HAM-SAS

CCB information

22 Feb 06

Coyne, Shoemaker, Wilkinson

What is this CCB?

- A request to fund the building of a HAM-SAS Prototype and characterize it
- Not a decision to change the baseline – want to be in a position to rationally consider a baseline change later IF it may be advantageous based on tests to do so
- This is not for the BSC, only the HAMs
- If we do this there will be a clear handoff from the people building the prototype to the seismic group for the evaluation
- Attempt to address manpower loading so that baseline continues without distraction

The Process

- Build a full scale system for evaluation at LASTI (LASTI “prototype”) based upon the current design (thru Aug, ‘06)
- Perform extensive testing & evaluation on the LASTI HAM-SAS system to enable a careful evaluation (thru Feb ’07)
- When a sufficient body of knowledge is accumulated, and if it appears warranted, ask the TRB to evaluate the two options (Feb ’07)
  - » May use outside reviewers, TBD
- Some elements in the decision:
  - » LASTI unit fabrication experience (costs, schedule, difficulties, …)
  - » LASTI test results (isolation performance, alignment stability, …)
  - » Status of Stiff HAM design, lessons learned from Stiff BSC unit to date
  - » Consideration of increased diversity in technologies (Stiff+Soft) if Soft adopted
- Make a decision prior to committing to the fabrication of the baseline “stiff” HAM prototype (Mar, ’07)

Motivations

- HAM seismic isolation requirements are being re-evaluated → Seems appropriate to re-evaluate the design approach as well
  - » A considerable relaxation in the requirements at 10 Hz is likely (total rms motion requirements are TBD)
  - » Baseline seismic design for the BSC & HAM chambers is a 3-stage, (18 degree-of-freedom) active system
    - – Hydraulic External Pre-Isolator (HEPI) – 6 dof
    - – Internal Seismic Isolation (ISI) – 12 dof
  - » A single, internal stage Stiff “ISI” system may suffice (probably with, or conceivably without, a HEPI)
  - » A revised requirements review & a review of a single-stage ISI performance is planned for Mar, ‘06
  - » A single, internal stage “SAS” system should suffice (without HEPI)
- Baseline ‘stiff’ concept is progressing well through prototyping and BSC fabrication
  - » Stanford test system is very HAM-like – confidence that this system would in fact work
  - » BSC system is coming together, will be tested; not questioning BSC Stiff approach
- Baseline system is
  - » Expensive: Current estimated cost is $49.9M (2005$), or ~30% of total AL project; Current estimated cost is ~$6M higher than proposed
  - » Complex: more complex than originally envisioned, leading to risk of higher costs during integrated test and commissioning; HEPI experience

Motivations for considering the HAM-SAS system

- Reduced hardware cost
- Reduced complexity – probably resulting in reduced integration & commissioning risk, cost, & schedule
  - » Lower control bandwidths, simpler control laws
  - » 6 dof vs 18 dof
- Possibly improved performance margin
- Continued R&D on the SAS approach has improved the design since the 2000 decision to baseline the “stiff” approach
  - » The design is simpler and aligns better with our application scenario
  - » The vertical isolation performance has improved (lower resonance frequency)
  - » The Q-factors of the horizontal and vertical resonances have decreased as the frequencies have been lowered
- Recent modeling has supported basic concept

Cost Comparisons

- Baseline currently has 6 HAM SEI systems per Interferometer
- Optical layout may allow reduction to 5 HAM SEI systems per IFO
- Cost reductions below are for 5 HAM SEI systems per IFO
- Estimates for ISI based on 2-stage system for two scenarios (with/without HEPI – not obvious that this is possible)

