
LIGO

Status & Overview

Barry Barish

NSF Management Review
April 9-11, 1996

Project Status

Highlights

- Facilities
 - » major contracts underway
 - » final designs
 - » contract management
 - » safety and quality assurance
- Detector/R&D
 - » Seismic design
 - » Lasers
 - » Core Optics
 - » PNI & 40m
- Project Replan
 - » recosting & integrated schedule
 - » taxes
- LIGO Management
 - » reorganization
- Community
 - » LIGO Research Community (LRC)
 - » LIGO Pre Program Advisory Committee (PPAC)

LIGO Facilities

Civil Construction

- Characteristics

- » Structures, Foundation, Roads, etc..
 - Large and Clean Laboratory Bldgs
 - Beam Enclosures
 - Office/Lab Space
- » Requirements
 - Seismic Stability, Noise Sources, etc..
 - Cleanliness

- Status and Plans

- » Sites Status
 - Washington cleared; graded; pouring slab and constructing enclosure
 - Louisiana cleared, grubbed; compacting, building berm underway; pipeline crossings
- » Facilities Design
 - R.M. Parsons - slab, enclosures complete; FDR buildings April 26
 - trade Studies; value engineering
- » Construction Management
 - LIGO/Parsons -- in place in Washington

LIGO Facilities

Civil Construction

Progress since Fall NSF Review

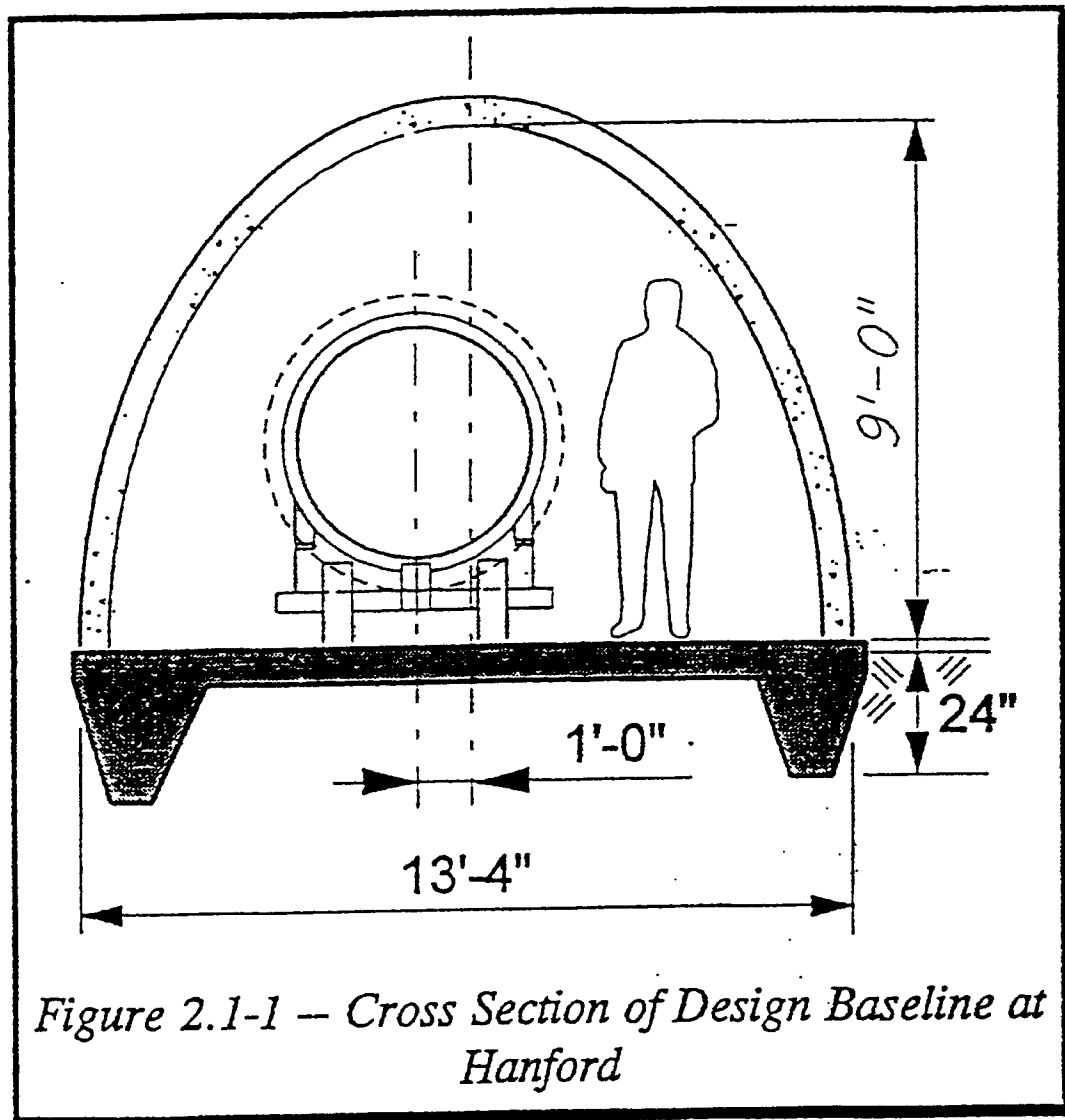
- Slab and Beam Tube Enclosure
 - » Final design beam tube enclosure - 10/95
 - » Contract - ACME Material & Construction (WA)
 - » Began pouring concrete (WA)
- Buildings and Infrastructure
 - » Preliminary design review - Nov 95 (WA)
 - » Detail design packages; FDR April 26 (WA)
 - » Initiate rough grading (LA)

Plans for the Coming Months

- Slab and Beam Tube Enclosure (BTE)
 - » Award contract for BTE installation (WA)
 - » Complete bid package for BTE fabrication (LA)
- Buildings and Infrastructure
 - » FDR April 26 (WA)
 - » Award contract and initiate construction (WA)
 - » Complete rough grading (LA)
 - » Detailed design package (LA)

LIGO Facilities

Beam Tube Enclosure



LIGO Facilities

Vacuum Equipment

● Characteristics

- » Enormous Volume (~20,000 m³)
- » Mostly Standard Vac. Equipment
 - 1st stage roughing - Atm -> 0.1 torr
 - 2nd stage roughing - 0.1 torr -> 10⁻⁶ torr
 - Steady State - Ion/getter pumps.
- » Large Gate Valves (4ft diam)
 - access and flexibility
- » Controls and Monitoring

● Status and Plans

- » Specifications Defined
 - Science Review Complete - 8/94
- » RFP for Design and Manufacturing
 - CBI and PSI awarded design contracts
 - Down-selected PSI 6/95
 - contract initiated 10/95

LIGO Facilities

Vacuum Equipment

Progress since Fall NSF Review

- Beam Tube Deliverables
 - » Pump carts; large gate valves under contract
- Beam Splitter Chamber Prototype
 - » under fabrication
- PSI clean shop space acquired
- Chamber configurations firmed up
- Ion pump order placed

Plans for the Coming Months

- FDR May 22-23
- Large Gate Valve completed
- Complete fabrication of prototype BSC
- Complete testing of small 80K pump
- Acceptance test of first pump cart
- Complete cleaning and viton study

LIGO Facilities

Beam Tube

- Characteristics:
 - » length = 4 km (4 arms)
 - » diameter = 4 ft
 - » volume = 20, 000m³

- Design Contract with CBI
 - » Design report accepted
 - thin wall stainless spiral weld structure
 - 65 foot sections with bellow
 - quality control in material selection, welding, cleaning, etc..
 - » Qualification test -
 - 130 ft section assembled, cleaned, baked and tested -- achieved design

- Construction contract
 - » negotiated option with CB&I (prepared to compete if necessary)
 - » contract placed December 95
 - » update design review - March 27

