

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY  
- LIGO -

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LIGO Length Sensing System: Design considerations for a table-top prototype interferometer			
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# 1 ABSTRACT

This note collects ideas about LIGO operational scenarios which may have some relevance to CDS.

# 2 KEYWORDS

Operational Scenario, Installation, Commissioning, Operation, CDS

# 3 OVERVIEW

Activities at the remote Facilities (“sites”) are different during the installation/commissioning (I/C) phases from the activities during regular operation (RO). As installation/commissioning of the different systems and interferometers is phased, installation/commissioning activities may take place in parallel with regular operation activities.

## 3.1. Definitions

### 3.1.1. Detector System

A detector system is a complete set of (at least) one interferometer, the corresponding part of the data acquisition and the data handling systems

### 3.1.2. Regular operation

Regular operation of LIGO in this context is the coordinated, technically correct operation of all subsystems of a LIGO detector together with all necessary CDS systems (like data acquisition); it does not mean in this context that the interferometers are necessarily locked or that the observatory works at full sensitivity.

### 3.1.3. Installation and Commissioning

The Installation and commissioning phases cover all activities required to get a detector system into the operational phase

# 4 LIGO INSTALLATION AND COMMISSIONING

## 4.1. Scenarios in the Control Rooms during I/C phases

## 4.2. Activities in the control rooms during I/C phases

### 4.2.1. People in the Control Rooms during I/C phases

During the I/C phase the facility control room (FCR) serves as communication hub for all people

working on site.

For this purpose the Installation Engineer/Scientist in Charge (ESC) should be permanently located in the FCR as long as no regular operation takes place. When parts of the facility become operational, one may consider to move him to another location. (At least) one operator is permanently present in the FCR as long as people are working on the site.

His tasks include

- logging the access of people to the restricted -access areas
- watch the facility monitor and control screen
- serve as telephone switchboard operator (as he knows who is where)

#### 4.2.2. Flow of materials through the Control Rooms during I/C

There is no regular flow of materials through the control rooms during I/C.

I could think of the following things which might be involved:

- (paper) documentation

#### 4.2.3. People flow through the Control Rooms during I/C phases

The following matrix illustrates the people flow through the Control Rooms. Control Rooms here are both the facility Control Room and the Diagnostic Control Room. Local traffic between these two rooms is not considered

**Table 1: People flow involving the Control Rooms**

<i>Room</i>	<i>to</i>	<i>from</i>	<i>notes</i>
Computer Room	x	x	occasional
Tape Room	x	x	occasional
LVEA	x	x	all people going into the LVEA have to report in person or by phone to the facility control room. I assume that the corresponding paperwork will be handled there
Conference Room or other small meeting room			during commissioning, frequent on-the-spot meetings will be required near to the control rooms

## 4.3. Scenarios in the EMTA during I/C phases

### 4.3.1. Activities in the EMTA during I/C phases

Activities in the EMTA include:

- testing electronic modules in pre-configured test stands (VME crates) using computing workstation
- testing electronic modules in ad-hoc set-ups
- execute minor repairs on electronic modules
- assemble and test cable sets
- 

### 4.3.2. People in the ETMA during I/C phases

ETMA provides

- permanent desks for two technicians
- a “glass cage” for an engineer
- a number of electronic workbenches (increasing with time) for use by the “permanent residents” of the ETMA and by temporary users.

### 4.3.3. Flow of materials during I/C phases

#### 4.3.3.1 Cleaning

All equipment leaving the ETMA for a clean area (mainly the LVEAs) requires cleaning before it leaves. Where is this cleaning done?. The items to be cleaned are:

- cable sets
- electronic modules
- crates (full and empty)
- complete pre-cabled cabinets (with or without electronic modules)
- measurement instruments (oscilloscopes etc.)
- tools

#### 4.3.3.2 Categories of materials

The following table lists the materials categories which enter and leave the ETMA

**Table 2: CDS equipment going through the ETMA during I/C**

	<i>description</i>	<i>from</i>	<i>to<sup>a</sup></i>
a	empty 19” equipment cabinets	supplier	n.a.
b	pre-cabled 19” equipment racks	contractor	LVEAs or Store <sup>b</sup>
c	VME crates	supplier or LVEAs	LVEAs or Store <sup>c</sup>
d	Electronic modules	supplier or LVEAs	LVEAs

**Table 2: CDS equipment going through the ETMA during I/C**

	<i>description</i>	<i>from</i>	<i>to<sup>a</sup></i>
e	Instruments	supplier or LVEAs	LVEAs
f	paper documentation	other sites	other sites
g	small electronic components & accessories	supplier	n.a.
h			

- a. all items which =go to the LVEA have to undergo cleaning  
b. most likely these items need cleaning and wrapping before being put into the store  
c. most likely these items need cleaning and wrapping before being put into the store

#### 4.3.4. People flow through the ETMA during I/C phases

The following matrix illustrates the people flow through the ETMA.

