



Observatory Operations & Issues

Fred Raab
PAC10 Meeting
June 15, 2001



What Is Our Role & How We Plan To Do It

- Hanford & Livingston share these issues but I will often use Hanford to illustrate issues
- Scope of Observatory Work
 - » Facilities Operation
 - » Product Pipeline (Detector → Data) Operation
 - » Outreach
- Staffing & Budget & Infrastructure
- Transition from installation to commissioning to science runs
- What makes Observatory Heads lose sleep



Facilities Infrastructure

The “Easy” Part

- LIGO Hanford Observatory facilities comparable to a moderately-sized “hi-tech” college campus
 - » 10 buildings w/ ~ 100,000 air-conditioned sq ft
 - » ~70,000 sq ft are moderate to high-level clean laboratories
 - » ~475,000 sq ft of total enclosed space
 - » 6 miles of roads, parking spaces for 80 vehicles
 - » 10,000 cu meters of high to ultra-high vacuum systems, 5 miles long, with > 500 control & measurement points
 - » 90,000 gallons of liquid nitrogen for cryo-pumping
 - » Independent potable water & waste disposal plants with 2.5 miles of pipeline; fire suppression system (tested!)
 - » 28 electrical transformers, 2 independent electrical distribution systems, ~100 miles of fiber optic lines



“Hi-Tech” Infrastructure: Hanford’s Product (Data) Pipeline

- Wide Area Network (WAN) lines to campus through DOE; our routers/security/etc. start at PNNL
- Three large Local Area Networks (LANs)
 - » General Computing (GC) – principally science/engineering analysis on ~50 computers plus WAN interface, security, web hosting, electronic document archiving/reproduction, digital A/V systems
 - » Control & Data System (CDS) – observatory central nervous system and machine diagnostics
 - » LIGO Data Analysis System (LDAS) – production real-time data analysis and data shipping of 0.5 Terabyte/day
- Flat-loaded 24/7 duty by 2002
 - » If any system at either site goes down, US GW effort is “off-line”



Product Pipeline Example: LDAS at Hanford

- 4 Sun Enterprise 450 servers w/ 2-4 secondary servers
- 4-8 onsite user machines for visitors
- 15.5 Terabyte Disk Farm
- 100ea, 1-GHz-PC, Beowulf Cluster w/ Megapoint FFT Rating (28 Gflops)
- 1.5 Terabyte Tape Library System (Tape robot & AIT tapes: 2 tapes 24/7 at 6 MB/s)
- Gigabit & 100BaseT Ethernet LAN
- R/T data-handling & analysis software
- Major power/cooling requirements; vibration source



Observatory Staff Responsibilities 1996-2001

- Management and quality control during construction and installation of facilities
- Site maintenance
- Installation of interferometer, *in partnership with campus staff*
- Initial interferometer commissioning, *in partnership with campus and LSC staff*

