LIGO

Third Interferometer aka 3rd IFO Storage I. Main Presentation

NSF Review June 2016

v7

Fred Raab, Calum Torrie and Nichole Washington

Please note while all links in this document may not click through to available DCC links, all links (not directly available) can be accessed via the related documents from the DCC page of this document i.e. at https://dcc.ligo.org/LIGO-G1601083/public.

LIGO

Summary of talk contents

- The past
  - Acceptance & Deliverables
- The Present
  - Transition between aLIGO→Operations
  - Review of Acceptance, Initial Walkthrough & Fault Report System, FRS
  - 3rd IFO Storage & Security / "lock down"
  - FAMIS Inspection & Maintenance Schedule
  - Component Request Log
- Next
  - 3rd IFO Modifications/Change Control (Development Effort)
- The Future
  - 3rd Physical Inventory Tracking
  - Physical Inventory "Stock-taking"
- And then
  - Shipping to India …

Acceptance & Deliverables

Acceptance Review

- 15 sub-systems reviewed [out of 15]
- Product reviewed and received

3rd IFO Acceptance and Punch-list

- 14th Sept 2015: 3rd IFO Acceptance documentation was submitted (Calum Torrie and Jodi Fauver) for approval by Systems Engineer (Dennis Coyne).
- 15th Sept 2015: Confirmation of no issues or bugs for transfer to existing “bug-lists”.
- 16th Sept 2015: Signoff and acceptance complete.

Refer to Documentation

- 3rd IFO Long-Term Storage Acceptance and Punchlist, LIGO-M1300164 [Approved]
  - *This document provides information on the status of 3rd IFO (aka H2/India) storage at the end of the aLIGO project. At the time of close-out all sub-systems have completed handover to 3rd IFO. As part of the hand-over it is noted that a full integration of all of the parts lists and bill of materials into one system did not occur. This will be passed to Operations as a recommendation.*

Transition between aLIGO→Operations

Hand-off to Ops staff

- Includes all 3IFO storage plan responsibilities identified in E1300001 and in subsystem storage documentation
  - Storage – Security - Routine inspections and maintenance - Inventory tracking - Component modifications/change control
- aLIGO Project was responsible for 3rd IFO components until formal acceptance → Upon acceptance of 3rd interferometer, custodianship became the responsibility of LIGO Lab Operations
- Run by Operations (Fred Raab), supported by systems engineering (Dennis Coyne/Calum Torrie), oversight from business/property management (Hannah Hansen/Nichole Washington), assigned support by subsystem custodians

Ops subsystem / custodial responsibilities

- Storage & security "lock down", LIGO-E1600178: WASP Database Spreadsheet
- Routine inspections and maintenance, LIGO-E1300001: Long Term Storage Plan for the Components of the Third Advanced LIGO Interferometer
- Check out & request tracking, LIGO-F1500003: Third IFO Component Request Form and Procedure, LIGO-E1500229: Third IFO Component Request Log
- Component modifications/change and more importantly development / upgrade effort
- Inventory tracking, LIGO-E1300044: Top Level 3rd IFO BOM (work in progress), LIGO-E1300001: Long Term Storage Plan for the Components of the Third Advanced LIGO Interferometer LIGO-E1600122: 3rd IFO Sub-System Template for Inventory
- Shipping

Operations effort – Review of "Acceptance & Deliverables"

- June 2016: As part of Operations effort the team reviewed Storage Acceptance and Punchlist.
  - Each tab has verified bill of materials from each sub-system, which will be used as part of Inventory Control System (ICS) data collection and physical inventory (see later in talk)
  - Example page from 3rd IFO Long-Term Storage Acceptance and Punchlist, LIGO-M1300164 -v10 (SUS)

TITLE	3rd IFO Long Term Storage Acceptance and Punchlist						
DATE	1st June 2016						
SUB SYSTEM	SUS						
RESP PERSON(s)	Betsy Weaver	Norna Robertson					
RELEVANT DOCS							
ACCEPTANCE							
ITEM NUMBER	*ITEM*	*DEFINITION*	*COMMENTS*	*DCC NUMBERS / ICS LINK*	*STATUS (NOTES)*	*SIGNED OFF 3rd IFO*	*DATE*
1	STORAGE PLAN REVIEW	*Long Term Storage Requirements and Procedures are up to date.*	*For grouping of all Subsytem Storage Requirements Documents updated (see E1300001)*	SUS Storage plan is LIGO-T1200527	DONE	Norna Robertson	
2	BOM REVIEW	*Types and quantities of parts/assemblies/spares/tooling to be received by LTS are clearly understood.*	*Coordinate with LTS lead*	D1500108	DONE	Jodi Fauver	Dec 19th 2015
			Also review to ICS link	https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1500108-3IFO			
3	CROSS CHECK	*All Hardware (parts/assemblies/spares/tooling) checked into LAM. All in-vacuum parts have correct ICS information.*	*LAM=Long-Term Storage Asset Management (aka barcode system)*	D1500108	DONE	Jodi Fauver	Dec 19th 2015
				T1500107			
4	BOM RECEIVED	*All assemblies/spares listed in BOM have been delivered to LTS custody. LTS lead has physical or virtual control of assemblies/spares.*	*Virtual custody means that any hardware still in use is checked into LAM/ICS for 3IFO but is checked out to responsible owner.*	T1500107	DONE	Jodi Fauver	Dec 19th 2015
5	STORAGE VERIFICATION	*Verification that Hardware is stored according to aLIGO and relevant substystem LTS plans.*		Refer to T1500107		Jodi Fauver	
PUNCHLIST							
ITEM NUMBER	*DESCRIPTION*	*STATUS*	*VENDOR*	*RESP PERSON @ LHO*	*BUYER*	*DUE DATE*	*ADDITIONAL NOTES*
	STATUS - CLOSED. No Defects						
ITEMS STORED WITH NOTES/DEFECTS							
	STATUS - CLOSED. No Defects						

Initial Walk through & Fault Report System, FRS

Initial Walk-through

- March 2016 - 6 month after acceptance scheduled an initial walk-through of storage
- Requirements for inspection and maintanance
  - Building and room requirements
  - Environmentally controlled containers and cabinets
  - Inventory and access controls
  - Change control and defect tracking
  - Routine monitoring and inspection

- LIGO-E1600178: WASP Database Spreadsheet
  - Familiarization by new team of (Container level) Database of all items stored

LIGO FRS

- The new LIGO Fault Reporting System (FRS) is being used to track and resolve issues associated with the 3rd IFO Storage
- 9 issues have been highlighted, 5 are resolved and 4 are pending
  - These range from storage condition e.g. finalizing wrapping and positioning on shelf to labelling of product on pallet, example: -
    - Issue - Incomplete maintenance schedule documentation
    - Resolution - All maintenance schedules are now documented on FAMIS

3rd IFO Storage & Security [now]

Inventory of Stored Containers

Record Types of Storage Units (Custodian & FLS Crew)

Components, Containers, Crates, Pallets

Record Identifying Information (Custodian & FLS Crew)

BOM, Label, Lock, Record Number

Record Location (Custodian & FLS Crew)

Building, Room, Cabinet, Shelf

Record Data (Custodian with input from Property Manager)

Database E1600178

Review (Property Manager)

FAMIS Inspection & Maintenance Schedules [now]

The following schedules are currently in FAMIS recording all inspections and maintenance.

