Planning LIGO Project Management

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NSF Review

September 20, 1994

LIGO-G940016-00-M

An Early Project Management Plan

"See first that the design is wise and just: that ascertained, pursue it resolutely; do not for one repulse forego the purpose that you resolved to effect."

William Shakespeare

(with thanks to Paul Dinsmore who pointed this quotation out to many of us at SSC)

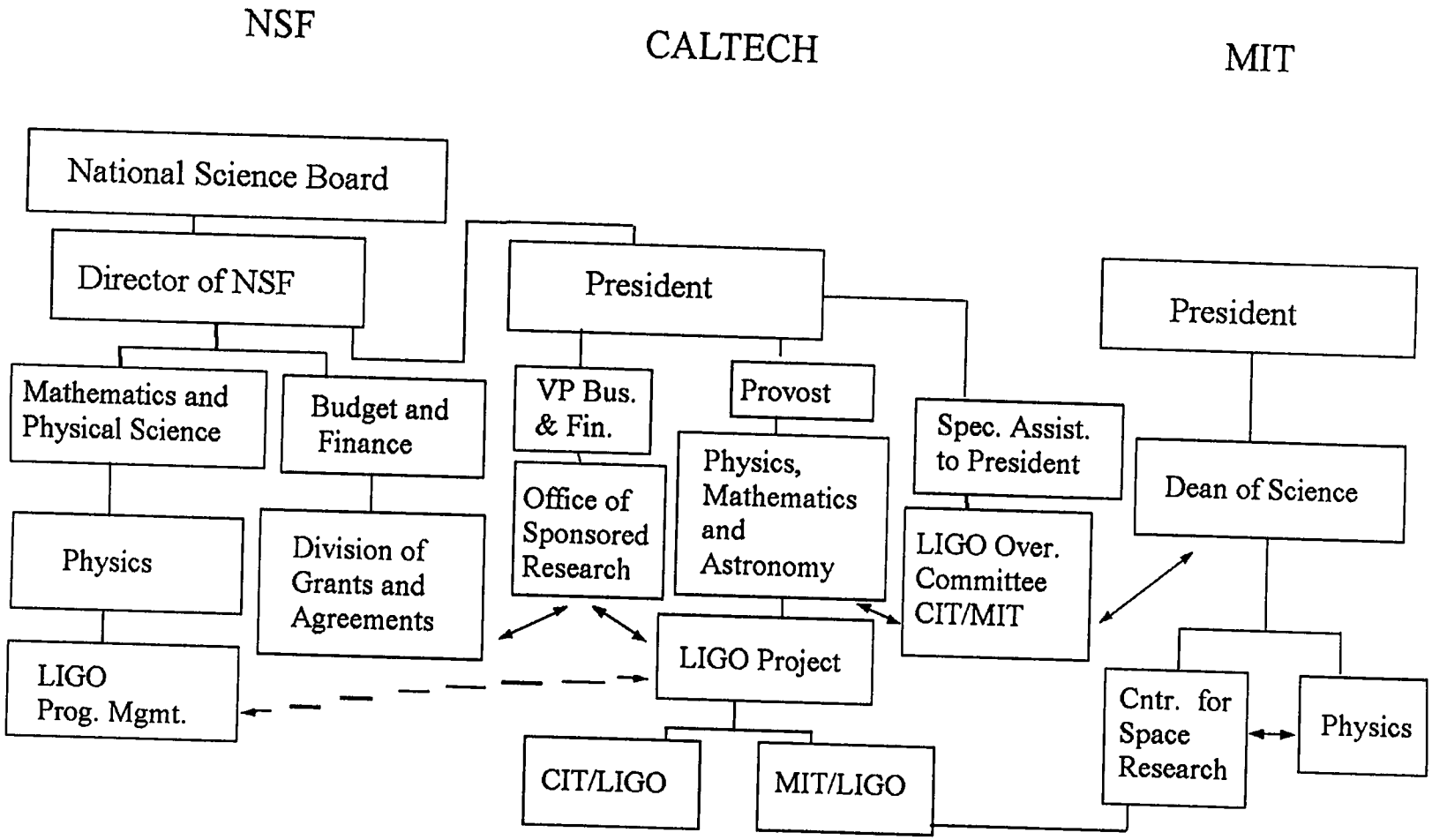

Figure 2-1. Organizational Hierarchy.

