LIGO Project Status

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NSF Technical Review

October 22-24, 1996

This Talk

- Technical Status
- Cost/Schedule Status
  - ››covered mainly in this talk as emphasis in this review is technical
- Evolution of LIGO Organization
  - ››LIGO Collaboration and LIGO Laboratory
  - ››LIGO Program Advisory Committee

LIGO Construction is 34% complete!

Technical Highlights - Vacuum Equipment

- Vacuum Chambers
  - ›› First BSC article built and tested, outgassing data available
  - ››PSI has placed full BSC chamber contracts and is fabricating HAM chambers in-house
- Gate Valves
  - ›› First two large valves are on site
    - — One is installed on slab
  - ›› Much learned during first article testing of operation and shock
- Pump sets, bellows, bakeout equipment, etc. now being fabricated
  - ›› Deliverables for Hanford Beam Tube installation are nearly complete

Vacuum Equipment System Cartoon

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Beam Splitter Chamber

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48” Gate Valve Body

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Technical Highlights - Beam Tube

- Beam Tube Fabrication is qualified and underway in the field
  - ›› materials conformance, spiral welding, other welding, leak checking, and cleaning have been qualified, verifying major technical risks are under control
  - ›› ~50 tubes fabricated and no leaks in 28 checked
- Installation is ready to proceed
  - ››Installation Readiness Review successfully completed last Thursday
- 300 baffles ready for installation at Hanford
- CB&I team performing very well and LIGO team witnessing all operations

Big Pasco CB&I Fabrication Plan View

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Stainless Steel Delivery

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Spiral Mill

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Stiffening Ring Welding

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Segment Vacuum Testing Cask

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Expansion Joint at Fab. Readiness Review

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Weiss Lecturing to CB&I Boilermakers

Installation Cartoon Plan View

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Installation Cartoon Detail

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Technical Highlights - Hanford Civil Construction

- Hanford beam tube enclosures construction very far along
  - ›› ~1400 enclosures fabricated, rejection rate ~1%
- Hanford site concrete work nearly done
- Hanford buildings construction 7% complete

Beam Tube Enclosures at Fab. Site - Aerial View

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Enclosure Segment Installation

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LVEA Aerial View

Technical Highlights - Livingston Construction

- Livingston rough grading essentially complete (The rain is not mainly in Spain!)
- Livingston concrete and building packages bids opened on October 15

Contract	LIGO Cost Book	Bid Price
Slab, Enclosures, Roads, Enc. Inst.	$9.2 million	$8.8 million
Buildings	$13.39 million	$13.46

- These contracts are the last of the very large LIGO contracts, marking LIGO passage beyond major bid jeopardy

  ›› we must now manage these fixed price contracts to the contract cost

Livingston Site View 1

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Livingston Site View 2

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Technical Highlights - R&D

- MIT Phase Noise Interferometer

  ››Demonstration of phase sensitivity 3.5×10^{-10} rad/√Hz, to the best of our knowledge the highest optical phase sensitivity ever, and only a factor of 3 less than the LIGO goal

- CIT 40 Meter Interferometer

  ››Successful test of single loop suspension

  ››Completion of optical recombination

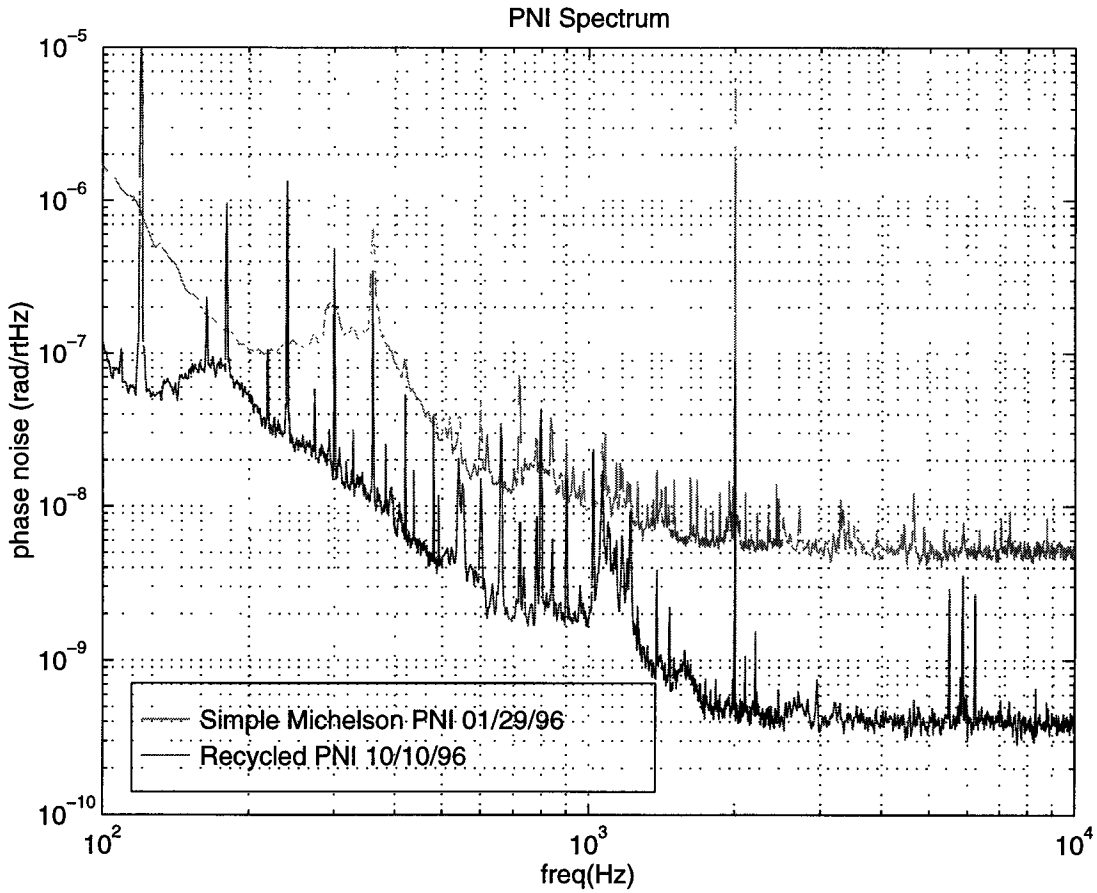
  ››Power recycling experiment in early stages

