

2 SUMMARY OF FLEXIBLE SUSPENSION

"What would it take to make the SUS design (quad) flexible for either sapphire or fused silica for both the controls and noise prototype?"

a) FLEXIBLE CONTROLS PROTOTYPE

b) FLEXIBLE NOISE PROTOTYPE

1 TASK SUMMARY

Sheet 1 to 5 Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary (UK & US EFFORT)

Sheet 6 of 6 Summary Information associated with design e.g. tapped holes, material etc ...

T040016-09 Sent to the following e-mail list on September 9th 2004  
JHR CIET NAR KAS JG CAC DC DS

T040016-06 On DCC (includes task summary, sheet 1 to 5, as it appears in the version 09)

T040016-04 UK / US teams agreed on sections of work associated with the quad controls prototype



Added as a second sheet to the task summary, T040016. The lists formed for the next 2 sheets are based on the breakdown form both the task summary and the cost book.

**The question from DC / DS: -**

**"What would it take to make the SUS design (quad) flexible for either sapphire or fused silica for both the controls and noise prototype?"**

**The assumptions made: -**

Full flexibility is assumed in the design for both the controls and noise prototype

It is further assumed that controls will not be recycled into noise prototype parts

The controls and noise are considered separately

The dimensions of both silica and sapphire are fixed to one design each. (i.e. sapphire 314mm x 130 and fused-silica 340mm x 200mm)

The reaction chain stays as "sapphire based" if using silica for test mass

COC costs not included

JHR supplied cost book estimates of what it cost in dollars and effort to build a controls prototype quad. (~ \$90,000 and ~ 80 man weeks) These costs were made a number of years ago!

For mechanical design the labour from the cost book is defined to cover Engineer, Scientist and Technician

**Input: -**

**CONTROLS**

This total was split over the various sections associated with the quad and then each section was split according to the sub-sections in the Task Summary.

We are confident with the equipment and labour relationships within the sub-tasks.

The numbers were then compared to those in the cost book.

**NOISE**

For the noise prototype we added the sections we believed that are associated with the "glass" aspects of the suspension to ALL of the items associated with the controls prototype

Remember that for a noise prototype you need the metal masses etc ... !

**Body: -**

**CONTROLS**

Firstly for the controls prototype we consider all of the sections in the task summary, the task summary covers the work associated with a controls prototype, and whether or not there would be "more work" to do for a flexible suspension design and a brief summary of what this work would involve.

If a section has "more work" involved it is compared to the breakdown of the cost book assumptions and added costs are estimated.

**NOISE**

Secondly each of the sections associated with the noise prototype are considered wrt "more work".

Some items are paid for by the COC group and are not included.

The costs were not split according to who is responsible for paying the bills! (CIT / RAL / Glasgow / Birmingham)

**Calculations: -**

As already mentioned for the noise assumption we take ALL of the controls work and add to it the sections we believe are involved in a noise prototype.

**Conclusions: -**

In conclusion we offer a \$ and labour estimate as well as a % increase that would be involved in maintaining a design that is flexible for either sapphire or silica for both controls and noise prototypes separately.

To maintain flexibility through to final design add the costs & man power from BOTH the controls and noise pages

### FLEXIBLE QUAD CONTROLS PROTOTYPE

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR x 1.8	EQUIP	LABOR	
				%	%	(\$)	1.18	(\$)	(weeks)	
1	<b>OVERALL ASSEMBLY</b>									
	OVERALL ASSEMBLY LAYOUT	-	YES	0	100	0	2.36	-	2.36	x2 designs
	MODELING	-	YES	0	100	0	2.36	-	2.36	x2 designs
	INTERFACE	-	YES	0	25	0	0.59	-	0.1475	
2	<b>SUSPENSION</b>									
	<b>OSEMS</b>									
	local control (hybrid)	YES	-	-	-	0				
	global control	YES	-	-	-	0				
	<b>TOP MASS</b>									
	top mass assembly	YES	-	-	-	7500	11.8			main + reaction
	<b>UPPER INTERMEDIATE MASS</b>									
	Upper Intermediate mass assembly	-	YES	0	15	7500	11.8	0	1.77	Actuator distance changes! main + reaction
	<b>PENULTIMATE MASS</b>									
	penultimate mass assembly controls ptype	-	YES	100	100	1000	2.36	1000	2.36	x2 designs
	<b>PENULTIMATE REACTION MASS</b>									
	penultimate reaction mass assembly controls ptype	-	YES	0	15	1000	2.36	0	0.354	actuation
	<b>TEST MASS</b>									
	test mass assembly controls ptype	-	YES	100	100	2000	2.36	2000	2.36	
	<b>REACTION TEST MASS</b>									
	reaction test mass assembly controls	YES	-	-	-	2000	2.36			assuming nominal e-drive suff.
	<b>TABLECLOTH</b>									
	top assembly	-	YES	25	25	1000	0.885	250	0.22125	x2 designs
	upper intermediate assembly	-	YES	25	25	1000	0.885	250	0.22125	x2 designs
	<b>ROTATIONAL ADJUSTER</b>									
	rotational adjuster	YES	-	-	-	1000	1.18			
	assembly for top blades	-	YES	75	50	1000	1.18	750	0.59	Adjustable chains!
	<b>EDDY CURRENT DAMPERS</b>									
	4 x 4 assembly	YES	-	-	-	500	0.59			
	adjustment	YES	-	-	-	500	0.59			