Institutional Roles and Responsibilities

- NSF - General oversight, monitoring, evaluation, funding
- NSF LIGO Program Manager - Scientific, technical, cost/schedule review, agency guidance
- NSF - Caltech Cooperative Agreement
- NSF Division of Grants and Agreements and Caltech Office of Sponsored Research - Responsible for Cooperative Agreement matters and approvals
- Caltech and MIT - Joint role in Project defined by MOU and annual subcontract revision. Boundary minimized.
- Caltech and MIT Presidents - Establish Oversight Committee
- LIGO Principal Investigator
- LIGO Project Manager

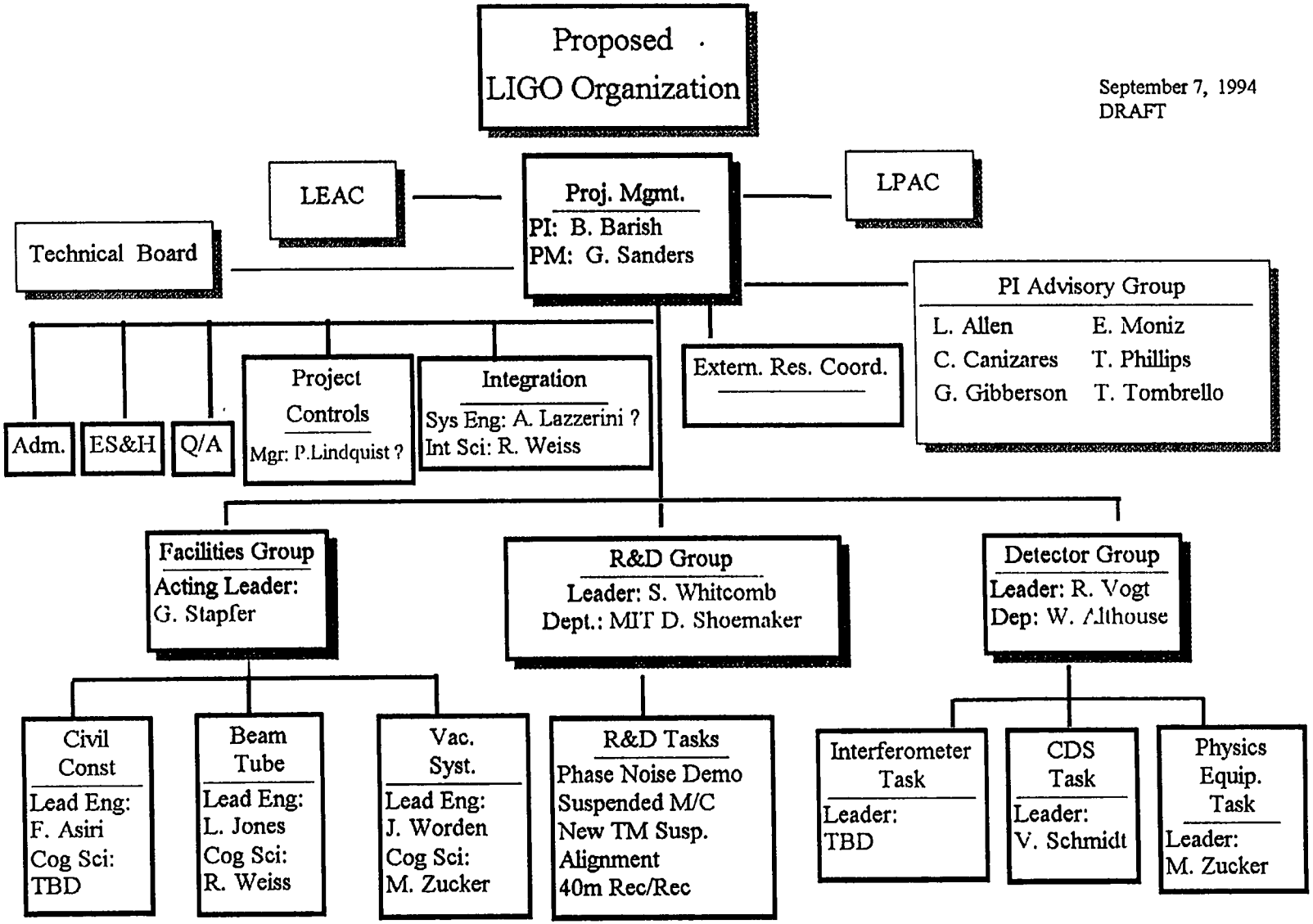

Figure 2-2. LIGO Organization.