3rd IFO Building walk-through [weekly]

- Inspect for access violation, pest or insect intrusion, water/moisture problems etc.

3rd IFO Environmental Controlled Container Inspection [Monthly]

- Inspect all sealed storage containers that include either dry nitrogen or desiccant for mechanical damage, exposure to ambient air, saturation of desiccants or other problems.

3rd IFO Equipment Inspection [Monthly]

- Inspect stored equipment for signs of unauthorized access, damage or other problems that indicate the integrity has been compromised.

3rd IFO Property Inspection [Annual]

- 1st inventory and check against the master 3IFO BOM, in planning.
  - If seals are intact this will verify that the contents are intact.

Request Log

LIGO-E1500229: Third IFO Component Request Log

A log of all (approved and rejected) requests for loan of Third Interferometer (IFO) Component Requests

- 17 approved (including handover from acceptance)
- $410k total implicit escrow total [*75% is two line items, highlighted below*]

Extract from Log on 15th June 2016

Third IFO Component Loan Log

E1500229

6/15/2016	today's date

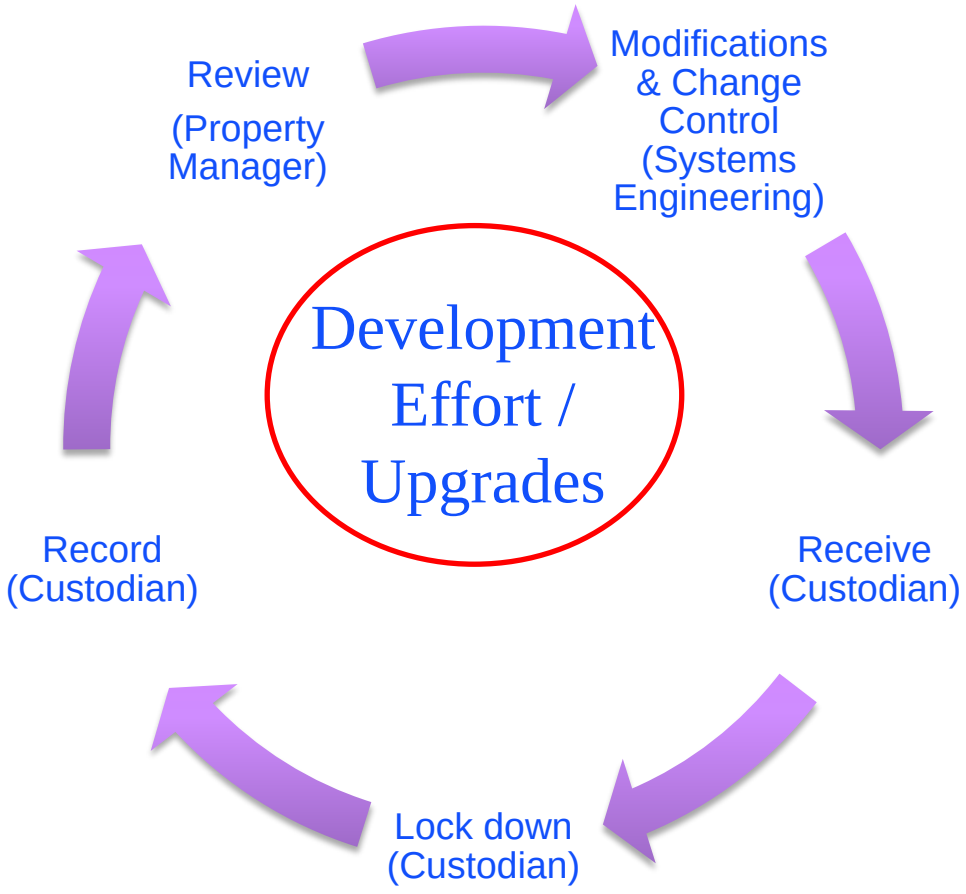
$411,313.00	total implicit escrow total

Request	status	start	end	extention	loan value	released?	follow-up	returned?	form completion	escrow value	comments
E1500227	approved	4/27/2015	7/1/2015	1/20/2017	$7,813.00	yes	12/20/2016	no		$7,813.00	1/26/16 Component request combined with E1500399. 4/28/2015 quote from Physik Instrumente: qty 1 S-330.4SD Piezo Tip/Tilt Platform, 5mrad (10 mrad Optical), Closed-Loop, Sub-D Delivery is ~ 4 weeks ARO . PSL-PZT Actuator . 03/15/16 - Per Rick S. At CIT. Should be ready for return. 04/25/16 - Spoke to Rick. He is going to check on the return.
E1500231	approved	4/27/2015	9/1/2015	8/1/2016	$170,000.00	yes	7/1/2016	no		$170,000.00	1/26/16 Waiting for LLO to complete the installation then will have to have the boards from LLO modified before returning to 3rd IFO. The primary delay was commissioning not allowing installation of components at LLO. Return date should be changed to 8/1/16.
E1500298	approved	7/16/2015	1/1/2016	1/1/2017	$16,000.00	yes	12/1/2016	no		$16,000.00	1/26/16 - The two busted PMC's are still being investigated and then still need to be reworked and rebuilt and then sent to LLO before the 3rd IFO one is released. I have no time frame on this work and it could quite easily be another year until this is complete. 03/15/16 - The two 3IFO PMCs. One at LLO as hot spare. One in LHO Lab being worked on.
E1500399	approved	10/1/2015	1/1/2016	1/1/2017	$18,000.00	yes	12/1/2016	no		$18,000.00	1/26/16 Staff only just identified (Alena Ananyeva) to work this. Work not started. Estimated work will start Feb 2016 and last 9 months. Return date should be changed to 1/1/2017