LIGO Facilities

Beam Tube

Progress since Fall NSF Review

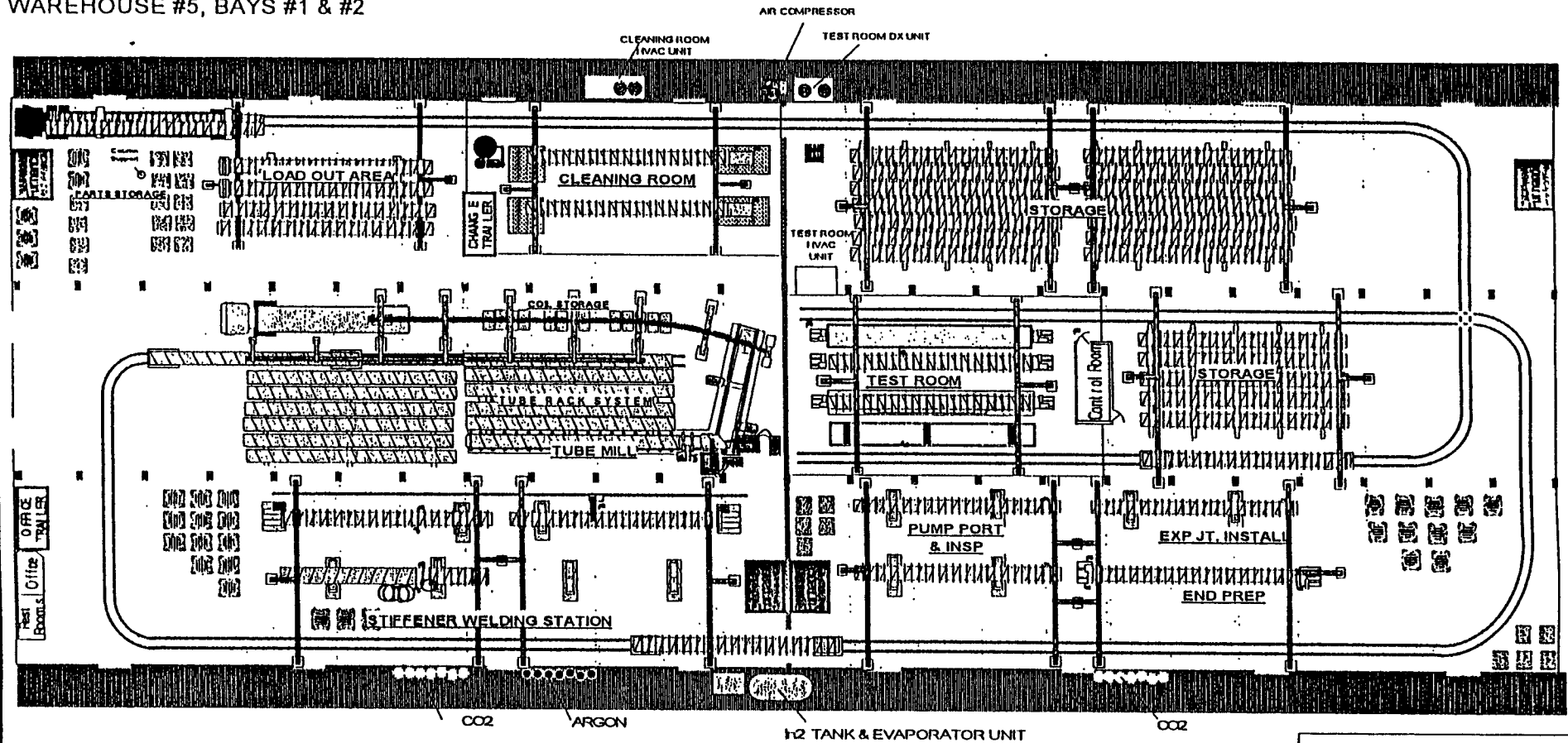
- **Beam Tube - CB&I under contract**
 - » developed management and implementation plans
 - » ordered long lead item
 - » completed design, fab, install plan (review 3/27)
 - » leased fabrication facility
 - » forming fab/install team
- **Baffles**
 - » mechanical design complete; contract awarded
 - » baffle coating completed; issued RFQ

Plans for Coming Months

- **Beam tube**
 - » CBI to qualify spiral tube mill 6/13/96
 - » CBI initiate fabrication 8/16/96
- **Baffles**
 - » LIGO deliver 300 Baffles (WA) 9/1/96
- **Initiate Beam Tube Install 10/15/95**

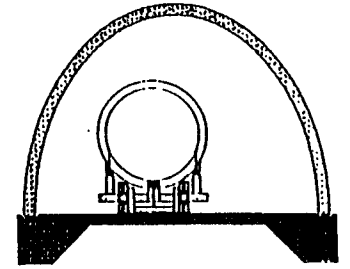
BIG PASCO

WAREHOUSE #5, BAYS #1 & #2



CONTROL SHEET	CB		LABOR SITE/TEMPERATURE GRAVIMETRIC ANALYSIS OBSERVATION
	HANFORD LOCATION FABRICATION FACILITY BIG PASCO WAREHOUSE #5, BAYS 1 & 2		
	Customer ID: PC111320		99-0574
	By: _____	Date: 07/23/98	Page: _____
	Enclosure Size Factor: _____		
BIGPAS01.CVS			

