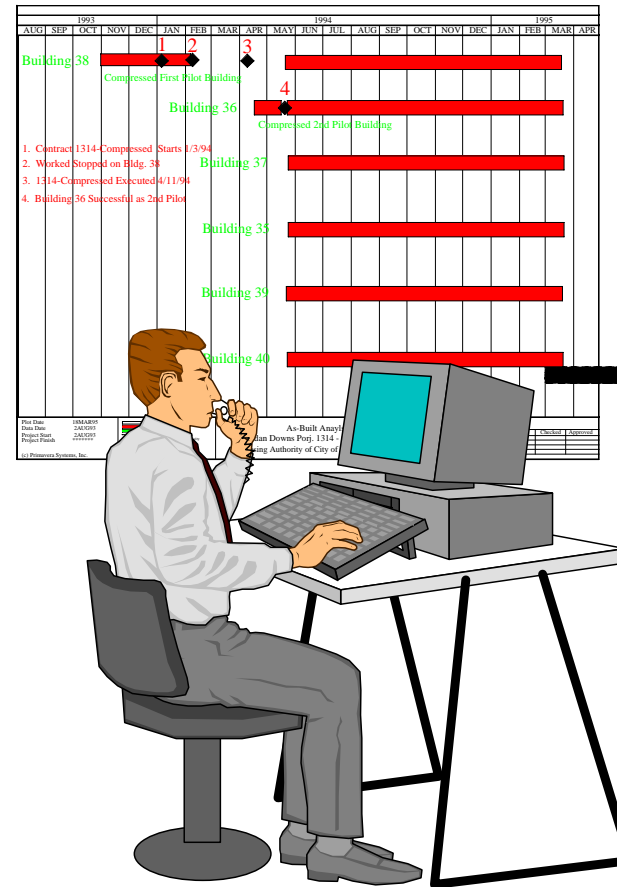
---

- For Planning and Scheduling we are using Primavera Project Planner. This provides:
  - » Traditional WBS (Work Break Down Structure)
  - » Use of defined project life cycle and structure.
  - » Uses Cost Codes
  - » Resource Dictionary by Discipline. –
    - Resource Pool Listing by Discipline
  - » Reporting capability at any level within the WBS
  - » Earned Value Analysis - AKA Variance Analysis. –
- For Cost data development and integration we are using MS Access. This provides:
  - » Cost and Schedule Integration. –
    - LIGO II Cost Book Tool on the Web.
  - » Resource Data control and maintenance



# Why CPM (Critical Path Methodology)

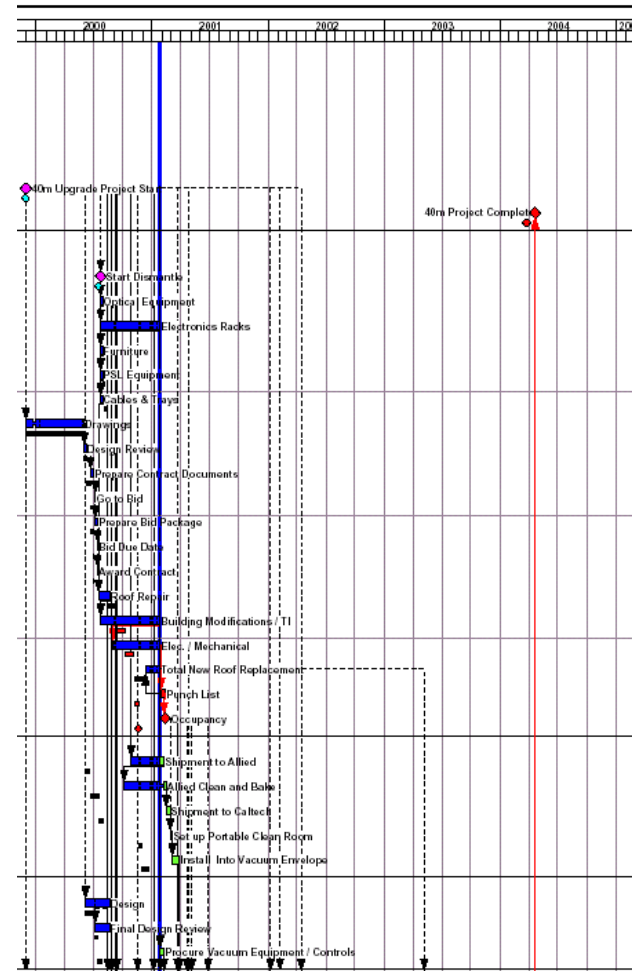
- What elements make CPM work.
- Sample Plan
- Why MS Project is not true CPM.
- Primavera Project Planner – True CPM tool.





