

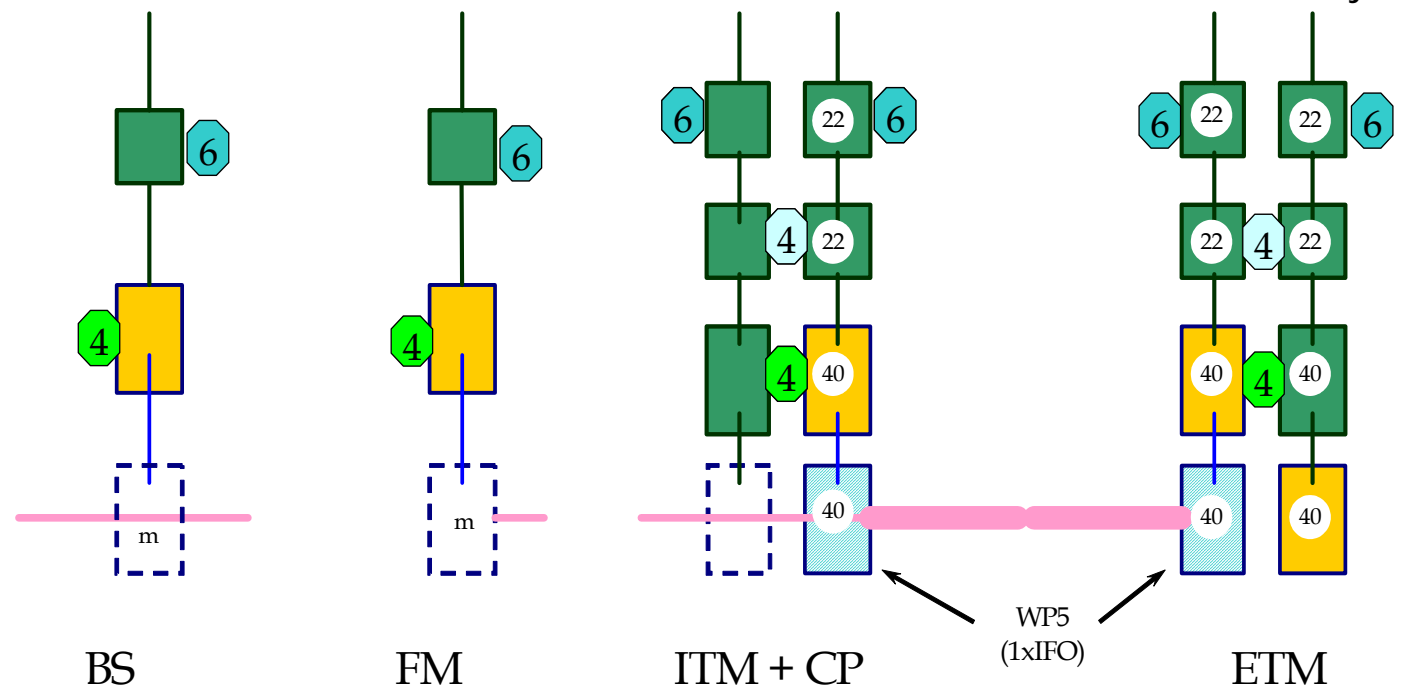
Scope of ALUK work packages			
Area	Item (WP) Included	Item Inclusion to be defined	Item Excluded
A Suspension types	A1 (3) See figure 2 for which SUS are included (these are “the BSC SUS”). One ETM is a first article. A2 (3) Six spare SUS		
B Suspension structures	B1 (3) Structures B2 (3) All blades and clamps B3 (3) Suspension wires B4 (3) mass catcher and earthquake stops B5 (3) All metal masses (see figure 1) B6 (3) Baffle fixings – for main optics baffles B7 (3) Baffles to protect fibres from beam B8 (3) Fittings for CP heating B9 (3) Adjustable fittings for OSEMS and EC dampers (extent of adjustability TBD by RJSG and JR) B10 (3) All parts to be cleaned. B11 (2, 3) Violin mode damping method and parts.		BE1 Baffles for main optics BE2 CP heaters BE3 UHV cleaning not required except for UHV cleaning of noise prototype if it will help schedule. BE4 Any parts of the violin mode damping which do not mount on the suspension (eg active control system).
C Optics	C1 (2) All non-metal masses except some TMs, see figure 1 and addendum 4. C2 (5) Four test mass blanks C3 (2) Ears/prisms for all BSC optics including spares and compensator plate. C4 (2) “H” pieces if they are used. C5 (2) Ribbons for noise prototypes	CU1. Possible opportunity: ears for HAM suspensions	CE1 Test mass for two IFOs, any spare test masses CE2 Polishing of test masses CE3 Folding mirror, compensator plate, beam splitter CE4 Gold coating