  —higher transmission vertex mirrors installed

  —vacuum, beam splitter, recycling mirror changes this winter and spring

- MIT Fixed Mirror Interferometer experiment ~ complete

Phase Noise Sensitivity From MIT Interferometer



New Single Loop 40 Meter East Vertex Suspension

Technical Highlights - Detector

- 10 W laser contract started with Lightwave Electronics; breadboard unit being assembled
- Placed order for fused silica blanks for all Core Optics
- Placed order for polishing primary lot of End Test Masses
- Proposals for polishing remaining Core Optics being evaluated now

Technical Highlights - Detector

- Preliminary designs for Length and Alignment Sensing and Control Systems underway
- Preliminary mechanical design for suspensions completed and prototypes in fabrication/test
  - ››SOS prototype in test now
- Seismic Isolation Stack requirements defined and preliminary design started at HYTEC
- Preliminary design of Control and Data System global architecture completed
- Preliminary design of Vacuum Control and Monitoring System complete and awaiting review

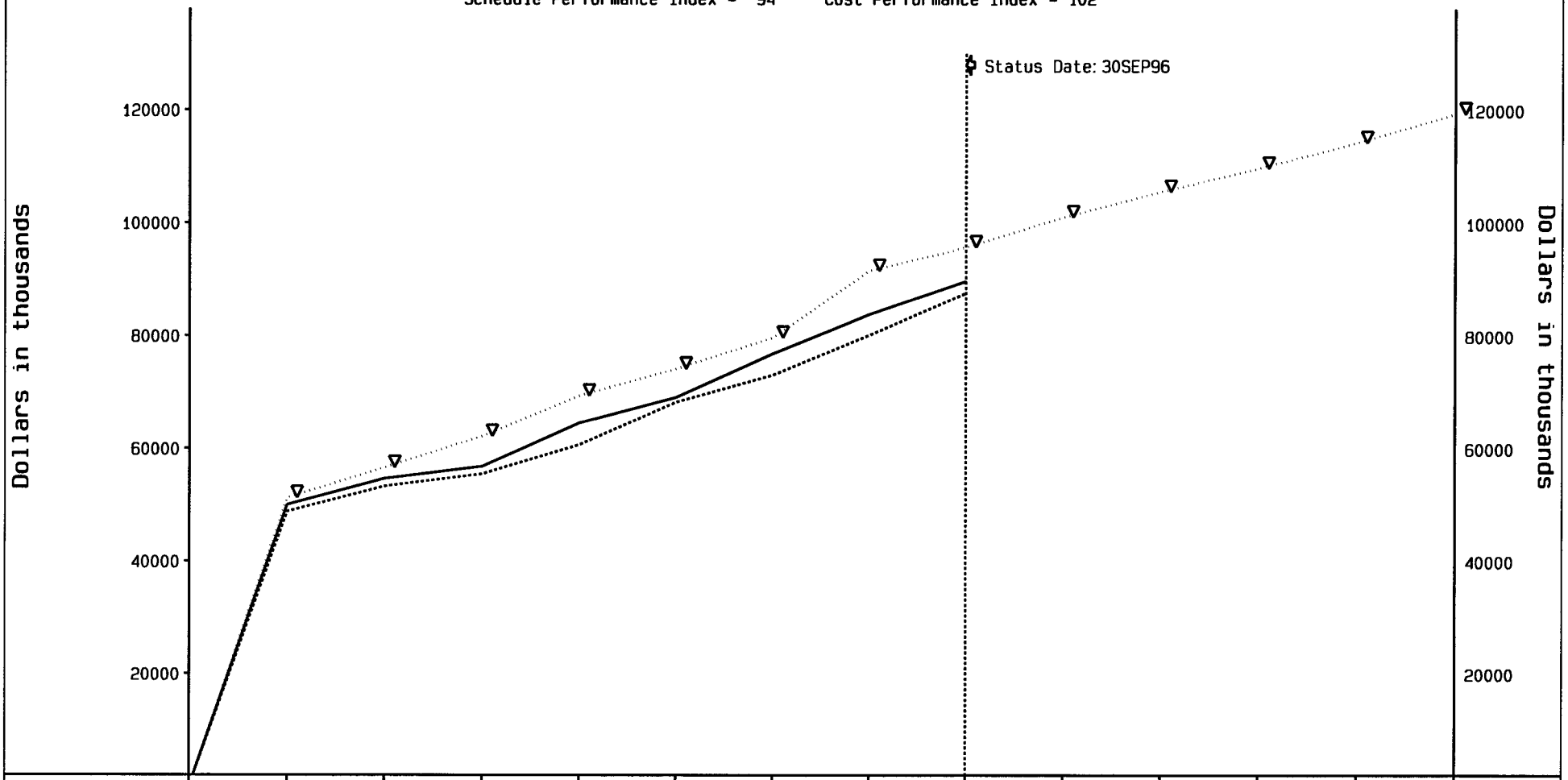
LEGEND
Bud
Per
Act

LIGO PROJECT
1 LIGO Construction

Date: 17OCT96
Program: PMB_0996
Report: LIGOSPA
COBRA (R)