LIGO INSTALLATION PLAN



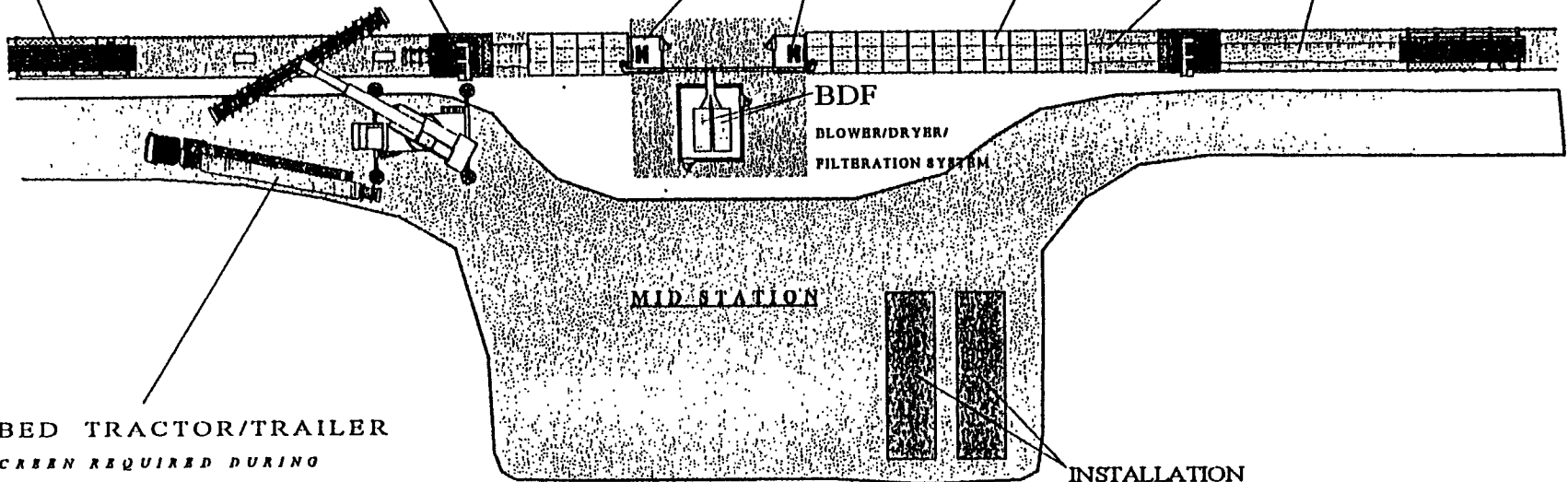
WHEELED
CLEAN ROOM

WHEELED WELD/
TEST SHELTER

TERMINATION
STRUCTURE
& VALVE

CONCRETE
COVER

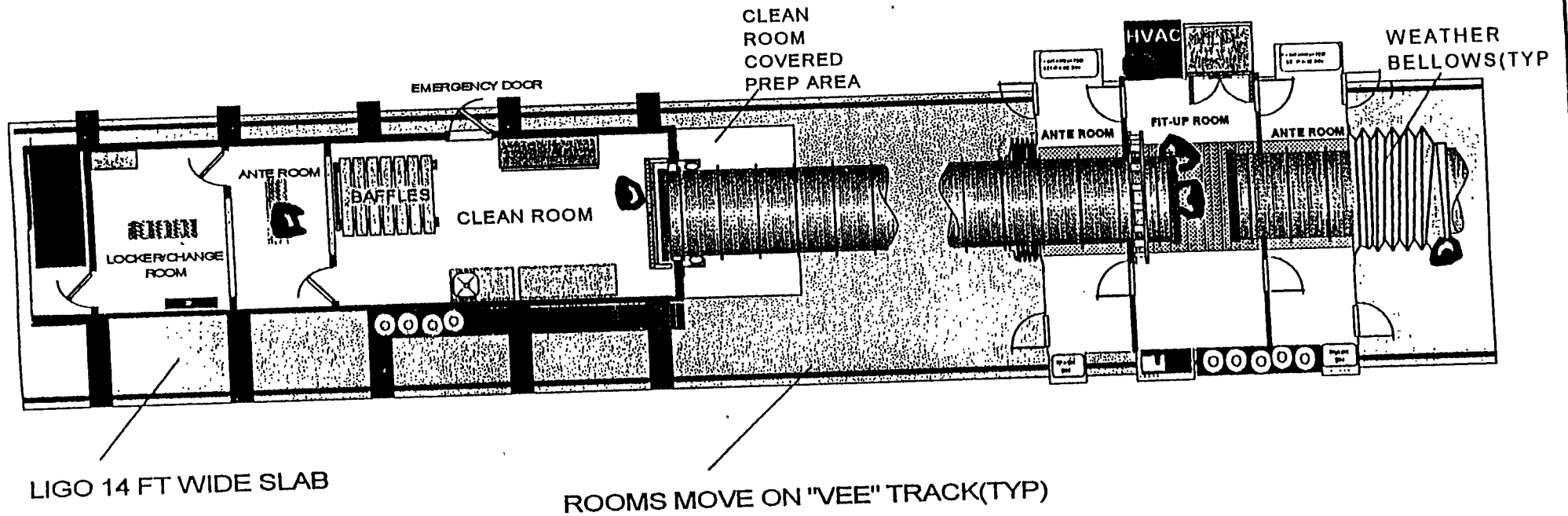
SUN SCREEN
COVER



FLATBED TRACTOR/TRAILER
(SUN SCREEN REQUIRED DURING
TRANSPORT)

INSTALLATION
CHANGE &
OFFICE TRAILERS

INSTALLATION PLAN



LIGO

R&D Program

- Sensitivity
 - » main features of 40 m spectrum understood
 - » monolithic test masses improve sensitivity
- Demonstration Experiments
 - » optical recombination demonstrated on 40 m
 - » acquisition locking with LIGO controls
 - » MIT phase noise experiments
- Pre- [detector design freeze][<1998]
 - » Program testing directed at tasks that could effect design over the next two years
- Post- [detector design freeze][>1998]
 - » Advanced R&D program on techniques for improved sensitivity;
 - » understand performance - initial interferometer
 - » gain experience running an interferometer facility (perform search)

LIGO

R&D/Detector

Progress since Fall NSF Review

- Core Optics conceptual design
 - » adapted for new laser (completed)
- Core Optics Pathfinder
 - » polishing contracts (completed)
- Nd:YAG Laser
 - » RFP issued; proposal evaluations underway
- Length Sensing and Control
 - » Topology defined
- Seismic Isolation
 - » design initiated at HYTEC (trade studies)
- Global CDs Network
 - » Conceptual design complete
- Test Mass Suspension
 - » New prototype fabricated for 40m tests
- PNI Recycling Mirror Installed
- Prestabilized Laser - computer control

LIGO

Integration/System Eng.

- Establish science goals for initial and improved detectors

- Establish systems requirements

- Interfaces
 - » facilities, detector

- Installation/Commissioning Plan

- Modeling
 - » environment - AVS
 - » end to end model - underway
 - » lock acquisition, optics, etc
 - » help final design and understand performance

- Data Analysis Group

LIGO

Integration/System Eng.

Progress since Fall NSF Review

- Facilities Monitoring and Controls
 - » Systems requirements definition
- LVEA/VEA slab thickness resolution
- Site alignment requirements defined
- Science requirements document
 - » under configuration control
- All major ICDs issued
- Implemented integrated layout drawing management system
- LIGO IFO frequency domain model implemented in AVS
- Parallelization of LIGO diffractive propagation model
- Implement AVS based noise model modules for IFO noise floor predictions

LIGO

Integration/System Eng.

Plans for the coming Months

- Data formats and analysis w/ VIRGO
- Issue systems plan for reliability
- Refined integration plan beyond '95 operations proposal
- Initiate 3D chamber layout and integration details
- Conduct system level configuration audit (after facilities FDRs complete)

LIGO Management

Approach

Project Revalidation

- LIGO Cost Estimate and Schedule
 - » approved 9/94
- PMP Submitted to NSF
 - » submitted 12/94
- Project Operates under the PMP
 - » draft modifications 4/95

NSB Revalidation & Budget Approval

- Construction + R&D Budget - \$292.1M
 - » Construction Completed in 1999
- Commissioning/Operations - \$68.7M
 - » Commissioning Commences in 1997
 - » 3-fold Sensitivity 10^{-20} by July 2000
 - » First Search for Gravitational Waves
 - » Sensitivity 10^{-21} by end of 2001
- Established as our Working Baselines

LIGO

Approved Funding

Fiscal Year	Construction	R&D	Operations	Total
1992	\$15.9M	\$3.2M		\$19.1M
1993	\$20.0M	\$4.0M		\$24.0M
1994	0	\$4.0M		\$4.0M
1995	\$85.0M	\$4.0M		\$89.0M
1996	\$55.0M	\$4.0M		\$59.0M
1997	\$55.0M	\$0.8M	\$0.3M	\$56.1M
1998	\$41.2M		\$7.3M	\$48.5M
1999			\$20.9M	\$20.9M
2000			\$21.1M	\$21.1M
2001			\$19.1M	\$19.1M
Total	\$272.1M	\$20.0M	\$68.7M	\$360.8M

LIGO

Replan & Reorganization

- Reorganization for construction phase
 - » strengthen top level leadership; technical configuration management; integrated detector/R&D effort; viable subsystems

- Integrated Schedule
 - » Include all contractors schedules
 - » includes facility delays LA; Nd:YAG change
 - » integrated with operations schedule

- Resource loaded budget plan
 - » includes new schedule and impacts
 - » includes all contracts
 - » includes all CCB actions
 - » includes other new costing where available



Project Management
 Principal Investigator:
B. Barish
 Project Manager:
G. Sanders

LIGO Principal Scientist:
R. Vogt

Administrative Group
 Admin. Assist.:
B. Moore

Project Controls Group
 Manager:
P. Lindquist
 Technical Configuration Manager:
W. Athouse

Integration Group
 System Engineer:
A. Lazzarini
 Deputy:
D. Coyne
 Integration Scientist:
R. Weiss

LIGO External Advisory Committee

LIGO Program Advisory Committee

PI Advisory Group
L. Allen
C. Canizares
G. Giberson
E. Moniz
T. Phillips
T. Tombrello

Community Research Coordinator
S. Meshkov

Quality Assurance Officer
W. Tyler

Environment, Safety & Health Officer
B. Lucas

Science Education Program
TBD

Industrial Liaison Program
TBD

Technical Board

Remote Site Planning
 Hanford Site:
F. Raab
 Livingston Site:
M. Coles

Project Office

Groups

Facilities Group
 Leader:
M. Coles
 Deputy:
G. Stapfer

Detector Group
 Group Leader: *S. Whitcomb*
 Deputy Group Leader: *D. Shoemaker*
 Detector Eng.: *TBD*
 Programmatics: *R. Fischer*

Tasks

Det. Site Implementation and Operations
F. Raab & M. Coles
40 m Interferometer
R. Spero

Civil Construction
 Task Leader:
F. Asiri
 Cog. Scientist:
R. Savage

Beam Tube
 Task Leader:
L. Jones
 Cog. Scientist:
R. Weiss

Vacuum Equipment
 Task Leader:
J. Worden
 Cog. Scientist:
M. Zyker

Lasers and Optics
 Task Leader:
S. Whitcomb (Acting)

Suspensions and Isolation
 Task Leader:
F. Raab (Acting)

Interferometer Sensing & Control
 Task Leader:
M. Zucker

Control & Data Systems
 Task Leader:
R. Bork



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 Programatics: *R. Fischer*

Det. Site Implementation and Operations
F. Raab & M. Coles
 40 m Interferometer
R. Spero