	Included	TBD	Excluded
D OSEMs for BSC noise prototypes	D1 (4) OSEM head, wired, with emitter/detector pair D2 (4 in collaboration with 3) Magnet and flag assembly D3 (4) Pigtail fixed to OSEM and with fitted plug D4 (4) Fixing bracket for OSEM D5 (4) “system spares” D6 (3) EC dampers	DU1 Number of in-process spares required – for Bham and RAL to decide	
E OSEMs for production SUS	See figure 2 for which are the BSC SUS E1 TO E5 (3 switched to 2) As above E6 (3) EC dampers E7 (3 switched to 2) System spares		EE1 LIGO-1 type OSEMs ; OSEMs for “Aux” suspensions.
F Drive electronics For noise prototypes and production SUS, BSC and HAM	F1 (4) Minimum spec for wiring between pigtail and satellite box F2 (4) Drive electronics taking analogue signals F3 (4) Amplification of sensor signals giving analogue outputs F4 (4) Hardware of satellite boxes using supplied DC power supply F5 (4) Final regulation of provided DC power F6 (4) Wiring “pigtails” that go from the OSEM to a bulkhead fitting on the SEI, near the SUS. F7 (4) System spares		FE1 Bulkhead connector on SEI table. FE2 Wiring from SEI bulkhead fitting near the SUS, to the satellite box or equivalent outside but local to the tanks. FE3 Power supplies converting mains to DC power supply FE4 Any electronics other than as noted under F2 and F3
G ES drives for ETMs	G1 (2) design for ES drive electrode pattern G2 (2) feasible method to fix wires to reaction test mass electrodes G3 (3) System to bring wires from reaction test masses to SEI bulkhead fittings G4 (3) application of ES drive electrode pattern (“gold plating”) G5 (4) Drive electronics for ES drive G6 (4) Drive electronics taking analogue signals G7 (4) Wiring “pigtails” that go from the reaction mass to a bulkhead fitting on the SEI, near the SUS. G8 (4) System spares	GU1 (should the coatings be in WP3, 4 or 5?) ¹	GE 1,2,3,4 As above

¹ The reaction masses are in WP5, the design of the coating is in WP2 and the coating is in WP3.

	Included	TBD	Excluded
H Assembly procedures and equipment	<p>H1 (3) Procedure and equipment to safely assemble all masses into SUS structure</p> <p>H2 (2) “research” procedure to make ribbons and to assemble TM/fibre/PM (aka “catcher”) and ears to reaction mass (this equipment will be used on the noise prototypes)</p> <p>H3 (3) “production” procedure and equipment to make ribbons and to assemble TM/fibre/PM and ears to reaction mass, at one site.</p> <p>H4 (3) Procedure and equipment to safely assemble ready-made monolithic TM/fibre/PM assembly into SUS</p> <p>H5 (3) Procedure and equipment to make the assembly secure for movement to storage, thence to vac tank, and thereafter to bring the assembly into its usable state</p> <p>H6 (3) Procedure and equipment to allow alignment (details unclear)</p> <p>H7 (3) Procedure and equipment to replace broken fibre and broken wire</p> <p>H8 (3) Draft assembly procedures and “mark one” assembly tooling at LASTI for noise prototypes</p> <p>H9 (3) Assembly, with local staff, of noise prototypes at LASTI. Iterate on tooling. Some commissioning work, extent TBD</p> <p>H10 (3) Assembly, with local staff, of two SUS at each site (LLO, LHO)</p> <p>H11 (3) Assistance and advice with assembly work by others</p> <p>H12 (3) fixing positions for alignment targets.</p> <p>H13 (5 and 3) Procedures and equipment to bond ears and H pieces</p> <p>H14 Assembly tooling to be UHV cleaned and baked.</p>	<p>HU1. Possible opportunity: item H3 for the second site.</p> <p>HU2. Possible opportunity: item H3 for HAM optics.</p>	<p>HE1 Procedures, Lifting beams etc to install assembly into vac tank. Note that some assembly equipment may be used during installation. Such equipment is included in the scope of the UK work.</p> <p>HE2 Measuring equipment for alignment</p> <p>HE3 Assembly of SUS beyond the first two at each site</p> <p>HE4 Any assembly work beyond the scope of the procedures and equipment we are supplying</p> <p>HE5 Targets to be used during installation and alignment</p>
J Design documents	<p>J1 (3,4,5) Interchange, as required, of 3D models</p> <p>J2 (3,4) Full drawings in electronic form (dxf or pdf) as used for manufacture</p> <p>J3 (3,4,5) Design review documentation – drawings and descriptive text plus presentations</p> <p>J4 (3,4,5) Participation in design reviews.</p>	<p>JU1. Possible provision of as-built models in electronic form.</p>	

