



Advanced LIGO Seismic Isolation R&D

Dennis Coyne

8 Oct 2002

Current status

(see images in LASTI report)

- Program has bifurcated into internal & external isolation efforts due to acceleration of the external pre-isolator

AdvLIGO SEI:

- Selected a conceptual design approach April/2001
- Held a design requirements review Jan/2001
- Completing assembly & beginning test of the Technology Demonstrator (Servo-controls test bed) at the Stanford ETF
- Preparing an RFP for design and fabrication of the BSC and HAM full-scale prototype structures for LASTI
 - » Contingent on early ETF results
- PDR is scheduled immediately after LASTI prototype results
 - » Really should have a review of the RFP & ETF results before buying the LASTI prototypes
 - » To avoid further delay, could review in parallel with prototype contract award & before committing to fabrication

External Pre-Isolator (EPI):

- Held a design requirements review April/2002
- PEPI is operational at LLO
- Integrating and evaluating the MEPI and HEPI external pre-isolators at LASTI now
- PDR for the EPI is scheduled immediately after LASTI prototype results
- CCB request for EPI production is planned at the time of the PDR

Plans for 2003

AdvLIGO SEI:

- Hold design review for preliminary phase LASTI prototypes
- Begin servo-controls testing on the ETF Tech Demonstrator
- Initiate contract for design & fabrication of the LASI HAM and BSC prototypes (1 ea.)

EPI:

- Complete evaluation of the MEPI and HEPI prototypes
 - » Preliminary results by Dec, 2002
 - » Hold PDR Jan, 2002; select approach for Observatories
- Fabricate & Assemble EPI
 - » Get CCB approval for production
 - » May need to start long lead procurement before PDR (say ~Dec)
 - » Incremental FDRs on each subsystem/subassembly as required before production orders
- Install & Stand-alone testing of EPI
 - » Plan to be ready to install at LLO ASAP after S2 (target 4/14; current projection mid-May)
 - » Installation and test will take 4+ months at LLO
- EPI for LHO?
 - » Per the DRR (T020050-02), the baseline is PEPI on 6 Chambers at LHO (ETM, ITM, MC)
 - » Implementation after LLO iff funds permit in FY03

Technical Risks and Opportunities

AdvLIGO SEI:

- Technical Risks and opportunities: what is technically scary?
 - » Limiting effect of tilt-horizontal coupling
 - » Achieving structural resonances well above the control band
 - » Magnetic fields from SEI internal actuators may need considerable shielding to prevent noise injection to the magnets on the SUS assemblies
 - » Heat dissipation of the internal electromagnetic actuators may be difficult
 - » Materials in the electromagnetic actuator need to be vacuum qualified, or replaced with compatible materials (development effort on a commercial unit)
 - » BSC unit may need to be larger (higher) than can readily be integrated into the LASTI facility (complicates installation with SUS)
- What new ideas not in the plan might we pursue?
 - » None

Technical Risks and Opportunities

EPI:

- Technical Risks and opportunities: what is technically scary?
 - » Interaction of structural support modes with the control system may limit gain/bandwidth and performance, or cause us to consider structural modifications/additions, or an entirely different approach.
 - » Modeling is still lagging the hardware development though catching up
 - » Contamination from hydraulic fluid – careful, robust engineering can mitigate; To date engineering has been on more fundamental design trade-offs, not focused on minimization of leak risk
- What new ideas not in the plan might we pursue?
 - » Structural modifications or additions such as stiffening elements, constrained layer damping, tuned mass damping, etc. (HAM support structure & BSC pier)
 - » As a deep fallback if significant problems are encountered soon in LASTI testing: Drop the ‘stiff’ approach and employ the VIRGO ‘soft’ (pendulum & GAS) approach.

Schedule issues

Schedule issues: what is going too slowly, what is faster than thought, how are interacts with other activities?

AdvLIGO SEI:

- Far behind original schedule due to acceleration of the EPI system for initial LIGO
 - » Delay is mostly due to diversion of personnel to accelerate the external pre-isolator for initial LIGO
 - » HPD effort was considerably longer than expected as well
- Need timely ETF results and RFP development to prevent further schedule slip
- SEI delays virtually all elements of the LASTI program, most particularly SUS
- Milestones:
 - » ETF results (elastic modes >> control band, low frequency tilt-horiz coupling within limits) by ~11/18
 - » RFP issued ~11/15
 - » RFP award Jan, 2003
 - » Delivery to LASTI for assembly ~Dec, 2003

Schedule issues

Schedule issues: what is going too slowly, what is faster than thought, how are interacts with other activities?