FLEXIBLE QUAD CONTROLS PROTOTYPE

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR x 1.8	EQUIP	LABOR	
3	<b>STRUCTURES</b>									
	<b>TOP STRUCTURE</b>									
	Detail	-	YES	0	33	-	20.06		<b>6.6198</b>	More holes / slot etc ...
	Layout	YES	-	-	-	-	-			
	Top half	-	YES	33	0	18000		<b>5940</b>	-	
	Lower half	-	-	-	-	-	-			reference catcher
	<b>TABLE CLOTH CLAMPS</b>									
	Assembly	-	YES	10	25	1000	1.18	<b>100</b>	<b>0.295</b>	
	<b>NON ASSOCIATED SUSPENSION PARTS</b>									
	Earthquake Stops etc ...	-	YES	40	20	1000	2.36	<b>400</b>	<b>0.472</b>	
4	<b>JIGS</b>									
	<b>TOP / UPPER INT MASS ASSEMBLY RIG</b>									
	assembly rig	YES	-	-	-	1000	1.18			
	mass support	YES	-	-	-	-	-			
	<b>GAZEBO</b>									
	Gazebo design	YES	-	-	-	5000	0.295			
	<b>WIRE JIGS</b>									
	wire jigs	YES	-	-	-	2000	1.18			assuming adjustable jig
	<b>CATCHER</b>									
	initial controls ptype	-	YES	100	100	5000	4.72	<b>5000</b>	<b>4.72</b>	
	wrt structure and e stops etc ...	-	-	-	-	-	-			
	support	YES	-	-	-	-	-			
	adjustment	-	-	-	-	-	-			
	<b>I BLADE DEFLECTION JIG</b>									
	assembly	YES	-	-	-	1000	1.18			
	<b>VERTICAL ADJUSTMENT</b>									
	+/- 500 g	YES	-	-	-	500	0.59			
	<b>ASSEMBLY TECHNIQUES (metal masses)</b>									
	Metal masses	YES	-	-	-	1000	0.59			
	Catcher	YES	-	-	-	-	-			
	Structure	YES	-	-	-	-	-			

**FLEXIBLE QUAD CONTROLS PROTOTYPE**

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR x 1.8	EQUIP	LABOR	
5	<b>GLASS (CONCEPT)</b>									
6	<b>MODELING AND SOFTWARE</b>									
7	<b>SPRINGS</b>									
	<b>BTF</b> assembly prototyping	YES	-	-	-					
	<b>CANTILEVER BLADE ASSEMBLIES</b>									
	Top Blade assembly	YES	-	-	-					
	Middle blades assembly	YES	-	-	-					
	Bottom blades assembly	YES	-	-	-					
	<b>BLADE ANALYSIS</b>									
	design	YES	-	-	-					
						20000	0			
8	<b>INSTALLATION and Alignment TOOLING</b>									
	Adjustable support table, etc ...	YES	-	-	-	10000	4.72			
9	<b>ELECTRONICS</b>									
	ELECTRONICS	-	YES	-	-					??