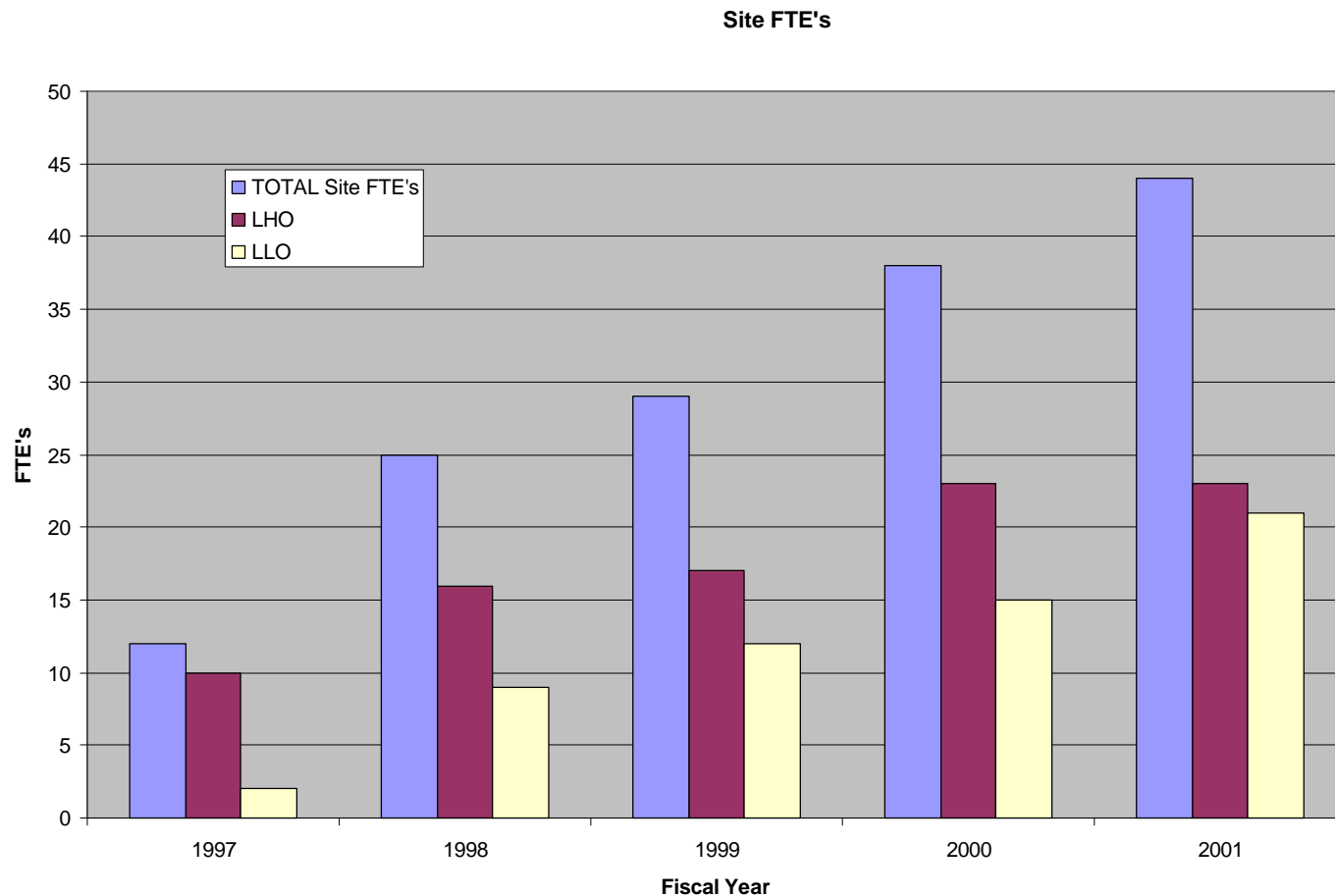


Observatory Staff Responsibilities 2001 - 2006

- Professional scientific and technical staff participate in LIGO Scientific Collaboration
- Scientific staff
 - » Participate in detailed studies of detector performance
 - » Quality control of interferometer operation and data collection
 - » Operation of on-site Data Analysis System (LDAS)
- Engineering support staff
 - » Participate in installation and commissioning
 - » Maintain operation of installed systems
 - » Provide on-site technical support, in partnership with CIT/MIT staff
- Operations Specialists
 - » Support installation and commissioning activities
 - » Provide operations support for commissioning, science investigations



Site Staffing History



- Staff placed at both sites to participate in installation and commissioning of the interferometers, and to maintain the sites.

- Would like to grow total to 60 for full operation and maintenance.