Budget vs Performance vs Actual

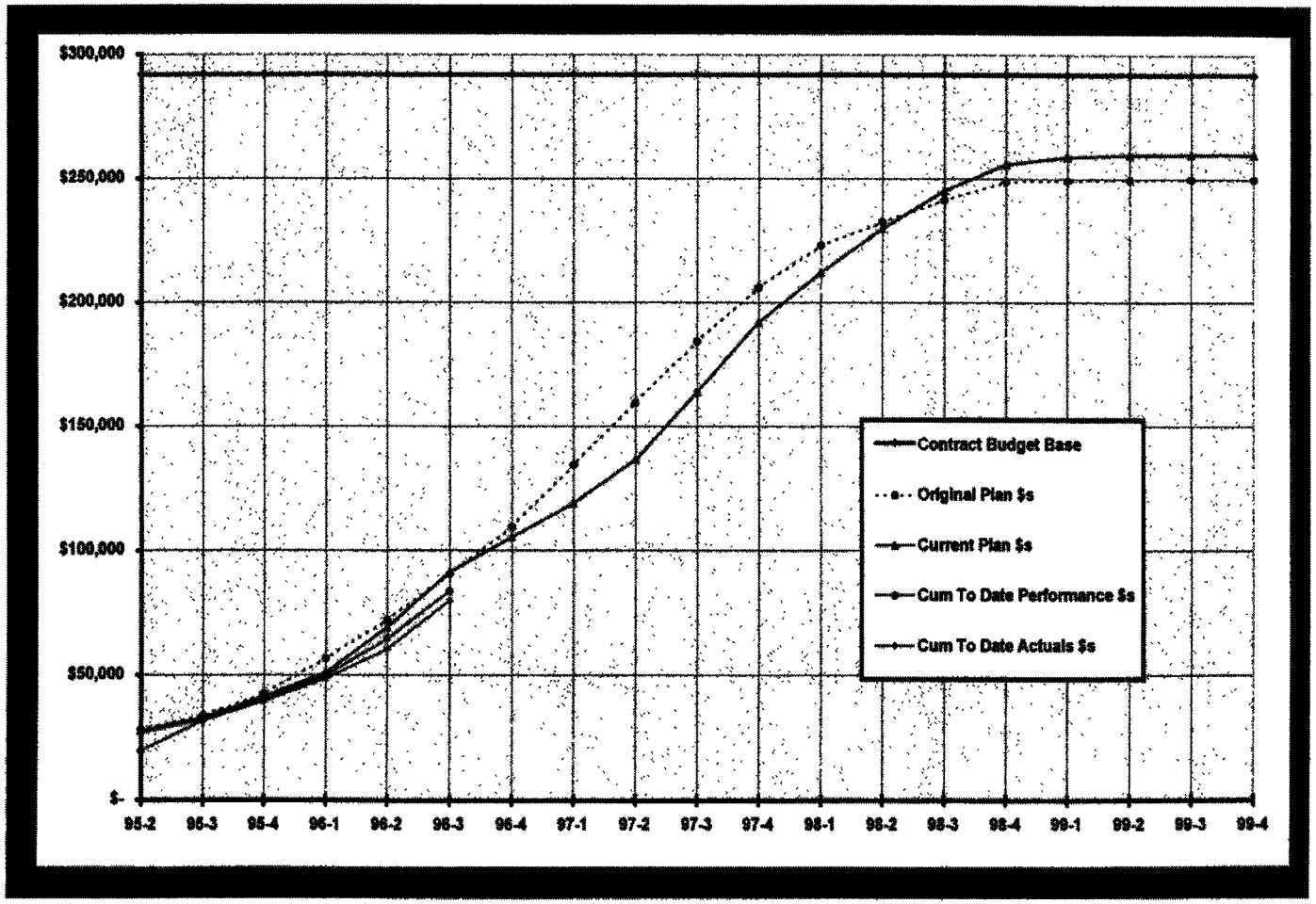
Schedule Performance Index = 94 Cost Performance Index = 102