# Why CPM (Critical Path Methodology)

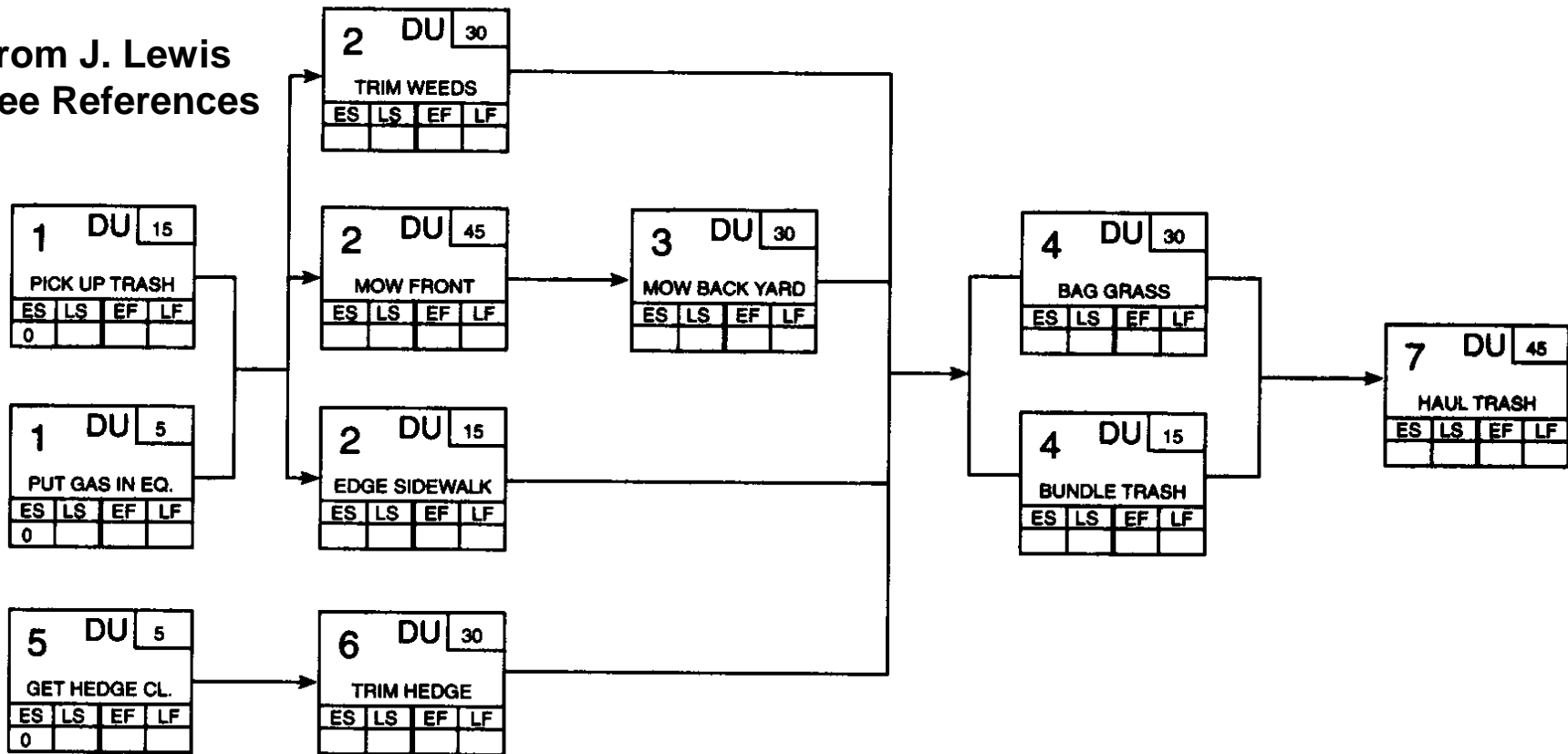
- Elements of CPM
  - » Uses activity logic. Most common application is precedence format.
  - » Calculation algorithm uses forward and backward pass.
  - » Tool provides critical path.
  - » Provides information regarding float, free float, early dates and late dates.
    - Allows negative float as a means for quantifying delays.
  - » Actual Cost can exceed budget. (Negative Cost and Schedule Variances)