(\$) weeks

COMPARED TO COST BOOK CONTROLS      91500      81.715

(\$) weeks

\$ 15690      24.8508      CONTROLS

<b>CONTROLS</b>	<b>CONCLUSIONS BASED ON</b>
MECHANICAL DESIGN COST BOOK NUMBERS OBTAINED FROM JHR	
CONTROLS PROTOTYPE, \$	<b>\$91,500.00</b> and <b>20.429</b> labour months (assuming 4 weeks in a month)

<b>CONTROLS</b>	<b>CONCLUSIONS</b>
ADDITIONAL COST TO KEEP DESIGN COMPATIBLE WITH EITHER SAPPHIRE OR SILICA	
CONTROLS PROTOTYPE, \$	<b>\$15,690.00</b> and <b>6.2127</b> labour months
	<b>17%</b> <b>30%</b>

**FLEXIBLE QUAD NOISE PROTOTYPE**

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR	EQUIP	LABOR	
				%	%	(\$)	(weeks)	(\$)	(weeks)	
1	<b>OVERALL ASSEMBLY</b>									
	OVERALL ASSEMBLY LAYOUT	-	YES	0	100	0	2.36	-	2.36	x2 designs
	MODELING	-	YES	0	100	0	2.36	-	2.36	x2 designs
	INTERFACE	-	YES	0	25	0	0.59	-	0.1475	
2	<b>SUSPENSION</b>									
	<b>OSEMS</b>									
	local control (hybrid)	YES	-	-	-	0	0			
	global control	YES	-	-	-	0	0			
	<b>TOP MASS</b>									
	top mass assembly	YES	-	-	-	7500	11.8			main + reaction
	<b>UPPER INTERMEDIATE MASS</b>									
	Upper Intermediate mass assembly	-	YES	0	15	7500	11.8	0	1.77	Actuator distance changes! main + reaction
	<b>PENULTIMATE MASS</b>									
	penultimate mass assembly controls ptype	-	YES	100	100	1000	2.36	1000	2.36	x2 designs
	glass noise ptype	-	YES	125	100	27000	COC	33750	COC	Assuming fused silica more expensive than SF2
	<b>PENULTIMATE REACTION MASS</b>									
	penultimate reaction mass assembly controls ptype	-	YES	0	15	1000	2.36	0	0.354	actuation
	noise ptype (METAL)	-	YES	0	15	1000	2.36	0	0.354	actuation
	<b>TEST MASS</b>									
	test mass assembly controls ptype	-	YES	100	100	2000	2.36	2000	2.36	
	glass noise ptype	-	YES	COC	COC	COC	COC	COC	COC	
	<b>REACTION TEST MASS</b>									
	reaction test mass assembly controls	YES	-	-	-	2000	2.36			assuming nominal e-drive suff.
	glass noise ptype	YES	-	-	-	27000	COC			assuming nominal e-drive suff.
	<b>TABLECLOTH</b>									
	top assembly	-	YES	25	25	1000	0.885	250	0.22125	x2 designs
	upper intermediate assembly	-	YES	25	25	1000	0.885	250	0.22125	x2 designs
	<b>ROTATIONAL ADJUSTER</b>									
	rotational adjuster	YES	-	-	-	1000	1.18			
	assembly for top blades	-	YES	75	50	1000	1.18	750	0.59	Adjustable chains!

FLEXIBLE QUAD NOISE PROTOTYPE

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR	EQUIP	LABOR	
	<b>EDDY CURRENT DAMPERS</b>									
	4 x 4 assembly	YES	-	-	-	500	0.59			
	adjustment	YES	-	-	-	500	0.59			
3	<b>STRUCTURES</b>									
	<b>TOP STRUCTURE</b>									
	Detail	-	YES	0	33	-	20.06		<b>6.6198</b>	More holes / slot etc ...
	Layout	YES	-	-	-					
	Top half	-	YES	33	0	18000	-	<b>5940</b>	-	
	Lower half	-	-	-	-					reference catcher
	<b>TABLE CLOTH CLAMPS</b>									
	Assembly	-	YES	10	25	1000	1.18	<b>100</b>	<b>0.295</b>	
	<b>NON ASSOCIATED SUSPENSION PARTS</b>									
	Earthquake Stops etc ...	-	YES	40	20	1000	2.36	<b>400</b>	<b>0.472</b>	
4	<b>JIGS</b>									
	<b>TOP / UPPER INT MASS ASSEMBLY RIG</b>									
	assembly rig	YES	-	-	-	1000	1.18			
	mass support	YES	-	-	-					
	<b>GAZEBO</b>									
	Gazebo design	YES	-	-	-	5000	0.295			
	<b>WIRE JIGS</b>									
	wire jigs	YES	-	-	-	2000	1.18			assuming adjustable jig
	<b>CATCHER</b>									
	initial controls ptype	-	YES	100	100	5000	4.72	<b>5000</b>	<b>4.72</b>	
	wrt structure and e stops etc ...	-	-	-	-					
	support	YES	-	-	-					
	glass noise ptype	-	YES	100	100	5000	4	<b>5000</b>	<b>4</b>	
	adjustment	-	-	-	-					
	<b>I BLADE DEFLECTION JIG</b>									
	assembly	YES	-	-	-	1000	1.18			
	<b>VERTICAL ADJUSTMENT</b>									
	+/- 500 g	YES	-	-	-	500	0.59			
	<b>ASSEMBLY TECHNIQUES (metal masses)</b>									

