



LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1200344-v4

Advanced LIGO

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**All BSC, Install Completed Cartridge Into Chamber Procedure,
aLIGO**

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Distribution of this document:
Advanced LIGO Project

This is an internal working note

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**Note v3 (update by CIT) includes equipment list from v1 and note to take teams back to Top Level install procedures.*

**Note v2 had 31st Oct 2012 as date, this was typo. v3 (this doc) is more up to date than v2.*



1 Overview

This document covers the procedure for the installation of a BSC Cartridge into a BSC chamber at either the Hanford and Livingston facilities. This document along with the respective "BSC Cartridge Installation Hazard Analysis" must be read before beginning work on the installation.

Each of the BSC chamber installations will differ somewhat depending on the orientation and payload. A separate document for each chamber will be required to outline the variations in weight, CG, and the flight path for insertion (Requirements and Procedure, Cartridge Flight and Insertion into BSC Chamber).

For example LIGO document E1101016 contains BSC8 specific requirements and must be read prior to insertion of BSC8 ISI and payload into the H2 BSC8 chamber.

A note about clean room standards

For a clean procedure all LIGO standards should be followed. Clean room garb including gloves should be worn when working with parts. Parts should be cleaned and handled according to the standard in LIGO document number E960022. Class A and Class B cleaning procedures and requirements on garbing and handling parts are specified in the LIGO documents M990034-C, LIGO Contamination Control Plan.

All tools that come in contact with the ClassA assembly should be cleaned to LIGO ClassB standards. The ISI should be handled under a portable clean room. Any time a part of the ISI assembly is not covered by the portable clean room or not being actively worked on it should be covered with appropriate clean covers. (C3 polyester or equivalent).



Required Equipment List:

(Assume quantity of one (1) unless noted)

- ☐ BSC Dome Cover for Dome
- ☐ BSC Dome-Tall for Chamber
- ☐ BSC-ISI C-3 Cover
- ☐ Wire Ties for Cabling (many)
- ☐ D1000753—Lift Hook Receiver (3)
- ☐ Bumax-88 3/8-16x2" SHCS & Washers (18)
- ☐ D1101583—BSC Cartridge Cover
- ☐ D1101836—Crane Debris Cover
- ☐ ELT 3pt Spreader Lift & Counterweight
- ☐ Grade 8 5/8-11x2" 12pt CS (3)
- ☐ 12pt 5/8x3/8 offset wrench
- ☐ 3/8"x125 ft-lbTorque wrench
- ☐ 3/8" breaker
- ☐ Load Cell, Shackles, & Hook
- ☐ D1102282--Alignment Pins (4) & 1/8" Hex Key
- ☐ Spring Clips (Many)
- ☐ Stage0/Support Tube Attach Hardware: Ag-Plated 3/8-24x2" SHCS & Washers(NAS 1149 3/8x.625x.063"thk flat washers) (14 each)
- ☐ 5/16 Hex Key wrench, sockets, & ratchets
- ☐ Inspection Mirrors (2)
- ☐ Headlamps, Flashlights, & Floodlight

2 Related documents:

[LIGO-E1200023](#): aLIGO Chamber Installation Procedures.

[LIGO-E1200900](#): aLIGO BSC Installation Procedures (from sub-systems)

[LIGO-E1200901](#): aLIGO BSC Safety Procedures(associated with install)

