**LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY**

*LIGO Laboratory / LIGO Scientific Collaboration*

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# Catcher Jig Product Design Specification for the ETM Controls Prototype

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*Revision 00: For early discussion (RAJ, April. 04)*
*Revision 01: Comments back from CAC & NAR (RAJ, June. 04)*
*Revision 02: Adapted to be more specific to the Controls Prototype…comments from CIT and MPL (RAJ, July. 04)*

**Design Brief** (from T040084-00)

Design and develop a "Catcher Jig" for use in the Quad Controls Prototype.

The "Catcher Jig" shall perform the following functions:

- Define the position of two 40kg metal/combination masses relative to each other and the rest of the structure
- Simplify the process of joining of the masses
- Rigidly clamp and protect the joined assembly (masses, ears and fibres) during transportation, and installation
- Provide the facility to catch masses in the event of a major failure in the suspension chain
- Restrict exaggerated motion caused by extreme excitation of the suspension chain
- To *become* the lower portion of the ETM structure once fully installed, or *to form the major part of* that lower structure*

## Introductory notes[1]

General:

- The masses for the ETM Controls Prototype have no wedge angle and no optical tilt angle

Assembly[2]:

The connection of the Catcher Jig to the upper quad structure is to be done inside the vacuum tank.

The general strategy for assembly may resemble the following:

- The optical table is to be mounted onto a Gazebo structure (beside the BSC chamber) at the same four points that will later fit to the crossbeams
- A pre-assembled upper quad section shall then be assembled to the optical table
- This 'cartridge' shall be lifted into place by a crane, and the final adjustment/precision positioning is to be done using the HEPI system
- The lower section/structure is to be brought into place through the door of the BSC chamber

**1.0**

[1] Notes from Mass Catcher Discussion in SUS summit (LSC March 2004), J. Greenhalgh
[2] LIGO-T040151-00 Advanced LIGO Quad Installation Fixture Design (J. Romie)

## Function and Performance

Positioning of the Masses

- The ERGO Arm (below) shall be used to accurately position the 40kg masses in the Catcher Jig

  - The test mass shall be inserted first and the flats and faces aligned with respect to predetermined reference marks/surfaces
  - The penultimate mass shall then be inserted, and its ears aligned with respect to the test mass

Joining the masses

- Joining of the test mass to the intermediate mass (in both the main chain and the reaction chain) with a pre-assembled 'clamp-wire-clamp' assembly, will require the test mass to be 'lifted' up towards the intermediate mass
- Joining of the intermediate mass to the UI mass (in both the main chain and the reaction chain), will require the lower structure/catcher to be 'lifted' up towards the UI mass

The design should consider the requirements of the chosen welding process, addressing some of the following issues:

- Process repeatability
- Maximised access for welding
- Shielding/protection of important materials/surfaces/parts
- Access for repair of fibres
- Others to be added…

*TBD. Interface with design team working on CO2 Laser Pulling/Welding machine*

Clamping / Restricting Motion:
During installation:

- The Catcher Jig must provide rigid clamping, and define a centre-to-centre separation of 602mm between the penultimate and test masses
- Each mass must be clamped with a consistent force that does not overstress the barrel

Once installed:

- The design must limit free motion at the lower stages of the suspension[3].

Interface with Upper Structure:

- Interface between the lower structure/catcher and upper structure[4] must facilitate the safe connection of wire loops coming from the UI mass
- The design must fix rigidly to the Upper Structure

Assembly & Installation
(The overall assembly philosophy, refer back to the Introductory Notes)

- The catcher jig shall always remain vertical

*(TDB. Look at the combined dimensions of the installation fixtures and the lower structure with respect to the BSC door)*

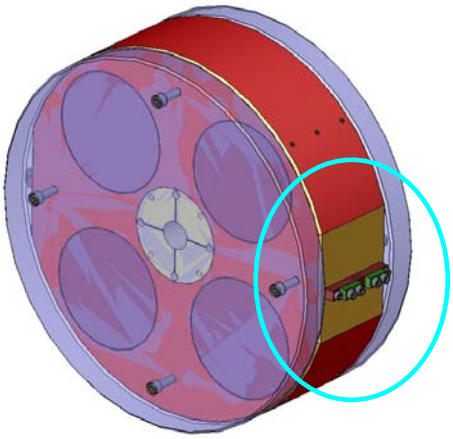
- All important surfaces must be protected during installation (mirror/fibres etc)
- The jig must ensure that steel wires from the upper-intermediate mass can be connected to the penultimate mass safely
- Once installed all non-essential mass must be removed from the catcher jig to ensure it meets the mass budget and is vacuum compatible.