Organization of the LIGO Project

- LIGO PI and PM each have primary responsibilities, but work very closely together
- PI has overall responsibility for the LIGO Project, to ensure the implementation of LIGO with goal of detecting gravity waves, principal NSF contact, community contact
- PM primarily responsible for executing the construction of LIGO and for organizing and directing the project team at Caltech and MIT
- Both are fully informed and mutually involved in the decision making, share the overall project management and both can speak for LIGO

Organization of the LIGO Project

- Project Controls Group (Project Controls Manager) responsible to Project Management for control of cost, schedule and technical configuration. Implements C/S system, tracking, reporting, subcontract management, finance, acquisition, change control process. Use of Project Control Meeting
- Integration Group (Systems Engineer and Integration Scientist) responsible to Project Management for integration. Uses a LIGO-wide Integration Meeting as forum

Organization of the LIGO Project

- Organization is "product oriented" with each management line responsible to apply resources to deliver a subsystem of LIGO
- LIGO Project Management (PI and PM) supported by External Advisory Committee
- LIGO PreProgram Advisory Committee advises on formation of standing LIGO Program Advisory Committee
- Technical Board supports PI/PM as lead forum for technical issue resolution in LIGO and as Change Control Board
- QA and ES&H Officers report to PM
- LIGO External Research Coordinator responsible to work with Project Management to communicate with scientific community and support scientific exploitation of LIGO

LIGO Collaborative Program

- MIT and Caltech build LIGO
- LIGO will be operated for the scientific community
- LIGO Collaborative Program to be the connection between LIGO and the community
  - » LIGO Project - MIT/Caltech
  - » LIGO Research and User's Group - adds external collaborators
    - – exploratory workshops
    - – discussion with NSF
  - » International Gravitational Network Partners
    - – VIRGO, GEO, AIGO, Japanese project
- LIGO PAC, Oversight Committee, NSF review

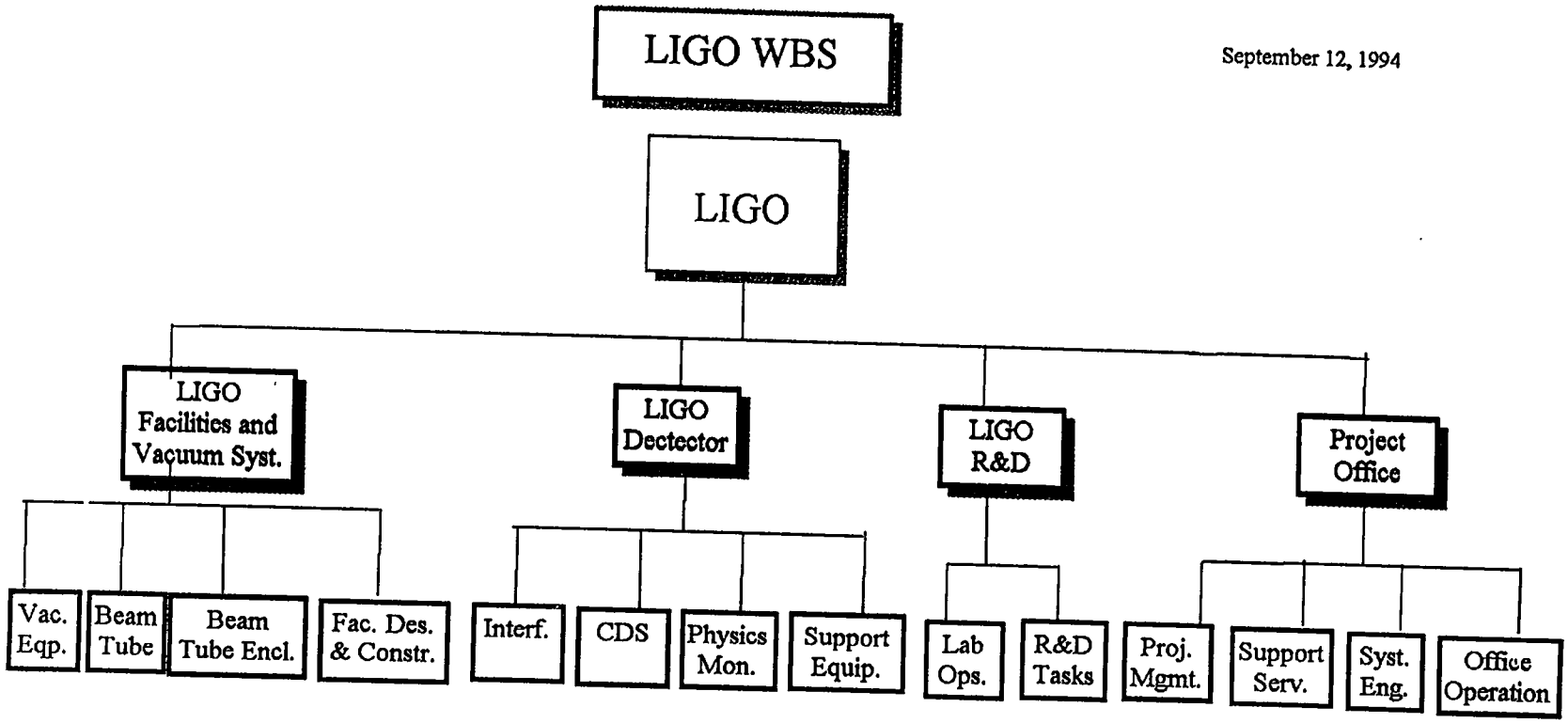

Figure 2-3. LIGO work breakdown structure.