# Why CPM (Critical Path Methodology)

**Figure 5-4.** CPM diagram for yard project.

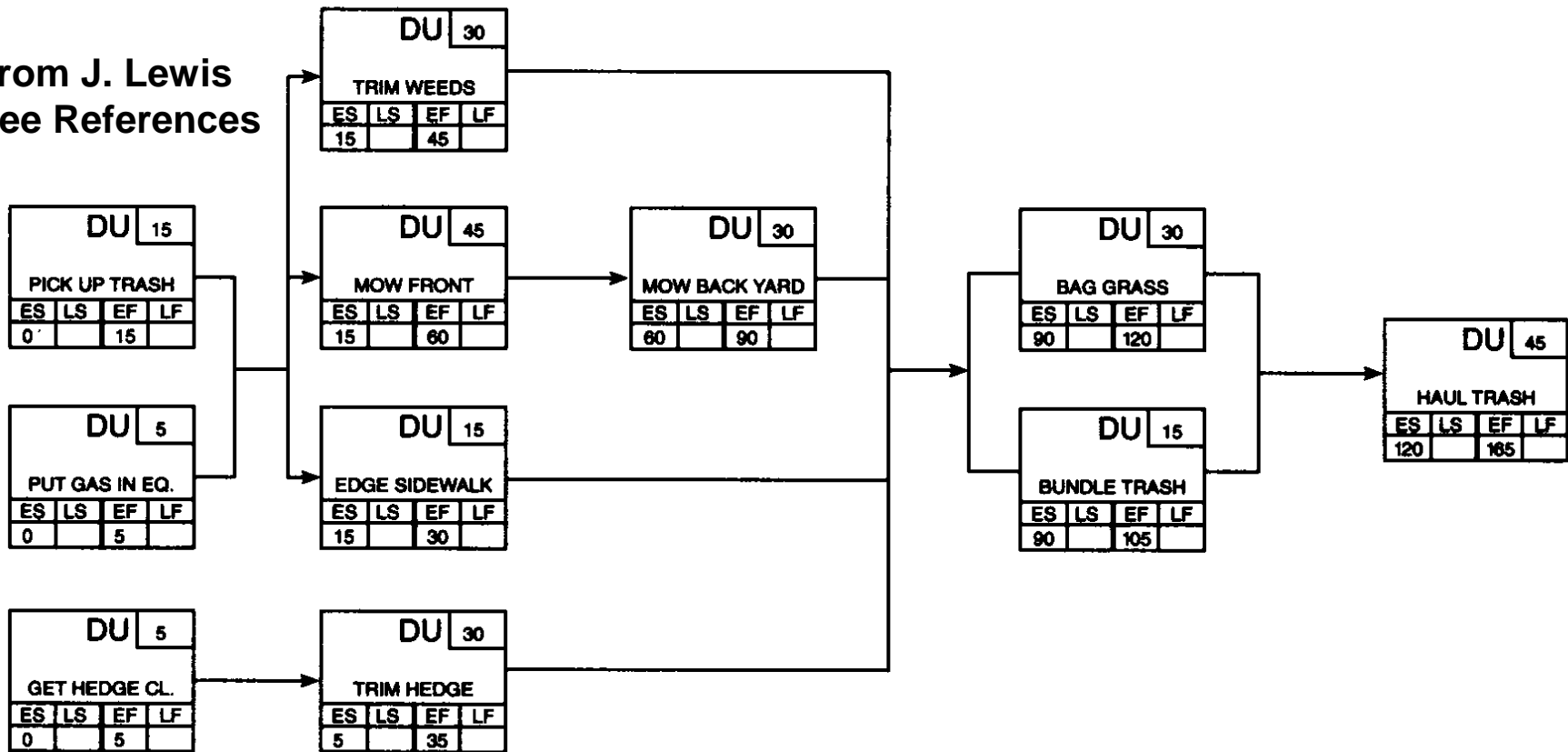
From J. Lewis  
See References



# Why CPM (Critical Path Methodology)

**Figure 6-2.** Forward pass computations for yard schedule.

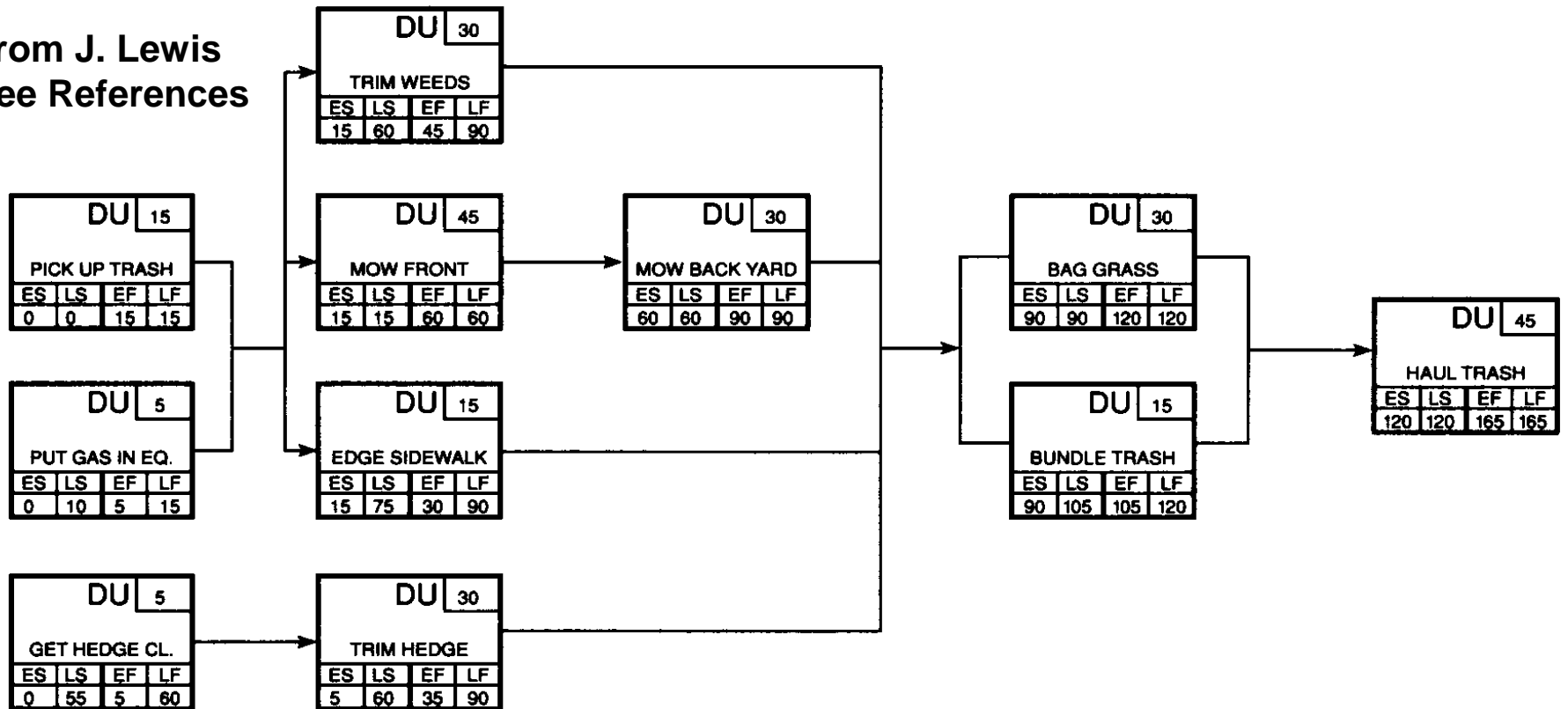
From J. Lewis  
See References



# Why CPM (Critical Path Methodology)

**Figure 6-3.** CPM diagram for yard project (filled in).

From J. Lewis  
See References