				Contingency			
		Non-Labor $K	In-Lab Labor $K	%	$K	Total $K	Comments
HAM-SAS							
	LASTI Experiment	476	655	38%	430	1561	estimated contingency on non-labor costs is $181K (38%) labor costs are guessed as 60% of HAM-ISI
	Prototype Unit Cost	500	655	38%	439	1593	
	Production Unit Cost	500	50	38%	209	759	
Baseline: HAM-ISI + HEPI							
	HAM ISI Prototype Unit Cost (R&D ETC)	1365	1091	38%	933	3389	
	HAM-ISI Production Unit Cost (proposal)	877	82	38%	364	1323	
	HAM HEPI Production Unit Cost	291	41	12%	40	372	
	HAM (ISI+HEPI) Production Unit Cost	1168	123	31%	404	1695	
Single stage HAM-ISI							
	estimate from line items in proposal	584	67	38%	247	898	Assume roughly stage0 (25%), stage1 (35%), stage2 (40%), so stage0 + stage2 = ~65% of baseline structure all other costs itemized
	single stage ISI + HEPI Production Unit cost	875	108	29%	287	1270	
Difference: HAM-SAS - HAM Baseline							
	Production Unit cost	-668	-73		-195	-936	
	Total: 5 HAMs x 3 IFOs (but 4 HEPIs @LLO)	-8856	-931		-2770	-12557	**$12M savings compared to baseline**
Difference: HAM-SAS - [single stage HAM-ISI + HEPI]							
	Production Unit cost	-375	-58		-78	-511	
	Total: 5 HAMs x 3 IFOs (but 4 HEPIs @LLO)	-4461	-706		-1014	-6181	~$6M savings compared to single stage ISI+HEPI
Difference: HAM-SAS - single stage HAM-ISI							
	Production Unit cost	-84	-17		-38	-139	
	Total: 5 HAMs x 3 IFOs	-1260	-255		-576	-2091	~$2M savings compared to single stage ISI

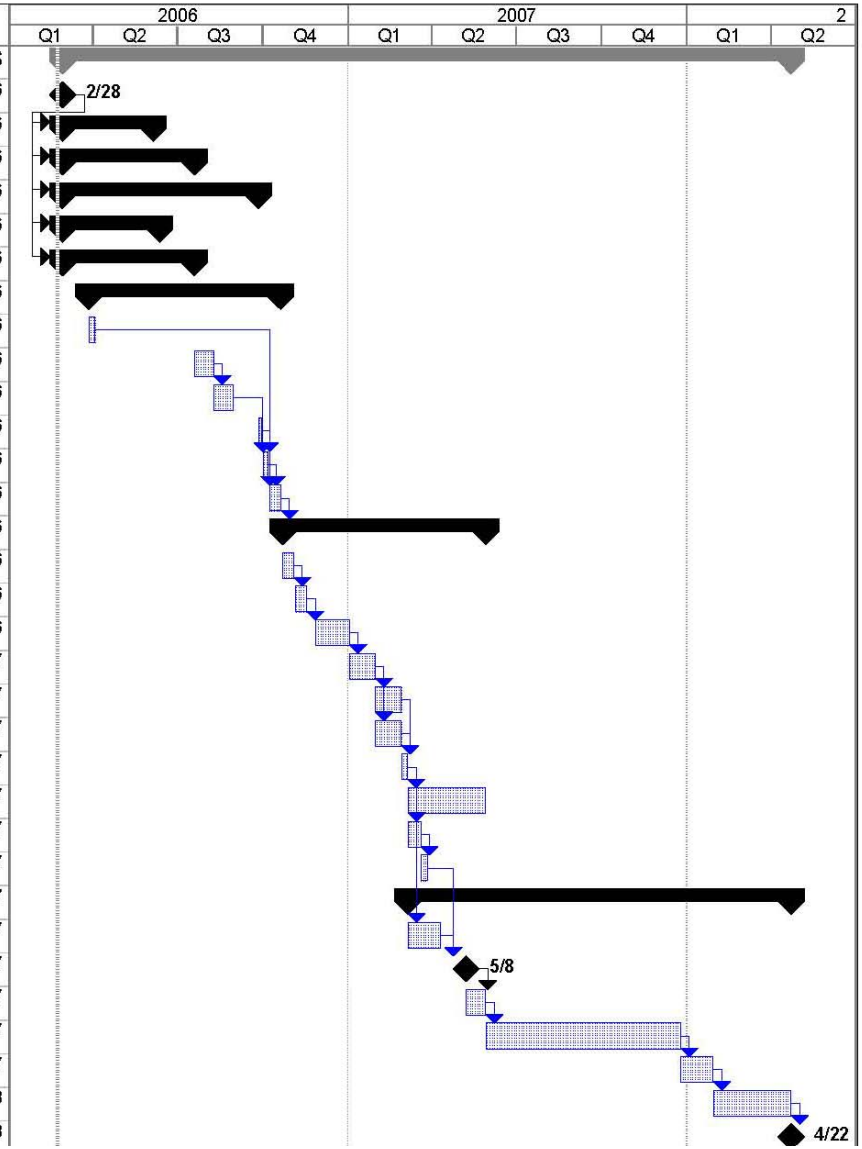
N.B.: The above cost saving estimates do not include expected considerable reduced commissioning time/labor savings.