Environment

- The final form of the Mass Catcher must operate in UHV conditions[5]
- Provision for routing & securing of wires must be considered during the design
- Provision for the installation of fibres/ribbons must be considered during the design

[3] Refer to **LIGO-E021000** Earthquake and Safety Stop Design Requirements (J. Romie et al)
[4] **LIGO-T040141-01-D** ETM Upper Structure PDS (J. Romie et al.)
[5] **LIGO-E960050-B** Vacuum Compatible Materials List (D. Coyne)

## 2.0 Size



Structure

- Maximum outer Lower Structure/Catcher Jig dimensions
  - Width (y) = 440mm
  - Depth (x) = 480mm
  - Height (z) = 1109.2mm

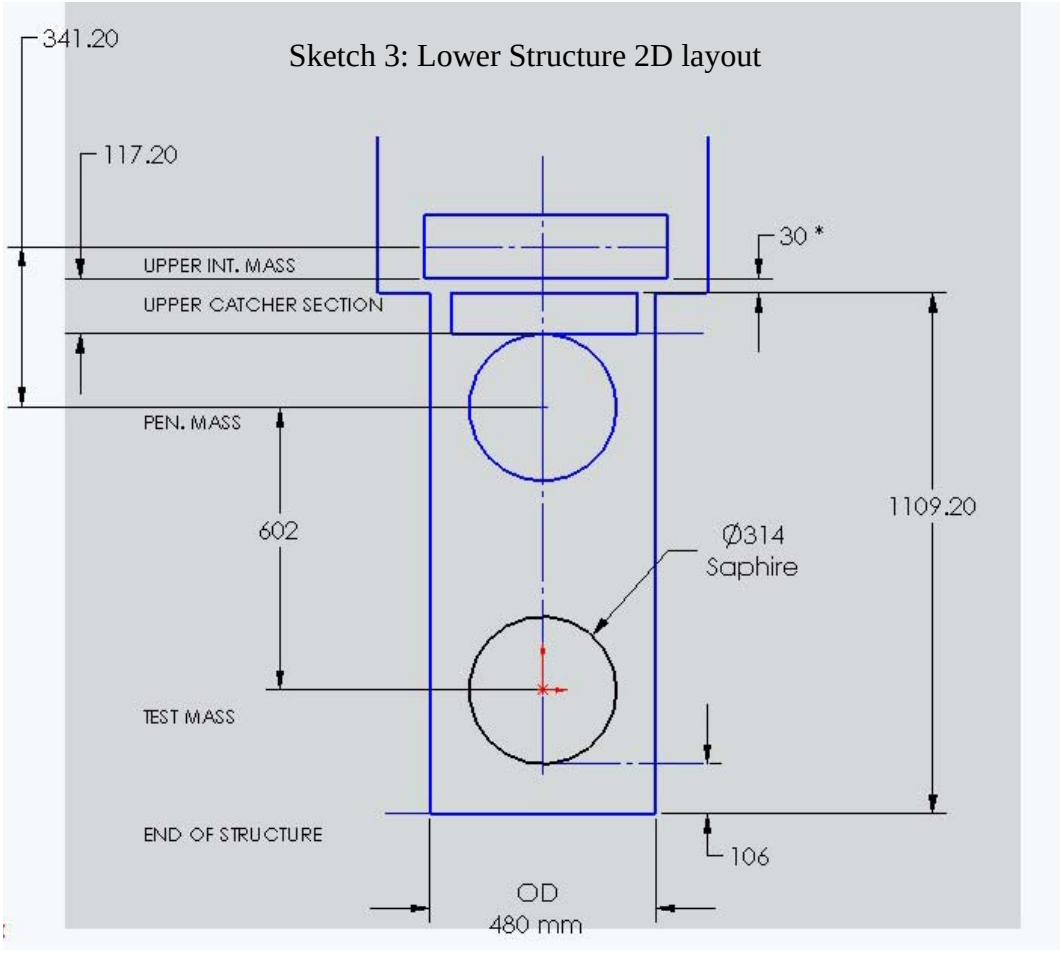
Mass Details

- Penultimate/Test Mass Dimensions
  - Diameter = 314mm
  - Overall thickness = 130mm
  - Size of flats (remembering the intrusion of the cylindrical faces) = 95mm x 79.2mm

[TBD. Insert the details of the masses in the reaction chain[6]]

Sketch 3 below (by C.I.Torrie) illustrates some of these key dimensions.

Sketch 3: Lower Structure 2D layout




[6] **LIGO-T040013-04** … ETM Controls Prototype: Information related to design, p.4 (C.I.Torrie, N. Robertson, M. Perreur-Lloyd)

One issue raised in this sketch is that of the space between the intermediate and upper-intermediate masses, and whether there is sufficient space to accommodate the upper clamping mechanism of the proposed Catcher Jig.

An initial assessment based on a scaling of the GEO 600 Catcher Design has led us to the conclusion that there is indeed sufficient space available.

TBD. Other related dimensions still to be referenced…

- Separation of steel wires (relates to design of the upper-intermediate mass?)
- Ear dimensions**
- Fibre/ribbon separation

**3.0 <u>Weight</u>**

- The mass of the system (*as left inside the vacuum tank*) should not exceed **28.75**kg[7] in its final state

  The breakdown of this mass is as follows:
  => EQ stops + lower structure mass + 25%
  => 7 + 7 + 9 + 25% = **<u>28.75kg*</u>**

***** This number assumes that the catcher jig will become the lower half of the ETM structure

**4.0 Ergonomics**

- Clamping mechanisms should be easy to operate