Civil Construction Task Leader:
F. Asiri

Beam Tube Task Leader:
L. Jones

Vacuum Equipment Task Leader:
J. Wordan

Lasers and Optics Task Leader:
S. Whitcomb (Acting)

Suspensions and Isolation Task Leader:
F. Raab (Acting)

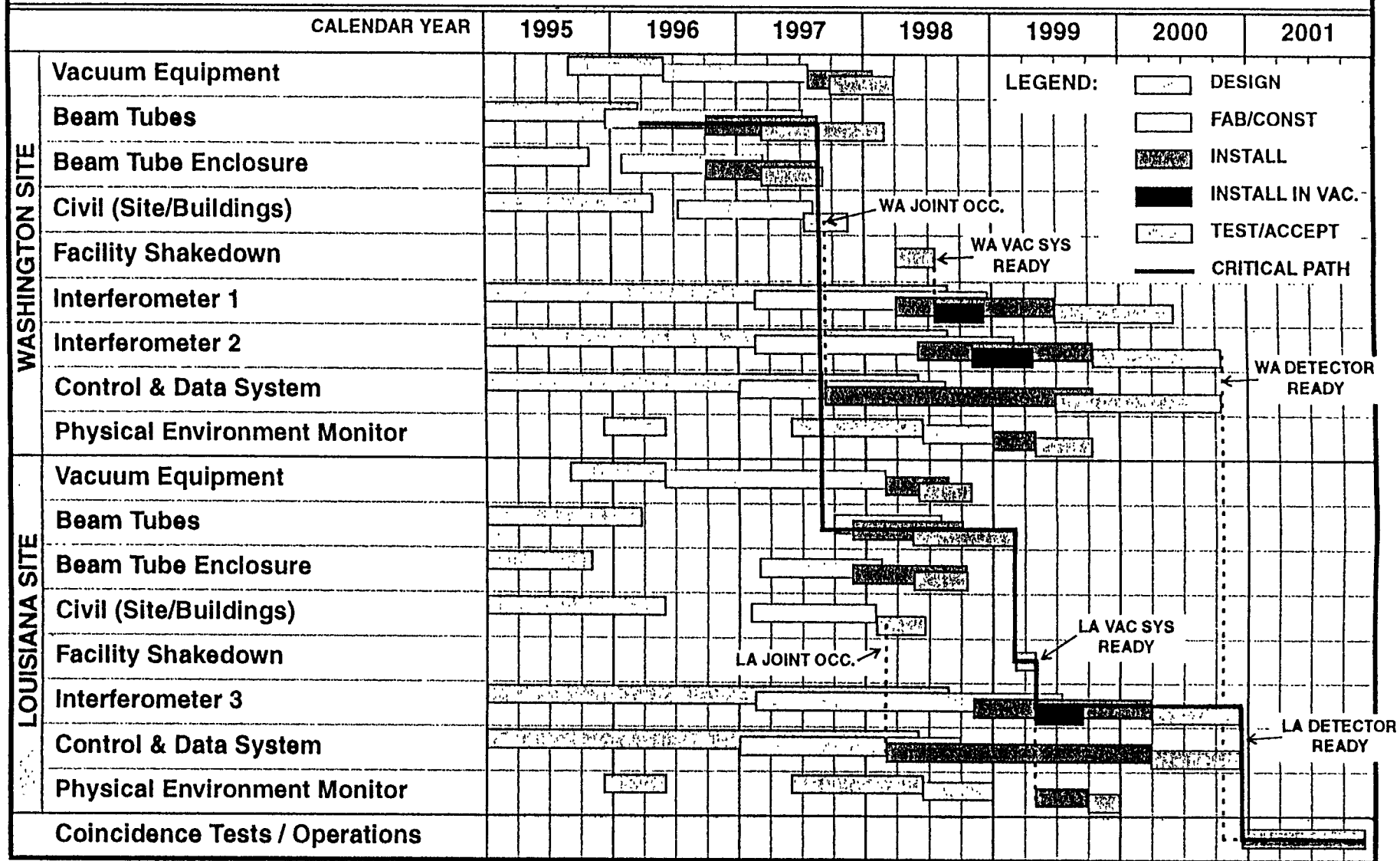
Interferometer Sensing & Control Task Leader:
M. Zucker

Control & Data Systems Task Leader:
R. Bark

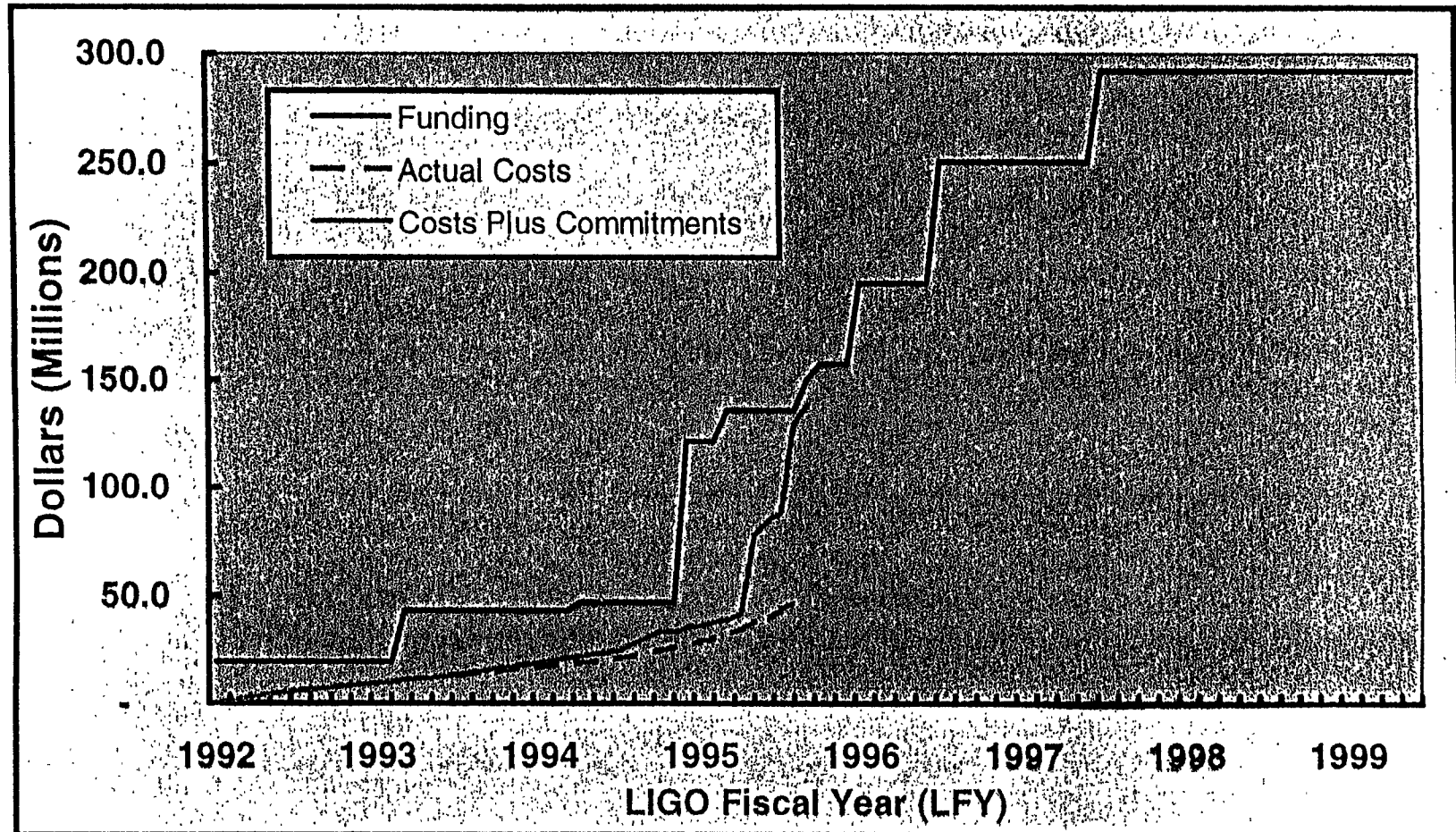
Integrated Schedules

- Subcontractor schedule plans have been entered into the integrated cost/schedule **PMB**.
- Analysis of contractor scheduling contingencies and potential contractor interference is underway (continuing) to improve schedule robustness and work-around response times.
- Facility construction and Detector design/fabrication, installation, and commissioning schedules have been integrated.
- The Detector installation schedules connect to the Facilities schedule at two points at each site (Joint Occupancy and Facility Shakedown Complete). As schedule evolves, the installation plans will be further optimized.
- The critical path for Facilities construction is the fabrication and installation of the beam tubes (LA doesn't start until WA is completed and CBI moves their equipment).
- The critical path for Detector installation and commissioning is determined by the Facilities Shakedown completion in LA.
- The most critical paths in the Detector design/fabrication are production of the Core Optics components, design/production of the Seismic Isolation stacks, and design/development of the Nd:YAG Prestabilized Laser subsystem.