Schedule

- Big Picture:
  - » Fabricate HAM-SAS
  - » Install in LASTI
  - » Test to specifications
  - » Technical review board: Review of test results, lessons learned
  - » Go/nogo decision
  - » IFF go, re-fab prototype with lessons learned
    - – Somewhere between small deltas, and from scratch (plan on latter)
  - » Integrated test with suspensions, etc.
  - » Production for AdL
- ‘Off Ramps’:
  - » If selected Fab contractor comes back with significant problems at the outset
  - » If Fab takes too long to allow reasonable test interval
  - » If initial setup of prototype indicates fatal flaw (dirty, unstable, interface problem)
- Detailed schedule: next page

HAM SAS Schedule

ID	Task Name	Duration	Start
0	**HAM-SAS LASTI Prototype**	**546 days**	**Tue 2/28/06**
1	CCB Decision to proceed with LASTI ptype	0 days	Tue 2/28/06
2	**Continued Modeling/Analysis**	**70 days**	**Tue 2/28/06**
7	**Place Mechanical Orders (incl. sensors)**	**100 days**	**Tue 2/28/06**
11	**Fabricate Mechanical Parts**	**148 days**	**Tue 2/28/06**
25	**Vacuum qualification**	**75 days**	**Tue 2/28/06**
30	**Controls (Electronics, Software)**	**100 days**	**Tue 2/28/06**
52	**Installation & Test @LASTI**	**146 days**	**Tue 3/28/06**
53	install 4 CAS units on LASTI Y-end HAM	1 wk	Tue 3/28/06
54	Instrumentation Test	3 wks	Thu 7/20/06
55	Electronics Install & C/O (diagnostic interface)	3 wks	Thu 8/10/06
56	Unpack Mech Hardware, inspect, assemble	3 days	Wed 9/27/06
57	Pre-installation Functional Test	1 wk	Mon 10/2/06
58	SAS installation in HAM chamber	2 wks	Mon 10/9/06
59	**HAM-SAS Testing**	**145 days**	**Mon 10/23/06**
60	IP DC controls & tuning	2 wks	Mon 10/23/06
61	GASF DC controls & tuning	2 wks	Mon 11/6/06
62	SAS dynamic characterization (system ID)	4 wks	Mon 11/27/06
63	low BW damping controls	4 wks	Wed 1/3/07
64	high frequency damping (passive, active &/or IP re-tuning)	4 wks	Wed 1/31/07
65	drift stability evaluation	4 wks	Wed 1/31/07
66	Review	1 wk	Wed 2/28/07
67	Further testing/characterization if/as needed	12 wks	Wed 3/7/07
68	HAM re-baseline evaluation	2 wks	Wed 3/7/07
69	HAM re-baseline decision	1 wk	Wed 3/21/07
70	**HAM-SAS Production Protoype (IFF entire re-fab is needed)**	**295 days**	**Wed 3/7/07**
71	re-design, prepare bid pkg	5 wks	Wed 3/7/07
72	receive bids	0 days	Tue 5/8/07
73	evaluate, approve, award	3 wks	Wed 5/9/07
74	fabrication	150 days	Wed 5/30/07
75	install @LASTI (& observatories?)	5 wks	Wed 12/26/07
76	Test Production Prototype	12 wks	Wed 1/30/08
77	HAM-SAS Production Prototype ready for HAM SUS	0 days	Tue 4/22/08