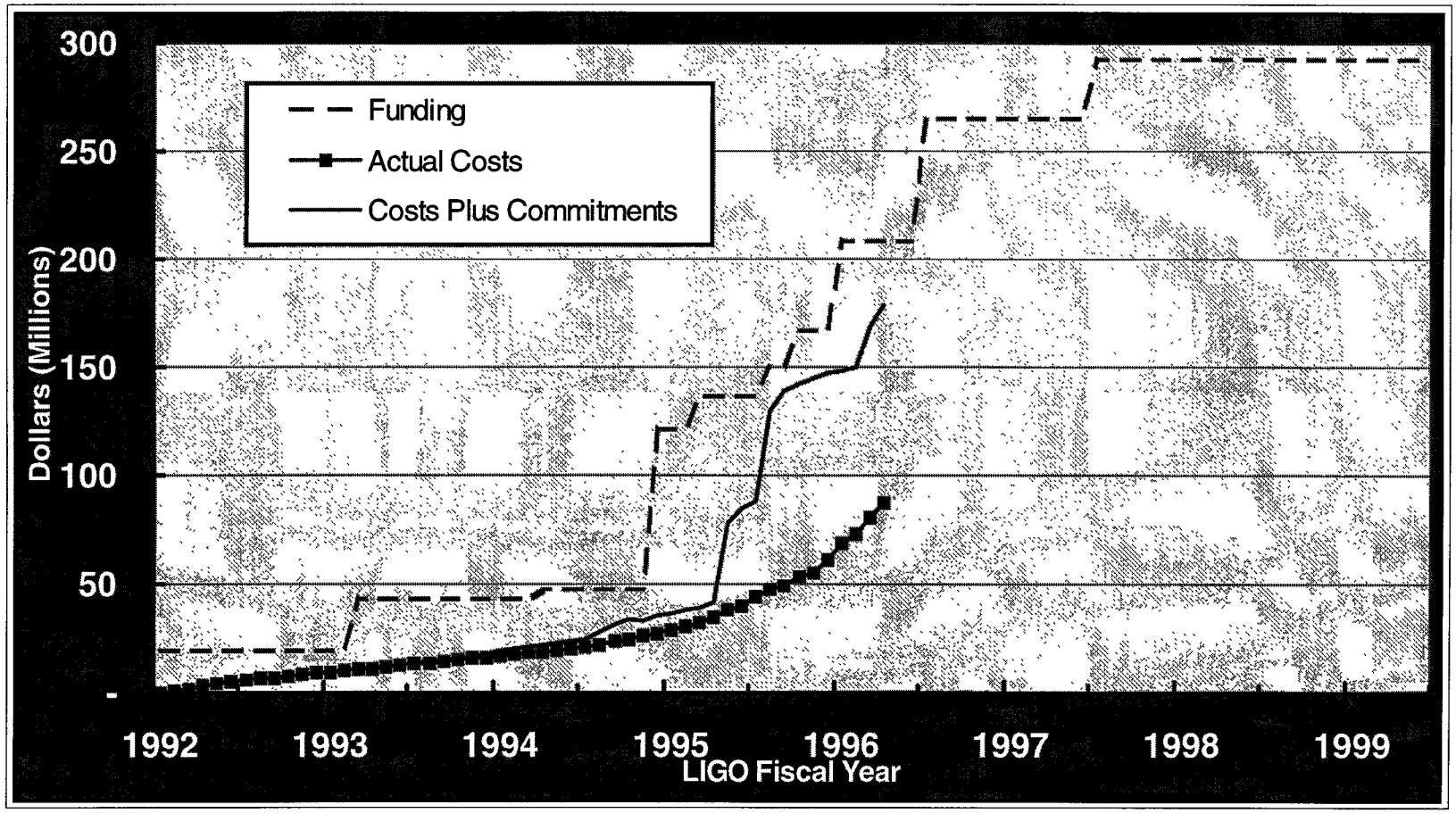
	FEB96	MAR96	APR96	MAY96	JUN96	JUL96	AUG96	SEP96	OCT96	NOV96	DEC96	JAN97	FEB97	SCALE
Planned Budget	51,168	56,547	62,162	69,351	74,102	79,650	91,525	95,667	101,052	105,543	109,719	114,256	119,309	K$
Performance	49,962	54,586	56,741	64,526	69,091	76,784	83,782	89,671						K$
Actuals	48,777	53,219	55,432	60,656	68,220	73,037	80,104	87,570						K$
Schedule Variance	-1,206	-1,961	-5,421	-4,825	-5,011	-2,866	-7,743	-5,996						K$
Cost Variance	1,185	1,367	1,309	3,870	871	3,747	3,678	2,101						K$

Schedule Variance = Perf-Budg Cost Variance = Perf-Actual Schedule Performance Index = Perf/Budg Cost Performance Index = Perf/Actual

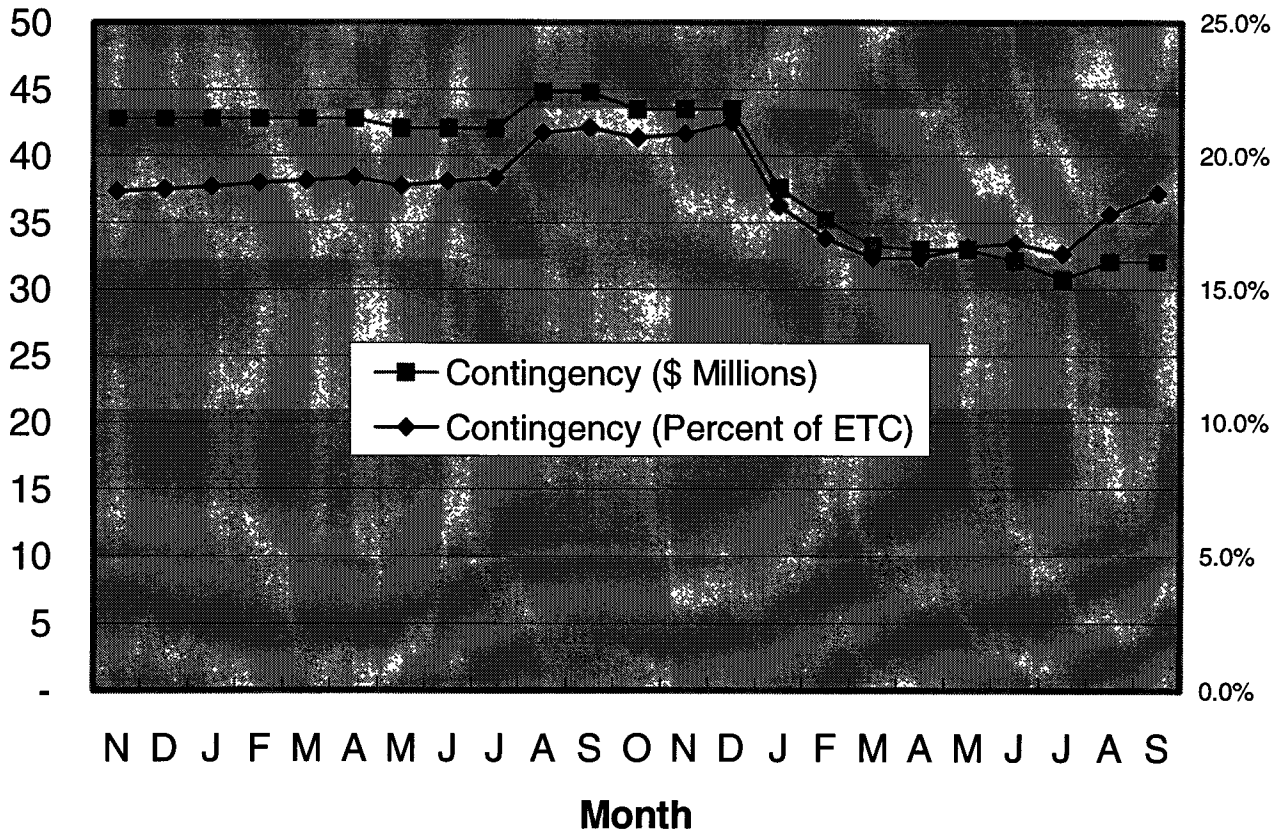
Cost Schedule Status as of End of August 1996