E1500430	approved	11/2/2015	11/1/2016		$40,000.00	yes	10/1/2016	no		$40,000.00	OFI Assembly - Shipped eLIGO weldment to LLO. This was not a 3IFO part. 01/29/16 - Gerardo shipped the internal parts for the OFI (from 3IFO inventory) on ICS shipment load #7973.
E1600026	approved	1/26/2016	7/1/2016		$10,000.00	yes	6/1/2016	no		$10,000.00	View Ports - Shipped 01/28/16, Shipment load # 7969
E1600034	approved	2/1/2016	5/1/2016		$2,000.00	yes	4/1/2016	no		$2,000.00	Ring Heater Cables - Shipped to LLO, ICS shipment load #7982.
E1600090	approved	3/25/2016	2016			yes	9/25/2016	no	requires signature	$0.00	DCC #D1101005 S/N 20 - 6" HQ 0.75deg VP Optic. 04/25/16 - Shipped to LLO on ICS shipment load #8102.
E1600138	approved	5/6/2016	8/1/2016		$12,500.00	yes	7/1/2016	no		$12,500.00	5 PSL HPO Laser Crystals - Peter K. shipped to LLO. Due to be replaced when LLO receives rplacement crystals in 08/2016. 05/25/16 - Peter K. & Jeff B. Searched the 3IFO and spare inventory accounted for a full set of laser crystals. (9 total 4 for the laser and 5 are spares). It was agreeded these 5 crystals came out of LHO spares and not 3IFO.
E1500003	approved	3/14/2016	2016		$6,000.00	yes	9/14/2016	no	required	$6,000.00	DCC # 9722012, 7.8" Viewport S/N 001. Released to Gerardo per E-Mail, with paperwork to follow. Verifyed with Joe DeRenzis this view port did come from the 3IFO inventory. Follow up paperwork will be required.
Prior to F1500003	approved	2015	2016			yes	9/1/2016	no		$0.00	14 OpLev lasers. 4 - (HAM2-5) at Mid-X. 9 - Jason has for testing and will return when ready for storage. 1 - is owed to 3IFO, Jason will supply the LHO spares.
Prior to F1500003	approved	2015	2016		$117,000.00	yes	9/1/2016	no		$117,000.00	ASC RFPD (x4), LSC RFPD (x2), DCPD for OMC (x2), Fast Shutter for ISC, Rich Abbott. Checked out and stored at CIT.
Prior to E1500003	approved	2015	2016		$12,000.00	yes	9/1/2016	no		$12,000.00	SEI Chasis checked out by Ops. These are in test stands and in lab being modified for Hardware watchdog work.
E1500447	approved	3/1/2016			$22,000.00	HOLD				$0.00	The Tiptilts are borrowed from spares inventory, NOT 3IFO inventory. There is a request for cables from 3IFO inventory not listed on this form. 01/28/2016 Checking with Dennis for approval of change.
E1500462	approved	2/1/2016	after 02		$2,500.00	HOLD				$0.00	1/26/16 pending with Jeff. 04/25/16 - Spoke with Jenne, AA chassis will be needed soon.

3rd IFO Modifications/Change Control (Development Effort) [coming soon 1-2 months]

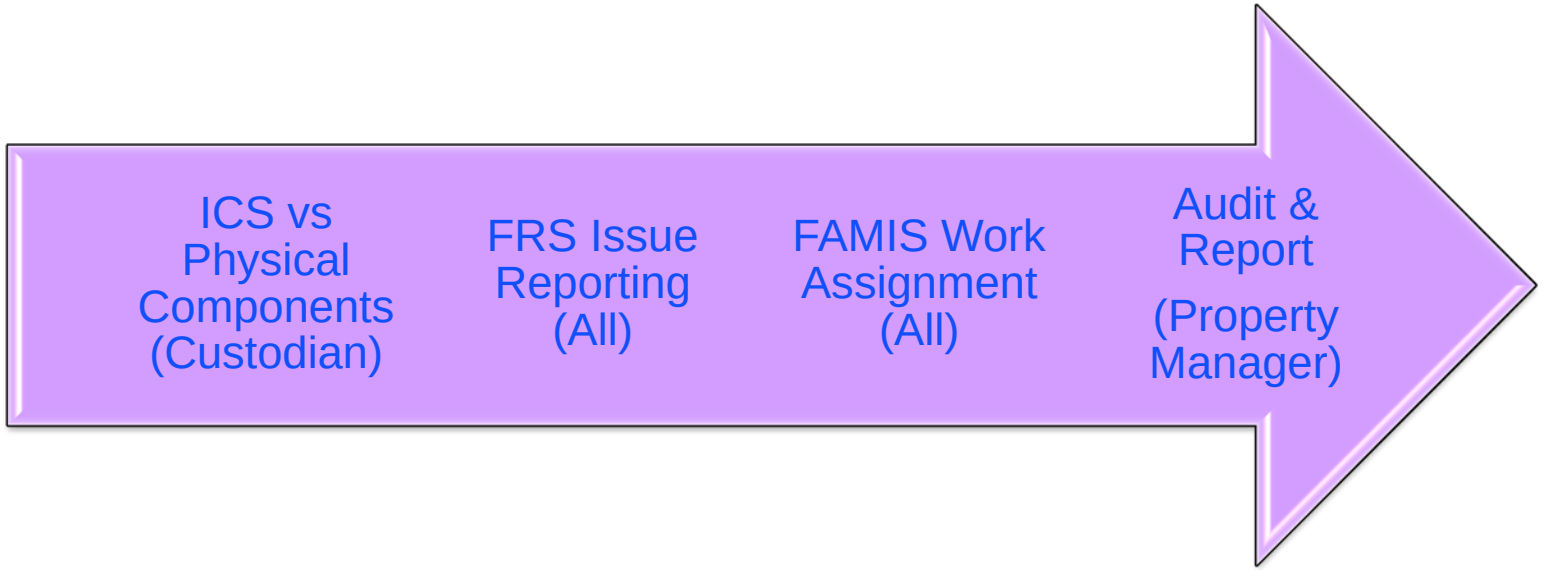
Examples:

- SR3 Actuator.
- Test Mass Bounce and Roll Mode Dampers
- Test Mass non-magnetic blade dampers



3rd Physical Inventory Tracking [later 6-12 months]