**Table 3: People flow involving the ETMA**

<i>Room</i>	<i>to</i>	<i>from</i>	<i>notes</i>
Contol rooms	x	x	all people going into the LVEA have to report in person or by phone to the facility control room. I assume that the corresponding paperwork will be handled there

#### 4.4. Deliveries and storage at the remote sites

##### 4.4.1. CDS components delivered to the sites during I/C

**Table 4: CDS equipment delivered to the remote sites during I/C**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
a	cable on drums		
b	fibre optic cable on drums		
c	empty 19" equipment cabinets		
d	pre-cabled 19" equipment racks		

**Table 4: CDS equipment delivered to the remote sites during I/C**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
e	VME crates		
f	Electronic modules		
g	computing equipment		
h	computing peripherals (tape and disk units)		
j	cable trunking materials		
k	instruments		
l	paper documentation		
m	empty tapes		
n	small electronic components & accessories		
o			

The flow is different for the different items.

#### 4.4.1.1 Large items

For large items (a, b, c, e, j) the sequence is as follows:

- unpacking in the shipment/receiving area
- transported to the long-term storage

#### 4.4.1.2 Electronic Modules

For small electronic items (f) the sequence is as follows:

- unpacking in the shipping and receiving
- “registration” in the ETMA
- temporary storage in the ETMA
- acceptance testing (if applicable) in the ETMA
- cleaning (where?)
- packaging in sealed envelopes (where?)
- transport to store (ETMA?)

#### 4.4.1.3 Pre-cabled cabinets

For item d the sequence is as follows:

- unpacking in the shipping/receiving area
- transport to the ETMA
- “registration”, inspection, testing in the ETMA
- cleaning (where?)

- sealing
- transportation to the long-term store or to the final destination (LVEA), as applicable

#### 4.4.1.4 Computing Equipment, Instruments

For items g, h, k the sequence is:

- unpacking in the shipping/receiving area
- transportation to the final destination:
  - computer room for compute servers and tape/disk units
  - Facility control room, diagnostic control room, user control room or individual office for workstations/desktop computers
  - ETMA for instruments

#### 4.4.1.5 Small items

Sequence:

- registration in the shipping/receiving area
- delivery to the end user
- unpacking by the end user
- 

#### 4.4.2. Deliveries from the sites during I/C

**Table 5: CDS equipment shipped from the remote sites during I/C**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
a	VME crates		
b	Electronic modules		
c	computing equipment		
d	computing peripherals (tape and disk units)		
e	paper documentation		
f	full tapes		
g			

Some categories of items may require shipping from the sites during I/C.

##### 4.4.2.1 VME crates, Electronic modules, computing equipment

VME crates, electronic modules, computing equipment (a, b, c, d) may need shipping for repair off-site. The sequence is as follows:

- transport from location (store or actual installation location) to the ETMA
- preparation for shipping (ETMA)
- transport to shipping/receiving area

- packaging (shipping and receiving area)

#### 4.4.2.2 Tapes

The present scenario provides for a complete set of tape copies to be shipped to the data analysis site on a daily basis once the facility is operational. During commissioning some data tapes will be produced. The number will be lower than in the operational phase.

of about 18 tape cartridge per day and interferometer

#### 4.4.3. Storage

**Table 6: CDS equipment stored at the remote sites during I/C**

	<i>description</i>	<i>size/weight</i>	<i>location<sup>a</sup></i>
a	cable on drums		LTS
b	fibre optic cable on drums		LTS
c	empty 19" equipment cabinets		LTS
d	pre-cabled 19" equipment racks		ETMA or LTS <sup>b</sup>
e	VME crates		LTS <sup>c</sup>
f	Electronic modules		ETMA <sup>d</sup>
g	computing equipment		normally not stored
h	computing peripherals (tape and disk units)		normally not stored
j	cable trunking materials		LTS
k	paper documentation		ETMA
l	empty tapes		Tape Room, Computer Room
m			
n			

- LTS: Long-Term Store
- wrapped and sealed after cleaning
- wrapped and sealed after cleaning
- wrapped in sealed envelopes after cleaning



## 4.5. Cabling

All cabling activities will take place during Installation and Commissioning phases.