3 General Process of Installation

3.1 Pre-Flight

Tasks here can be done with Cleanroom in place

3.1.1 Cover suspended items from below with covers provided by Sub System Teams.

3.1.2 Position C3 cloth Cartridge Cover on top of cartridge.
(D1101583)

3.1.3 Position C3 cloth 3pt-Lifter undercover over cartridge cover.
(D1101836)

3.1.4 Attach 3pt-Lifter (D1003140) to Crane with Load Cell in line.



3.2 Test-Flight

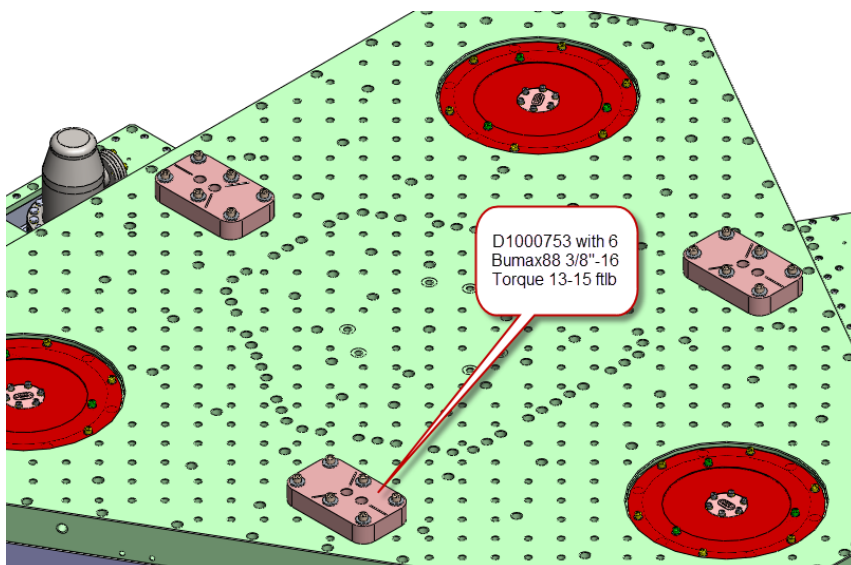
These tasks require the cleanroom to be moved to use the crane. The Cartridge while clothed in C-3 will be accumulating dust and efforts should be made to expedite this period.

3.2.1 Move Cleanroom to allow clear lift of Cartridge.

3.2.2 Move (crane) 3pt-Lifter (D1003140) to Cartridge.

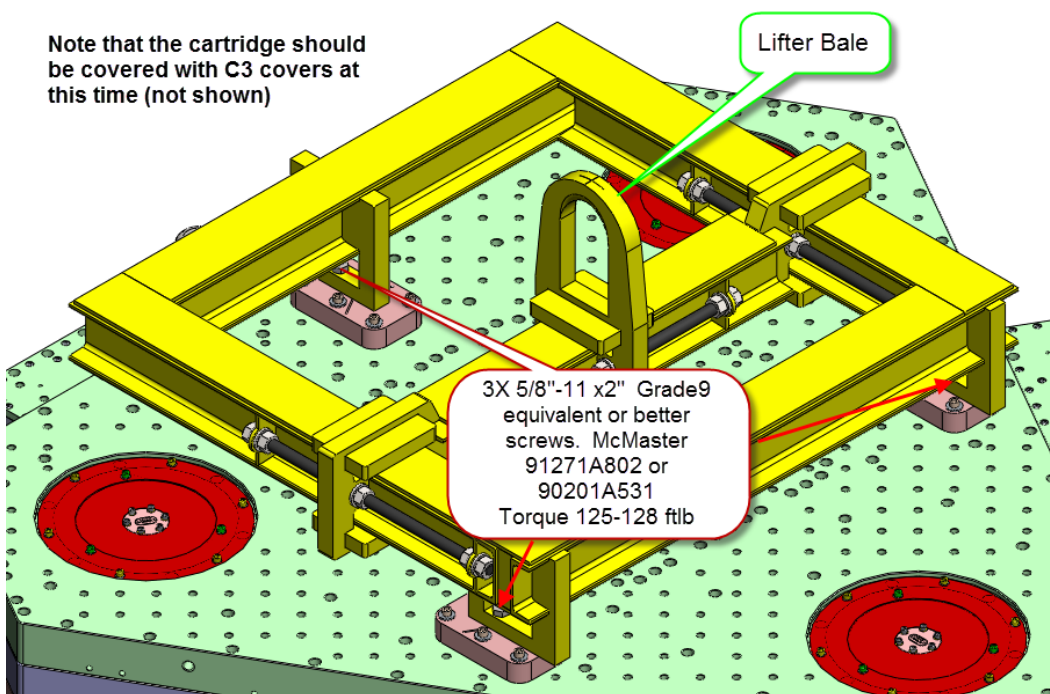
3.2.3 Attach the three (3) Lift Hook Receivers (D1000753) on the ISI Keel-plate, if not already present (See D1000756 for layout and use Bumax-88 3/8"-16 Screws, Torque, 13-15 ft-lb).