LIGO Work Breakdown Structure

- Product oriented, emphasizes delivery of subsystems, and separate programmatic deliverables such as R&D, integration, and project controls
- Parallels the organizational structure
- Managed by establishing an initial WBS Dictionary as part of establishing a firm LIGO technical baseline and employing change control process to develop it as a management tool

LIGO Work Plan

- Facilities - Contract most work in civil construction, beam tube enclosure, beam tube, vacuum equipment
- R&D - Major early thrust to define enabling technology for initial interferometer leading to final design phase, followed by work on enhanced and advanced interferometers
- Detector Design/Fabrication - Following R&D, final design, fabrication and test carried out by project staff and external contractors, with installation by coherent team under direction of site managers
- Integration - Project staff defines requirements and interfaces, test plans and does full system level modeling

LIGO Work Plan

- QA - Responsibility of PM, includes Reliability, Maintainability, Availability as well
- ES&H -
  - » Design for minimum risk
  - » incorporate safety devices
  - » provide warning devices
  - » employ procedures and training
- Procurement -
  - » Major procurements (>$100,000) to NSF for concurrence
  - » written acquisition plan for >$500,000
  - » Caltech/MIT procurement systems approved by ONR

Cost Estimate

WBS LEVEL	WBS No.	WBS TITLE	TOTAL COST (1994 K$)
1	1	LIGO	$276,216
2	1.1	Facilities and Vacuum Systems	$170,597
2	1.2	Detector	$57,812
2	1.3	Research and Development	$26,798
2	1.4	Project Office	$21,009

Cost Estimate - Contingency

- Total Estimate in "run out" dollars is $292M using NSF deflators
- Contingency -
  - » Estimate to assure funds to resolve technical, cost, schedule risks
  - » Estimated for each item at lowest practical WBS level
  - » Rolled up to top level
  - » Contingency funds held by Project Management
  - » Released after documented requests reviewed by Technical Board and approved by Project Management
  - » Recorded as configuration change at $100K
  - » Reported to NSF in normal reporting and at 50% of any Level 3 WBS contingency estimate

Significant Facility Milestones

MILESTONE NAME	WASHINGTON LATE DATE	LOUISIANA LATE DATE
Initiate Site Development	03/14/94	08/07/95
Beam Tube Final Design Review	04/21/94	common
Select A/E Contractor	11/15/94	common
Complete Beam Tube Qualification Test	01/16/95	common
Select Vacuum Equipment Contractor	03/28/95	common
Initiate Beam Tube Fabrication	01/22/96	common
Complete Performance Measurement Baseline	04/28/95	common
Initiate Slab Construction	02/05/96	01/06/97
Initiate Building Construction	06/11/96	01/06/97
Accept Tube and Cover	03/16/98	09/28/98
Joint Occupancy	09/02/97	03/30/98
Beneficial Occupancy (Accept Buildings)	03/16/98	09/28/98
Accept Vacuum Equipment	03/16/98	09/28/98
Initiate Facility Shakedown	03/16/98	09/28/98

Significant Detector Milestones

MILESTONE NAME	WASHINGTON LATE DATE	LOUISIANA LATE DATE
HAM Final Design Review	09/03/97	common
BSC/TMC Final Design Review	09/22/97	common
I/O Optics Final Design Review	09/23/97	common
Core Optics Support Final Design Review	09/23/97	common
Initiate Interferometer Installation	07/06/98	01/29/99
CDS DAQ Final Design Review	10/01/98	common
Begin Coincidence Tests	07/04/00	common

Cost and Schedule Control

- Plan all activities to meet technical goals, cost baseline, milestone dates
- Monitor and report cost and schedule status
- Goal is to provide early warning of potential cost or schedule problems which require corrective action
- Task Leaders responsible for hands-on monitoring
- Project Management assists in corrective actions
- Controls provided by Project Controls Group
- Changes to cost/schedule baseline subject to Change Control process
- NSF visibility in Quarterly and Annual Reports
- Annual Work Plan will include revisions to baseline