Unless otherwise noted, procedures include devising and writing a procedure subject to review. Hardware items include design subject to review, procurement, payment, and delivery. (By procurement I mean organise required tender action or otherwise locate a supplier, visit suppliers to verify competence, place tender, liase with supplier during manufacture, inspect goods on receipt and correct any problems).



BS

FM

ITM + CP

WP5
(1xIFO)

ETM

Key

- = non-metal, WP2
- = not UK
- = metal, WP3
- = WP2, 1 IFO only
- 6 = B'ham style OSEMs with sensors
- 4 = LIGO 1 style OSEMs, no sensors
- 4 = B'ham style OSEMs without sensors

Figure 1. Masses included in ALUK scope

Also includes current OSEM counts and approximate masses for information only - not part of specification. BS/FM masses will be identical see RODA.

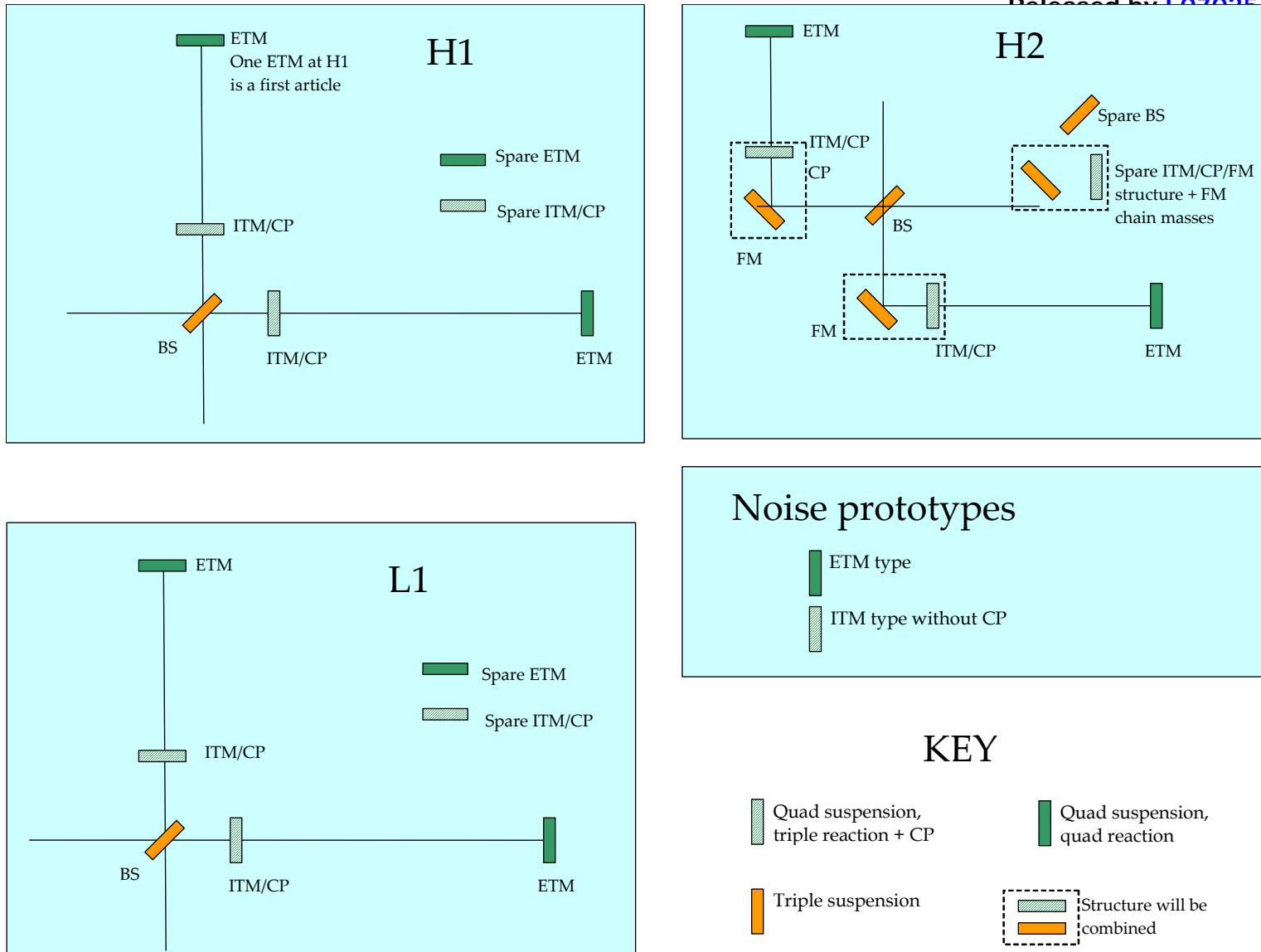


Figure 2 – SUS types in ALUK

Note: non-metal masses spares are slightly different from the spare suspensions shown here. See addendum 4.

Revision history

A – made during the Hannover LSC meeting

B – ditto after discussions with Dennis and Jim

C – after feedback from Norna, and others, and adding issues list from Glasgow August 2003 meeting.

D – feedback from David Shoemaker – see email sent 090903 at 12:03.

E - added scope item numbers

00 – First release on DCC after telecon of 30 Sept 2003 – see email of 1 oct 03

01 – added third noise prototype 13 nov 2003

02 – removed third noise prototype, included OSEMS for HAM noise prototypes ($14*(4+1+1) +6$) plus 10% extra Minor changes in wording of main table row A, (RODA now makes CP/IM commonality the baseline). Some WP5 items should be WP2. FM and BS have no test reaction mass in final table. January 2004.

03 – May 2004: Clarified cleaning requirements (B10, H14). Modified count table to split out OSEMs and electronics in a clearer form. Removed possible separate CP suspension (M040005 and T040085 refer). BS and FM now likely to be triples (See T040027). July 2004: Added addendum 2 with table of penultimate and reaction masses (from CAC). EC dampers for noise prototypes (item D6) now part of WP3. Added query GU2 on gold plating masses.