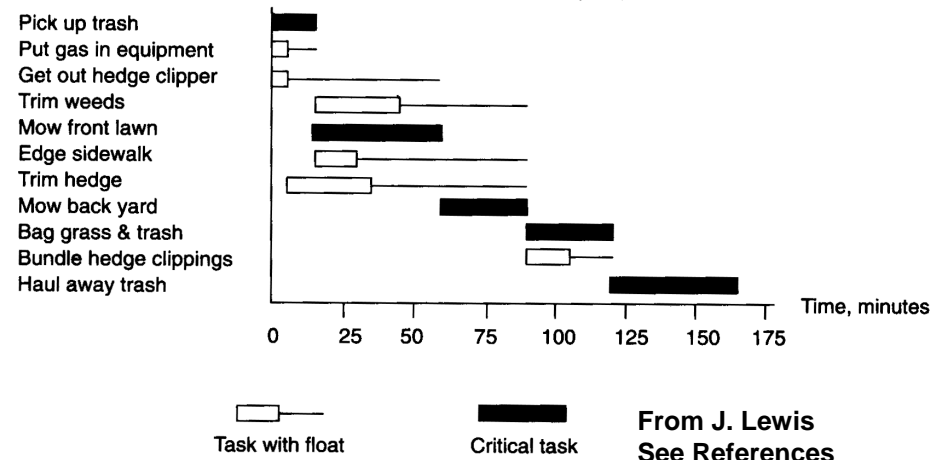


# Why CPM (Critical Path Methodology)

- Sample Project

- » Yard Project.
- » We will show this sample project in MS Project and P3.
- » We will show how progress is represented in each case.
- » We will evaluate the application of constraints.
  - Haul Away Trash has a finish no later than date of June 19, 2003.
- » Using days as time unit for this exercise.

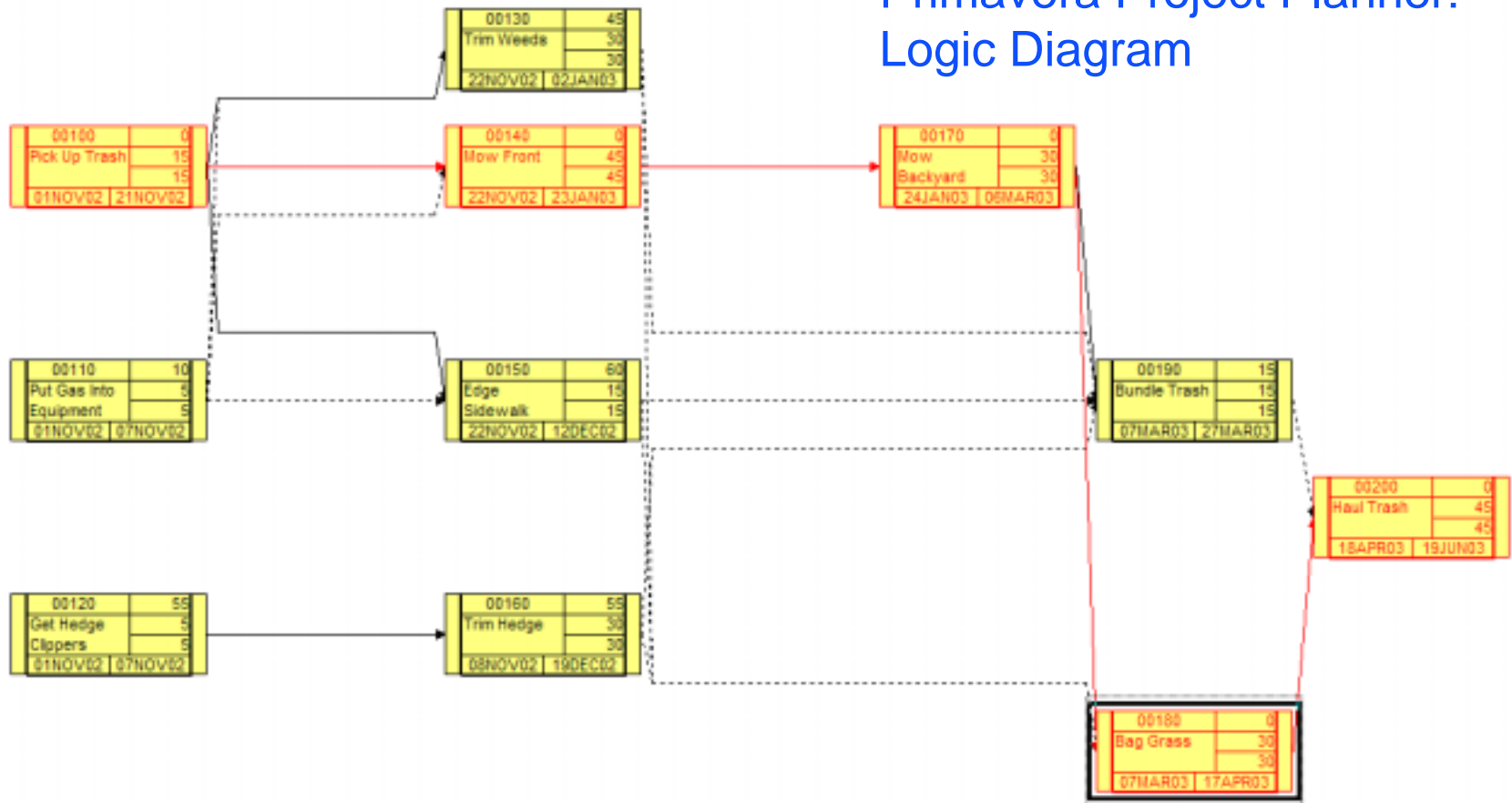
**Figure 6-4.** Bar chart schedule for yard project.