(Note: all pictures are examples from BSC6, but are applicable to all BSC)

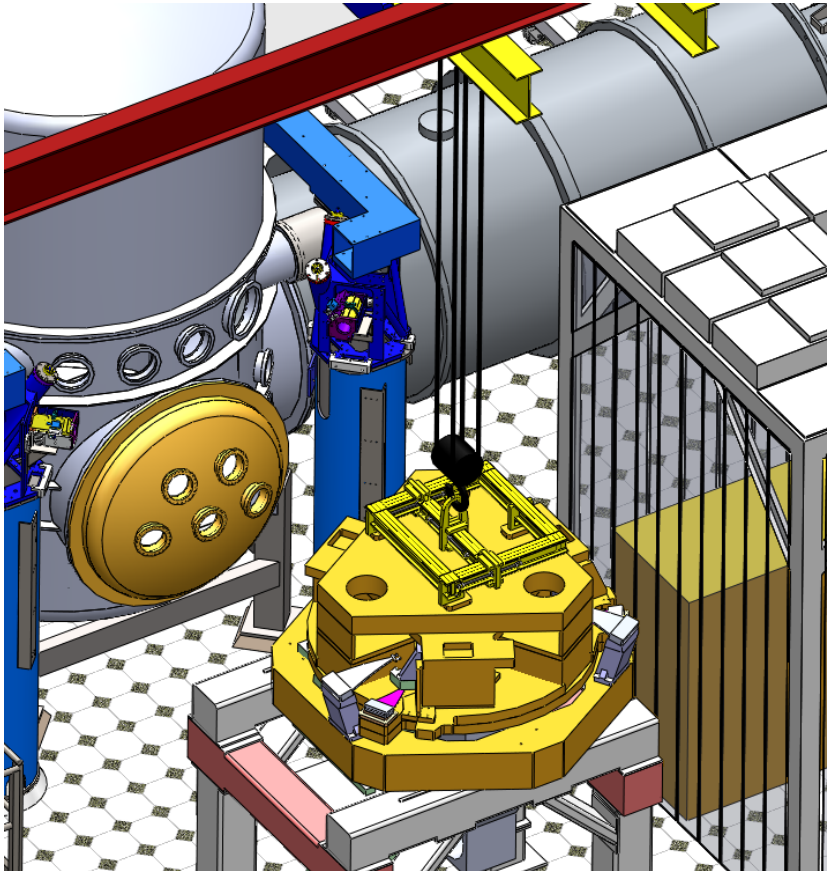


3.2.4 Attach 3pt Lifter to Lift Hook Receivers (*D1003140*), use 5/8"-11 Grade9, equivalent or better (91271A802, 90201A531), 125-128 ft-lb

Note that the cartridge should be covered with C3 covers at this time (not shown)



3.2.5 Adjust 3pt lifter bale to predicted X-Y CG location (some keel plate hole patterns are rotated by 120deg from the that shown in the assembly documentation, adjust x-y of the lifter bale to compensate for rotation.)



3.2.6 Remove counter weight from 3pt-Lifter, if used to balance the lifter during flight.

3.2.7 Lower crane enough to remove tension from cable and adjust crane position to TDC above cartridge.



3.2.8 Level the Cartridge: Lift cartridge slowly and stop if any point in the Stage0-Test Stand contact area exceeds a $\frac{1}{4}$ " gap while any other point remains in contact. Visual inspection is sufficient. If visually not level within the needed $\frac{1}{4}$ ", set the cartridge back down and adjust 3pt-Lifter bale location to compensate. Repeat as necessary until level within $\frac{1}{4}$ ".

3.2.9 Check Cartridge weight: Lift cartridge from test-stand with load cell and crane approximately 1-2 inches, If load cell starts to exceed 10,000lb, stop, and set cartridge back down. Remove weight and try again. Note final total weight, set back down and remove load cell.