Composition of Present Staff at Each Site

- 7 Scientific staff positions available
- 7 Engineering and technical support staff
 - » Facilities maintenance, vacuum, electrical, control and data acquisition software, optics, network and computing
- 9 Operations specialists (mixture of technical skill backgrounds to support installation, maintenance, and control room operation)
- 1 site administrator
 - » Campus provides engineering and scientific support, administrative support for contracts, purchasing, travel
- Contract labor utilized to augment staff as required while maintaining flexibility



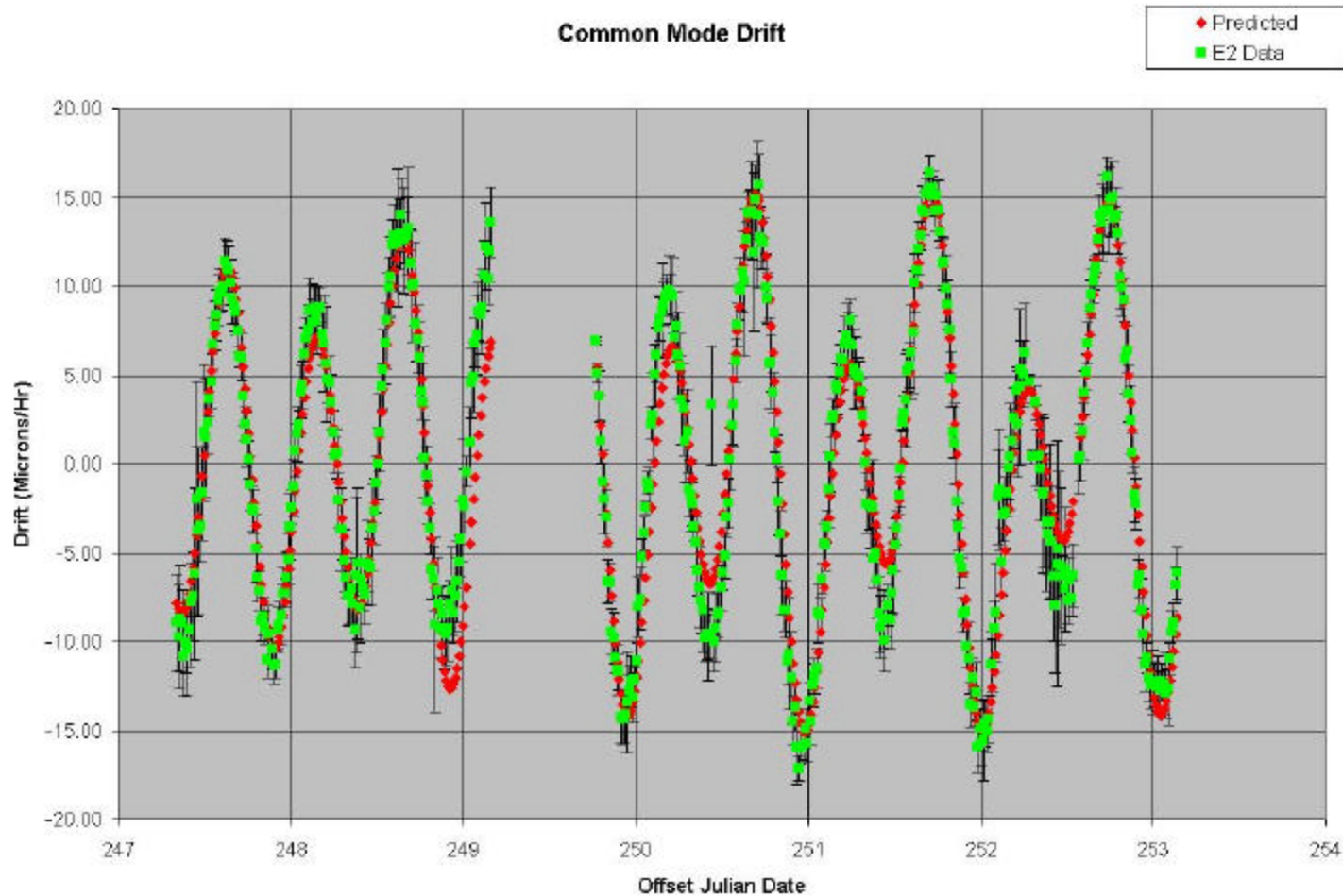
Staffing Example: Operations Specialist Hugh Radkins