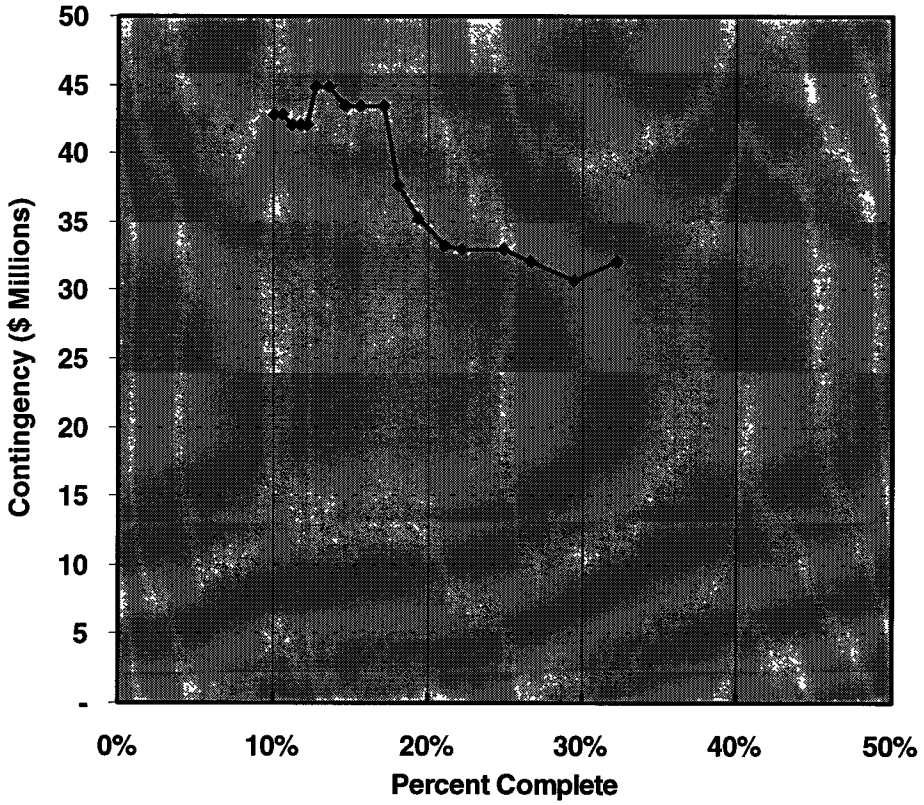
Funds, Commitments, Costs



Contingency vs. Estimate to Complete



Contingency vs. Percent Complete (through August 1996)



LIGO Funding by NSF Task and by Year

Fiscal Year	*Construction*	*R&D*	*Operations*	*Advanced R&D*	*Total*
				Proposed	
Thru 1994	**35.9**	**11.2**			**47.1**
1995	**85.0**	**4.0**			**89.0**
1996	**70.0**	**2.4**			**72.4**
1997	**55.0**	**1.6**	**0.3**	**1.7**	**58.6**
1998	**27.1**		**7.3**	**2.7**	**37.1**
1999			**20.9**	**2.7**	**23.6**
2000			**21.1**	**2.7**	**23.8**
2001		**10 months >**	**19.1**	**2.6**	**21.7**
All funds shown in 'then'-year $M					

Costs and Commitments through September 1996

(All Entries are $ Thousands)

WBS	Costs Thru Nov 1995	Three Quarters LFY 1996	Sep-96	Oct-96	Nov-96	Cumulative Costs	Open Commitments	Total Cost Plus Commitments
1.1.1VacEquip	4,081	14,425	415			18,921	22,749	41,670
1.1.2 BmTube	2,736	6,822	3,862			13,420	36,575	49,995
1.1.3 BTEncl	468	3,924	947			5,339	3,568	8,907
1.1.4 Civil	6,677	4,981	1,377			13,035	19,622	32,657
1.2 R&D	2,430	2,620	258			5,308	5,529	10,837
1.3 Detector	13,321	2,963	152			16,436	1,185	17,621
1.4 ProjOffice	10,152	4,544	455			15,151	1,782	16,933
Unassigned	79	(122)	(1)			(44)	74	30
TOTAL	39,943	40,157	7,465	-	-	87,565	91,084	178,649
Cumulative Actual Costs	39,943	80,100	87,565					
Open Commitments	44,993	88,814	91,084					
Total Costs Plus Commitments	84,935	168,914	178,649					
NSF Funding	*138,063*	*208,463*	*208,463*					

Note: Unassigned costs have not been assigned to a LIGO WBS, but are continually reviewed to assure proper allocation.