FLEXIBLE QUAD NOISE PROTOTYPE

T040016-09

#	QUAD SECTIONS	COMMON	MORE WORK	ADDED % Cf. ORIGINAL		COST BOOK		ADDED COSTS		COMMENTS
				EQUIPMENT	LABOR	EQUIP.	LABOR	EQUIP	LABOR	
5	Metal masses	YES	-	-	-	1000	0.59			
	Catcher	YES	-	-	-					
	Structure	YES	-	-	-					
	<b>GLASS (CONCEPT)</b>									
	<b>EAR</b>									
	penultimate mass	YES	-	-	-					
	test mass	YES	-	-	-					
	<b>TEST MASS</b>									
	Assembly	YES	-	-	-					
	<b>FIBRES / RIBBONS</b>									
	fibres / ribbons	YES	-	-	-					
<b>ASSEMBLY TECHNIQUES</b>										
Monolithic	YES	-	-	-						
Catcher	YES	-	-	-						
Catcher wrt Structure	YES	-	-	-						
ERGO-ARM	-	YES	25	12	20000	8	5000	0.96		
CARRY CASES	-	YES	100	30	5000	2	5000	0.6		
TEMPLATES FOR EARS	-	YES	100	20	3000	4.72	3000	0.944	masses have different thickness'	
6	<b>MODELING AND SOFTWARE</b>									
7	<b>SPRINGS</b>									
	<b>BTF</b> assembly prototyping	YES	-	-	-					
	<b>CANTILEVER BLADE ASSEMBLIES</b>									
	Top Blade assembly	YES	-	-	-					
	Middle blades assembly	YES	-	-	-					
	Bottom blades assembly	YES	-	-	-					
	<b>BLADE ANALYSIS</b>									
	design	YES	-	-	-					
						20000	0			
8	<b>INSTALLATION and Alignment TOOLING</b>									
	Adjustable support table, etc ...	YES	-	-	-	10000	4			





T040016 - 09 - R

DRWG NO. REV. GID

SHEET

SEE BOTTOM LEFT

ASSEMBLY NO.

D040068

W.I.P. TASK LIST (CONTROLS PROTOTYPE)

TITLE: - Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary

NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION				
								#	AS	PC	AF	
<p><b>TO DO</b> Add more related documents Thomas &amp; JHR to add link the task list to the plan - ON HOLD!</p> <p><b>ADDED</b> rev 05 includes updates by CIUT and MPL June 17th 2004</p>												
<b>QUAD SECTIONS</b>		Pages 1 to 5										
	1 OVERALL ASSEMBLY	CIT	D040068									
	2 SUSPENSIONS	CIT										
	3 STRUCTURE	JHR										
	4 JIGS (inc CATCHER)	JHR										
	5 GLASS CONCEPT	CAC										
	6 MODELLING + SOFTWARE	CIT										
	7 SPRINGS	RAL										
	8 INSTALLATION TOOLING	JHR										
	9 ELECTRONICS	MB										
	10 DOCUMENTS	CIT										
	<b>SUMMARY INFORMATION</b>	Page 6 of 6										
1	<b>OVERALL ASSEMBLY</b>	CIT										
	OVERALL ASSEMBLY LAYOUT	CIT				MPL / NAR						
	isolation of suspension from structure	CIT			With potentially ~ 100 earthquake stops it would be nice to be able to use a continuity test or equivalent to test suspension							
	MODELLING	NAR				CIT / MB						
	pitch of a MC and ETM	NAR			request to apply a pitch at top mass and record motion at test mass							
	INTERFACE											
	SEI											
	COC											
	AOS											
	INSTALLATION											
2	<b>SUSPENSION</b>											
	<b>OSEMS</b>	RAJ			90 HEADS COMING FROM GLA							
	local control (hybrid)	JHR						P50610		100		
	Head	RAJ	D030105		parts made in Glasgow	CIT		Q50620		100		
	Adjustment	RAJ			parts made in Glasgow	CIT						
	Winding	JHR			Winding done at vendor used for LIGO I osems							
	Assembly	HA			Assembly done at Caltech	BT	structure / tablecloth / top mass / ECD	F50640, A5065				
	SolidWorks Assembly	CIT				RJ	structure + tablecloth					
	global control											
	HYBRID DESIGN	CIT			Previously thinking of using LIGO 1 design by JHR		modelling	F50950, Q50960, q51074				
	<b>TOP MASS</b>	MPL										
	top mass assembly	MPL				CIT / NAR		d51074		50		
	magnet assembly	MPL				HA						
	magnet assembly for pitch / roll	MPL				HA						
	moving mass pitch adjuster	MPL			using analysis in LIGO-T030716							
	suspended mass wire clamps	MPL			Previously RAL, swapped with rotational adjuster (agreed informally with IW and MPL)							
	pitch adjustment for suspended mass wire clamps	MPL			required?		moving mass pitch adjuster					
	copper section of eddy current damper	CIT			refer to ECD							
	blade assembly	RAL			refer to Blades in Springs							
	bench test of blade on mass	MPL										
	FEM	MPL			Blade wrt main section of mass	CIT	Report by Dan Mason					
	<b>UPPER INTERMEDIATE MASS</b>	MPL						d51074		50		