- MS in Geophysics; surveying expertise
 - » Installation of seismic isolation systems
 - » Installation/troubleshooting of seismic actuator systems
 - » Detector initial alignment surveying
 - » Seismic isolation transfer function characterization
 - » Programming for analysis/fitting of earth-tides to model
 - » Development of earth-tide feedforward compensation to laser and seismic actuators
 - » Worked with Gladstone High and Kamiakin High SST teams on seismic measurements
 - » Control-room operator duties
- Typical of competence level required for operations



Earth Tide Analysis of E2

by Morganson, Raab, Radkins & Strom





Operations Staff Training

- We are broadly training staff in interferometer operation:
 - » Hands-on installation and commissioning activities
 - » Some formal lectures
 - » Evolving and expanding list of daily shift duties
 - » Trouble-shooting with expert staff when faults occur
- Control room staffing is presently Mon-Fri with day and evening shifts in LA, but barely able to cope with Installation/Commissioning at WA



Scientific Staff Development

- Stagger 3 year term appointments for 3 staff members, replace one per year
- Look for opportunities to “leverage” scientific staff positions:
 - » Agreements on joint appointments between LLO and Southeastern Louisiana University – Hammond, LA
 - one half-time faculty position filled beginning January '01,
 - search in progress to fill second position in fall '01
 - » Agreement with U Florida to share cost of basing two UF staff at LLO
 - » Cost sharing to place U of Oregon and U of Michigan staff at LHO



Intellectual Atmosphere at the Observatories

- We are trying to create intellectual centers, not outposts
 - » Conduct LIGO related research on-site where feasible
 - » Seminars
 - » Encourage participation and interaction with regional universities and with K-12 education
 - » Maintain strong connection to the campuses
 - ~10 visitors/day from LSC or Caltech/MIT
 - Weekly teleconferences with both sites and campuses
 - Site staff visit each other to share experiences, lessons learned, and to give “quick start” to new activities



Site Activities 2002-2006

- Interferometer operation and support
- Facility support and maintenance
- Related research and development activities based at sites
- Educational outreach



Interferometer Staffing During Operation

- 2 operations specialists per hour shift, plus scientific staff
 - » *at least one* scientist per shift for initial operation
 - » Role of scientist is to be “eyes and ears” of scientific community analyzing data – identify unique features of interferometer, environment, configuration, etc
- 24x7 operation requires ~ minimum 10 operations specialists vs 9 in current budget – assuming normal operation, no training courses, flu epidemics, etc
- Additional operating staff needed to make operation robust, ability to handle exceptional conditions, also maintenance and calibration, etc
- Accommodate staff turnover



Requested Site Staffing Increases From 47 \longrightarrow 60

FTE's

LDAS operation, maintenance, data management	2 scientists, 2 engineers
24x7 interferometer operation	4 engineers
LSC liaison with LSC	2 scientists
Computer and network systems administration	1 engineer
Educational outreach	1 technical, 1 admin/educator

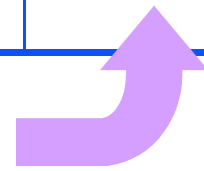
Annual cost ~\$1,063K



FY2001 Site Operations 12 Month Budget ~ \$9M

	FY01	FY02
Site labor	50%	50%
Building and site maintenance, utilities	20%	18%
Vacuum system operation, liquid nitrogen	5%	4%
Computer and network operations, supplies, maintenance	4%	12%
Electronics, optics, administrative supplies, telephone	3%	3%
Other miscellaneous – travel by site staff, repairs, etc.	3%	4%
Outreach	0%	2%
Installation and commissioning related: supplies, fixturing, travel from campus, etc.	15%	6%