- All sharp edges/corners should be removed to avoid injury and damage to delicate suspension components

**5.0 Maintenance**

In the event of ear/weld/fibre damage inside the tank, we must have the ability to remove the catcher jig through the tank doors to allow for repair[8].
This demands that we closely consider the relationship between the main chain and the reaction chain when designing the catcher jig (i.e. one catcher for both chains, or two separate catchers that mate).

- Access for cleaning the optic (with $CO_2$ snow gun / ion $N_2$ gun) must be accommodated by the structure
- Access for repair/replacement/adjustment of OSEMs and Electro-static actuators must be accommodated
- Access for repair of fibres/ribbons must be addressed in the design for the Controls Prototype

**6.0 Materials**

[7] **LIGO-T030137-03** Mass Estimate of an ETM suspension layout (C.I.Torrie et al)
[8] Refer to **LIGO-E000062-C** LOS Installation Procedures for BSC chambers (D. Cook)

- All materials must be UHV compatible[2] where being left as part of the final assembly
- Employ techniques to minimise cold welding effects[9]
- Materials that are to be used in close proximity to the mirrors should be chosen carefully to avoid build up of electrostatic charge
- Materials in close proximity to welding zones should be protected where necessary

**7.0 Lifting/Transportation**

*(TBD. Expand this section following Installation Fixture Meeting 21/07/04)*

- There should be clearly defined lifting points on the Jig for craning
- The joined masses must be rigidly clamped during transportation and all protective covers fitted on optics

**8.0 Quantity**

- TBD

**9.0 Product Cost**

- TBD

**10.0 Safety**

- Product assembly method must ensure maximum stiffness and appropriate factor of safety must be incorporated into all critical design components
- Reflectivity of surfaces in close proximity to the laser bear must be closely considered.
  (Possible solutions: angling or oxidising of surfaces, or the use of black glass)

[2] **LIGO-E960050-B** Vacuum Compatible Materials List (D. Coyne)
[9] TBD. Get LIGO document ref…