04 – December 2004: Modified cleaning requirements (B10). Added potential to make ears for HAMs (CU1)

Added ribbons for noise prototypes (C5) and ribbon-making equipment (H2, H3, HE5). Replaced ribbon welding equipment at two sites with ribbon making & welding equipment at one site (H3) with opportunity for second site (HU1). Added opportunity to provide ribbon making/welding for HAM optics (HU2).

Clarified provision of non-metal masses (spares policy subtly different from that for the suspensions. Suspensions have four ETM/ITMs and two BS/FM, non-metal masses have three ETM/ITM and three BS/FM).

March 2005 Removed GU2 about coating masses supplied by others. Added ES drives on N-Ptype in table 3. Removed reference to two ITM noise prototypes. Corrected colouring of items in table 2 (some ECD were blue, should be black).

September 2005 Modified table 3 to 5 ESD channels per ETM and 6 (not 3) ETMs, added proviso on complete spare ESD chassis. Clarified origin of electronics channel count.

Release A.

November 2006. Removed reaction chains from BS and FM and changed them to triples. Switched lower OSEMs to LIGO 1 type. Removed sensors from all suspended OSEMs. Changes to counts of optics especially spares for noise prototype.

Clarified cleaning requirements (B10). Added violin mode damping (B11). Glasgow to provide breakoff prisms for comp plate (C3)

Feb 2007 Changes to counts of OSEMs and electronics channels to allow for the above and other changes.

Release B

Oct 2007: switched responsibility for Bham OSEMs from LIGO to Gla + BHam (addendum 2; main table item E; change agreed at March 2007 OsC).

Added assembly prototype FM/BS to addendum 1 (change log item 52).

Added potential supply of electronic models (main table item JU1).

Removed "glass" PU masses from BS and FM, substitute metal masses (change log item 54) affects addendum 1 – addition of PU mass line - and addendum 4.