T040016 - 09 - R  
 DRWG NO. REV GID  
 SHEET SEE BOTTOM LEFT  
 ASSEMBLY NO. D040068

W.I.P. TASK LIST (CONTROLS PROTOTYPE)

TITLE: - Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary

NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION
	Upper Intermediate mass assembly	MPL				CIT / NAR		
	suspended mass wire clamps	MPL			reference note on line 57	MPL		
	global control osem holders				4 global control osems		modelling	
	blade assembly	RAL			refer to Blades in Springs			
	Upper Intermediate reaction mass assembly	MPL			almost equivalent to upper int mass with alt T-section for osems			
	FEM	MPL			Blade wrt main section of mass	CIT	Report by Dan Mason	
	<b>PENULTIMATE MASS</b>	CIT						
	penultimate mass assembly	CIT	D040132	DONE		MPL / NAR		D51090 25
	drawings	CIT						
	mass clamp assembly	CIT			discuss with IGR	MPL		
	<b>PENULTIMATE REACTION MASS</b>	CIT						
	penultimate reaction mass assembly	CIT	D040142	DONE		MPL / NAR		D51090 25
	drawings	CIT						
	mass clamp assembly	CIT			refer to penultimate mass assembly			
	osems	CIT			depends on choice, reference action in SUS			
	mounting osems	CIT						
	<b>TEST MASS + REACTION TEST MASS</b>	CIT						
	test mass assembly	CIT	D040038	DONE	includes removable alum faces			D51090 50
	drawings	CIT						
	test mass assembly	CIT	D040053	DONE	includes glass faces			
	drawings	CIT						
	reaction test mass assembly	CIT	D040161	DONE	includes removable alum faces			
	drawings	CIT						
	reaction test mass assembly	CIT	D040165	DONE	includes glass faces for electrostatic drive			
	drawings	CIT						
	sapphire concept	MPL		DONE				
	support for single pendulum test	CIT		DONE				
	support for double pendulum test	CIT		DONE				
	support for double pend with reaction chain	CIT		Sep-04	Have lab jack that works with 40kg mass work with RAJ on concept / bench test for catcher			
	Glass faces for test and reaction test mass	HA		ORDERED	7740 Pyrex for controls prototype includes electrostatic drive pattern by RAJ	CIT / MPL		
	<b>TABLECLOTH</b>							
	top assembly	JHR				CIT / MPL	structure, top mass, earthquake stops	
	upper intermediate assembly	JHR				CIT / MPL	structure, top mass, earthquake stops	
	alternative design (compatible with interferometric sensor)	RAL			reference idea from email by CAC		OSEM work at Birmingham	
	<b>ROTATIONAL ADJUSTER</b>	MPL						
	assembly for top blades	IW			swap for wire clamps able to do once document is passed to IW from SUS (MPL, AG, CIT) REF: LIGO-T040118 by MPL, CIT and AG	RAL / CIT	top blade clamps blade assembly + structure	D51080 20
	Concept				Prototype tested at Caltech by MPL . CIT ETM concept developed by MPL , AG, CIT			
	FEA							
	other suspended blades?				are they required? AG considered wrt suspended masses			
	<b>EDDY CURRENT DAMPERS</b>	CIT				JHR / MPL		
	4 x 4 assembly	CIT			further support from ECD paper group	AG	structure / tablecloth / top mass / osem	D50720, F5073
	adjustment	CIT			further support from ECD paper group	AG		Q50740, D5077