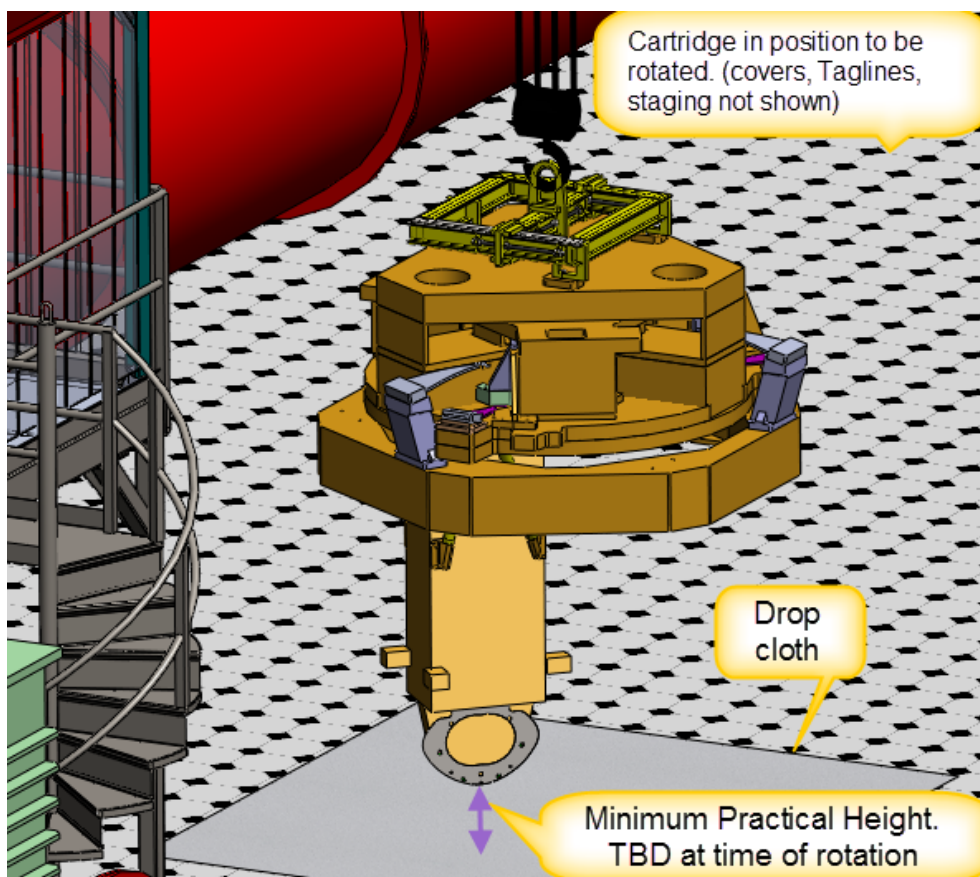
3.2.10 Flight to Chamber

Remove load cell and reconnect Crane to 3pt-Lifter with just the crane hook, get to TDC position.

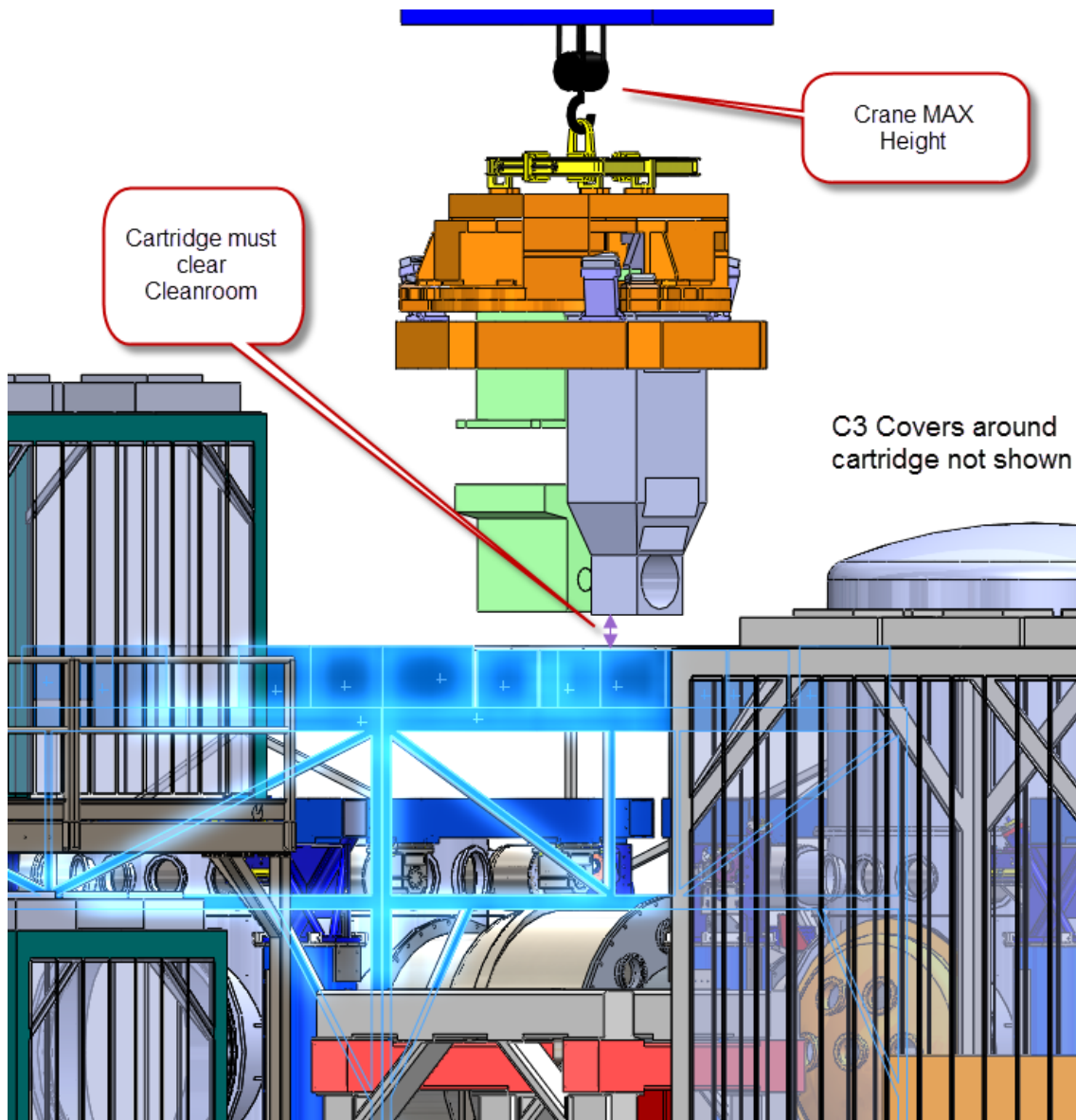
3.2.11 Hoist a few inches. Hold in this position for several minutes and watch for drifting, creep, or any other unsafe condition.