Requested FY02 Budget ~ \$10.7M





Site Related Budget Augmentation FY2002-2006

- Annual equipment maintenance and replacement of LIGO Data Analysis and Computing hardware on 4 year cycle:
 - » ~\$1,380K annually
 - » *recognized by NSF review panel*
- Networked data distribution via OC3:
 - » ~\$540K annually
 - » *recognized by NSF review panel*



Site Related Budget Augmentation FY2002-2006

- Annual maintenance and replacement of control room data acquisition and control hardware, custom electronics, and embedded controllers
 - » ~\$514K annually
 - » Represents about 10% of total value of control room computers and 5% of total value of custom electronics and VME controllers



Effect of NSF Downsizing Request on Observatories

- FY2002 request of \$10.7M → \$8.9M
- Staffing of 60 pared to 56, staffing increases deferred in FY2002
- No outreach
- No LSC support
- Deferred LDAS maintenance



Long Term Major Repairs

- LIGO has not included a budget request for major facility and infrastructure repairs that will be needed as the sites age
- We do not expect to need funds for this during 2002-6
 - » The buildings and supporting infrastructure are new
- We have raised the issue now, hoping for proper planning in advance of future need



On-site Research Activities During FY2002-6

- Characterization of seismic environment at LHO and LLO:
 - » “TriNet” real-time earthquake information system – Caltech, USGS
 - » Louisiana Tech U collaboration to operate seismometers, collect and analyze data
- Advanced seismic isolation system development for LIGO-II:
 - » reduce ground motion at 10 Hz by 3-4 orders of magnitude
 - » LLO provides lab and office space, project management, site infrastructure
- Operation of high power laser test facility at LLO:
 - » Anticipate upgrade in LIGO laser power to 100-200 W (from 6 watts)
 - » Measure thermal lensing, thermally induced birefringence, component selection, of core optics, modulators, isolators
 - » Facility jointly utilized by LLO, UF, Southern Univ., and SLU staff
- No advanced R&D role identified yet for LHO



Educational Outreach Using CIT & LIGO “Reserve” Funds

- SST - Scientist, Student, Teacher program at LHO
 - » Collaboration with Pacific Northwest National Laboratory, but PNNL program not renewed
 - » moves components of LIGO research to high school curricula through summer internships and academic-year research programs
- Classroom resource: "The Scientific Method at Work" video taped at LHO and distributed by The School Company as a classroom resource for Middle/High School science education



Educational Outreach

- Distance Learning: LHO developed interactive program for 8th grade science for broadcast over the the WA state K-20 teleconferencing network. Program involves discussion and experiments on the law of falling bodies to demonstrate the process of science
- LIGO Public Lecture: LHO sponsored a free lecture by Kip Thorne and John Archibald Wheeler, detailing Wheeler's contributions to local and global science - from the first production nuclear reactor at Hanford to LIGO
 - » Cooperative ventures during the Wheeler visit included B-Reactor Museum Society reunion and book signing at Columbia River Exhibition of History, Science and Technology



Educational Outreach

- Field trips by community and professional groups at both sites
- More than 3,000 visitors in last year at LLO (mostly school classes); 750 during public open house
- Teacher open houses at LLO in summer and winter; more than 100 middle and high school science teachers in Livingston Parish have toured LIGO as part of teacher in-service
- LLO hosted more than 100 African-American high school science students participating in Southern University's Timbuktu Academy
- Development of hands-on activities and educational resource materials at each site



Optical Telescope Project at LLO

- Funded through Prof. Greg Guzik at LSU via Louisiana Technical Innovation Fund and Louisiana Board of Higher Education (only state employees are eligible to apply)
- Endorsed by LIGO and to be located at LLO site
- \$98K in state funds for 16 inch robotic telescope, dome, controls
- Web accessible for remote use by classrooms
- LLO to provide:
 - » Site, internet connection, staffing
- Opportunities for outreach and possibly a modest science program in association with community organizations
 - » Monitoring variable stars, supernovae searches, etc
 - » Opportunity to attract staff with formal backgrounds in astronomy and interests in LIGO science



