ALUK design requirements - open issues

Justin Greenhalgh, Caroline Cantley, Dennis Coyne, Ken Strain, Alberto Vecchio, Stuart Aston, Norna Robertson, Janeen Romie, Calum Torrie. March 2005

Version 04 following discussions at telecon on May 17th 2005. Items in red are changes.

Summary of actions:

Ref	who	Reference in table	Action	Due date or status
1	JHR	D15	Supplemental document on welding	June 15
2	DCC	D3	Mass/frequency requirement on structure	Early June
3	TJH	-	Discuss ring heater and baffles	End June
4	RJSG CIET	D1	Check mass budget completeness	End June
5	DCC	D4	Three-dimensional envelope ETM, ITM, BS: ITM with FM:	 June 15 To follow
6	RJSG	D4	Get Solidworks at RAL (at least for reading – Ian Wilmut is chasing)	End June
7	DCC	A29	New optical layout	June 15
8	RJSG	A2	Statement on alignment	First draft done
9	DCC	D31	Chase Mike Smith for anti-glint spec	June 15 (chase) End July (spec)
10	DCC	A2	Finalise RODA on alignment	June 15
11	All	A2	Comment on alignment proposals	June 15
12	RJSG	A1	Figure out what adjustment provision required, check P970151	End June
13	RJSG	D30	Verify size of gap with KAS (5mm +/- 0.5mm, constant to +/-0.1mm?)	End June
14	DCC//NAR	-	Blade damping – decide if it is needed. (Decision made to allow for it on N Ptype and fit only if required)	October 2005? (depends on CP tests)
15	RJSG	-	Note decision above in DRD doc	End June
16	SYS forum	D10	Is violin mode damping required? (Decision made to provide mounting points on N Ptype)	April 2006?
17	Blade cttee (RJSG to convene)	D7.1	Confirm decisions on clamps, heat treatment, etc.	End June
18	Blade cttee	D33	Decide on stress limits in blades and wires	End June
19	DCC	D22	Earthquake requirement	Initial answer given; final answer end June
20	RJSG	-	Static electricity provision in earthquake stops – watching brief	End 2005

21	M Barton	-	Approve a local controller design to allow us to decide how much ECD, on which axes?	End June 2005
22	ALUK	-	Finalise decision	Final decision 1 October 2005?
23	RJSG	S2	Liaise with CAC on covers for optics	End June
24	RJSG	D28	Check OSEM working range against alignment requirements	Started. End July.
25	RJSG	D26	Check PF still happy with OSEM forces in G010086.	End June
26	SYS (DCC)	-	Confirm sensor requirements	DONE
27	B'Ham	-	Outgassing tests on complete OSEM vs temperature	End June
28	DCC	D15	Revise vacuum-approved materials list	End May
29	SMA/DCC	-	Agree OSEM clean/bake procedures	End June
30	Bham	O1	Specify OSEM conditioning and testing regime	OSEM DRD
31	ALUK	E12	OSEM ECD requirements (KAS has done some initial sums)	OSEM DRD
32	KAS	D34	KAS to check with PF on ES actuator force capability. Note that there will be no definite answers.	June 2005
33	RJSG	D24, D25	Check SMA familiar with RFI documents	DONE
34	NAR and ALUK	D17, D5	Iterate on masses etc	As design proceeds
35	CAC and COC	D18, D19, D20	Exact sizes of optics	ETM/ITM by end July?
36	RJSG	P8	Extract and check wedge angles	End June

For reference, here are the principal existing documents, in increasing order of specificity:
E010613 (aka E101023): Generic requirements for subsystems ("Universal Universal DRD") Available from Denis's web page.
T000053: Universal SUS DRD
T010007-02: Cavity optics DRD (updated ~ end 2004)
T010103: Conceptual design
E030486: ALUK requirements (distilled from above, most recent version dec 2004).
E040373, 374 and 379: Birmingham ICDs
E030647: ICD (Dennis)

List of open issues, MAY 2005:

Ref in E030486	Area	Status/comment	Action
Mechanical design related			
D15	Welding practice	Use E960022-A supplemented by a	JHR will

		document to be supplied by Janeen. (what she has been been using for CP structure)	revisit
Not listed	Required accuracy of masses, spring constants, d distances, lengths of pendulums	Provided things are good enough to keep the "d" distances OK then that is all we need to do. "d" distance tolerances were considered in deciding the steps for the clamp variants (ie +/- 0.5mm). Note also need to match d distances.	None required
D16	Drawings – we will use imperial threads, but are mm dimensions OK?	E030350-05 specifies inch dimensions (page 6, item 6). We will use mm dimensions or inch with mm dual dimensions.	None required
D3	Confirm frequency requirements on Sus structure and additional masses to be allowed for (ring heaters, baffles)	Currently "officially" 150 Hz. (100 Hz in T010007?) "interim" 200 100 100 (all + 15% to allow modelling errors). See T050005-01. Dennis is trying to make this requirement more precise (and, we hope, easier).	DCC
Not listed	Details of attachments for baffles, ring heater. Mass of ring heater.	RODA existence statement. Phil Willems is working on a ring heater definition for initial LIGO. Proposal soon after LSC. Downselect affects this for AdLIGO. Tim Hayler to discuss with Phil Willems/Mike Smith in May 2005.	Tim Hayler
D1	Confirm mass budget for each Sus	Is E040136-00 is current. T040137 also refers. RJSG to verify completeness.	RJSG
Not listed	Confirm preferred axis system (x,y,z)	Documented in MPL's DCC note.	None required
D4	Geometrical envelopes ("footprint") for ETM, ITM, ITM+FM, BS	Need to be collected + defined in 3D (by DCC?). (Justin: trial of solidworks research license @ RAL?). DCC hopes to have collected info by 19 April.	DCC RJSG
A29	Location of TM wrt given references (eg corner of footprint on SEI)	Within envelope – needs Larry's redline on Dennis's layout approved. T010076-01 updates in last year. DCC to discuss with CIET. New optical layout at the systems telecon.	DCC
D16	Avoiding thread binding.	SeeT040111. Remember that nitronic 60 inserts are an option.	None required
D21	Clearance for "extra" light paths – pickoff beams etc	Mike Smith could confirm, but there are none.	None required
D31	Anti-glint surface treatment	Need input from Mike Smith. Action put on AOS in T050005-01. DCC to	DCC

		remind Mike Smith	
A2	Alignment – how well must things be aligned for handover of assembled suspensions?	This may be only one or two key issues external to SUS + a set of issues (OSEM alignment etc) internal to SUS See G030409 Within range of seismic = 0.5mm placement vert + lateral use initial LIGO as basis (Janeen talk from Glasgow summit). Justin needs to study existing info and verify completeness. RODA from Ken Mason – circulated for signature; need closing	RJSG NB see draft in addendum 1 to this note. DCC
		Justin has written an addendum to this note with his proposals for alignment. All to comment.	All
A1	What provision must be made for further adjustment?	This includes OSEM residual range. ACTION: as above Plus check P970151.	RJSG
D30	Size and accuracy of gap between TM and reaction mass in ETM.	Internal SUS. RJSG to discuss with KAS – 5mm nominal.	RJSG
D11	Blade matching – how well do we need to match blade pairs and in what respect?	SUS internal. Use 1.5% max difference in a pair; target 0.5%.	
Not listed	Is blade damping required?	Internal to SUS. Working paper of NAR. Need to compare risks. Agenda item for Systems telecom. (DCC) NAR to revise working paper using new info from C Ptype, DECISION to provide for it on N Ptype, and supply dummy magnets in case not needed. (RJSG to note)	DCC NAR RJSG
D10	Is violin mode damping required?	ISC interaction required. KAS, Peter Fritschel. Potential designs are amorphous Teflon (does not affect SUS design at all) or some sort of electrostatic system (requires mounting for a lightweight device near ribbons). Programme of work may be starting at Glasgow. DECISION to provide mounting points on noise prototype. (RJSG to note)	RJSG CAC ACTION transferred to SYS forum.
D7.1	What to do about creak in clamps?	In principal, internal to SUS. Solve by the anti-creep and anti-creak heat treatment proposed by Riccardo. Blade committee to confirm.	Blade ctte
D33	Creep in wires – what	As above – use 55% of yield limit for	ditto