3.2.12 Lift Cartridge high enough to pull big cover down around cartridge and between the cartridge and test stand. This may require stages of raising the Cartridge and pulling down the cover so that the cover does not touch the floor. Tie off open end of cover under the full Cartridge.

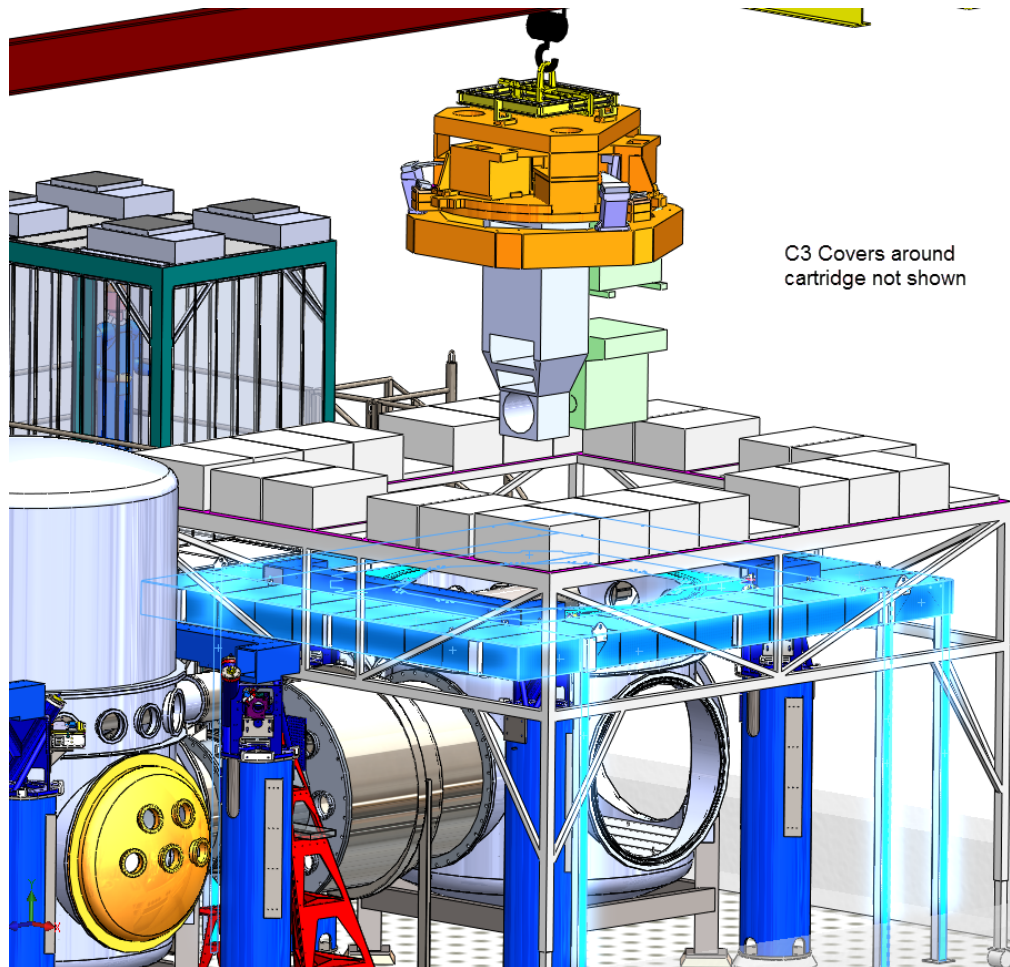
3.2.13 Orient the Cartridge as required for installation per G1000125. Do this away from the Test Stand at a minimum height above the floor. Insure a protective tarp with clean side up has been placed on the floor in the rotation area, otherwise cartridge cover may contact floor. Attach 2 to 4 taglines to 3pt lifter (to rotate cartridge, or serve as backup) Lift cartridge to clear the Test Stand. Move it to designated area over tarp. Lower cartridge to minimum practical height without suspensions contacting the floor. If rotating "by hand" Move staging from around test stand and place around cartridge with access to stage0, or use taglines. Using either taglines or the "by hand" method, rotate cartridge to align with chamber orientation. If pivot on hook becomes jammed, return cartridge to test stand and repair. There is clearance to allow this.