### 4.5.1. Cabling in the BTEs

CDS cables in the BTE fall into the following categories:

**Table 7: Cable categories in the BTEs**

<i>type</i>	<i>uses</i>	<i>installation notes</i>
multiple, armoured fibre optic cable	Ethernet Fibre Channel Remote Diagnostic Links Diagnostic TV	runs connect only station buildings and mid-pumping stations
multiple, armoured fibre optic cable	industrial I/O	connects all 250m additional pumping-stations

Armoured fibre optic cables can stand rough handling.

They are to be installed into the cable trays which are pre-installed in the BTEs. Armoured cable is typically supplied on reels of 2000m length. Handling is similar to heavy power cabling as it is relatively stiff (minimum bending radius typically 250mm).

### 4.5.2. Cabling in the Operation Support Building

Cabling in the operation support building falls into different categories (see LIGO-T940002)

**Table 8: CDS cable categories in the OSB**

<i>type</i>	<i>uses</i>	<i>installation notes</i>
multiple, reinforced fibre optic cable	Ethernet Fibre Channel Remote Diagnostic Links Diagnostic TV	runs connect only equipment inside the same station building
single, reinforced fibre optic cable	Ethernet Fibre Channel Remote Diagnostic Links Diagnostic TV Timing System	runs connect practically all rooms only equipment inside the same station building
Thin Ethernet cable	Ethernet	
other signal cable	TBD	

All cables are to be installed in easily accessible cable trays in side the buildings. The topology

has to be agreed upon. For the fibre optic connections and (most likely) the ethernet connections a star-structured scheme will be adopted. The main hub of the star structure will be placed in the computer room.

The indoors fibre type proposed cannot be pulled into trays, it needs to be placed. This requires easy access to all cable trays in the building.

#### **4.5.3. Cabling in the LVEAs**

#### **4.6. Installation of CDS equipment in the control/computer area**

#### **4.7. Installation of CDS equipment in the LVEAs**

#### **4.8. Commissioning scenario**

### **5 LIGO REGULAR OPERATION (RO)**

#### **5.1. Activities in the control room/ computer area during RO**

##### **5.1.1. Operations in the facility control room**

###### **5.1.1.1 Operation crew in the facility control room**

###### **5.1.1.2 Activities in the facility control room**

##### **5.1.2. Operations in the diagnostic control room**

###### **5.1.2.1 Operation crew in the diagnostic control room**

###### **5.1.2.2 Activities in the diagnostic control room**

##### **5.1.3. Computer-related activities**

###### **5.1.3.1 Tape handling**

#### **5.2. Activities in the EMTA during RO**

#### **5.3. Deliveries and storage at the remote sites during RO**

##### **5.3.1. CDS components delivered to the sites during I/C**

**Table 9: CDS equipment delivered to the remote sites during I/C**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
	cable on drums		
	fibre optic cable on drums		
	empty 19" equipment cabinets		
	pre-cabled 19" equipment racks		
	VME crates		
	Electronic modules		
	computing equipment		
	computing peripherals (tape and disk units)		
	cable trunking materials		
	paper documentation		
	empty tapes		

**5.3.2. Shipments from the sites during RO****5.3.3. Storage at the sites during RO****5.4. Maintenance of CDS equipment in the control/computer area**

**during RO****5.4.1. Scheduled Maintenance****5.4.2. Troubleshooting****5.5. Maintenance of CDS equipment in the office area during RO****5.6. Maintenance of CDS equipment in the LVEAs during RO****5.6.1. Scheduled maintenance****5.6.2. Troubleshooting****5.7. Maintenance of CDS equipment in the BTEs during RO****5.7.1. Scheduled maintenance****5.7.2. Troubleshooting****Table 10:**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
a			
b			
c			
d			
e			
f			
g			
h			
j			
k			

**Table 10:**

	<i>description</i>	<i>size/weight</i>	<i>comment</i>
l			
m			
n			

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