	stress limits to use? Insist on maraging?	blades. Blade committee to confirm and to decide on limit for wires.	
D22	What are the earthquake survival requirements?	Please give static equivalent! Not clear how to decide if earthquake stops will damage masses. DCC to supply reference to initial LIGO requirement. (See initial answer in email DCC 26 April 2005)	DCC
Not listed	Static/anti-static electricity requirements on earthquake stops	Ensure they are modular. Testing of fused silica-tipped stops in hand to address the charging question. Needs a method to gauge distance from optic? E021000 and E040457 Greg Harry for static stuff. Greg Harry is in charge of research – JHR hopes to start tests soon	RJSG to pursue if outcome from SUS not clear
Not listed	How much ECD, on which axes?	Internal to SUS. Needs significant amount of work. M Barton to approve a controller design for the local damping. SUS telecom item. (Provisional suggestion for design studies: vert & roll; use two off 4x2 units. Long, pitch and yaw use three off 4 x 2 units. Transverse not required)	M Barton SUS telecon. ALUK to lead final decision
S2	Protection of optics during assembly Protection during laser welding.	RODA on covers – needs more detail. RJSG to liaise with CAC (optics, general) + Helena (coating specific)	RJSG
OSEM/electronics related			
Not listed	Limits on size of magnets (magnetic moment issues)	As D26	
D28	OSEM working range	Need to check against A1 and A2. RJSG to verify numbers, but decision already made! Note Laurant Ruet has written a note T050063 including comment on aligning OSEMs	RJSG
D26	OSEM force capability	G010086 talk. Need to check Peter still happy. Discussed in T050005-01.	RJSG?
Not listed	Confirm NO SENSORS on global OSEMs	Current deal – fit to CP but not to final design. Put into a RODA (RJSG). See email exchanges April 3 & 4 2005. SYS meeting outcome: sensors on NP but not on final SUS.	Transferred to SYS
Not listed	Limits on heat generation in OSEMs	Discussed in T050005-01. Temperature limit related to outgassing and to lifetime. Needs temperature-outgassing test on assembly.	B'Ham

D15	Need to finalise vacuum approval for OSEM sensors, coil wires, leads, plugs/sockets	Current E960050-B-E of Jan 2004 does not allow kapton wire or teflon coated kapton wire for pigtails! (DCC to update) Also need temperature dependence for some items.	DCC
Xxx	Cleaning and baking of OSEMs	Need to ensure this is agreed. See E960022 procedure as baseline.	SMA & DCC
D14	OSEM electrostatic buildup	Fixed by using metal OSEM.	
O1	OSEM MTBF	Any tests beyond the ones Nick is doing (eg high power test on coils)? Need high-current burn-in test. Consider: 1. Initial burn-in of emitter to minimise subsequent change in output 2. Routine overvolt test on coils – "HIPOT" tests?	BHam soon & RAL later
E12	OSEM ECD requirements	Internal SUS? Need to quantify? Needs check against Mark B document on ECD for initial LIGO for OSEMs at test-mass.	ALUK
D34	ES actuator force capability	Use controls design? How to progress this? Ask Peter F. Needs E2E for full answer.	KAS to check with PF
D24, D25	RFI (grounding and shielding) requirements. Limits on how much we can generate and ability to cope with EMC from others.	Is E960036-A sufficient? More up to date are E020350-08 and E040288-00. RJSG to check Stuart is familiar with these.	RJSG
Science/performance related			
D17, D5	Masses, lengths etc for ETM, ITM, FM, BS suspensions. Masses and moments of inertia of all masses in chains.	Internal SUS – need to iterate with Norna as design proceeds. Initial need is to update ETM/ITM design for silica.	NAR and designers
D18, D19, D20	Exact masses and sizes for test masses (ETM, ITM, FM, BS) and CP	Provisional ETM TM drawing in hand (by Janeen), CAC has a copy. COC has to approve the final drawing.	CAC and COC
P8	Wedge angles on test mass blanks and on reaction masses	Defined in SYS optical layout T010076-01 scenario 4 except wedge angle for BS has error. RJSG to extract numbers & get error fixed.	RJSG

Addendum 1. DRAFT FOR COMMENT

Initial alignment requirements. Comparisons with Initial LIGO are taken from G030377-00, Janeen's alignment talk at the Glasgow summit. The other reference is G030409, Dennis's talk at the same meeting.