- 3.2.14** Raise cartridge up to height to clear BSC Clean-room (max height) Insure BSC Clean-room is at minimum height (just above spools), Walking Plates (D1002410) and Platforms (D1001990) are in place without railings, around chambers (See install procedure E1101051). Clean-room clearance should be ~8" or more.



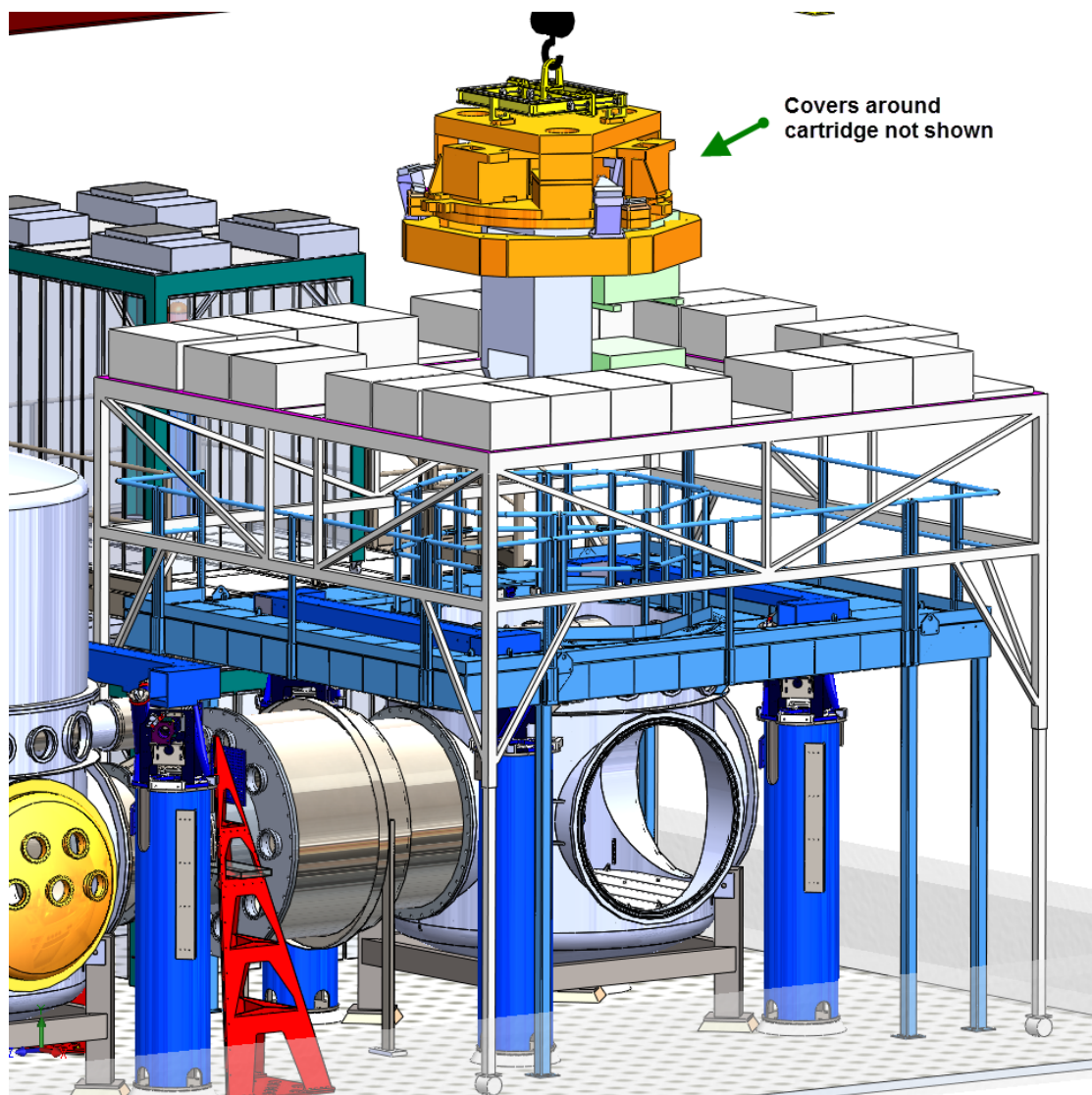
3.2.15 Move crane to a point centered above BSC chamber and clean room as shown in Fig. below.