# Why CPM (Critical Path Methodology)

Primavera Project Planner:  
Logic Diagram



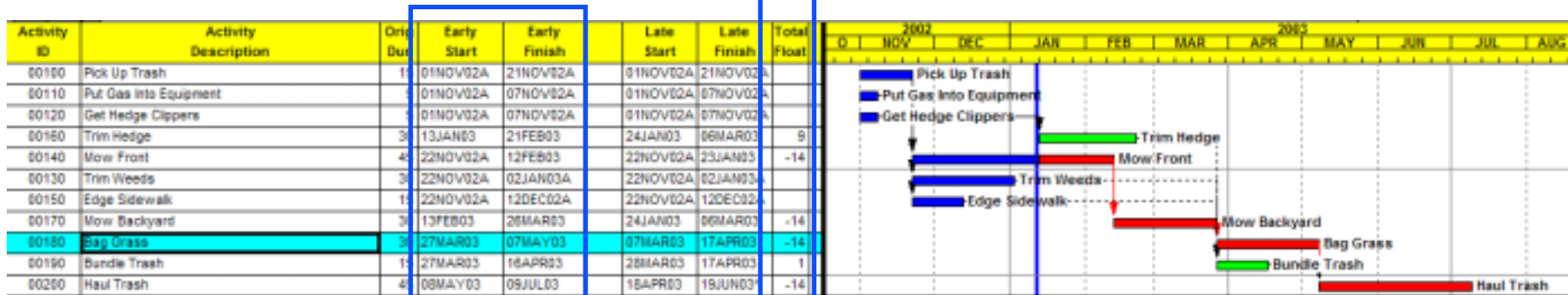
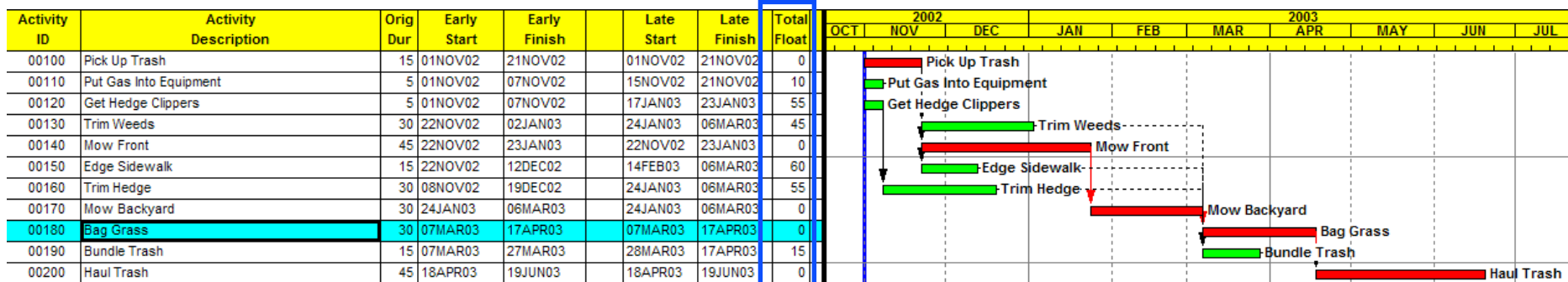