1. When the suspension is installed in the vacuum tank and has been initially aligned, and the OSEMs are switched off, ALL of the below must be met:

1a. the location of the test mass should be correct to:

Vertical: center of test mass at nominal location wrt LIGO alignment system to +/- 1mm (See G030409 page 3 and comment under 2a below).
Initial LIGO had +/- 0.5mm (for smaller masses!)
Lateral: center of test mass in nominal location wrt LIGO alignment system to +/- 1mm
Initial LIGO required only to keep the OSEMs working
Longitudinal: no requirement defined.
Initial LIGO required only to keep the OSEMs working
Pitch: (NB cannot correct with SEI system – this is a pendulum!) sufficiently close to LIGO alignment system that only 0.1mm OSEM movement is required to make it perfect. 0.5mRad would comfortably meet this.
Initial LIGO had +/- 0.5mRad.
Yaw: correct to LIGO alignment system so that SEI table can do remaining correction: = +/- 0.5 mRad (G030409 page 3 gives +/- 0.7 mRad)
Initial LIGO required only to keep the OSEMs working
Roll: no requirement
Initial LIGO required only to keep the OSEMs working

1b. OSEMs at their nominal positions within +/- 0.1mm

1c. A further +/-0.1mm of OSEM range is available for static corrections and the coils can dissipate the associated heat loads. (Is this reasonable???)

1d. The location of the reaction mass (ETM) should be correct to:
distance from test mass = nominal distance +/- 0.5mm
pitch wrt tests mass:
yaw wrt test mass:
roll: no requirement.

1e. Earthquake stops all set to a gap of minimum xxx mm, maximum yyy mm.

1f. the location of the compensator plate should be correct to:
height: center of compensator plate at correct height wrt test mass within +/- 5mm
lateral: center of compensator plate at correct height wrt tests mass within _+/- 5mm
longitudinal: face of compensator plate at nominal distance from tests mass within +/- 5mm

pitch, yaw: to give no more than +/- 2mm error from parallelism with test mass.
Roll: no requirement.

1g. Folding mirror must be aligned as follows:
vertical: centre of folding mirror within +/- 1mm of minimal
lateral: distance from centre of test mass within +/- 1mm
pitch, yaw: must be near enough correct wrt test mass such that only 0.1mm of OSEM movement is required to make it perfect wrt test mass.

2. (derived requirement, but for an earlier assembly state). When the suspension is assembled outside the vacuum tank and the OSEMs are switched off:

2a. the location of the test mass should be correct to:
Vertical: centre of test mass at nominal distance from SEI interface plane to +/- 0.5mm (this allows a further +/- 0.5mm error in height of the SEI to meet the requirement in 1a above).
Initial LIGO had a blank
Lateral: centre of test mass should be within +/- 10mm of nominal wrt structure
Initial LIGO had +/- 1 or 5mm
Longitudinal: no requirement (other than as needed by assembly procedure)
Initial LIGO had +/- 3mm
Pitch: aligned to true vertical within same limit as given in 1a above.
Initial LIGO had +/- 0.1 mrad
Yaw: no requirement (corrected by adjusting SUS/SEI interface)
Initial LIGO had +/- 0.1 mrad
Roll: no requirement (except as needed by ears/fibres).
Initial LIGO had n/a

2b: alignment markers: there should be alignment marks or targets on the structure which are:
vertical and lateral: location within +/-6 mm of test mass true centre, known within +/- 0.5mm.
longitudinal: not defined.

2c: OSEMs all set to within 0.1mm of nominal

2d: earthquake stops: tbd, need to understand if they are the “cage” mechanism and how this ties in to the catcher etc.

2e: compensator plate or reaction mass:
Aligned wrt test mass as in 1 above.

Addendum 2 – email from Dennis Coyne summarising the Electronics discussion with highlighting in red by Justin for the "UK" parts.