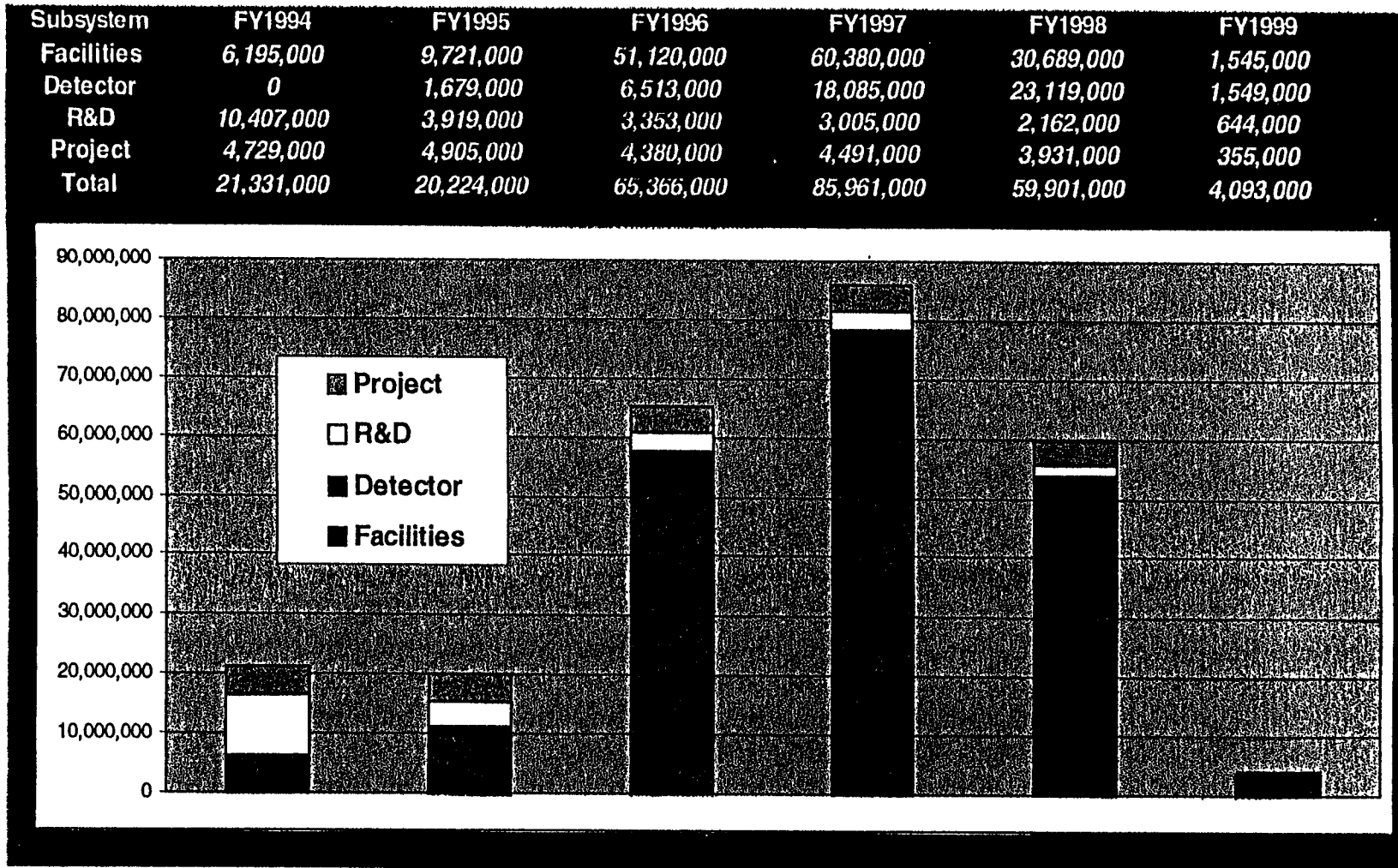
SUMMARY INTEGRATED SCHEDULE



LIGO Actual Costs and Commitments



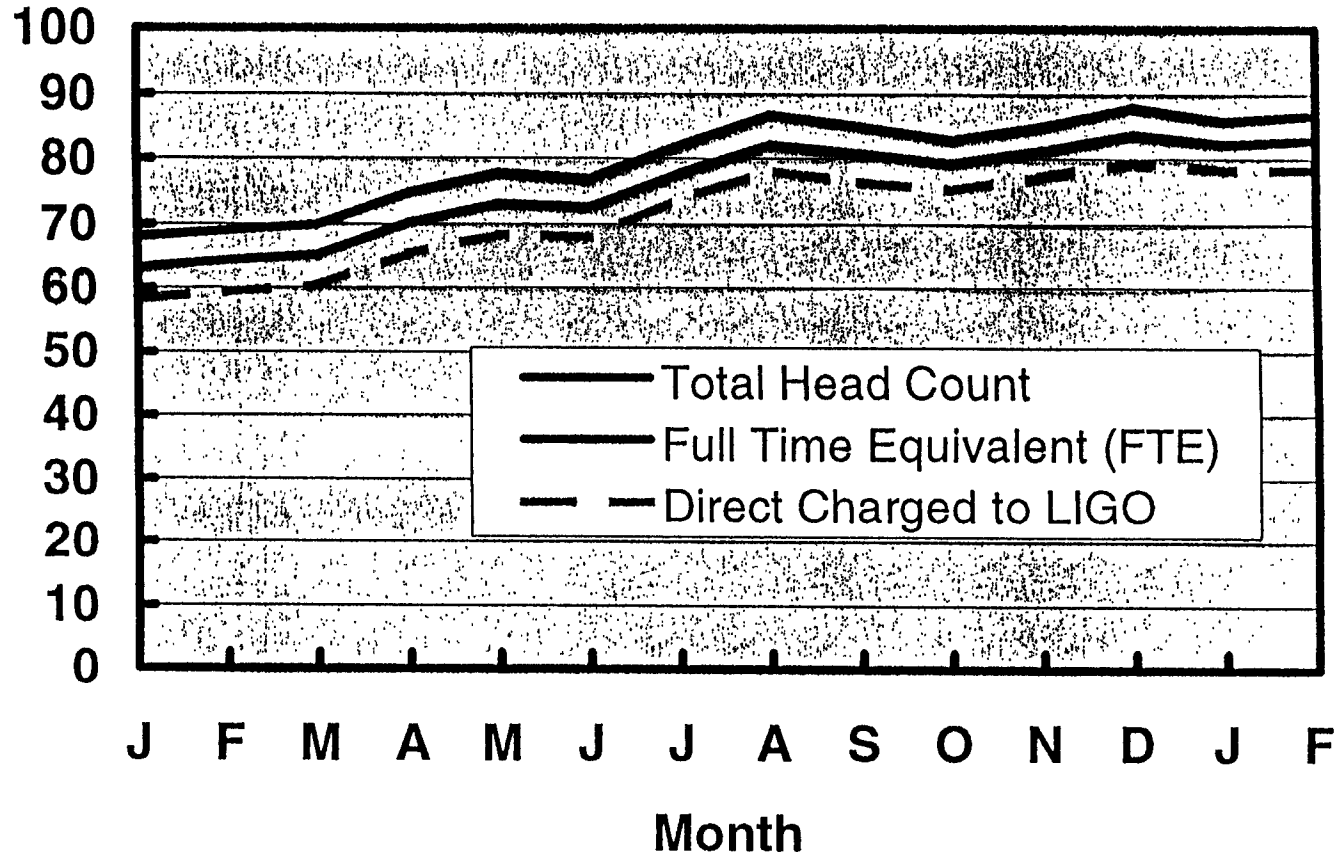
New LIGO Construction Budget Baseline



Replan (continued)