3.3 Flight Path at the Chamber

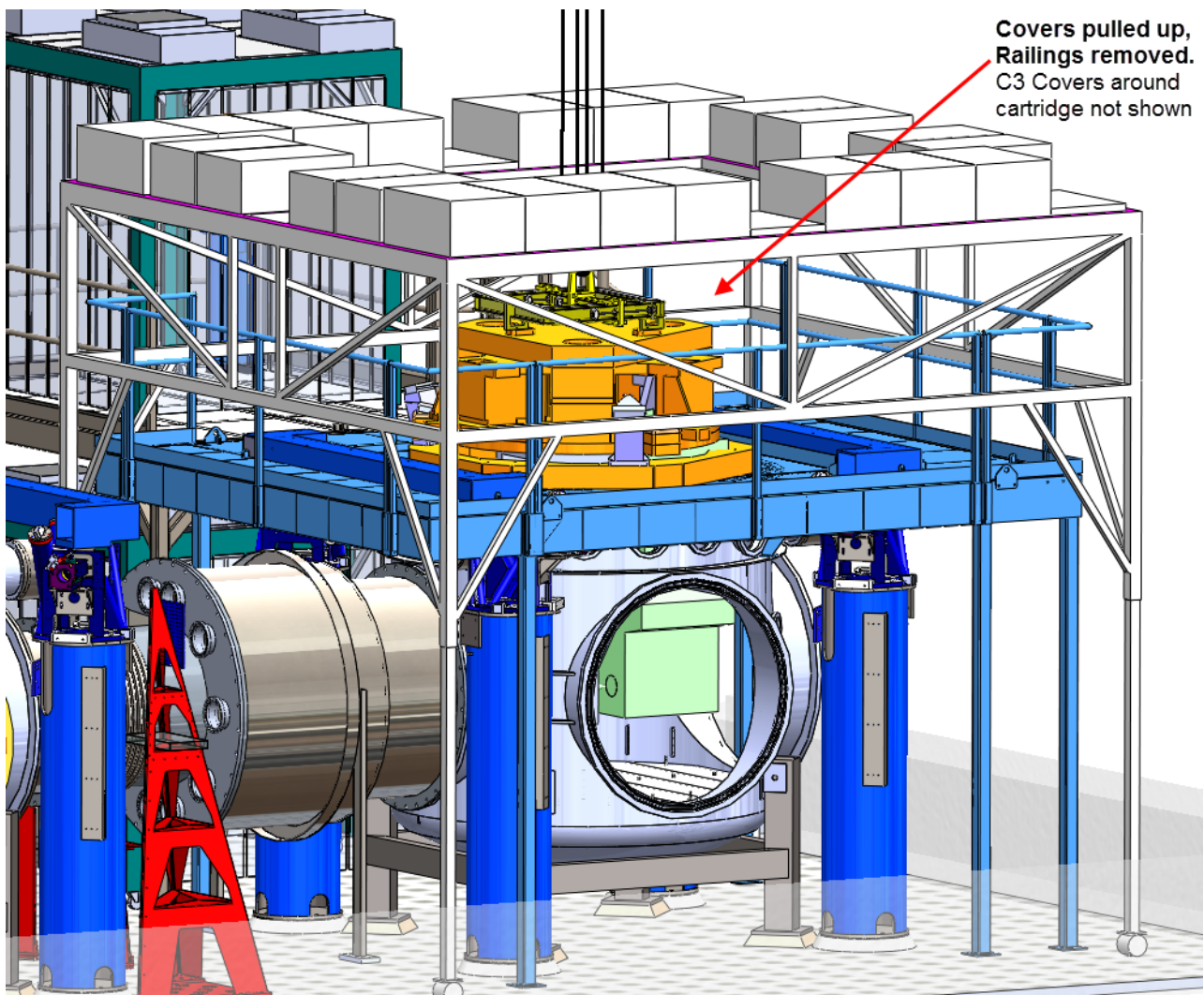
3.3.1 This requires personnel in the Cleanroom on the Walking Plates wearing fall arrest equipment. The raising of the cleanroom, lowering of the Cartridge, and opening of the sock may be iterative. The intent is to not have the BSC chamber uncovered when the cleanroom ceiling is open.