# Why CPM (Critical Path Methodology)

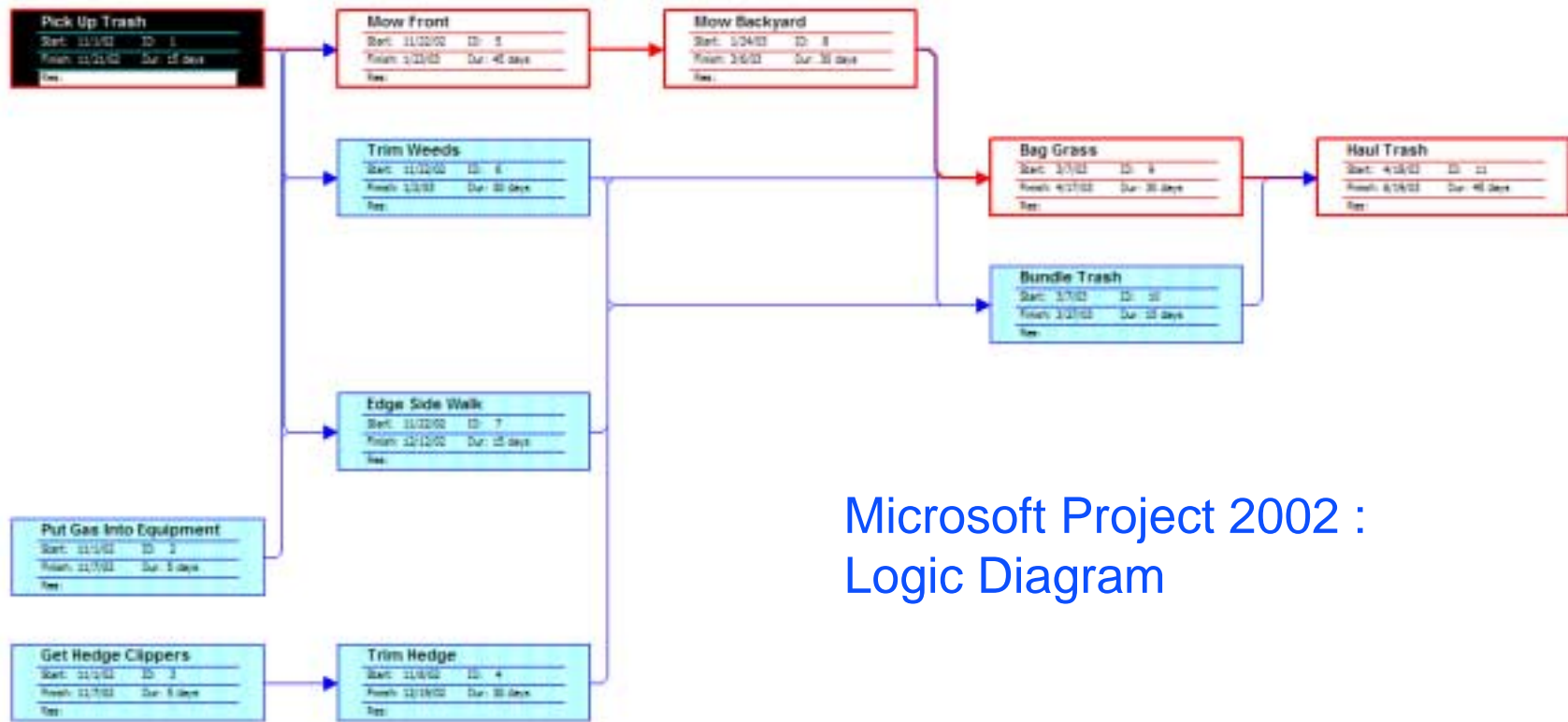
## Primavera Project Planner: Schedule Views

NOTE: Progress shows negative float indicating the amount of delay and forecasting an early finish later than the planned finish.





# Why CPM (Critical Path Methodology)



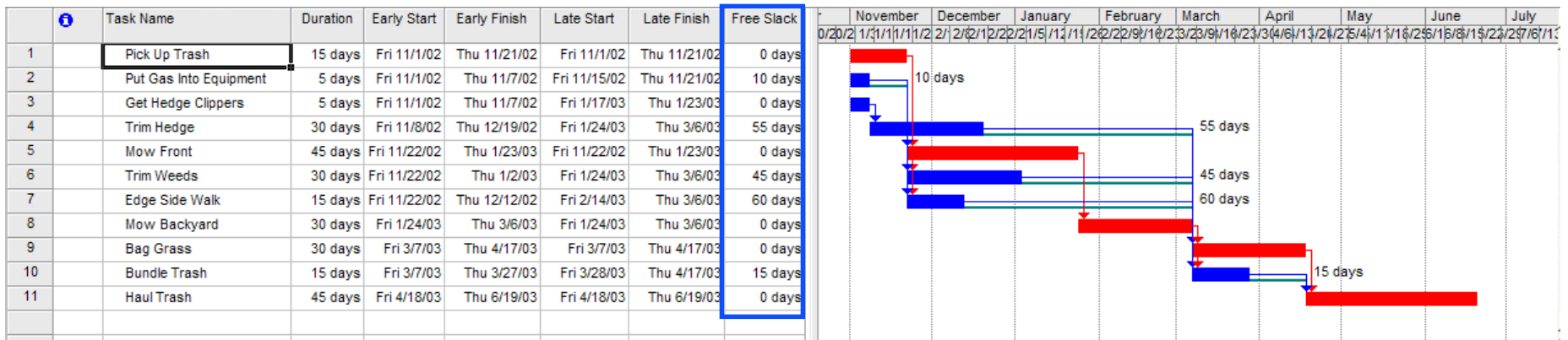
Microsoft Project 2002 :  
Logic Diagram



# Why CPM (Critical Path Methodology)

## MS Project 2002: Schedule Views

NOTE: Progress does not show negative float indicating the amount of delay and the forecast finish has not changed to reflect the delay.