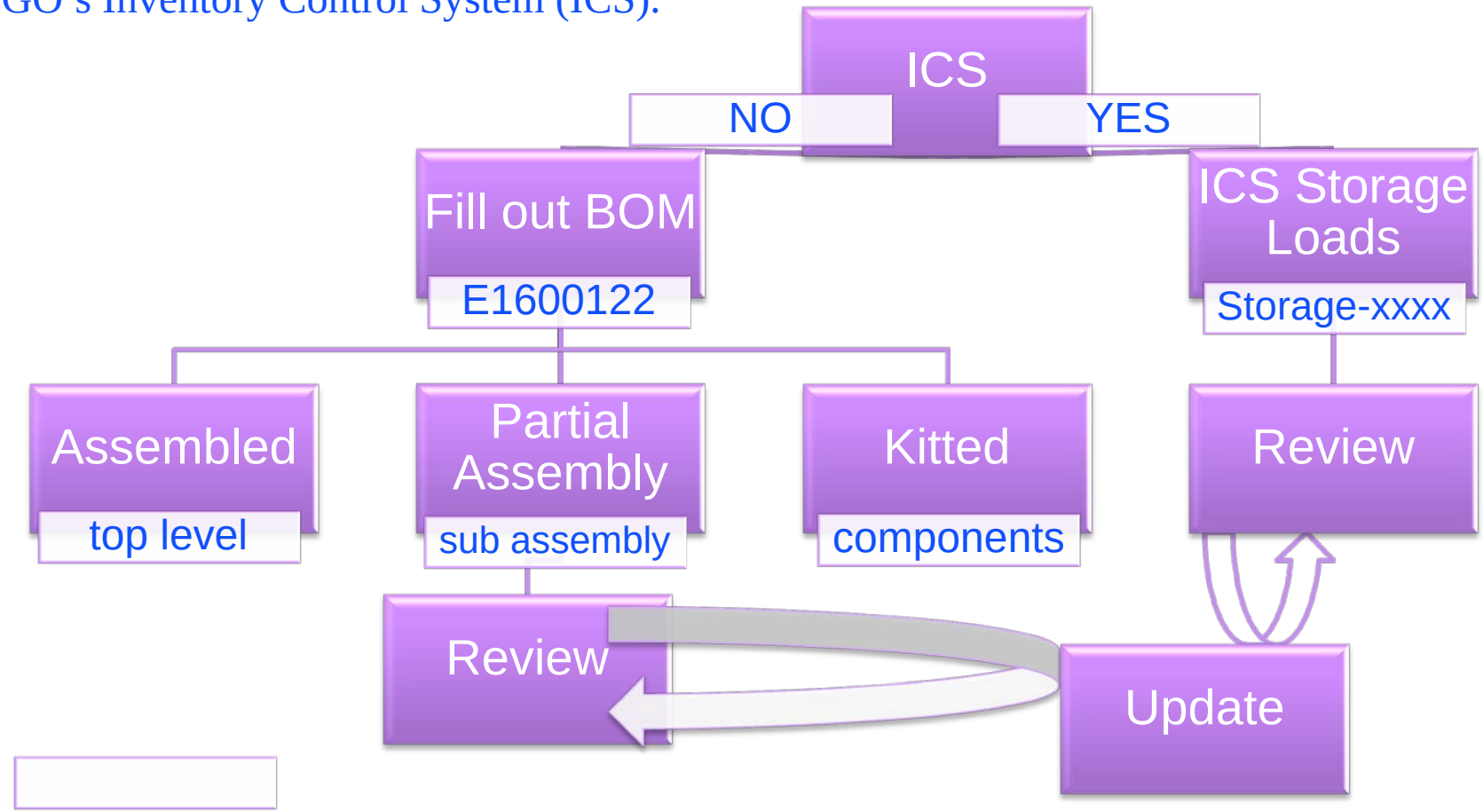
Inventory Control System (ICS) data will be verified for record accuracy prior to physical inventory [using BOM's supplied by sub-systems as initial input]



At this point an overall "storage state" BOM will be created LIGO-E1300044: Top Level 3rd IFO BOM (work in progress)

Workflow for 3rd IFO Inventory Database [later 6-12 months]

Workflow planned for team that will work on Inventory Database using LIGO's Inventory Control System (ICS).



Physical Inventory “Stock-taking” (Annual)

Even though we have confidence in the Acceptance process (Sept 2015) and in the Check-out procedure, a “stock-taking” is planned

- Physical verification of the condition of items in storage plan valid?
- Physical verification of the quantities of items in storage check out procedure, working?
- Support our plan to consolidate the storage database using Google Docs, see LIGO-E1600122 below via the LIGO Inventory Control System (ICS)
- Match & update the storage condition to the Bill of Materials (BOM) LIGO-E1300044: Top Level 3rd IFO BOM (pending)

v1		LIGO-E1600122-v1		3rd IFO Sub-System Inventory Template (storage condition)												
#	IN ICS	SUB-SYSTEM	PART TYPE	PART NAME	DRAWING/CATALOG#	REVISION	TYPE	SERIAL NUMBER	3IFO	MATERIAL	BUILDING	ROOM/CABINET/SHELF	CONTAINER NUMBER	NOTES/LINKS	CHAMBERS	IN or OUT of VACUUM
1																
2																
3																

Final Check-out: Shipping of H2 Components [much later, few years]

LIGO Laboratory shares responsibility with partner for shipping 3rd interferometer components overseas

- India is responsible for all costs associated with shipping except LIGO staff time as presented below

LIGO Lab primary responsibilities

- Preparation and execution of export licenses
  - NB: all components covered under Export Administration Regulations (dual use)
- Check-out and final inspection of H2 components

Partner primary responsibilities

- Design and manufacture of shipping containers
- Develop crating procedures
- Providing clean/secure storage
- Identify best shipment methods

Joint responsibilities

- Component and assembly packing

LIGO Lab provides oversight on all partner activities

H2 Component Shipping: Logistics

LIGO shipment readiness review required before shipment is authorized. Must pass certification checklist:

- Final inspection: component/assembly complete and in proper condition
- Shipping container design approved; shipping container(s) ready and available
- Receiving area ready (matches LIGO storage requirements); receiving team trained and certified in proper handling
- Documents ready (‘traveler’, export license)

We will adopt Advanced LIGO component shipping containers where possible

- Designs have been ‘battle-tested’ during aLIGO
- Some new containers will be designed as needed for components assembled at LIGO sites

LIGO Lab Operations caretaker is responsible for overseeing packing and shipping all subsystems

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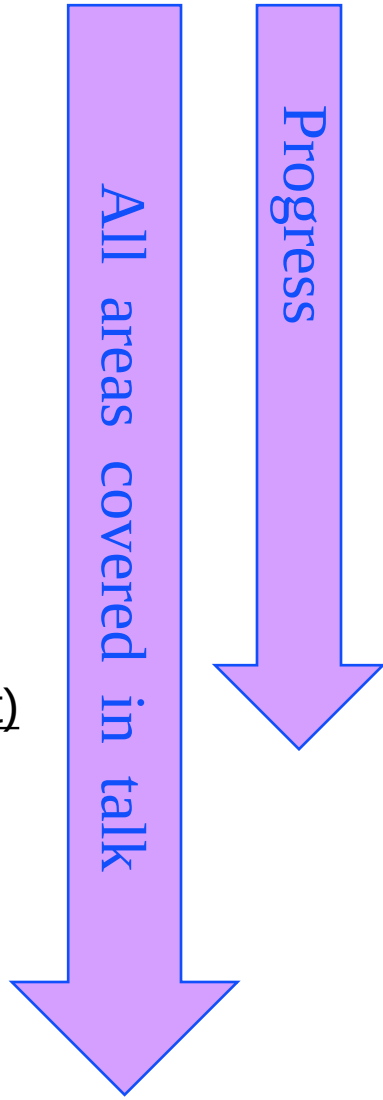