Configuration Management

- LIGO will be managed to a technical, cost, schedule baseline
- Technical configuration will be identified in controlled documents and retained in a Document Control Center
- Changes to technical, cost, schedule baseline requested in writing to Project Controls Manager
- Project Controls Manager reviews request using Integration Meeting and documentation
- Review and request considered by Change Control Board which is the Technical Board
- Result used as input to decision by Project Management
- Configuration and change process to be fully auditable
- Final "as-built' to be verified against configuration

Change Control Thresholds

- Cumulative cost estimate changes within a subsystem which exceed $50,000
- Schedule changes to LIGO system Level 1 (external) or subsystem Level 1 (external) milestones greater than one month
- Interface Control Document changes at subsystem level
- Specification changes at system or subsystem level
- Configuration changes at system or subsystem level
- Burden is to request review in gray areas

Reporting to NSF

- Quarterly Progress Report - Defined in Cooperative Agreement as including summary of work, accomplishments, status against schedule, problem areas and corrective actions, action items with NSF, personnel changes, financial status
- Annual Report - similar but includes summary of work to be performed during succeeding year
- Annual Work Plan - Through Office of Sponsored Research submittal of annual work, funding request, revised cost estimate and schedule
- Caltech Office of Federal Financial Activities submits quarterly reconciliation report against Letter of Credit

Meetings and Reviews

- Internal LIGO meetings
  - » internal technical reviews and design reviews (as needed)
  - » acquisition reviews and source selection meetings
  - » Project Control Meeting (regular)
  - » Integration Meeting (regular)
  - » Technical Board and Change Control Board (regular)
- External Advisory Committee
- LIGO Oversight Committee
- Program Advisory Committee
- NSF Reviews
- Scientific workshops

Cost Estimating Plan

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Basic Requirements

- Standardize procedures for all estimators
- Estimates to be traceable to detailed Basis of Estimate (BOE)
- Estimate organized along WBS with summary Dictionary
- Standardized risk analysis for technical, cost and schedule risks for each item at lowest WBS level yields contingency estimate
- Relational database in SUCCESS in format compatible with project control system to be used in tracking project
- Estimate to be a "Bottom-Up" estimate
- Estimated in 1994 $ but spread over actual years in SUCCESS
- Each WBS item to include labor, materials, contracts, contingency
- NSF provided escalation rates used for "run out" $ estimates

Estimate Basis Types

- Engineering Estimate (EE)
- Vendor Quotation (VQ)
- Placed Order (PO)
- Actual Costs (AC)

Contingency - Risk Analysis

- Contingency (%) = Technical risk factor x Technical risk % +
  Cost risk factor x Cost risk % +
  Schedule risk factor x Schedule risk %
- Risk Factors - from 1 to 15
- Risk Percentages - 1% to 4%
- Range of contingency generated falls between 5% and 98%
- Best technical judgement used to override this specific graded approach to risk analysis

Risk Percentage

	CONDITION	RISK PERCENTAGE
TECHNICAL	Design or mfg concerns only	2%
	Design and mfg concerns	4%
COST	Material cost or labor rate concern	1%
	Material and labor rate concern	2%
SCHEDULE		1%

Risk Factors

Risk factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Labor Rates

- Standardized rates throughout
- Direct funded labor categories for Caltech and MIT based upon composite of known Caltech rates
  - » Scientist
  - » Engineer
  - » Technician
  - » Graduate Student
  - » Undergraduate Student
  - » Manager
  - » Administrative Support
- Contract Labor rates based upon standardized databases

LIGO PROJECT FTE LABOR RATES

SEPTEMBER 1994

In-house Labor Crafts	*$K/FTE-Manmonth*
Administrative Support	7.170
Engineer	11.770
Graduate Student	2.910
Management Staff	16.890
Scientist	10.560
Technician	6.860
Undergraduate Student	2.910

Baseline Implementation

- Proposed in June NSF review to be completed by April, 1995
- Deliverables:
  - » LIGO Science Requirements
  - » Level 1, 2, 3 Specifications including Availability
  - » Detector Implementation Plan
  - » R&D Plan
  - » Document/Drawing Control Plan
  - » Configuration Management Plan and Procedures
  - » Interface Control Plan and Procedures
  - » WBS Dictionary to Level 4
  - » Configuration Identified/Controlled to Level 3 (envelopes, parameters, interfaces)
  - » Responsibility Matrix
  - » Baseline Cost Estimate
  - » Integrated Project Schedule
  - » Performance Measurement Baseline
  - » Financial Status including Earned Value and Estimate to Complete
  - » PreOps/Operations Commissioning Plan (Acceptance and Test)