EPI:

- Schedule (M020142-06) is very aggressive
- Schedule has slipped many months in the hardware development phase – which is nearly done, so risk of further hardware related delays is low
- May take longer than scheduled to test the LASTI prototypes
- Fabrication/assembly schedule is not generous (3 months)
- Milestones:
 - » Debug & initial results 4 weeks after install (~12/1)
 - » PDR Jan, 2001
 - » FDRs as needed for drawing releases
 - » Final results in another 4 weeks (~1/7)

Cost baseline and issues

Cost baseline and issues: what do we expect to expend this year (not a guess, something backed up with a spreadsheet)? anything changed? anything uncertain?

AdvLIGO SEI:

- FY03 Costs cover:

- » 1 engineer at LLO
- » 0.5 PostDoc shared with LSU? (assume that this no longer part of the plan)
- » Both the BSC and HAM prototypes were originally estimated at \$670K total including all instrumentation and electronics and pre-isolation
- » The HPD contract for the structure alone cost \$750K
- » Already have some (most?) instrumentation for the BSC & HAM adv SEI prototypes
- » Rough estimate is that the BSC and HAM prototypes will cost ~\$750K each
- » Total rough cost in FY2003 = ~\$1.4M (with \$0.4M required in FY04 for completion)

- Changes in baseline:

- » Mechanical design work:
 - Originally design work was to be done in the Lab after the ETF Technology demonstrator. Now we will outsource the design; perhaps less cost since the adv. LIGO program schedule is stretching
 - ETF Technology Demonstrator effort far exceeded the original estimate (estimated \$500, actual \$750+)

- Uncertainties:

- » Price for RFP on mechanical design
- » Sensor pod sealing costs
- » Cost of in-vacuum actuator

Cost baseline and issues

Cost baseline and issues: what do we expect to expend this year (not a guess, something backed up with a spreadsheet)? anything changed? anything uncertain?

EPI:

- FY03 R&D Costs cover:
 - » a hydraulic servo-valve test stand (\$10K)
 - » some additional components of the LASTI prototype pump station (\$10K)
 - » Distribution plumbing at LASTI (\$18K)
 - » Total = ~\$40K
 - » N.B.: Most R&D costs for EPI in FY2002 covered under the MIT LASTI facility funds
- Changes in baseline:
 - » Integrated costs for the EPI R&D far, far exceed the original estimates
 - » Added MEPI
 - » N.B.: PEPI hardware costs covered in operations funds allocation
 - » N.B.: Production costs for EPI will be a CCB request for an operations funding allocation
- Uncertainties:
 - » If structural modifications or alternative approaches are needed (e.g. 6 dof piezo-electric actuator) then R&UD costs will increase; relatively low risk

Staffing baseline and issues

Staffing baseline and issues: who is working how much on this effort? enough people?
right skills?

AdvLIGO SEI:

- $\sim 1/4$ Brian Lantz, $\sim 1/8$ Joe Giaime, Wensheng Hua, $\sim 1/4$ Marcel Hammond, $1/10$ Rich Abbott, $1/4$ Larry Jones, $1/10$ Gerry Stapfer
 - » Only Marcel's time is charged to LIGO Lab R&D
 - » Travel for LLO staff is charged to R&D (but not CIT, MIT); non-symmetric
- Insufficient staffing (people diverted to EPI)
- Hope to complete EPI development early in FY03 and move some staff back to adv LIGO SEI

Staffing baseline and issues

Staffing baseline and issues: who is working how much on this effort? enough people?
right skills?

EPI:

- $\sim\frac{3}{4}$ Brian Lantz, $\sim\frac{1}{4}$ Joe Giaime, $\sim\frac{3}{4}$ Jonathan Kern, $\sim\frac{3}{4}$ Marcel Hammond, Ken Mailand, $\frac{1}{4}$ Rich Abbott, Ken Mason, $\frac{3}{4}$ Myron McInnis, $\sim\frac{1}{2}$ Dave Ottaway, Rich Abbott (plus help from Mike Zucker, Peter Fritschel, Dennis Coyne, Prof. Samir & students,...) = ~ 6 FTE
- Barely sufficient staffing
 - » some hardware delays could have been helped by added staffing
 - » Should we add staff to make final design & production schedule more robust?
- Plan to have all/most useful staff deployed for LASTI testing