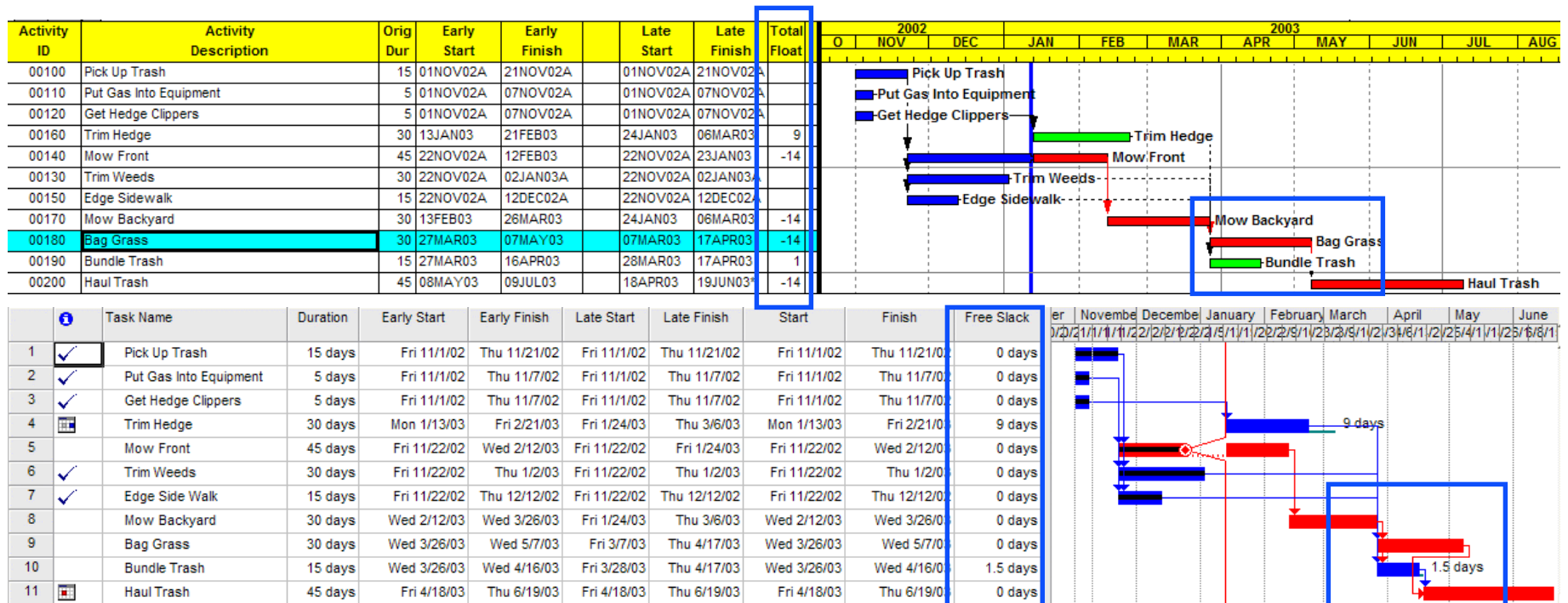




# Why CPM (Critical Path Methodology)

- CPM, With Out A Doubt.

- » CPM tool provides clear quantifiable data regarding delay.
- » Forecasts a new finish date based upon known progress.
- » Basis for making corrective action to recover delay.





# Real World Example

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- Working with a LIGO Lab collaborator preparing a proposal we were asked to help.
- We will discuss how LIGO Lab used the tools available to provide the following:
  - » Detailed Cost Estimate
  - » Detailed Schedule
  - » Cost Loaded Schedule
  - » Cost Profiles with Escalation



# Real World Example

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- Using the Cost Book Tool, we coded the cost sheets that represented the collaborator's scope.
- Using MS Access and the data, we applied the collaborator's cost rules and labor rates.
- We also provided cost data by institution for the collaborator.





# Real World Example

## Advanced LIGO Cost Estimate Summary (UG, UB, RAL)

WBS LIGO.4 Advanced LIGO Construction

WBSNo	Description	Direct Labor		Contract Labor		Equipment	Travel	Material	Subcontracts	Indirect	SubTotal	Contingency		Total
		Hours	Total (\$)	Hours	Total (\$)							%	(\$)	
LIGO.4.03	Suspension (SUS)	20,257	989,463			4,925,450	202,700		300,000	521,528	6,939,140	24.89%	1,726,910	8,666,050
LIGO.4.06	Core Optics Components (COC)					391,944				0	391,944	43.00%	168,536	560,480
LIGO.4.13	Installation (INS)	3,840	209,500				396,000			157,430	762,930	5.00%	38,146	801,076
		24,097	1,198,963			5,317,394	598,700		300,000	678,958	8,094,014	23.89%	1,933,592	10,027,606

## Advanced LIGO Cost Estimate Detail (UG, UB, RAL)

WBS Number	LIGO.4.03.1
WBS Description	SUS Subsystem Management
Activity	SUS.50200B
Description	SUS-Sub System Management (UG, UB, RAL)
Location	Capital Project
Cost Code	12-4031-14

Duration	2215 days
Estimated By	E. Floy
Last Modified On	06/15/2002

Line	NSF Res Code	Cost Category	LIGO Resource Code	Description	Estimator Comments or Vendor	Cost Basis	Quantity (Hrs/Ea)	Direct Labor (AA, B1-B5)		Contract Labor (GR)		Equipment (D1, D2)		Travel (E1, E2)		Material (G1-G4)		Subcontracts (F5)		Total Cost (\$)	Reference	
								Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)	Unit Cost (\$)	Total (\$)			
1	B2	Labor	SE	Senior Engineer		HD	1500	TD	118,500											118,500		
2	E1	Int Travel	E1	Travel Budget for Subsystem Mgmt.	10 Trips / 1 week	HD	30						3,000	30,000						30,000		
Subtotal SUS.50200B SUS-Sub System Management (UG, UB)									118,500					30,000							148,500	