- Contingency Status and Analysis
- Staffing Status and Analysis
- Out of Scope Items
 - »Increased Staff (NSF Panel recommend) ~\$3M
 - »Tax liabilities ~\$16M (before reduction)
 - »road in LA (~+\$0.5M State of LA)
 - »pipelines (~\$0.5M)
 - »Nd:YAG (~\$3.M moved from postconstruction)

Current LIGO Staffing



LIGO Staffing

Head Count

Task	Caltech	MIT	Total
Proj Mgt	4	0	4
Admin	6	2	8
P Control	8	0	8
Syst Int	6	1	7
Facilities	7	0	7
Detector	17	2	19
R&D	10	7	17
Grad Stud	4	5	9
TOTAL	62	17	79

LIGO

Major Contingency Actions

- Number Change Requests: 49
- Approved: 23
- Pending: 18

Significant (>\$1M) Change Actions

Change Request No.	Description	Submittal Date	Disposition Date	\$ Amount
CR-95008	Vacuum Equipment - Getter Pumps Remove TMC Chambers (Design,	5/3/95	5/31/95	\$ (1,685,000.00)
CR-950014	Fab, Installation, Test)	7/25/95	7/14/95	\$ (1,677,000.00)
CR-950019	1.1.1 - Vacuum Equipment, Adjustment to Negotiated Price	9/22/95	9/25/95	\$ 1,003,000.00
CR-950022	1.4.4.2 General Computing - Increase Budget to Cover Scope	9/25/95	10/16/95	\$ 1,318,782.00
CR-950024	1.1.2 Request for Funds for Beam Tube Contract	11/14/95	11/16/95	\$ 4,257,000.00
CR-960007	1.2 - Detector, Increases Due to Conversion to Nd:YAG Laser	2/6/96	2/9/96	\$ 3,390,000.00

LIGO Project Change Request Log

Change Request No.	Description	Submitted By	Submittal Date	Client Status	Disposition Date	Baseline Date	Net Contingency
CR-950001	Improve Beam Tube Cleaning Process	L. Jones	April 14, 1995	Approved \$137,000	May 1, 1995 L950334		\$42,095,000
CR-950002	Reduce Field Module Bake Time to 5 Days	L. Jones	April 14, 1995				
CR-950003	Develop Spiral Weld Procedure/QA Procedure (to assure adequate weld penetration)	L. Jones	April 14, 1995				
CR - 950004	Advanced Procurement of 10 RGA's	L. Jones	April 14, 1995				
CR-950005B	Contract for clearing Livingston site	F. Asiri	April 21, 1995	Approved \$135,735	May 1, 1995 L950334		\$41,959,265
CR-950006	Revisions to Project Office Budget Baseline	P. Lindquist	April 22, 1995	Replaced by CR-950010			
CR-950007	Vacuum Equipment - Change Specification to Rev 1 (Tube Termination Interface)	J. Worden	May 3, 1995	Approved	May 31, 1995 L950472		
CR-950008	Vacuum Equipment - Getter Pumps	J. Worden	May 3, 1995	Approved (\$1,685,000)	May 31, 1995 L950472	Sept. 1995	\$43,644,265
CR-950009	Test Beam Tube Expansion Joint to Failure	L. Jones	May 10, 1995	On Hold	May 15, 1995 L950372		
CR-950010	FY 1994 Actual Cost Allocation	P. Lindquist	May 12, 1995	Approved \$584,000	May 15, 1995 L950372	May 1995	\$42,232,000

LIGO Project Change Request Log

Change Request No	Description	Submitted By	Submittal Date	Current Status	Disposition Date	Baseline Date	Net Contingency
CR-950011	Beam Tube Factory Fabrication	R. Weiss	April 27, 1995				
CR-950012	Vacuum Equipment - 48 inch Gate Valves	J. Worden	July 12, 1995	Replaced by CR-950015			
CR-950013	Facilities Final Design Concept and Direction to Parsons	F. Asiri	July 21, 1995	Approved	July 24, 1995 L950576		
CR-950014	Remove TMC Chambers (Design, Fab, Installation, Test)	J. Worden	July 25, 1995	Approved (\$1,677,000)	Aug 14, 1995 L950630	Sept. 1995	\$45,321,265
CR-950015	Vacuum Equipment - 48 inch Gate Valves/80K Pumps	J. Worden	August 4, 1995	Approved	Aug 14, 1995 L950630		
CR-950016	LA Rough Grading - Pipeline Crossings	F. Asiri/R. Fischer	August 14, 1995	Approved \$520,000	Aug 14, 1995 L950630	Sept. 1995	\$44,801,265
CR-950017	1.1 Facilities and Vacuum Systems - Update LIGO Arm Layouts	L. Jones	August 15, 1995				
CR-950018 Rev A	1.1.2.1.2.2 Beam Tube Design Contract - Beam Tube Baffle Drawings	L. Jones	September 25, 1995	Withdrawn	Oct 16, 1995 L950800		
CR-950019	1.1.1 - Vacuum Equipment, adjustment to negotiated price	J. Worden/F. Fernandez	September 22, 1995	Approved \$1,003,000	Sept 25, 1995 L950751	Feb. 1996	\$43,798,265

LIGO Project Change Request Log

Change Request No	Description	Submitted By	Submittal Date	Current Status	Disposition Date	Baseline Date	Net Contin- gency
CR-950020	1.4 Project Management Plan, Rev B	G. Sanders	September 25, 1995	Approved no cost	Sept 27, 1995 L950751		
CR-950021	1.1 Facilities and Beam Tube - Update Interface Drawings (D950029 and D950093)	A. Lazzarini	September 25, 1995				
CR-950022	1.4.4.2 General Computing - increase budget to cover scope	A. Lazzarini	September 25, 1995	Approved \$1,318,782	Oct 16, 1995 L950800	Feb. 1996	\$42,479,483
CR-950023	1.1.3 TDM to Parsons Regarding Hanford Beam Tube Enclosure	F. Asiri	October 23, 1995	Approved no cost	Oct 25, 1995 L950834		
CR-950024	1.1.2 Request for funds for Beam Tube Contract	L. Jones	November 14, 1995	\$4,257,000	November 16, 1995 L950903	Feb. 1996	\$38,222,483
CR-950025	1.1.4 Expand End Stations at Hanford to Accommodate Two Full-Length Interferometers	R. Savage	November 15, 1995	\$200,000	November 16, 1995 L950903	Feb. 1996	\$38,022,483
CR-950026	1.1.4 - TDM 95-16 to Parsons to Approve Preliminary Design Draft Report	F. Asiri	November 20, 1995	No cost	November 20, 1995 L950912	Feb. 1996	\$38,022,483
CR-950027	1.1.4 - Observation Deck above LVEA	F. Asiri	December 1, 1995	\$15,731 Construction: NTE \$80K	December 4, 1995 L950950	Feb. 1996	\$38,006,752

LIGO Project Change Request Log

Change Request No.	Description	Submitted By	Submittal Date	Current Status	Disposition Date	Baseline Date	Net Contingency
CR-950028	1.1.4 - Increase LVEA area at Hanford to accommodate three interferometers	F. Asiri	December 1, 1995	\$150,067 Construction: Est. \$1.3M	December 4, 1995 L950912	Feb. 1996	\$37,856,685
CR-960001	1.1.4 - Facilities Monitoring and Control System enhancements	F. Asiri x2971	January 11, 1996	\$240,000			
CR-960002	1.1.1 - Vacuum Equipment, WA Beam Manifold	J. Worden x4438	January 26, 1996	\$200,557	January 26, 1996 L960066	Feb. 1996	\$38,057,242
CR-960003	1.1.1 - Vacuum Equipment, Corner Station Pipe Bridges	J. Worden x4438	January 26, 1996		January 26, 1996 L960066	Feb. 1996	\$38,057,242
CR-960004	1.1.1 - Vacuum Equipment, Roughing Pump Fail-safe Valves	J. Worden x4438	January 26, 1996		January 26, 1996 L960066	Feb. 1996	\$38,057,242
CR-960005	1.1.1 - Vacuum Equipment, Main Ion Pump Auxiliary Ports	J. Worden x4438	January 31, 1996	Notification Only \$9,854	January 31, 1996 L960095	Feb. 1996	\$38,047,388
CR-960006	1.1.2 - Beam Tube and Beam Tube Enclosure Model	L. Jones x2970	February 5, 1996	\$40,600	February 9, 1996 L960108	Feb. 1996	
CR-960007	1.2 - Detector, Increases Due to Conversion to Nd:YAG Laser	S. Whitcomb x2131	February 7, 1996	\$3,390,000	February 9, 1996 L960108	Feb. 1996	