- 3.3.2** With the fabric cover on the chamber, open the top of the chamber and raise the BSC clean room back up around the cartridge to max height. *It will not be possible to install walking plate railings as shown bellow due to lack of clearance.*



- 3.3.3** Lower the cartridge just far enough that the cleanroom ceiling can be secured around the lift hook sealing the cleanroom.
- 3.3.4** When dust counts are low enough, pull up covers as needed to expose ISI Stage0/Support Tube contact. This should only be the Cartridge Cover which is tied below. Roll this up as possible, raising and then lowering the Cartridge as required.

- 3.3.5** Raise the cartridge enough to remove the chamber cover. Maneuver the Cartridge to avoid contact with the chamber.
- 3.3.6** Lower the cartridge enough to evaluate its position wrt the chamber and potential interferences.
- 3.3.7** Continue lowering the cartridge, shifting horizontally as required in Chamber specific *Cartridge Flight & Insertion* Document until all obstructions are cleared. Someone will be needed in the chamber assisting in guiding.
- 3.3.8** Center position and continue lowering adjusting position as proximity to Support Tubes improves feedback.



3.4 Flare, Rollout, & Tiedown

View of the alignment pins mounted in the Stage0 holes will not be easy from above. Someone will be needed in the chamber assisting in guiding the landing. Two people will be required, and should stand in the chamber door flanges outside the Support Tubes.

3.4.1 Slip ISI Stage0 ever so smoothly over alignment pins and hold ISI just above the tubes to allow movement.

3.4.2 Install (14) 3/8-24 x 2" silver plated SST cap screws with washers through stage 0 into the tube removing the guide pins last. It will be necessary to install these screws from inside the BSC chamber. Remove the alignment pins and replace with screws. Try to lower the cartridge in small increments such that the screws can all be threaded in by hand

3.4.3 Lower the cartridge until it is supported by the support tubes. If gaps remain between the Support Tubes and ISI Stage0 (might be difficult to assess) raising a Support Tube with HEPI 'Set Screws' may be called for. When all gaps are closed, torque bolts to 23 ft-lbs. Remove all load from Crane and do final torquing.

3.5 Debrief

3.5.1 Break loose but don't remove the three (3) 5/8-11 bolts from 3pt-lifter/base plates

3.5.2 Disconnect Base Plates (D1000753) from Keel and lift high enough to cover ISI with C3 (BSC Dome Tall). Use the Crane Debris Cover to cover the lifter by folding it up over the lifter. Open cleanroom ceiling and hoist 3pt lifter clear. Close up clean room and finish removing C3 covers. Secure 3pt lifter, Base Plates and hardware.

It is now time to move back to Top Level install procedure i.e. relevant link from related documents in LIGO-E1200023: [aLIGO Chamber Installation Procedures](#) folder e.g. Section 5.5 of LIGO-E1200634: [aLIGO Installation Procedure: LBSC1](#) (added by CIT, 29th Oct 2012)



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3.6 Post Install

Work in progress below as evident--HR

- 3.6.1 Check level of stage 0 using a clean precision level. Adjust with HEPI if necessary until stage 0 is level to within .4 mrad.
- 3.6.2 Replace keel masses and viton pads on top of stage 2 per E0900357.
- 3.6.3 Attach in vacuum cabling to all sensors, actuators and payload. Be careful not to bend pins or put force on feed-thrus.
- 3.6.4 Install other payloads as specified in the chamber specific procedure.
- 3.6.5 Unlock all six lockers between stage0 and stages 1 & 2.
- 3.6.6 Rebalance and continue testing per LIGO E1000304.