Increased ESD channels to 6 per SUS in line with outcome of OsC March 2007 (opportunity 5 in that report, only partially approved see opportunity 5 in the OsC report of October 2007)

Release C

Table 1. Count of structures and metal masses (Excludes temporary metal masses used for assembly)										
	BSC								assembly prototype FM/BS(**)	Total
	ITM + CP	ITM+CP+FM			ETM	Noise prot		BS		
		ITM+CP chain	FM chain	structure		ITM	ETM			
Count (L1)	2				2			1		
Count (H1)	2				2			1		
Count (H2)		2	2	2	2			1		
Count (spare)	2		1	1	2			1		
Count (NP)						1	1			
Total	6	2	3	3	8	1	1	4		
	<i>numbers per SUS</i>									
Structure	1	1	0	1	1	1	1	1	2	27
TOP mass	1	1	1		1	1	1	1	1	26
UI Mass	1	1	0		1	1	1	0		18
TOP R mass	1	1	0		1	1	1	0		18
UI R Mass	1	1	0		1	1	1	0		18
PU mass			1					1		7
PU R mass	1	1	0		1	1	1	0		18
Metal masses total	5	5	2		5	5	5	2	1	105
Mass set (*)	A	A	B		A	A	A	B		

(*) The "Mass set" is the combination of masses in the chain (eg 22-22-40-40)

(**) This is the prototype planned for early 2008 to check no obvious problems in assembling FM/BS.

There will be a new FM/BS chain and top stage

The BS will use one of the frequency-test structures + the new chain

The FM will use a new structure, the new BS chain, and the noise prototype ETM chains.

Table 2. Count of OSEMs.																		
<i>OSEMs which are to be provided by LIGO labs are included only to allow calculation of channel numbers for electronics</i>																		
	BSC						HAM								Total			
	ITM + CP	FM	ETM	Noise prot		BS	RM	IMC	OMC	RM NP	IMC NP	OMC NP	Aux NP	Aux	Bham	LIGO	Gla + Bham	Overall
				LASTI	UK													
production sus qty	6	2	6	1	1	3	6	9	3	1	1	2	4	30				
spare sus qty	2	1	2			1	3	3	3					0				
	Per SUS																	
BHam-type OSEMs	16	6	16	16	6	6	6	6	6	6	6	6	4	0				
LIGO-1 OSEMs	4	4	4	4	1	4	8	8	0	8	8	0	5	5				
	Total numbers																	
BHam-type OSEMs	128	18	128	16	6	24	54	72	36	6	6	12	16	0	62	0	460	522
LIGO-1 OSEMs	32	12	32	4	1	16	72	96	0	8	8	0	20	150	0	451	0	451
	Total numbers with system spares																	
Spares level (hybrid)	20%	20%	20%	20%	20%	20%	33%	33%	33%	33%	33%	20%	20%	20%				
Spare level (LIGO 1)	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%				
	with spares																	
BHam-type OSEMs	154	22	154	20	8	29	72	96	48	8	8	15	20	0	79	0	575	654
LIGO-1 OSEMs	39	15	39	5	2	20	87	116	0	10	10	0	24	180	0	547	0	547

Key	Black	RAL	UK provides these Electronics channels (no spares shown here; see table 3)														
	Blue	Birmingham	ETM/ITM	hybrid	278	total quad	347										
	Red	LIGO Labs	FM/BS	hybrid	42	total triple	476										
			HAM	hybrid	202												
				LIGO1	204												
			Aux (not UK)	LIGO1	150												

Table 3. Electronics channels				
	OSEMs (from table 2)		Electrostatic	
	Bham type	LIGO 1 type	6 per ETM	Noise prototype
ESD channels			36	6
ETM/ITM	278	69		
FM/BS	42	28		
HAM	202	204		
System spares level	20%	20%	6 Per site (*)	2
With system spares	626.4	361	48	8

(*) A complete spare fully-functional 5 channel chassis is to be provided at each site unless the amplifiers are fully "plug-and-play" swappable