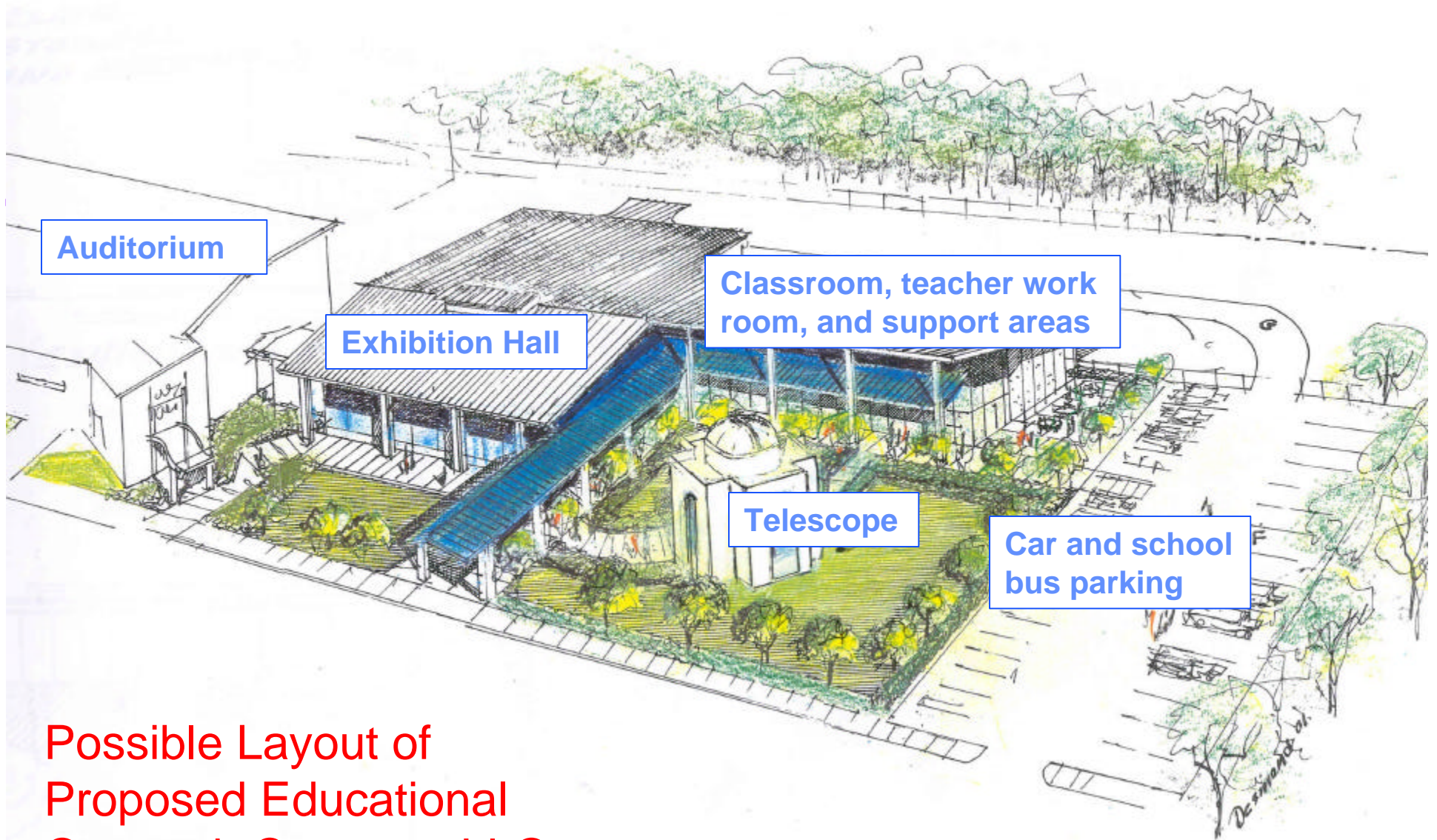
Educational Outreach Goals If We Can Get NSF Participation