-----Original Message-----
From: Greenhalgh, RJS (Justin)
Sent: 29 March 2005 18:33
To: sma@star.sr.bham.ac.uk; av@star.sr.bham.ac.uk; Dave Hoyland
Cc: k.strain@physics.gla.ac.uk; Dennis Coyne; Greenhalgh, RJS (Justin); romie_j@ligo.caltech.edu
Subject: FW: Notes from the Informal SUS Electronics Discussion

All,

Just to avoid any confusion I have highlighted in red below the things for which I understand the UK (AV, SMA, DH) to be responsible following a discussion at the sus_weekly telecon.

Cheers - Justin.

From: Dennis Coyne [mailto:coyne@ligo.caltech.edu]
Sent: Thu 24/03/2005 21:44
To: Alberto Vecchio; Stuart Aston; Jay Heefner; Mohana Mageswaran; Joseph Giaime; Janeen Romie; David Hoyland
Cc: Greenhalgh, RJS (Justin)
Subject: Notes from the Informal SUS Electronics Discussion

Notes from the Informal SUS Electronics Discussion

SUS/UK Schedule requires an electronics Preliminary Design Review (PDR) no later than mid-July
This means PDR documents available no later than end of June (2 weeks earlier)
Let's assume that we'll be ready (US & UK) and revisit after the meeting and as the effort progresses

Key/essential attendees for the PDR:
SUS: Stuart Aston, Dave Hoyland, Alberto Vecchio, Justin Greenhalgh, Ken Strain, Jay Heefner, Mohana Mageswaran, Janeen Romie, Mark Barton, Dennis Coyne, Norna Robertson
SYS/PM, other: Peter Fritschel, Carol Wilkinson, David Shoemaker, Rai Weiss, Rana Adhikari, Daniel Sigg, ...

** Coyne to email to key personnel to get consensus on best date in July (note: 7/22-29 is not good)

Review documents/content to be prepared:
SUS Elect design req (RD)
- one for UK analog front end electronics
- one for US digital electronics

SUS Electronics Preliminary Design Document (PDD)
- one for UK
- one for US

Interface Control Document (ICD)
- document(s) for SUS US & UK interfaces (collaborative)

System block diagram (Jay)

Module/Box Block Diagram for each module (UK)
Prelim Design Module Schematics (UK)
Test results from PD prototypes (performance, features, lessons learned, ...)
[Note: Preliminary design level for UK scope, but likely Conceptual design level for US scope]

EMC requirements (aka RFI) and guidance/example; references from the "LIGO Drawing Requirements & Guidelines" document, E030350-A(pending):

- M. Zucker, "LIGO Interferometer Electronics EMC Requirements", E020986-01

  http://www.ligo.caltech.edu/docs/E/E020986-01.pdf

- M. Zucker, J. Heefner, "EMC, “Shielding and Grounding Retrofit Plan”, E020350-08,

  http://www.ligo.caltech.edu/docs/E/E020350-08.pdf

- B. Abbott, "Installation of RFI Mitigated HEPI System at LLO", E040288-00, 18 Jun 04

  http://www.ligo.caltech.edu/docs/E/E040288-00.pdf

Jay gave an overview presentaiton of the LIGO digital control architecture. This archetecture may change some for advanced LIGO, but the principles and capabilities will be similar. Stressed the need to monitoring points in the slow data acquisition (EPICS) system -- cheap and useful. Jay's presentation can be found from his web page:
http://www.ligo.caltech.edu/~jay/

We walked through the new Rack Room and the LVEA to see the current electronics infrastructure, layout, cabling plant and practices.

Walked through UK's three ICDs. We looked at revised (up-to-date) versions of the following:
http://www.ligo.caltech.edu/docs/E/E040373-00.pdf (OSEM Interface Control Document)
http://www.ligo.caltech.edu/docs/E/E040374-00.pdf (OSEM Drive Electronics Interface Control Document)
http://www.ligo.caltech.edu/docs/E/E040379-00.pdf (Electrostatic Actuator Drive Electronics Interface Control Document)

Noted that these ICDs mix requirements and design description/choices with interface definition. UK Team to consider reducing the content to interface specific items and possibly combining to a single document.