T040016 - 09 - R  
 DRWG NO. REV GID  
 SHEET SEE BOTTOM LEFT  
 ASSEMBLY NO. D040068

W.I.P. TASK LIST (CONTROLS PROTOTYPE)

TITLE: - Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary  
 NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION
<b>3 STRUCTURES</b>								
	<b>TOP STRUCTURE</b>	DC			Based on forthcoming requirements	JHR/ CIT		
	Requirements document	JHR				CIT, MPL		
	Analysis, FEA	CIT / JHR			+ LIGO-T030044 and MC Preliminary Results	DC / LJ	d51110	100
	SolidWorks	JHR			DC, MPL and CIT created versions		d51072	
	Detail	JHR						
	Top half	JHR				CIT	Suspension + Catcher	d51070 90
	Lower half	JHR			refer to catcher section			
	<b>TABLE CLOTH CLAMPS</b>	JHR						
	Assembly	JHR			Adjustment wrt suspensions structure		tablecloth + structure	d51070 10
	Adjustment	?						
	<b>NON ASSOCIATED SUSPENSION PARTS</b>	JHR						
	Earthquake Stops	JHR					d51100	60
	Stiffening concepts	JHR					d51100	30
	Shims	JHR			between SEI and Structure		d51100	10
<b>4 JIGS</b>								
	<b>TOP / UPPER INT MASS ASSEMBLY RIG</b>	RAL				MPL		
	assembly rig	RAL				MPL	D033254, D512	15
	mass support	RAL						
	<b>GAZEBO</b>	JHR						
	Gazebo design	JHR	DONE		KM to aid as per SUS meeting 10 Feb 04		Installation tooling for SEI	D033254, D512 10
	<b>WIRE JIGS</b>	RAL				MPL / CIT	SEI table + stay clear zones	
	top blade to top mass wire jig	*			clamp to clamp		top mass	D033254, D512 30
	middle blades to upper intermediate mass wire jig	*			clamp to clamp		top mass	
	bottom blades to penultimate mass wire jig	*			clamp to clamp and loop		penultimate mass	
	penultimate mass to test mass wire jig	CIT			clamp to clamp		test mass + test mass clamp assembly	
	advanced "dial a jig" (one jig for all)	RAL			* Depends on outcome of adjustable jig?			
	<b>CATCHER</b>	RAJ						
	initial	RAJ				JHR/CAC/CIT	structure + suspension	D51100 20
	wrt structure and e stops etc ...	JHR			refer to structure section			
	support	RAJ				JHR/CAC/CIT	structure + suspension	D51100 10
	glass concept	RAJ				JHR/CAC/CIT		D51100 10
	adjustment	RAJ			refer to glass section			
	<b>I BLADE DEFLECTION JIG</b>	RAL						D033254, D512 15
	assembly	RAL			RAL to explore alternate design to cover all blades			
	<b>VERTICAL ADJUSTMENT</b>							D033254, D512 15
	+/- 500 g	MPL						
	Winches	JHR						
	<b>ASSEMBLY TECHNIQUES (metal masses)</b>	RAJ			see section below for glass	JHR/CAC/CIT		D033254, D512 15
	Metal masses							
	Catcher							
	Structure							
<b>5 GLASS (CONCEPT)</b>								
	<b>EAR</b>	CAC			Pass on comments re thickness and get comments on metal concept			
	penultimate mass				Flats, wire separation, wedge, position of flat, chamfer etc ...		D50490	50
	test mass				wrt access around structure / catcher etc ...		D50490	50
	<b>TEST MASS</b>	CAC						
	Assembly						F50460	100
	<b>FIBRES / RIBBONS</b>	CAC						
	fibres / ribbons						Q504800	50



T040016 - 09 - R  
 DRWG NO. REV GID  
 SHEET SEE BOTTOM LEFT  
 ASSEMBLY NO. D040068

W.I.P. TASK LIST (CONTROLS PROTOTYPE)