- Planned for formally budgeted outreach activities in future operations, but it has now been removed from ops budget
- Possible extension of LIGO-SST (Scientist – Student – Teacher) program now underway at LHO to LLO (with NSF \$\$ this summer!!)
- Possible partnerships with professional K-12 educators
 - » Northwestern State University Space Science Education Program for middle school science enrichment
 - » Submitted NSF-IPSE program proposal to involve teachers in development of educational materials for schools
- Concentrate on sites-specific opportunities for outreach since needs and resources are different at each site



Educational Outreach Centers

- Hope to establish Education Outreach Centers at both sites
 - » Offer observatory visitors hands-on exhibits and science classes (like NSF-funded Arecibo and Lowell Observatory centers)
 - » Teacher in-service training and support for classroom enrichment (also like Arecibo and Lowell Centers)
 - » Host a modest school-to-work program for vocational training
- In the past the NSF has financially supported the development of program content and start-up labor costs, but has not provided funds for infrastructure such as building, parking lots, etc
- LLO has done substantial preparation work in this area
- LHO moving more slowly; building working relationships with CREHST, AASTA & BRMA to establish multi-venue Science/Technology Center for Inland Northwest



Possible Layout of Proposed Educational Outreach Center at LLO



Vision for Inland Northwest Regional Science Center

- Partners/Resources
 - » Columbia River Exhibition of History, Science & Technology
 - Access to non-classified Hanford DOE artifacts
 - Active K-6, summer & “latchkey” programs in science & environment
 - Museum at ‘gateway’ to Hanford Works & Nat’l Monument
 - » Alliance for Science Teaching Through Astronomy
 - Robot 0.8-m telescope atop Rattlesnake Mt for classroom use via internet or beamed into LHO for star parties
 - » B-Reactor Museum Society
 - World’s 1st production nuclear reactor
 - » Economic, Community and Tourism Development Agencies
 - Hungry to develop economic independence from D.O.E.
- Intend to develop formal proposal over next 5 years



Final Construction: LHO Staging Building

- Provides facilities for integration of hardware upgrades once initial LIGO detectors are operational
 - » Separate science & detector development chambers were “down-sized” from original LIGO concept but “upgrade” problem remained
 - » Minimizes down time of working detectors by pre-integration to optimize science goals
 - » High-bay area accommodates same “hook-height” as LVEA
 - » Machine shop (non-staffed)
 - » Separate work area for desks, computers, etc.
 - » Modifications will provide for materials handling
 - » Providing surge space during commissioning prior to completion of OSB East Bldg
 - » Similar facilities incorporated into LLO building

