

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 01 following discussions at LSC in March 2005.

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, March 2005:

Ref in	Area	Status/comment	Action
E030486			
Mechanical design related			
D15	Welding practice	Use E960022-A supplemented by a document to be supplied by Janeen. (what she has been using for CP structure)	JHR
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)	
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.	
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.	??? LIGO labs
D1	Confirm mass budget for each Sus	Is E040136-00 is current. T040137 also refers.	RJSG

		RJSG to verify completeness.	
Not listed	Confirm preferred axis system (x,y,z)	Along beam axis = See Hitec document for chamber-based stuff: u,v,w (local vertical). Co-ordinate planes talk to Calum + MPL. DCC to give Hitech ref. RJSG to chase MPL	DCC RJSG
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 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.	DCC
D16	Avoiding thread binding.	SeeT040111. Remember that nitronic 60 inserts are an option.	
D21	Clearance for “extra” light paths – pickoff beams etc	Mike Smith could confirm, but there are none.	
D31	Anti-glint surface treatment	Need input from Mike Smith. Action put on AOS in T050005-01.	???
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.	RJSG NB see draft in addendum 1 to this note.
A1	What provision must be made for further adjustment?	This includes OSEM residual range. ACTION: as above	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.	???
D10	Is violin mode damping required?	ISC interaction required. KAS, Peter Frischel.	???
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. Blade	ditto

	stress limits to use? Insist on maraging?	committee to confirm.	
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.	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.	?????
Not listed	How much ECD, on which axes?	Internal to SUS. Needs significant amount of work.	?????
S2	Protection of optics during assembly Protection during laser welding.	RODA on covers – needs more detail.	?????
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!	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.	RJSG
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! (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.	BHam soon & RAL later
E12	OSEM ECD requirements	Internal SUS? Need to quantify? Needs check against Mark B document.	???
D34	ES actuator force	Use controls design? How to progress	????

	capability	this? Ask Peter F	
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 E0402878-00. 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 whom?)	???
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.	
Others			
	Open issues on RM and PU mass?	All mass sizes need revising. Ear area needs confirming.	CAC + HA??

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 presentation of the LIGO digital control architecture. This architecture 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. Currently 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: After 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 temperature 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 temperature 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.