LIGO

Third Interferometer aka 3rd IFO Storage

II. Response to Recommendations from NSF Storage Review

NSF Review June 2016
v7

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Review of the Long Term Storage Plan For the National Science Foundation April 9, 2013 Final Report

Question #1

- *Please advise NSF on the appropriateness of LIGO's proposed plans to store the in-vacuum components of the second Hanford interferometer for a nominal 3-5 year period. Please advise NSF of any best practices or sources of expertise used elsewhere to store approximately similar components that may be of assistance to LIGO in further planning.*
  - Panel Response: The storage plans for in-vacuum components is appropriate with the exception of the omission of optical witness samples where high value/long lead optical assemblies and suspension systems would benefit from independent monitoring.
  - LIGO Response: Clean 4" silicon wafers placed in storage location, for future analysis. Equivalent to those used in LIGO chambers

Review of the Long Term Storage Plan For the National Science Foundation April 9, 2013 Final Report

Question #3

- *Please advise NSF on the appropriateness of LIGO's plans to inventory the stored items, including: Plans to uniquely identify and track the location of stored items and materials. Plans to maintain data and metadata pertaining to the stored items that may be required during their later use, as well as plans to maintain adequately documented software, software parameters, changes or other stored hardware-specific information. Plans for inventory control, security, and safety during storage. Plans for environmental control and environmental monitoring during storage.*
  - Panel Response The review panel feels that LIGO's plans are appropriate for the proper tracking of stored items. Inventoried items are tracked with a computer program called ICS (for Inventory Control System) that provides deep documentation. Software is under configuration control and is shared among LIGO sites. Plans for inventory control, security and safety are sufficient as containers are numbered and inventoried. Containers will be clearly marked and have paper copies of the container's contents including engineering drawings. The plan calls for locks and tamper evident seals. Containers without locks will be stored in locked, limited access rooms. Stored items for a 3rd IFO are not to be co-mingled with other LIGO components and 3rd IFO components cannot be used for other purposes without senior management approval and a plan for component replacement. The areas designated for 3rd IFO storage seem adequately safe from natural and man-made hazards like weather and power failures. All the stored equipment will be maintained indoors in clean temperature and humidity controlled rooms. Storage areas will be inspected periodically (weekly) for evidence of environment variations or pest control issues. The review panel recommends that LIGO verify that software, data and documentation is duplicated at a back- up server at a different location.
  - LIGO Response: Containers are clearly marked and include paper copies of contents and DCC numbers of all drawings. All drawings are on the DCC and searchable with DCC number.
  - LIGO Response: Key documentation (except full inventory) now on our Document Control Center (DCC) which is backed up. Working on getting all of the inventory into the LIGO Inventory Control System (ICS) which is also backed up.

Review of the Long Term Storage Plan For the National Science Foundation April 9, 2013 Final Report

Question #5 (only sections with actions listed)

- Given the approach that LIGO plans for the storage: Are any of the stored assemblies, any of their component parts, or their storage containers expected to exhibit performance capabilities that degrade with time in storage? If yes, why?
  - Panel Response From the information reviewed and discussed with the Project, there were no systems or components that are expected to exhibit degradation over the 3-5 years planned for storage. With respect to the storage containers, many of the systems are currently in temporary storage and the planned storage containers have not been fabricated yet. The main concerns on the storage containers have to do with the plans and procedures for dry nitrogen purge, use of optical witness samples, desiccants and humidity strip indicators.
  - LIGO Response: All items are now in the long term storage containers, refer to main talk and in particlaur to slide on Long Term Storage and associated documents. LIGO's FAMIS (refer to main talk) is the tool now utlilized for the tracking of the Nitrogen and desiccant levels.

Question #5 (only sections with actions listed)

- What assemblies or components will require retesting, re-characterization or recalibration after storage or will this be required for all stored items? How was or is this to be determined? Are any special facilities, instruments or fixtures required?
  - Panel Response The panel recommends that the Project consider the pros and cons of performing retesting (functional or performance) on any of the stored systems. They should consult with the provider of the system, subsystem, or component as to the benefits of performing any testing prior to shipping. In many cases (like the PSL), the advantages of performing one final system test may be outweighed by the risks of damage or contamination from unpacking, testing, and repacking.
  - LIGO Response: On review internally by LIGO the re-testing was considered not required.

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Third Interferometer aka 3rd IFO Storage
III. Supplemental Slides

NSF Review June 2016
v7

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Bill of Materials (BOM)

The detector drawings and BOMs are hierarchically linked in the SolidWorks vault, and in the LIGO Document Control Center (DCC). BOMs are embedded in the assembly and sub-assembly drawings (and of course within the SolidWorks CAD files). In addition, we provide BOMs at the chamber assembly level as separate documents. The chamber-level BOMs (for LLO) are as follows:

- E1101163 BSC1 L Top Level Chamber Assembly BOM
- E1101164 BSC2-L Top Level Chamber Assembly BOM
- E1101165 BSC3 L Top Level Chamber Assembly BOM
- E1201084 BSC4 L Top Level Chamber Assembly BOM
- E1300289 BSC5 L Top Level Chamber Assembly BOM
- E1200569 HAM1-L Top Level Chamber Assembly BOM
- E1100820 HAM2-L Top Level Chamber Assembly BOM
- E1100818 HAM3-L Top Level Chamber Assembly BOM
- E1101158 HAM4-L Top Level Chamber Assembly BOM
- E1101159 HAM5-L Top Level Chamber Assembly BOM
- E1101160 HAM6-L Top Level Chamber Assembly BOM

All of these are publically available either directly or by paging down from D0901491 which is a related document at: - https://dcc.ligo.org/LIGO-G1601083/public.

KEY	DESCRIPTION		
	DWG SIZE	DWG NUMBER	DWG STATUS

REV.	DATE	DCN #	DRAWING TREE #
v2	24 JAN 2014	-	-
v3	07 APR 2014	-	-
-	-	-	-

ADVANCED LIGO MECHANICAL LAYOUT

E | D0901491 | COMPLETED

LHO

aLIGO LHO SYSTEM LAYOUT — E D0901477 COMPLETED

- aLIGO LHO Y-END STATION SYSTEM LAYOUT — E D0901467 COMPLETED
  - BSC10 TOP LEVEL CHAMBER ASSY. — D D0901154 COMPLETED
  - BSC6 TOP LEVEL CHAMBER ASSY. — D D0900512 COMPLETED
- aLIGO LHO X-END STATION SYSTEM LAYOUT — E D0901468 COMPLETED
  - BSC5 TOP LEVEL CHAMBER ASSY. — D D0900502 COMPLETED
  - BSC9 TOP LEVEL CHAMBER ASSY. — D D0901180 COMPLETED
- aLIGO LHO CORNER STATION SYSTEM LAYOUT — E D0901469 COMPLETED