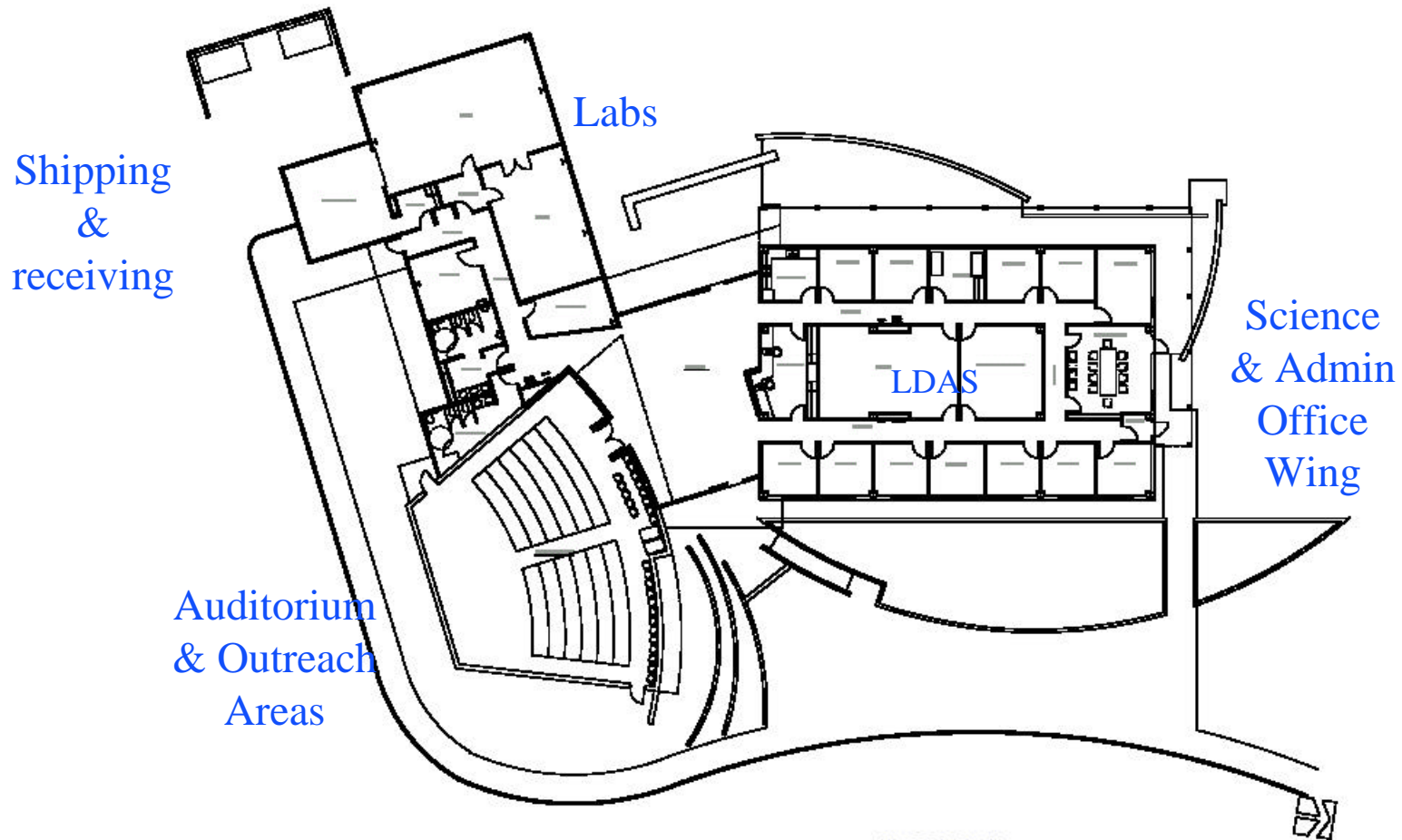


LHO Operations Support East Building

- Provides remainder of observatory office/laboratory space to take LIGO through next 5-10 yrs
 - » ~8,000 sq ft to expand functions in OSB West Building
 - » ~ 4000 sq ft of lab space, including home for LDAS computing needs
 - » Includes auditorium and office space to accommodate collaboration and outreach work as well as resident staff and visitors
- Final element of facilities construction



LHO Operations Support East Building





Issues That Keep Observatory Heads From Sleeping At Night

- Both Observatories:
 - » Do we have what it takes to operate observatories?
 - » Can we find/retain adequate staff?
 - » Can we provide intellectual environment to keep staff growing or will they become “obsolete”?
 - » Can we continue to do outreach w/o losing our soul?
- LHO in Particular:
 - » Can we get local university support?
 - » What will be our intellectual strengths?
 - » What will be our involvement in future LIGO R&D?
- LLO in Particular:
 - » Will we have sufficient strength in CDS and LDAS areas



Despite a Few Glitches, Science Starts in 2002

Earthquake graphic
goes here