Updated Scope Penultimate & Reaction Masses

LIGO.4.03.4.2.1. Penultimate Blanks		
New Name	Description	Quantity
SUS Penultimate Blanks - FA (First Article)		
ETM penultimate mass	ETM-BSC_IM - 317mm dia. X 133 mm thick	1
ETM reaction mass	ETM - BSC	1
ETM reaction mass SPARE	ETM - BSC SPARE	1
ETM/ITM penultimate mass SPARE	ETM - BSC_IM - 317mm dia.x133 mm thk -SPARE	1
SUB-TOTAL		4
SUS Penultimate Blanks - IFO1		
BS penultimate mass	BS-BSC_IM - now metal	0
ITM penultimate mass	ITM - BSC	2
ETM penultimate mass	ETM - BSC_IM - 317 mm dia. X 133 mm thick	1
BS penultimate mass SPARE	BS-BSC_IM - now metal	0
ETM reaction mass	ETM- BSC	1
SUB-TOTAL		4
SUS Penultimate Blanks - IFO2		
BS penultimate mass	BS-BSC_IM - now metal	0
BS penultimate mass SPARE	BS-BSC_IM - now metal	0
ETM/ITM penultimate mass SPARE	ETM - BSC_IM - 317 mm dia. X 133 mm thick SPARE	1
ETM reaction mass SPARE	ETM - BSC SPARE	1
ITM penultimate mass	ITM - BSC	2
ETM reaction mass	ETM - BSC	2
ETM penultimate mass	ETM-BSC_IM-317mm dia. X 133 mm thick	2
SUB-TOTAL		8
SUS Penultimate Blanks - IFO3		
ETM reaction mass	ETM - BSC	2
BS penultimate mass	BS-BSC_IM - now metal	0
ITM penultimate mass	ITM - BSC	2
ETM penultimate mass	ETM-BSC_IM - 317mm dia. X 133 mm thick	2
ETM/ITM penultimate mass SPARE	ETM - BSC_IM - 317 mm dia. X 133 mm thick SPARE	1
BS penultimate mass SPARE	BS-BSC_IM - now metal SPARE	0
FM penultimate mass	FM-BSC_IM - now metal	0
ETM reaction mass SPARE	ETM- BSC SPARE	1
SUB-TOTAL		8
TOTAL		24
Noise Prototypes - from RAL's 4.03.3.3.5.5.		
ETM reaction mass	ETM - BSC - Heavy Glass	1
ETM penultimate mass	ETM - BSC_IM-317mm dia. X 133 mm thick	1
ETM reaction mass - SPARE BLANK	ETM - BSC Heavy Glass	1
ETM penultimate mass - SPARE	ETM - BSC_IM-317mm dia. X 133 mm thick	1
ETM reaction mass - (Glasgow)	ETM - BSC	0
ETM penultimate mass - (Glasgow)	ETM - BSC	0
SUB-TOTAL		4
GRAND TOTAL		28

compared with proposal estimate of 64

compared with proposal estimate of 64

NOTES:

- (1) FA = First Articles will end up at IFO1
- (2) Noise prototype masses are currently costed under 4.03.3.3.5.5. In proposal. This scope and associated costs require to be transferred to Glasgow.
- (3) ETM pen and reaction masses are the same except for the wedge. Same blanks, different wedge, different polish.
- (4) ETM and ITM pens are the same.
- (5) BS and FM pens are now metal, since BS and FM are on wires.
- (6) Spares policy for suspensions as of 29 June 2004 (Janeen, Gari, Justin, Caroline). For each IFO there are a total of three (now two) glass spares as follows:
 1 ETM/ITM penultimate
 1 ETM reaction (has electrostatic & photon drive coatings + is wedged)
 1 BS/FM penultimate (now metal)
- (7) Added in required penultimate and reaction masses for noise prototypes of WBS LIGO 4.03.3.3.5.5.
- Based on two ETM noise prototypes.
- (8) Revised Noise Prototype sparing section in light of noise prototype polishing costs being higher than expected + CP will be metal (October 2006.)
- (9) ETM Reaction masses changed to silica

SUMMARY

Each IFO has: ETM pen x 2 ETM react x 2 ITM pen x 2 BS pen x 0 (now metal) One IFO has additional: FM pen x 0 (now metal) Each IFO has spares ITM/ETM pen x 1 ETM react x 1 BS/FM pen x 0 (now metal) TOTAL = 24	Add the two noise prototypes plus spares ETM pen x 1 ETM react x 1 ETM react (SPARE BLANK) x 1 ETM pen (SPARE) x1 TOTAL = 4
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GRAND TOTAL
28