H1:
- HAM1 TOP LEVEL CHAMBER ASSY. — D D0901821 COMPLETED
- HAM2 TOP LEVEL CHAMBER ASSY. — D D0901083 COMPLETED
- HAM3 TOP LEVEL CHAMBER ASSY. — D D0901094 COMPLETED
- HAM4 TOP LEVEL CHAMBER ASSY. — D D0901125 COMPLETED
- HAM5 TOP LEVEL CHAMBER ASSY. — D D0901129 COMPLETED
- HAM6 TOP LEVEL CHAMBER ASSY. — D D0901822 COMPLETED
- BSC1 TOP LEVEL CHAMBER ASSY. — D D0901137 COMPLETED
- BSC2 TOP LEVEL CHAMBER ASSY. — D D0901142 COMPLETED
- BSC3 TOP LEVEL CHAMBER ASSY. — D D0901146 COMPLETED

H2:
- HAM7 TOP LEVEL CHAMBER ASSY. — D D0901825 ON HOLD
- HAM8 TOP LEVEL CHAMBER ASSY. — D D0900449 ON HOLD
- HAM9 TOP LEVEL CHAMBER ASSY. — D D0900465 ON HOLD
- HAM10 TOP LEVEL CHAMBER ASSY. — D D0900469 ON HOLD
- HAM11 TOP LEVEL CHAMBER ASSY. — D D0900487 ON HOLD
- HAM12 TOP LEVEL CHAMBER ASSY. — D D0901828 ON HOLD
- BSC4 TOP LEVEL CHAMBER ASSY. — D D0900481 ON HOLD
- BSC7 TOP LEVEL CHAMBER ASSY. — D D0900405 ON HOLD
- BSC5 TOP LEVEL CHAMBER ASSY. — D D0900560 ON HOLD

ADVANCED LIGO HANFORD OBSERVATORY (LHO)

LIGO D0901477

ADVANCED LIGO LIVINGSTON OBSERVATORY (LLO)

LIGO D0901490

LLO

aLIGO LLO SYSTEM LAYOUT — E D0901490 COMPLETED

- aLIGO LLO Y-END STATION SYSTEM LAYOUT — E D0901464 COMPLETED
  - BSC8 TOP LEVEL CHAMBER ASSY. — D D0900506 COMPLETED
- aLIGO LLO X-END STATION SYSTEM LAYOUT — E D0901465 COMPLETED
  - BSC4 TOP LEVEL CHAMBER ASSY. — D D0900471 COMPLETED
- aLIGO LLO CORNER STATION SYSTEM LAYOUT — E D0901466 COMPLETED
  - HAM1 TOP LEVEL CHAMBER ASSY. — D D0901809 COMPLETED
  - HAM2 TOP LEVEL CHAMBER ASSY. — D D0900345 COMPLETED
  - HAM3 TOP LEVEL CHAMBER ASSY. — D D0900520 COMPLETED
  - HAM4 TOP LEVEL CHAMBER ASSY. — D D0900421 COMPLETED
  - HAM5 TOP LEVEL CHAMBER ASSY. — D D0900454 COMPLETED
  - HAM6 TOP LEVEL CHAMBER ASSY. — D D0901811 COMPLETED
  - BSC1 TOP LEVEL CHAMBER ASSY. — D D0900442 COMPLETED
  - BSC2 TOP LEVEL CHAMBER ASSY. — D D0900428 COMPLETED
  - BSC3 TOP LEVEL CHAMBER ASSY. — D D0900492 COMPLETED

REFERENCE DOCUMENTATION:

- FOR ALIGO DETECTORS SYSTEM DESIGN AND REQUIREMENTES, SEE LIGO T010075.
- FOR ALIGO SITES GLOBAL/LOCAL COORDINATES REFER TO T980044.
- FOR ALIGO OPTICAL LAYOUT DETAILS, REFER TO T010076.

ITEM NO.	PART NO.	DESCRIPTION	QTY.
1	D0901477	Aligo, Hanford System Layout (LHO)	1
2	D0901490	Aligo, Livingston System Layout (LLO)	1

MATERIAL	N/A	FINISH	N/A
NEXT ASSY	N/A	SYSTEM	ALIGO
SUB-SYSTEM	SYS		

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TITLE NAME: ADVANCED LIGO MECHANICAL LAYOUT

DRAWN	R.SANCHEZ	24-JAN-2014	SIZE	DWG. NO.	REV.
CHKD	R.SANCHEZ	24-JAN-2014	E	D0901491	v3
CHECKED	LIGO DCC	—	SCALE: NTS	TOLERANCES	SHEET 1 OF 1
APPROVED	LIGO DCC				

Bill of Materials (BOM)

One can path to the detector drawings (from top-level assemblies, to lower-level assemblies and down to the piece part level) by starting at the root document. For example (to 6th level only):

LIGO-D0901491: aLIGO, Mechanical Layout
LIGO-D0901490: aLIGO LIVINGSTON SYSTEM LAYOUT
LIGO-D0901464: aLIGO Systems Layout LLO Y-End Station
LIGO-D0900506: aLIGO Systems BSC5-L1, Top Level Chamber Assembly
LIGO-E1300289: BSC5 L Top Level Chamber Assembly BOM
LIGO-D0900507: AdvLIGO VE BSC5-L1, Vaccuum Equipment Assembly
LIGO-D0900516: AdvLIGO SEI BSC5-L1, XYZ Local CS for ISI Table
LIGO-D0901182: aLIGO, SEI, BSC-ISI, Top Assembly
LIGO-D0900517: AdvLIGO SUS BSC5-L1, XYZ Local CS for ETMY
LIGO-D0901346: Advanced LIGO Quadruple Suspension Assembly
ETC.
LIGO-D070056: Advanced LIGO, SUS, Quad N-PType, Quad Dog Clamp
LIGO-D1003190: aLIGO SUS BSC Shorter Dog Clamp
LIGO-D1100785: SUS Nitronic Flat Washers
LIGO-D1002424: aLIGO, SUS, VIBRATION ABSORBER, 5LB VERTICAL WITH O-RINGS
LIGO-D0900436: AdvLIGO SUS BSC5-L1, XYZ Local for ETM Tel Assy
ETC
LIGO-D1201071: AdvLIGO BSC5-L1 ISI Table, Payload & Suspended Mass Assembly
LIGO-D1200677: AdvLIGO SUS BSC5-L1, XYZ Local CS for SLC Arm Cavity Baffle
ETC
LIGO-D1200111: CABLE HARNESS ROUTING CONFIGURATION, LBSC5 / WBSC10
LIGO-D1000513: HEPI ASSEMBLY, BSC aLIGO
ETC
LIGO-D1003092: Flange Layout – L1 Beam Splitter Chamber 5 (BSC5) ETMY
LIGO-E1000337: AdvLIGO Detailed Mass Properties-CG Report BSC Tables (LLO)
LIGO-D0901465: aLIGO Systems Layout LLO X-End Station
ETC
LIGO-D0901466: aLIGO Systems Layout LLO Corner Station
ETC

All of these are publically available either directly or by paging down from D0901491 which is a related document at: - https://dcc.ligo.org/LIGO-G1601083/public.