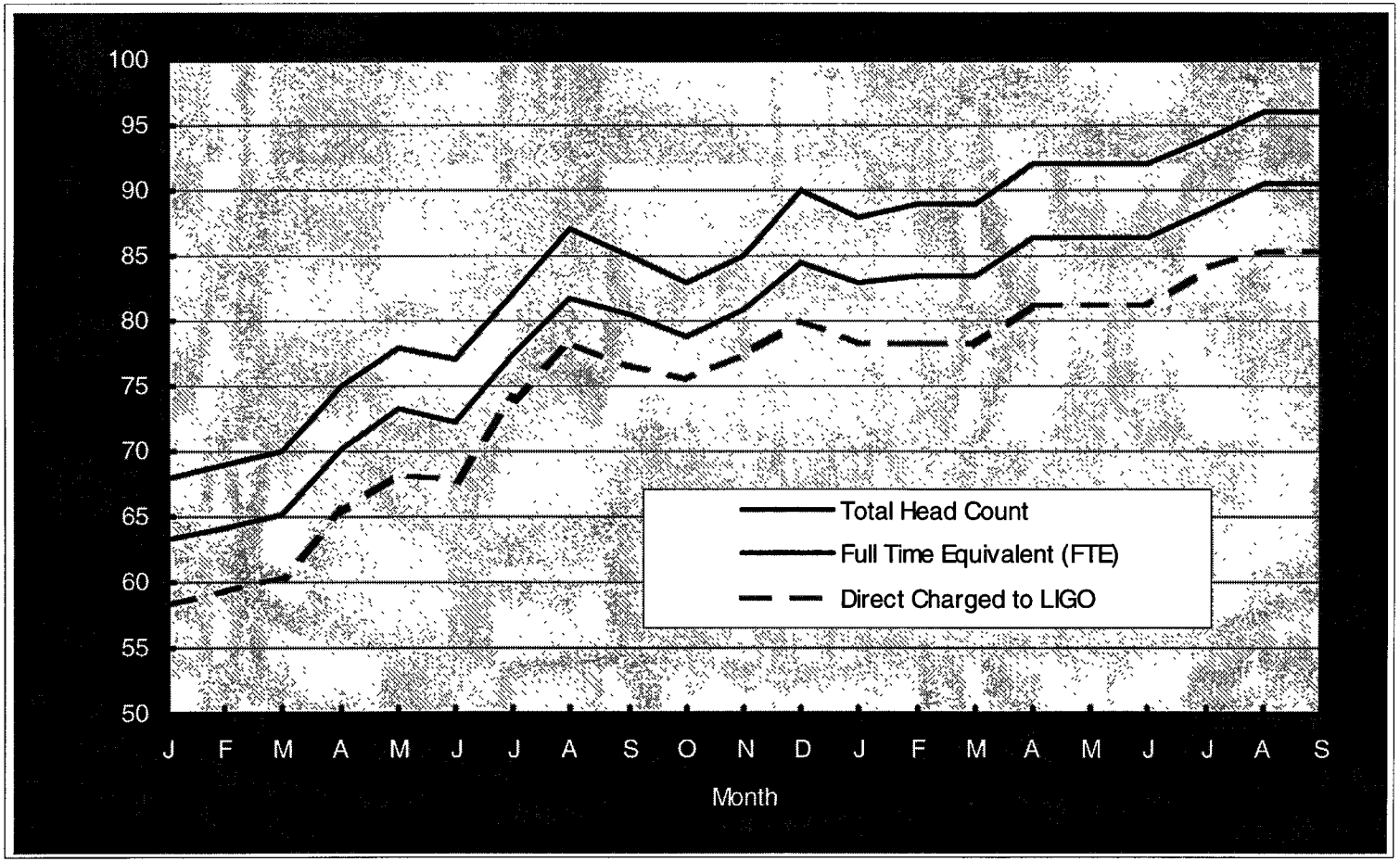
Major Subcontracts Awarded Since the Last Semi-Annual Review

Subcontract	Award Date	Award Amount	Selection Basis
Baffle Coating - West Coast Porcelain	April 1996	$163K	Competitive
Civil Construction (WA) - Levernier Construction	July 1996	$15,651	Competitive
Installation of Beam Tube Enclosures (WA) - Levernier Construction	September 1996	$1600K	Competitive
Nd3+ Lasers - Lightwave Electronics	May 1996	$735K	Competitive
Fused Silica Mirror Blanks - Heraeus Amersil (17 pieces)	August 1996	$1230K	Competitive
Fused Silica Mirror Blanks - Corning, Inc. (21 pieces)	August 1996	$360K	Competitive
Seismic Isolation Stack Development - Hytec	August 1996	$1865K	CO to Existing Contract
MIT Contract Change Orders 19 and 20	Waiting NSF Approval	$1023K	CO to Existing Contract