TITLE: - Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary

NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION
	<b>ASSEMBLY TECHNIQUES</b>	CAC			Support from SUS and DES team			
	Monolithic Catcher						Q504800	50
	Catcher wrt Structure						D0403322	50
							D0403322	50
6	<b>MODELLING AND SOFTWARE</b>							
	<b>TOOLS</b>							
	MATLAB 6.5	NAR			EXPAND			
	Thermal Noise						d51020	100
	Dynamics for local control						d51030	100
	Global Control						d51035	100
	Refinements / design guidance						D51040	100
	Compare with requirements and prototype test report						d51050	100
	MATHEMATICA	MB						
	EXCEL 2000 or 2002	-						
	IDEAS 9	JHR						
	ANSYS 8.0 (including workbench)	CIT						
	<b>CAD + FILE STORAGE</b>							
	SolidWorks 2003	CIT			SolidWorks 2004? When?	MPL		
	Pro-Engineer 2001	IW						
	PDMWorks 2004	CIT			June 2004?	MPL		
	LIGO-DCC	LT			Requirements for file storage?			
	.PDF files with embedded .STEP or SAT or ?	MPL				CIT		
	<b>CALCULATORS</b>							
	Flexure Point							
	Suspension Model							
	Osem count							
	Osem Type							
7	<b>SPRINGS</b>							
	<b>BTF</b>	RAL						
	assembly	RAL						
	prototyping	RAL						
	<b>CANTILEVER BLADE ASSEMBLIES</b>	RAL						
	Top Blade assembly	RAL			RAL to consider BTF wrt top stage of a quad	MVP , CIT	structure + suspension	D51080 20
	Rotational Adjuster	RAL			refer to rotational adjuster		rotational adjuster	
	Top Blades	RAL		31-May-04				
	Blade clamps	RAL					structure + suspension + Rotational adjuster	
	blade wire clamps	RAL			support top mass		structure + suspension	
	blade guard						structure	
	blade eddy current dampers	RAL			ref work done by CIT / RJ		structure + suspension + blade guard	D50680, F5069 33
	vertical adjustment	RAL			previously library of clamps		required	
	Middle blades assembly	RAL			MVP , CIT		top mass + suspension	D51080 20
	Rotational Adjuster	MPL						
	Middle blades	RAL		31-May-04				
	blade clamps	RAL					top mass + suspension	
	blade wire clamps	RAL			support upper intermediate mass		top mass + suspension	
	blade eddy current dampers	RAL			ref work done by CIT / RJ		top mass + suspension	D50680, F5069 33



T040016 - 09 - R  
 DRWG NO. REV GID  
 SHEET SEE BOTTOM LEFT  
 ASSEMBLY NO. D040068

W.I.P. TASK LIST (CONTROLS PROTOTYPE)

TITLE: - Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary

NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION
	vertical adjustment	RAL			previously library of clamps		required?	
	Bottom blades assembly	RAL			MVP , CIT		upper intermediate mass + suspensio	D51080 20
	Rotational Adjuster	MPL						
	Bottom blades	RAL		31-May-04				
	blade clamps	RAL					upper intermediate mass + suspension	
	blade wire clamps	RAL			support penultimate mass		upper intermediate mass + suspension	
	blade eddy current dampers	RAL			ref work done by CIT / RJ		upper intermediate mass + suspensio	D50680, F5069 33
	vertical adjustment	RAL			previously library of clamps		required?	
	<b>BLADE ANALYSIS</b>							
	design	NAR			from modelling and existing knowledge	CIT, MVP		D51080 20
	design	RAL			from BTF, linked through blade committee			
	process	-			blade committee			
	transmissibility	JG						
	creep	-			blade committee			
	stress concentrations	-			blade committee			
8	<b>INSTALLATION and Alignment TOOLING</b>							
		KMd			Doug Cook, Ken Mailand, Mike smith		Ken Mason visiting Caltech June 200	D033255, D513
	Moving table				Allows suspension to be moved from optical table to cart			
	Adjustable support table				For use both in and outside tank		Class B clean	
					Adjusts in vertical, pitch, yaw, long and side			
9	<b>ELECTRONICS</b>							
	ELECTRONICS	JH				DR		REFER TO PRIMAVERA
	Glasgow	DR						
	Caltech	JH						
	WIRING	JHR			JH, LJ and JHR to liaise			
	D-SPACE	MB						
	ELECTROSTATIC DRIVE + ELECTRONICS	JHR			KAS, MPL to liaise with JHR			REFER TO PRIMAVERA
10	<b>DOCUMENTS</b>							
	LIGO DCC #'s	CIT			refer to DCC and PDMWorks vault			
	LIGO-T040118	MPL			MC TOP BLADE ROTATIONAL ADJUSTER DESIGN			CIT / AG
	Quad Questions	JHR			based on visit by RAJ and NAR May 2004		comments added by CIT	
	LIGO-T040095	MPL			DESIGN BRIEF Upper Int Mass for ETM CPTtype			
	LIGO-T040096	MPL			PDS Upper Int Mass for ETM CPTtype			
		MPL			DESIGN BRIEF Top Mass for ETM CPTtype			
		MPL			PDS UpperTop Mass for ETM CPTtype			
	LIGO-T040112	MPL			Summary of CAD File format compatibility tests			CIT, IW
	LIGO-T040013	CIT			ETM CPTYPE INFORMATION RELATED TO DESIGN OF LOWER MASSES			NAR, HA, MPL