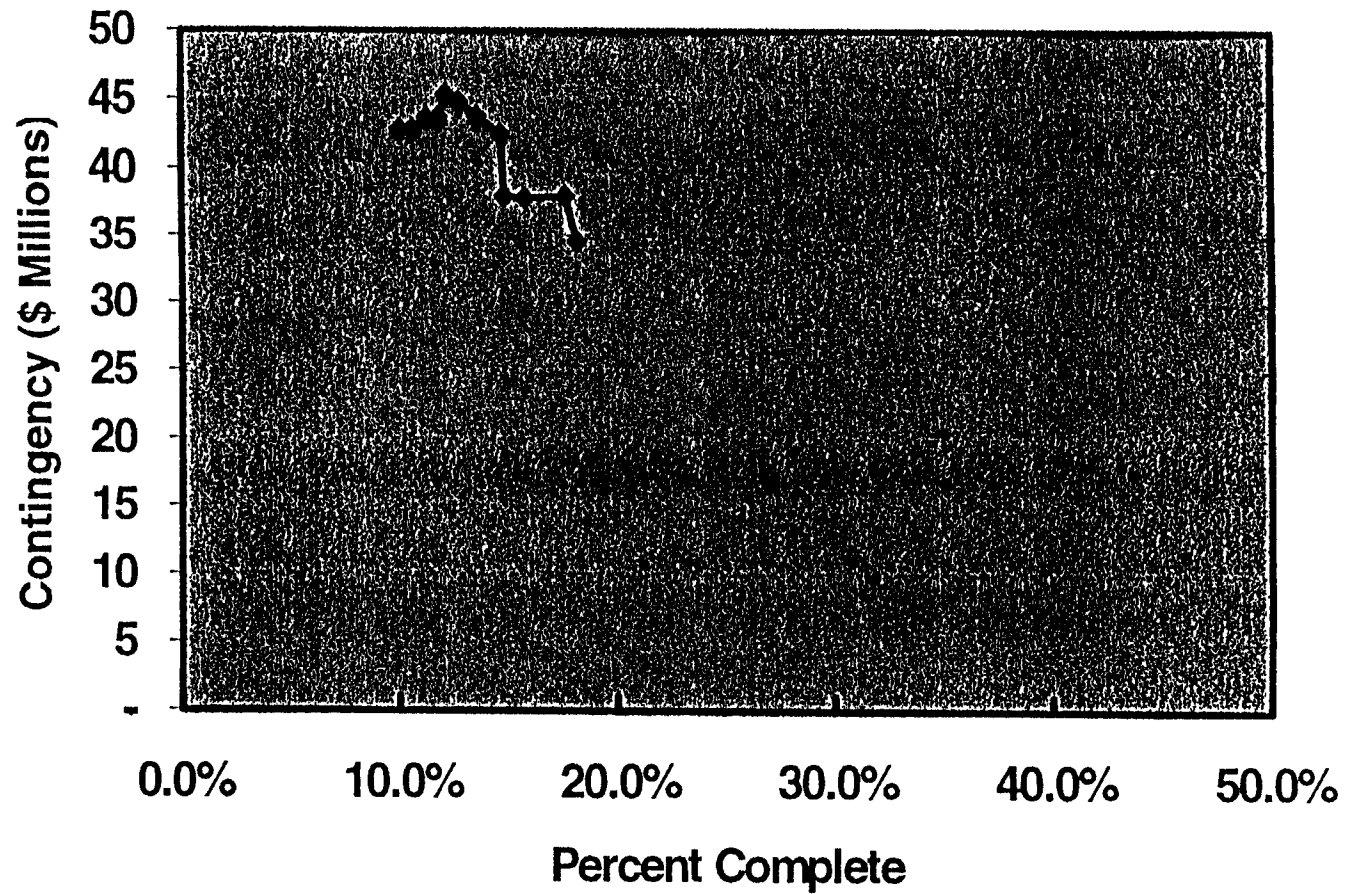
LIGO Project Change Request Log

Change Request No.	Description	Submitted By	Submittal Date	Current Status	Disposition Date	Baseline Date	Net Contingency
CR-960008	1.1.1 Vacuum Equipment - Gate Valve Weld Stubs	J. Worden x4438	February 6, 1996	Notification Only \$17,953	February 9, 1996	Feb. 1996	\$34,598,835
CR-960009B	1.4.1.1 Project Office - Allocation of Labor Charges	P. Lindquist x3193	March 30, 1996	Pending \$1,720,000			
CR-960010A	1.1.1 Vacuum Equipment - BSC Removable Spool Sections	J. Worden x4438	March 7, 1996	Approved \$110,000	March 11, 1996 L960201		\$35,110,924
CR-960011	1.1.1 Vacuum Equipment - BSC Floors (reduced number, increased loading)	J. Worden x4438	March 1, 1996	Approved \$11,962	March 4, 1996 L960180		\$34,586,873
CR-960012	1.1.1 Vacuum Equipment - Chillers for Deliverable Pump Carts	J. Worden x4438	March 1, 1996	Approved \$62,145	March 4, 1996 L960180		\$34,524,728
CR-960013	1.1.1 Vacuum Equipment - Reduce budget for miscellaneous	J. Worden x4438	March 1, 1996	Approved \$(700,000)	March 4, 1996 L960180		\$35,224,728
CR-960014	1.1.1 Vacuum Equipment - BTD Pump Cart modifications	J. Worden x4438	March 4, 1996	Approved \$40,031	March 4, 1996 L960180		\$35,184,697
CR-960015	1.1.1 Vacuum Equipment - Annulus Conductance Specification	J. Worden x4438	March 4, 1996	Approved (\$41,427)	March 4, 1996 L960180		\$35,226,124