General Storage Requirements

Several types of packaged interferometer components:

- Shipping crates – protected internally from contamination, but with outside housing incompatible with clean areas
- Storage containers
- "In air" parts are destined to function inside the clean area that houses the interferometers, but outside the vacuum system
- "In Vacuum" parts: Items intended for permanent in-vacuum service (Class A) or tooling that touches in-vacuum parts (Class B) are fabricated, cleaned, baked, and packaged according to specific and stringent protocols.
  - Class A and Class B parts must be stored in clean space, some of them under dry nitrogen (N2) purge (or vacuum) to avoid humidity impacts.

Storage

Venues arranged according to general storage condition requirements, LIGO-E1300001: Long Term Storage Plan for the Components of the Third Advanced LIGO Interferometer

- Temperature range: 72F +/- 3.5F
- Humidity range: 20-70% relative humidity (RH)
- Cleanliness
- Assignment of 3IFO Storage venue is further refined using each sub-system's specific humidity control requirements

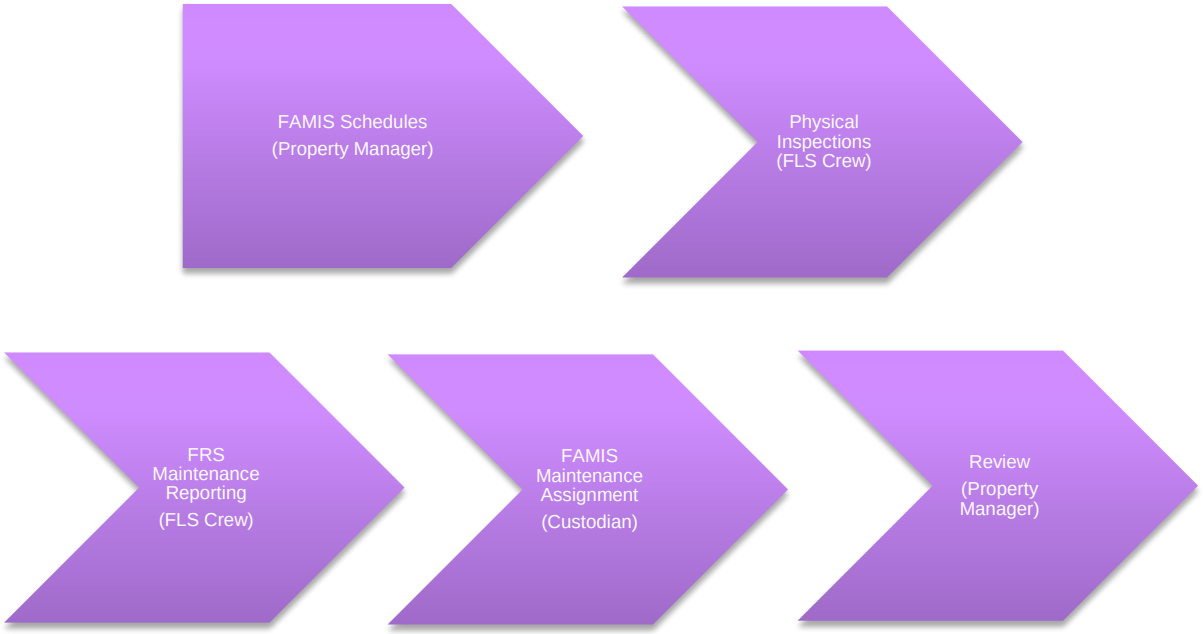
REF: Technical Progress-3IFO for NSF Review 2015 https://dcc.ligo.org/LIGO-G1500720

Storage Requirements

LIGO-E1300001: Long Term Storage Plan for the Components of the Third Advanced LIGO Interferometer

- The purpose of this document is to define the requirements and top-level plans for Long Term Storage (LTS) of the Advanced LIGO (aLIGO) Third Interferometer (3rd IFO) components . Detailed storage plans are defined in documentation referenced in the following sections.
- It should be noted that all components of the 3rd IFO are to be stored in LIGO facilities at the LIGO Hanford Observatory (LHO), under LIGO oversight/security and within clean and environmentally controlled spaces.
- There are very few items which require special consideration for long term storage. In addition all of these 3rd IFO components will be tracked and controlled using the same procedures and inventory control system used for the components of the other two aLIGO interferometers.
  - LIGO-T1200527: Suspension (SUS) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1200549: Seismic Isolation (SEI) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1200557: Pre-Stabilized Laser (PSL) Long Term Storage for the Third aLIGO Interferometer
  - LIGO-T1200567: Input Optics (IO) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300027: Interferometer Sensing and Control (ISC) Long Term Storage for the 3rd aLIGO Int
  - LIGO-T1300016: Core Optics Components (COC) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300010: Facilities Modifications and Tooling (FMP) Long Term Storage for the 3rd aLIGO Int
  - LIGO-T1300002: Control and Data Systems (CDS) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300006: Stray Light Control (SLC) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300003: Thermal Compensation System (TCS) Long Term Storage
  - LIGO-T1200558: Optical Lever (OpLev) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300011: Initial Alignment System (IAS) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300012: Photon Calibrator (PhCal) Long Term Storage for the 3rd aLIGO Interferometer
  - LIGO-T1300007: Transmission Monitor SUS (TMS) Long Term Storage (LTS) for the 3rd IFO and LIGO LTS
  - LIGO-T1300006: Stray Light Control (SLC) Long Term Storage for the 3rd aLIGO Interferometer

3rd IFO Inspections & Maintenance [now]



3rd IFO Check Out & Request Tracking [now]

Submit (Requestor)*	• Completion of E1500003
Approve (Systems Engineering)	• Recorded on E1500229
Locate, Release & Document (Custodian)*	• Physical components from storage • and documented on E1500229
Monitor Return (Property Manager)	• Review of E1500229
Receive, Lock Down & Record (Custodian)*	• Physical components to storage • and documented on E1500229
Review (Property Manager)	• Trust and verify

* Acting on-site property custodian Jeff Bartlett available for guidance / support here

Check Out Procedure

LIGO-F1500003: Third IFO Component Request Form and Procedure

This form is to be completed and submitted for approval by Systems Engineering for any loan or use of a Third Interferometer (IFO) component.