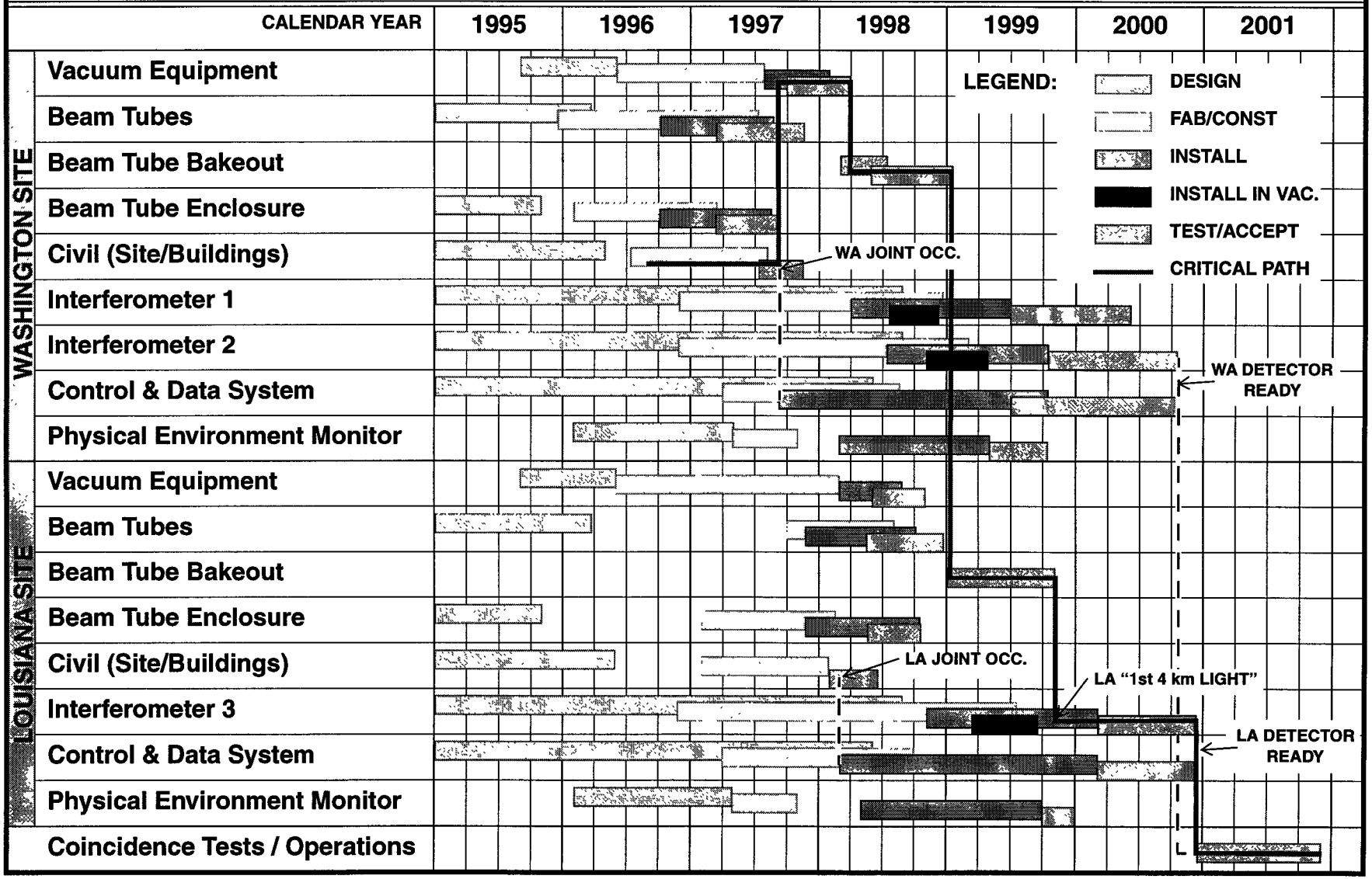
Major Subcontracts Planned in FY 1997 (and the remainder of this year)

Subcontract	Award Date	Award Estimate	Selection Basis
Civil Construction (LA)	November 1996	$13,500K	Competitive
Slab, Beam Tube Enclosures, Installation of Beam Tube Enclosures (LA)	November 1996	$8820K	Competitive
Optics Polishing	October 1996	$65K	Sole Source FFP
Full Service Polishing	December 1996		Competitive FFP
Optics Coating	Spring 1997		Change Order
Detector Stack Fabrication (multiple contracts)	Winter 1997		Competitive FFP
Suspension System Fabrication	Winter 1997		Competitive FFP
IOO R&D (University of Florida)	November 1996	$300K	Sole Source Collab
Optical Modeling	Winter 1996	$200K	Change Order NTE
Metrology (NIST)	Winter 1996	$200K	Change Order NTE