T040016 - 09 - R  
 DRWG NO. REV GID  
 SHEET SEE BOTTOM LEFT  
 ASSEMBLY NO. D040068

**W.I.P. TASK LIST (CONTROLS PROTOTYPE)**

TITLE: - **Advanced LIGO Suspensions Caltech Quadruple Pendulum Controls Prototype (ETM) Task Summary**

NOTE: - CALTECH WILL ORDER AND BUY ALL OF THE PARTS ASSOCIATED WITH THE CONTROLS PROTOTYPE.

#	DESCRIPTION	COORDINATOR	NUMBER	REQUIRED	COMMENT	CONSULTANT	LINKING SECTIONS	PRIMAVERA SECTION
<b>SUMMARY INFORMATION</b>								
	<b>SYSTEM: -</b>	<b>ADVANCED LIGO SUSPENSIONS</b>						
	<b>SUB-SYSTEM: -</b>	<b>SUS</b>						
	<b>NEXT ASSEMBLY: -</b>	<b>QUAD ETM (PROTOTYPE)</b>						
	<b>LOCATION: -</b>	Caltech PDMWorks Vault (131.215.115.155)						
	<b>LINKS: -</b>	DESIGN MEETING, (DM) <a href="http://www.ligo.caltech.edu/%7Ectortie/QUAD_ETM/quad_etm%20setup.html">http://www.ligo.caltech.edu/%7Ectortie/QUAD_ETM/quad_etm%20setup.html</a>			and	SUSPENSION WEEKLY MEETING (ALIGO_SUS) <a href="http://www.ligo.caltech.edu/SUS.html">http://www.ligo.caltech.edu/SUS.html</a>		
	<b>DOCUMENT INFO: -</b>	<b>DENSITY</b>		kg/m <sup>3</sup>		kg/m <sup>3</sup>		
		Copper	8.90E+03		Alum	2.70E+03		
		Steel	7.80E+03		Silica	2.20E+03		
		stainless steel	7.90E+03					
		maraging steel	7.90E+03					
	<b>TAP SIZE</b>	2-56		+ 0.003 OVERSIZE TAP				
		4-40	TO 1/4-20	+ 0.005 OVERSIZE TAP		discuss requirements on taps etc ... with Larry Jones		
	<b>CHECK</b>	All tapped holes to be checked with custom GO-NO GO GAUGE from Accu-Gauge						
	<b>HOLES</b>	refer to T030118 by MPL						
	<b>MATERIALS</b>	Stainless-Steel - 300-Series		300-SSTL		Silver Coated Stainless Steel	Ag-SST	
		Stainless steel		303 / 304 SSTL				
	(FROM)	Aluminium - 6061-T6		6061-T6-Al		Maraging Steel - Marval 18	MARAG	
	<b>COMMENTS</b>	Unless otherwise stated dimensions are in inches or dual dimensions with inches as the lead dimension Document numbers are etched into parts in all parts Scribe Marks and # are required for machined assemblies - in order to keep together after cleaning e.g. D020449, D020318, D020319, D020316 Most tapped holes go clear through. Any blind holes have vent holes and or vented screws. Interfacing of parts very important - therefore require prototyping Stainless part USE Silver Coated Stainless Bolts, leave bolts with density of 7800 kg/m <sup>3</sup> (as do not include thread in library) Aluminium part USE Stainless Bolts, leave bolts with density of 7800 kg/m <sup>3</sup> (as do not include thread in library) IGR, Caltech and MIT use SOLIDWORKS (RAL use Pro-E) - STEP is default translator ALL PARTS ARE IN IMPERIAL TO ANSI STANDARD ASSEMBLIES -show GROVES IN PLATES WITH SHIMS / WIRE DIAMETER - show MACHINING required on clamps All notes on a drawing should be contained in one area unless they are for internal use only. Numbering should not be repeated for different notes on the same drawing						