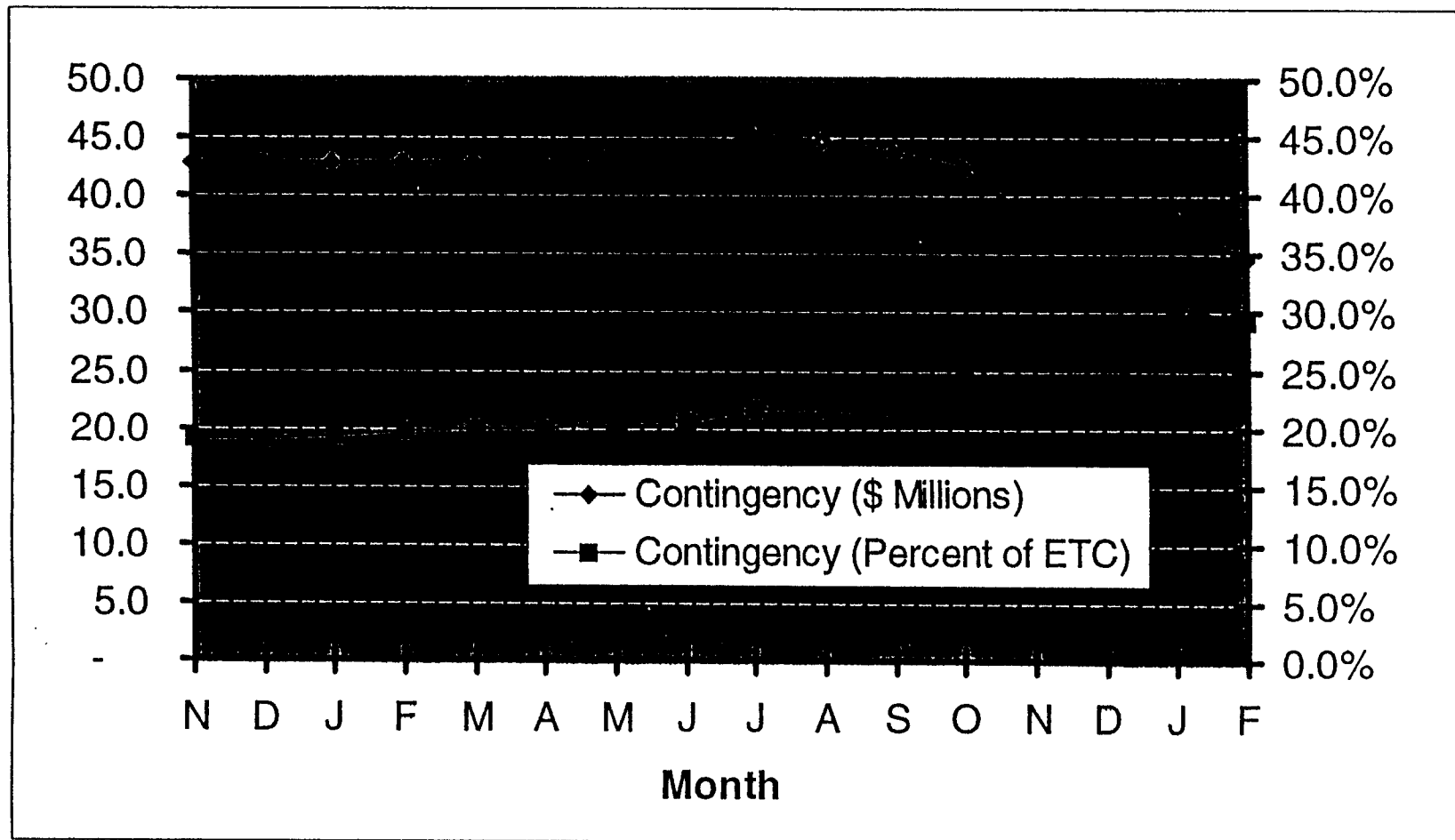
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Change Request No.	Description	Submitted By	Submittal Date	Current Status	Disposition Date	Baseline Date	Net Contingency
CR-960016	WBS 1.1.3 Beam Tube Enclosure, Hanford - shift Access Module centerline	D. Coyne	March 4, 1996	Approved \$5200	March 4, 1996 L960180		35,220,924
CR-960017	WBS 1.4.1.1 Project Management Plan - NSF Reporting Milestones	P. Lindquist	March 18, 1996	Pending additional information			

Contingency vs. Percent Complete



LIGO Contingency vs. Time



LIGO

Increased Staffing

- Project Management +2FTE/yr
- Vacuum Engineering +2 FTE/yr
- QA/Safety +1FTE/yr
- Civil Construction +1FTE/yr.
- etc

TOTAL: ~15 FTE-yr = \$3M

LIGO

Tax Reductions

- Washington

- » Special tax legislation passed by the Washington State legislature eliminates most LIGO sales and use taxes -- value ~\$7M (signed by the Governor and effective on March 20, 1996)
- » Potential additional tax liability ~\$0.75M (few ways to reduce)

- Louisiana

- » State Board of Industry and Commerce approved a LIGO Economic Development Zone which provides for a 4% rebate on sales and use taxes paid. (Approx. value ~\$4M)
- » Potential additional tax liability ~\$4M.
(Reduction of much of this will come from Cooperative Agreement modification to vest LIGO property immediately to the government. This language is to be included in all LIGO Louisiana subcontracts to receive a total tax exemption) Remaining tax liability ~\$1.25M



CERTIFICATION OF ENROLLMENT

SENATE BILL 6511

Chapter 113, Laws of 1996

54th Legislature
1996 Regular Session

EFFECTIVE DATE: March 20, 1996

Passed by the Senate March 7, 1996
YEAS 47 NAYS 0

Paul R. Hutchins
President of the Senate

Passed by the House March 7, 1996
YEAS 97 NAYS 0

Deane L. Cox
Speaker of the
House of Representatives

Approved March 20, 1996

Nike Torrey
Governor of the State of Washington

CERTIFICATE

I, Marty Brown, Secretary of the Senate of the State of Washington, do hereby certify that the attached is **SENATE BILL 6511** as passed by the Senate and the House of Representatives on the dates hereon set forth.

Marty Brown
Secretary

FILED

MAR 20 1996

Time 10:09 a.m.

Secretary of State
State of Washington

LIGO

Commissioning/Operations

- Management for Hanford:
 - » F. Raab (Head)
 - » O. Matherny (Facilities Manager)
 - » J. Worden (Vacuum Engineer)

- Management for Livingston
 - » M. Coles (Head)
 - » G. Stapfer (Facilities Manager)
 - » A. Sibley (Vacuum Engineer)

- MIT / Caltech
 - » installation, support operations and running
 - » advanced detector development
 - » data analysis and physics

Undergraduate Students with LIGO-Caltech

- 1996 Goal
 - »» To significantly enhance the presence and impact of undergraduates on LIGO
- Objectives
 - »» To provide research experience for UG's
 - »» To liven up LIGO R&D

Funding

- »» NSF: REU and LIGO \$s
- »» Caltech: SURF Fellowships

I. SURF = Summer Undergraduate Research Fellowship Program (<http://www.cco.caltech.edu/~surf/>)

- SURF Fellowships awarded by Caltech on the basis of student proposals (developed under guidance of potential research supervisors) in international competition. SURF Fellows are required to deliver final research paper.
- SURF stipend: \$3,600 / 10 weeks
- Duration of SURF season: 10 weeks (summer term)



,1996: 10 SURF students on LIGO, individually supervised by senior scientist mentors (7 Caltech, 2 Cambridge, UK, 1 Leicester, UK)

II. UGRA = Undergraduate Research Assistant Program

»»UGRA students selected by LIGO staff

»»UGRA stipends: ~ \$7.20 - \$13.75 / hour

»»Duration of season: potentially multi-year

1996: 6 UGRA students, individually supervised by senior scientist mentors.

1996 SURF R&D PROJECTS

- Laboratory study of high-Q materials and damping methods of LIGO test mass suspensions
- Laboratory development of high power laser cavity apparatus for vacuum qualification of LIGO detector materials (mirror contamination!)
- Development of user friendly software for FFT modeling of LIGO detector with LIGO/SUN-Caltech/PARAGON parallel processor system (front-end)
- Development of optimized parallel processor FFT software for the LIGO/SUN-Caltech/PARAGON system (back-end)
- Design and testing of servo amplifier for recycled 40m IFO
- Laboratory development of automated alignment system for laser beam into 40m IFO mode cleaner
- Laboratory development of automated lock acquisition of optical lever based alignment system for 40m IFO
- Study (FEA) of thermal and thermoelastic effects of high power laser beams on LIGO optics
- Analysis of 40m IFO slow monitor data for system effects and signal noise
- Development of 3-d contour software for modeling of locking sequence of IFO with 4 degrees of freedom



1996 UGRA R&D Projects

- Laboratory development of RTS (reflection, transmission, scattering) apparatus for characterization of LIGO optics
- Testing and performance analysis of LIGO detector electronic modules
- Parameter and performance analysis of LIGO core optics components from FFT modeling
- Development of 40m IFO diagnostics from analysis of time-domain data
- Laboratory development of servo control for optical lever beam drift in 40m IFO
- Laboratory development of calibration verification for 40m IFO with external interferometer
- LIGO / SUN system design activities

LIGO Status and Plans

Conclusions

- The LIGO Project
 - » technical considerations for civil construction and vacuum systems in hand
 - » major contracts established and actual construction of facilities well underway
- R&D and Detector design
 - » active and productive R&D program
 - » developing the detector design
 - » reconcile with requirements
- Detailed site planning underway
 - » staffing and organization
 - » plan for installation, commissioning and operations
 - » integration with the construction schedule
- Outside community being included, informed and organized

LIGO

Program Advisory Committee

- Pre Program Advisory Committee
 - » Members - Saulson (ch), Prescott, Hamilton, Reudiger, Giazotto, Finn
 - » Fall meeting: Formed charter and suggested members for the LIGO Research Community (LRC)
 - » Spring Meeting: Formed charter and suggested members for the LIGO Program Advisory Committee
 - » Recommended we not implement the External Advisory Committee