Procedure

- The requester/borrower reserves an E-number from the DCC, completes the form above, uploads the completed form, and requests the System Engineer to review via the DCC electronic approval.
- The System Engineer considers and dispositions the request: a. consults with the LTS Manager and/or requests clarification from the requester, as needed. b. If deemed warranted (e.g. high risk, high replacement cost, etc.), the System Engineer may request TRB and/or OMT review and approval.
- If rejected, the System Engineer explains the reason for rejection above and marks the request “rejected” in the “notes and changes” metadata field in the DCC, and informs the requester.
- If approved, the System Eng.:a. indicates any caveats above & marks the request “approved” or “approved with caveats” in the “notes and changes” metadata field in the DCC, and informs the requester and the LTS mgr. b. adds the approved loan to the Third IFO Request Log E1500229, and updates the total loan value c. informs the LIGO Business Mgr. of the implicit escrow amount if/when the total loan value exceeds $50K

Check out Procedure

LIGO

DCC E-Number: [Type here]

Document Title:
Third IFO Component Request: Click here to enter text.

Read the procedure below before completing this form.

Requester	
Requester's Name:	Click here to enter text.
Request Date:	Click here to enter a date.

Component Requested	
Source:	Choose an item.
Part Number (D-number if LIGO)	Click here to enter text.
Component Name or Description	Click here to enter text.
Quantity	Choose an item.
Next Level Major Assembly:	Click here to enter text.
Subsystem:	Choose an item.

Requested Loan Terms	
Requested Loan Start Date:	Click here to enter a date.
Proposed Return (or replacement) Date:	Click here to enter a date.
Loan Type:	Choose an item.
• IF updating component, THEN ECR E-number:	Click here to enter text.
• IF Spare, THEN which IFO (where):	Click here to enter text.
• IF testing/evaluating, THEN why and where?	Click here to enter text.
Risks and wear anticipated:	Click here to enter text.
UHV clean & bake required after loan?	Click here to enter text.
Inspection/test actions required upon return or replacement?	Click here to enter text.
Additional comments or references:	Click here to enter text.
Approx. Replacement Cost:	Click here to enter text.
Approx. Lead Time to Replace:	Click here to enter text.

Managed by Jeff Bartlett (operator) at LHO

LIGO

DCC E-Number: [Type here]

Disposition of Request *(section to be completed by Systems Engineering)*	
Systems Engineering Disposition:	Disposition Choose an item. Disposition
Caveats, Request for More Information, or reason for rejection:	Click here to enter text.
SE Personnel Name:	Click here to enter text.

Loaned Item Details *(section to be completed by Long Term Storage (LTS) Manager)*	
Serial Number (SN): (if relevant/known)	Click here to enter text.
S-number: (if relevant/known)	Click here to enter text.
LAM number:	Click here to enter text.
Additional comments:	Click here to enter text.
LTS Personnel Name:	Click here to enter text.

Return/Completion *(section to be completed by Long Term Storage (LTS) Manager)*	
All loaned items returned?	Click here to enter text.
Appropriately inspected and/or tested?	Click here to enter text.
Additional comments:	Click here to enter text.
LTS Personnel Name:	Click here to enter text.

Procedure:

1) The requester/borrower reserves an E-number from the DCC, completes the form above, uploads the completed form, and requests the System Engineer to review via the DCC electronic approval.
2) The System Engineer considers and dispositions the request:
   a. consults with the LTS Manager and/or requests clarification from the requester, as needed.
   b. If deemed warranted (e.g. high risk, high replacement cost, etc.), the System Engineer may request TRB and/or OMT review and approval.
3) If rejected, the System Engineer explains the reason for rejection above and marks the request "rejected" in the "notes and changes" metadata field in the DCC, and informs the requester.
4) If approved, the System Eng.:
   a. indicates any caveats above & marks the request "approved" or "approved with caveats" in the "notes and changes" metadata field in the DCC, and informs the requester and the LTS mgr.
   b. adds the approved loan to the Third IFO Request Log, E1500229, and updates the total loan value
   c. informs the LIGO Business Mgr. of the implicit escrow amount if/when the total loan value exceeds $50K
5) The LTS Manager informs the borrower of any modifications to the request. The form must be updated to be the final, accurate record of agreement.
6) The LTS manager puts a reminder in the calendar to follow-up with the borrower before the agreed end/return date.
7) The LTS Manager enquires of status on that date, and either prepares for return or informs the System Engineer of difficulties/request for change of date, etc.
8) The LTS Manager maintains civil pressure on situation and uses the System Engineer to resolve difficulties.
9) The LTS Manager coordinates return processing as appropriate (e.g., arranges shipping/receiving, inspection, lines up clean and bake, etc.)
10) The LTS Manager annotates the final (return) section of the form indicating satisfactory return to LTS (as this is the only acceptable completion)

aLIGO Project Responsibilities

3rd IFO storage protocols established by aLIGO Project

- Storage
- Security
- Routine inspections and maintenance
- Inventory tracking
- Component modifications/change control

aLIGO Project was responsible for 3rd IFO components until formal acceptance → Upon acceptance of 3rd interferometer, custodianship became the responsibility of LIGO Lab Operations

Ref: 3rd IFO Long-Term Storage Acceptance and Punchlist https://dcc.ligo.org/LIGO-M1300164
Procedures/protocols (E1300001) established by aLIGO Project to be adopted by Operations

Sub-System Custodian List

E1300001 Section Subsystems Primary Secondary Tertiary Notes

- 7.1 Suspensions (SUS) Betsy Travis Jeff
- 7.2 Seismic Isolation (SEI) Hugh Jim TJ
- 7.3 Pre-stablized Laser (PSL) Peter Jason Ed Jeff (Chillers)
- 7.4.1 Stray Light Control (SLC) Gerardo Betsy TJ
- 7.4.1 Viewports (VP) Gerardo Joe D Kyle? 7.4.2 Transmission Monitor Suspension (TMS) - SUS Jeff Betsy
- 7.4.2 Transmission Monitor Suspension (TMS) - ISC Corey Keita
- 7.4.3 Thermal Compensation System (TCS) - In Vac Betsy Nutsinee
- 7.4.3 Thermal Compensation System (TCS) - In Air Jason Nutsinee
- 7.4.4 Optical Lever (OpLev) Jason Ed TJ
- 7.4.5 Photon Calibrator (PCal) Rick Travis
- 7.4.6 Initial Alignment System (IAS) Jason Hugh Updated 2nd June
- 7.5 Input Optics (IO) Cheryl Corey Betsy
- 7.6 Core Optics Components (COC) Betsy Gerardo Travis
- 7.7 Interferometer Sensing & Controls (ISC) Corey Keita TJ
- 7.8 Data Acquisition, Diagnostics, Networking & Supervisory Control (DAQ) Richard Filliberto Dave B 7.9 Installation & System Test and Facility Modifications & Preparation (INS/FMP) Travis Betsy Jeff Jeff (assem tooling)

- FLS Crew Bubba