Comparison of HAM ISI and SAS Milestones

HAM 'Stiff" ISI R&D and Production Schedule	FY14 Finish Profiled Funding Start Schedule			
Activity	**Duration**	**Start Date**	**End Date**	**Costs**
Ham Design Requirements Review			Mar-06	
HAM 'Stiff' Fab Contract Award		Aug-06	Oct-06	
HAM Design Rework ~$300K	5 mos	Oct-06	Feb-07	~$300K
Decision to proceed with ISI Fab	3 wks	Mar-07	Mar-07	
LASTI Prototype Piece Part Fab	7 mos	Apr-07	Sep-07	~$1.1M
LASTI Assembly/Test/Cleaning	3 mos	Oct-07	Dec-07	
LASTI Shakedown/Installation	3 mos	Jan-08	Mar-08	
LASTI In vacuo Testing	3 mos	Apr-08	Jun-08	
LASTI Integrt'd SEI/SUS Controls Tests	3 mos	Jul-08	Sep-08	
Final Design Phase / cavity tests	8 mos	Oct-08	Jun-09	
AdL Production IFO1	22 mos	Jul-09	Apr-11	
Shutdown IFO1 (ISI critical path)			Apr-11	
AdL Production IFO2	20 mos	Dec-09	Jun-11	
AdL Production IFO3	19 mos	May-10	Nov-11	
Shutdown IFO 2 & 3			Nov-11	

HAM 'SAS' R&D and Production Schedule	FY14 Finish Profiled Funding Start Schedule		
Activity	**Duration**	**Start Date**	**End Date**
Decision to proceed - SAS			Feb-06
Fabrication HAM SAS	7 mos	Feb-06	Sep-06
Install and Test SAS @ LASTI	5 mos	Oct-06	Feb-07
Review Baseline HAM Decision	3wks	Mar-07	Mar-07
Bid, Award, Fab LASTI FD SAS	8 mos	Mar-07	Dec-07
Install FD SAS @ LASTI	1 mon	Jan-08	Jan-08
LASTI in vacuo FD SAS test	3 mos	Feb-08	Apr-08
LASTI Integrated SUS/SAS Controls tests	3 mos	May-07	Jul-08
Final Design Phase / cavity tests	8 mos	Aug-08	Mar-09
AdL SAS Production IFO1	22 mos	Apr-09	Jan-11
Shutdown IFO1 (SUS critical path)			Apr-11
AdL Production IFO2	20 mos	Dec-09	Jun-11
AdL Production IFO3	19 mos	May-10	Nov-11
Shutdown IFO 2 & 3			Nov-11

- Buy schedule relief and reality for HAM-SAS with parallel pursuit of Stiff Design rework (~$300k, 5 months)
  - » If we do not choose soft, lose $500k fab plus manpower
  - » If we choose soft, gain $6M-12M, minus $300k Stiff design costs
- Decision on HAM-SAS made after 5 months of testing
- At time of decision, Stiff design has finished detailed design – thorough knowledge of technical status/complexity
- Stiff HAM remains very well-understood and well-advanced backup if choose SAS but then run into trouble

Staffing plan

- Evolution of responsibility
- Mechanical Fabrication of initial prototype: **DeSalvo**, procurement oversight from Coyne, parallel participation from Ottaway
  - » Takes advantage of familiarity of DeSalvo with system, vendor
  - » Educates Ottaway and allows transfer for next phase
- Characterization of prototype at LASTI: **Ottaway** is responsible, 1/4 time
- Other participants:
  - » Boschi full time hands-on
  - » DeSalvo, Sannibale as visitors
  - » Flown-in Lab tech staff (e.g. Cardenas, Etzel), hourly MIT techs to help in installation
  - » Heefner (with CIT EE/ET support) to extend current LASTI DAQ rebuild to SAS additional channels, interface boards
  - » Mittleman: interface to LASTI Control and Monitoring infrastructure
  - » LASTI Postdoc to be hired (early replacement for Sarin) as additional FTE at LASTI in general fall 2006 – allows experienced and new people to spend time on SAS
- (Note: visiting postdoc from Lyon starting Oct 2006; shared LSU/LIGO postdoc joining when found to strengthen general LASTI/SEI/SUS effort)

What we are asking CCB to approve

- Approval of the basic plan to build, test and evaluate the HAM-SAS system as an alternative to the baseline HAM seismic isolation system
- Allocation of $500K in non-labor costs (without contingency) for the fabrication of a HAM-SAS prototype
  - » The estimated potential contingency required to cover risk for completion is < $180K
- Approval to allocate lab personnel (listed previously) and LASTI facility time to implement the HAM-SAS plan
- Approval to seek a suitable post-doc to work on LASTI experiments to improve the robustness of the test & evaluation team (in essence a possible single post-doc year beyond current budget allocation; not part of the $500K cost)