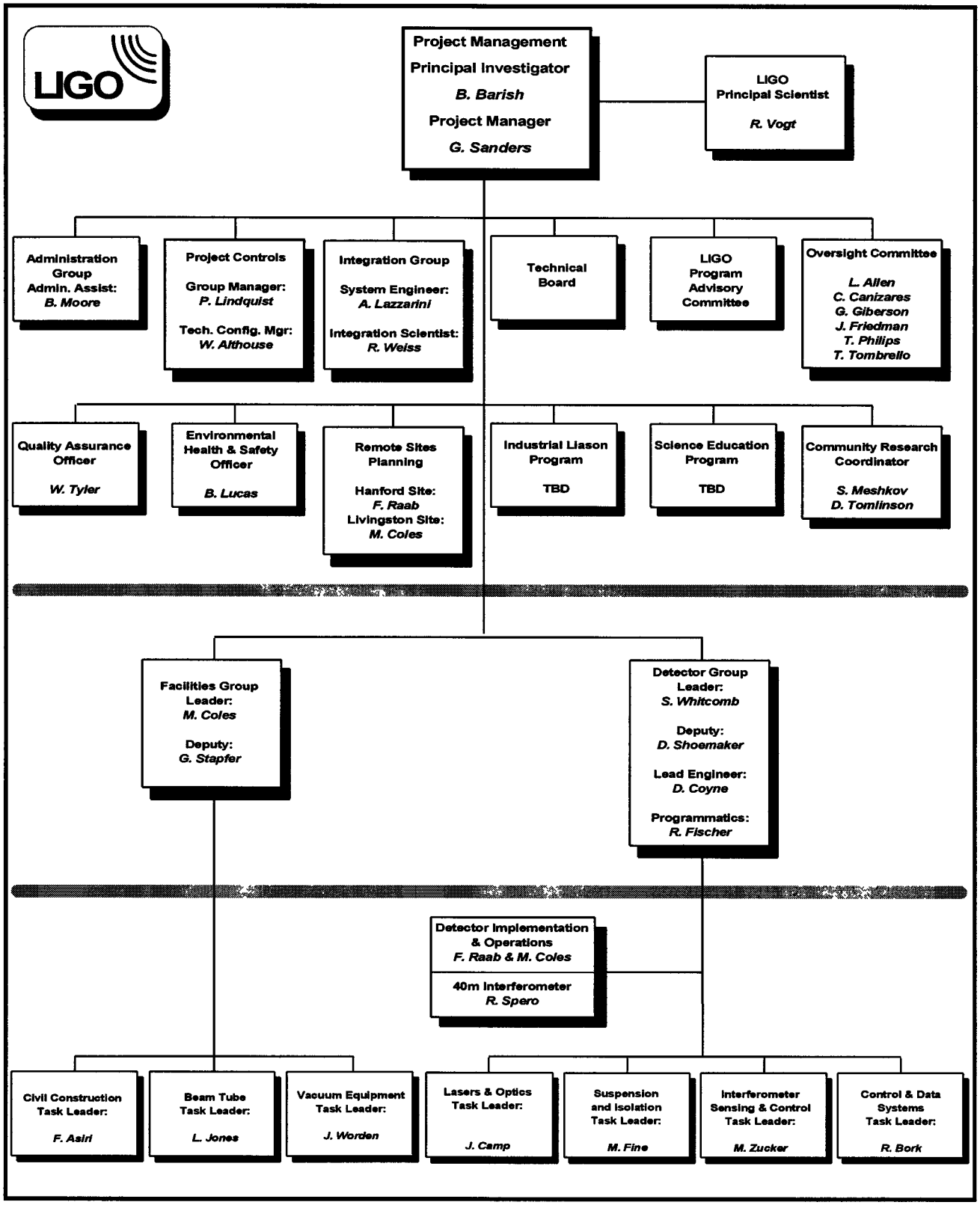
LIGO Project Staffing History



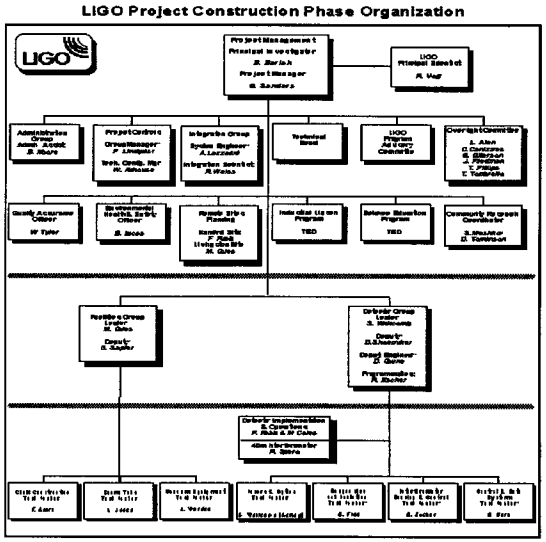
SUMMARY INTEGRATED SCHEDULE



LIGO Project Construction Phase Organization



Evolution of Organization



- Since last review, remaining management positions have been filled
  - ››Jordan Camp is the Laser and Optics Task Leader
  - ››Mike Fine is the Isolation Task Leader

Evolution of Organization

- Hanford Site Head Fred Raab moves to Hanford mid-1997
- Otto Matherney, John Worden, Cecil Franklin, Rich Riesen currently resident in Hanford
- Rolf Bork from CDS Group moves to Hanford early in 1997
- Livingston Site Head Mark Coles moves approx. one year later
- Gerry Stapfer, Allan Sibley locate in Livingston in 1997
- Other members of LIGO are currently planning relocation to the sites
- LIGO organization and reporting will become site-based

Evolution of Organization

- Organization will evolve to reflect this
- Beam Tube bakeout predominantly executed during site-based construction period, when integration of the system is at peak
- Beam Tube bakeout planning and execution will be coordinated by Bill Althouse, in collaboration with the Integration Group, and reporting to the respective site heads during execution

  ››LIGO Project is proceeding to plan the beam tube bakeout and execution, but commitment is made only to execute the first module bake. Commitment to remaining three module bakeouts will be made at a point close to execution.

LIGO Collaboration / Laboratory

- NSF McDaniel Report presented a vision of a Laboratory and a Collaboration after construction
- McDaniel Report urged definition of an appropriate R&D program and of adequate computation capability

  ››Our Advanced Detector R&D Proposal is consistent with R&D recommendation

  ››Albert Lazzarini will report later in this review on LIGO efforts in modeling, data format standards, and data analysis, and our view of the future. This will introduce the LIGO study to be considered at the next NSF review in spring 1997.

Program Advisory Committee

- LIGO Program Advisory Committee (being formed now) will be the principal review/advice mechanism used in guiding LIGO's program on
  - proposals for scientific use of LIGO
  - R&D proposals
  - McDaniel Report guidance
- First meeting will be held this year, several meetings by summer

Program Advisory Committee

- Members
  - ››Bill Fraser, Chair
  - ››Paul Avery
  - ››Alain Brillet
  - ››Sam Finn (LRC)
  - ››Bill Hamilton
  - ››Peter Michelson
  - ››Peter Saulson
  - ››Robbie Vogt
  - ››and others that round out the committee, currently considering our invitation

Summary of Technical Status

- Vacuum Equipment contractor is underway, all materials ordered, first article fabrication successful, designs validated, contract about 50% complete. Major technical issues resolved. ✔
- All major beam tube fabrication processes now qualified. Fabrication in progress. ✔
- All major beam tube installation processes have been successfully reviewed for readiness. Installation begins this week. ✔
- Beam tube baffle design, performance, fabrication processes qualified and in production. ✔

Summary of Technical Status

- Hanford slab construction complete and meets LIGO requirements. ✔
- Hanford beam tube enclosure proceeding on schedule and enclosures and installation have been qualified. ✔
- Hanford building construction 7% complete and no significant issues developed. ✔
- Livingston rough grading nearing completion and first surveys appear to meet our requirements. ✔
- Livingston early soil settlement appears very slow and very slight. ✔

Summary of Technical Status

- All facility design, integration and interface issues appear to be well within design envelope. ✔
- Phase Noise measurement has set a record. ✔
- New suspension design successfully tested at 40 Meter. ✔
- Fixed Mirror Experiment nearing completion. ✔
- Laser breadboard unit in fabrication. ✔
- Industry ready to produce blanks, polishing, coating meeting LIGO requirements. ✔
- SOS prototype successfully tested. ✔

Summary of Technical Status

- Seismic stack baseline and superior alternate designs progressing. ✔
- Preliminary design processes complete for suspensions, CDS global, Vacuum Control System. ✔

LIGO Construction is 34% complete!