KeyFac	Resource Code										Grad	UGrad	Admin									
	AA	B1	B2	B3	B4	B5	GR	D1	D2	E1				E2	G1	G2	G3	G4	F5			
Hours						1500														1500		
Person Years						0.6														0.6		

Risk Factor	Value	Risk Multiplier
Technique	3	2.00%
Cost	2	1.00%
Schedule	2	1.00%
Calculated Contingency	10.00%	
Estimator Override		

Staff Benefits at 0.80%	0
(GR) GRA Benefits at 0.80%	0
Indirect Cost at 0.80%	0
Total Cost	148,500
Contingency at 10.00%	14,850
Cost Plus Contingency	163,350

### WBS Definition

Technical management of the subsystems is covered in this WBS element. This is a level of effort task (the level may vary according to the development phase).

### Basis of Estimate

Labor: Hours estimated based on historical data.  
Travel: Estimated based on historical data.

### Task List

Task No	Description	Duration
SUS.50200B	SUS-Sub System Management	1215



# Real World Example

- Using the schedule, we coded the tasks that represent the collaborator's scope.
- Using the cost book Access database, we cost loaded the schedule and generated cost profiles.

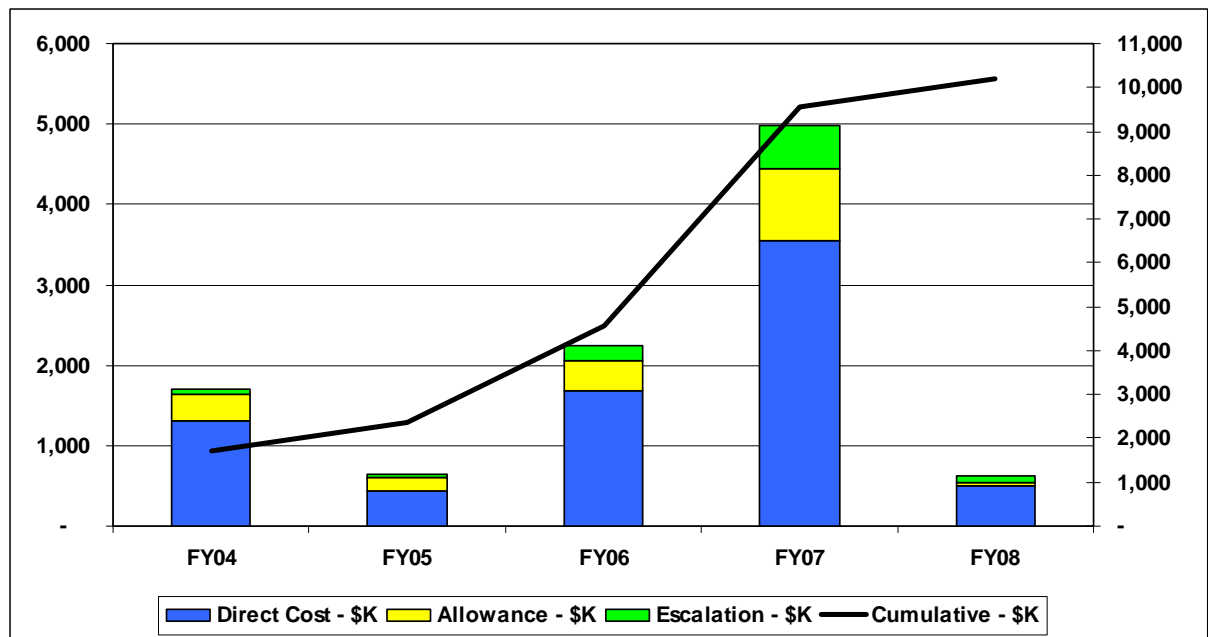






# Real World Example

- Using the cost loaded schedule, we exported the cost profile data to a spread sheet in base year dollars.
- Using MS Excel, we generated a cost profile by GB Fiscal Years and applied an escalation rate.





# Conclusion

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- Keep Sharp, Beat Your Budget!
  - » PMCS, PMIS, or EV MIS(s) offer greater PM value to stakeholders (customers and clients).
  - » EV Analysis, when implemented with integrity, offers the best method for identifying project areas of concern.
  - » EV Reports and Graphs can quickly communicate to stakeholders the status of the project.
  - » EV is a method with a proven track record. It is not an experiment.
  - » When executed on at least a monthly basis, it will provide the information needed for management to make good decisions.



# References

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- Lewis, James P.. “PROJECT PLANNING, SCHEDULING AND CONTROL”. Irvin Professional Publishing, 1995.  
ISBN 1-55738-869-5
- Lewis, James P.. “FUNDAMENTALS OF PROJECT MANAGEMENT”. AMACOM Publishing, 1995.  
ISBN 0-8144-7835-2
- Project Management Institute, “Project Body of Knowledge”, AKA. PMBOK. PMI, Four Campus Blvd., Newtown Square, PA 19073-3299, USA., 1996. ISBN: 1-880410-12-5
- Earned Value Management Web Site:  
<http://www.acq.osd.mil/pm/>



# Case Study of PMCS Implementation/Tools - Advanced LIGO

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- THE END