Coyne: define the expected temperature range for the OSEMs. Curently listed as 22 +/- 2 C seasonal variation, which I think is the original building specification. Will be elevated (slightly) by the dissipation of the SEI elements.

Note: Afetr the meeting, I spoke with Robert Schofield. LHO has long term building trend data in the FMCS system as well as the frame data. Robert says that at LHO the LVEA temperatuire is controlled to well under the original specification, year-round, about nominal +/- 1C or better. Not sure yet what data LLO has -- will check. Robert advised that we stick with the building requirements unless it is critical to tighten up the temperaturee variation since we are in the process of revising the HVAC to minimize the 60 Hz magnetic field noise and the revised control might degrade the performance observed to date slightly.

Calum & Jay: need "pigtail" layout drawing, i.e. a drawing of the wiring harness(es) from the interface connector at the SEI optics table to each of the OSEMs. US to provide this wiring harness as part of the controls prototype build.

UK to incorporate:
- a disable switch commanded by the digital control system to disable current drive to the SUS
- a slow blow fuse to protect the coil from overheating

UK to consider whether an opamp at the OSEM head is needed to reduce the effect of cross-coupling noise. Ken Strain is aware of LIGO's concern.

Started to walk through Dave Hoyland's draft circuit schematic.
The sensor output is currently bipolar +/- 10 V. There isn't a need to have a bipolar output. LIGO doesn't know what ADC will be used at this time. UK should plan on 0-10V range and LIGO Lab will adjust to match the range of the ADC eventually selected.

Jay & Mohana planned to continue the discussion with Dave in the afternoon. Further comments Jay?

N.B.: Joe Giaime had planned to 'pontificate' (and I mean this in the best sense of the word) about the need for self-test and provision to readily perform analog section end-to-end, in situ testing. Unfortunately his schedule didn't allow for this. We need to understand the specifics of Joe's proposal so that the implications for SUS are understood.

Addendum 3. email from Dennis of Feb 2005, should be noted when updating E030486.

-----Original Message-----
From: aligo_sus-admin@ligo.caltech.edu [mailto:aligo_sus-admin@ligo.caltech.edu] On Behalf Of Dennis Coyne
Sent: 17 February 2005 19:08
To: Janeen; aligo_sus@ligo.caltech.edu
Subject: [Aligo_sus] clarification on special "viton" recipe for LIGO

In the 2/15 meeting notes for item 7, "Installation Fixtures", it was noted:

" (Oddvar)... is considering using the motor from the initial LIGO course actuators with a longer stroke lead screw. He can cover the lubricated lead screw with a metal or viton bellow. He will pull out one of the stepper motors and check it out. We could order another stepper motor. He may use this with the air bearings. Doug mentioned that the special recipe Viton (the LIGO vacuum compatible version) is quite expensive now. They've just gone out for quote for some spare earthquake stop tips. And the still have to be processed by Walker & Sons, which is also pricey. Oddvar is considering telescoping tubes to enclose the lead screw."

The special LIGO formulation used for earthquake stop tips and coil spring seats is actually "Flourel" (TM) and not "Viton" (TM), though it is quite similar. BTW, the recipe is given here: http://www.ligo.caltech.edu/docs/E/E970130-A.pdf

One only needs to perform the DI water bake process (the "Walker" process) for components which remain in vacuum (i.e. class A parts per http://www.ligo.caltech.edu/docs/M/M990034-C.pdf), not for tooling which is removed before pump down (i.e. class B parts). For reference, the Walker process is defined here: http://docuserv.ligo.caltech.edu/docs/internal/L/L990205-00.pdf

In addition, I think an exception can be made to allow other formulations of Viton or Florel into the chambers if the risk of shedding is small. As a matter of fact, for initial LIGO the Viton caps on the base of the uneven legged stool used to stand on the dished bottom of the BSC chambers during installation were in fact composed of a common grade Viton.

Dennis

Addendum 5. Other documents to reference in E030486:

T040073: Top mass design brief
T050005-01: Interface issues following meeting in Feb 2005. Several issues including use of drum-ended wires in N Ptype.