New Folder Name Building Considerations for CDS

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Building Considerations for CDS

subject

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Keywords

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1 About this document

The note is an attempt to list the building considerations for the LIGO Control and Data System. This is a working document whose main purpose is to provide an as complete as possible list of issues to be considered. The document tries to identify all relevant areas. It's level of detail varies greatly from item to item. In some cases it gives definitive figures, in others it only mentions the existence of a possible concern.

This is the sixth draft version of the note on CDS building requirements. As the modifications are minor this update is not widely distributed. It is mainly intended to provide numbers for the CDS-related space requirement for the initial LIGO configuration.

Modifications from the previous draft LIGO-T940002–05–C are indicated by change bars.

The changes from LIGO-T940002–05–C are:

1. space requirements for initial LIGO have been added as appropriate in the text
2. a fourth, new table has been added in Appendix A with the space requirement calculations for the initial LIGO
3. mobile consoles are now suitable for transport by crane
4. trenches as option for cable ducts have been eliminated
5. added remarks about future extensions of CDS related space
6. a (short) chapter has been added at the end of the note to list requirements which the buildings impose on CDS equipment
7. requirement for compressed air has been added for the ETMA
8. the time resolution for the Facility Control and Monitoring System has been specified

2 CDS Hardware Components

This sections provides an overview of the hardware components of CDS together with their requirements on buildings.

2.1 Cabinets and Crates

Most of the CDS equipment consists of electronic modules according to the VME or VXI standards. Modules are housed in 19″ electronic crates which again comply with either the VME or VXI standards. Crates are mounted in electronic cabinets.

Each cabinet houses one or two crates as well as additional equipment (like rack-mounted power supplies, special electronics, ...) and the terminal blocks which connect the internal cabling in the cabinet to the outside cabling.

Typical cabinet sizes are as follows (TBD: cabinet size):

- width: 23″
- depth: 32″ to 37″
- height: 84″

The cabinets have removable side panels and a rear door. They may also have a (metal or transparent) front door. The cabinets can be mounted side to side in rows.

The minimum access requirements are:

- front access: 40″
- rear access: 40″

Minimum floor space requirement is 23″ wide by 120″ deep (19 sqft) for cabinets mounted in single rows. Space requirement is some what reduced if the cabinets are installed in multiple rows; in this case the space requirements is 23″ wide by 100″ deep (16 sqft).

The cabinets do not have forced ventilation.

The crates which are mounted inside the cabinets are equipped with forced ventilation for the modules and are equipped with power packs which also have forced ventilation.

Each cabinet houses one or two crates plus various power supplies and cabling.

The maximum power consumption of a crate with a normal load of modules is 1300 W.

For power budget purposes it can be assumed that the average power consumption for a CDS electronic cabinet is 2 kW.

CDS cabinets can be equipped with shielded isolation transformers where needed (TBD: details of isolation transformers).

The cabinets are designed to be transported by crane: they have lifting ears at the top and are constructed in such a way that they can be lifted fully equipped without mechanical deformation.

CDS VME crates inside the cabinets produce acoustic noise. Each crate is rated at 65dB over the acoustic spectrum at 1ft distance (TBD: acoustic noise from VME crates)

VME equipment EMI is rated as class TBD according CISPR11[1] (TBD: EMI interference from VME crates)

2.2 Computers and Mass Storage Units

Each LIGO facility will be equipped with a number of dedicated computing servers and mass storage units (disks and tapes) for data handling and storage.

Details of this equipment are still TBD (TBD: computer equipment details). A preliminary indication can be given as follows.

[1] Document CISPR11: 1990; International Electrotechnical Commission

The computing servers as well as disk units and tape units will be mounted in 19″ equipment cabinets similar or equal to the ones described above.

Four to six cabinets might be required at each facility. The power consumption is estimated to be 2.0 kW per cabinet.

2.3 Operator Consoles

All CDS operator consoles are functionally UNIX workstations. They fall into two categories:

- fixed consoles
- mobile consoles

2.3.1 Fixed Consoles

All fixed consoles are located in the facility control rooms.

At present we are considering different technical solutions for the fixed consoles: multi-headed conventional workstations or multi-headed VME based workstations.

A workstation based fixed console is physically a normal UNIX desktop workstation. Each station is equipped with two or three colour CRTs, one keyboard and a pointing device (trackball or mouse).

Workstation based consoles can be placed on normal office desks or can be built into a fixed, metal housing, typically with the CRTs arranged in two levels

A VME based station would combine several colour CRTs, one keyboard, an embedded VME computer and several controller VME boards in a dedicated VME crate, and (possibly) a knob unit. The console equipment would be built into a fixed, metal housing, typically with the CRTs arranged in two levels.

Independently of the type of implementation, the following can be used as guidelines for building requirements: one console is required for each major LIGO system.

The following table lists the estimated fixed system consoles required at each facility:

system	WA facility		LA facility	
	initial	final	initial	final
Supervisor	1c - 2s	1c -2s	1c - 2s	1c - 2s
Vacuum	1c - 2s	1c - 2s	1c - 2s	1c - 2s
Interferometer	2c - 6s	6c - 18s	1c - 3s	3c - 9s
Data Acquisition Systems	2c - 4s	2c - 4s	2c - 4s	2c - 4s
Data Handling	1c - 2s	1c - 2s	1c - 2s	1c - 2s
total	7 consoles 16 screens	11 consoles 28 screens	6 consoles 13 screens	8 consoles 19 screens

Table 1 Estimate of the number of fixed system consoles at the two facilities[2]

As a budget figure, each "screen" requires 200W and half an office desk (15 sqft) of floor space, independently of the type of implementation.

2.3.2 Mobile Consoles

Mobile consoles can be moved to any location at each facility where there is a computer network connection. They are temporarily installed in any convenient location with network access.

Mobile consoles will be rack-mounted, single-headed or double-headed workstations. Racks will be on wheels and suitable for transport by crane.

[2] c: number of consoles per system
s: number of computer screens per system

2.4 CDS Related Cabling

CDS components in the various parts of each LIGO facility are connected between them and with other LIGO systems by means of copper and fibre optic cables.

Cabling between buildings uses exclusively fibre optic cables. In this sense the Operations Support Building is a separate building

CDS related cables run in separate cable trunking with the exception of 120V power cables which share their trunking with non-CDS 120V cables.

CDS cables are grouped according to their characteristics as follows. The grouping and the cable types are different in the different buildings.

2.4.1 Cabling in the Beam Tube Enclosures

CDS cabling in the Beam Tube Enclosure (BTE) uses armoured[3] cable in order to reduce the risk of cable damage during installation and by rodents[4]. In the BTE's only fibre optic cables are used by CDS. The exact type of cable, including the number and type of fibres per cable is still TBD (TBD: cable type in beam tube enclosures). Part of this is the definition of connectors and of how to implement the transition from BTE cabling with armouring to station building cabling without armouring.

It is assumed that 120V mains power is provided at all necessary locations in the BTE.

2.4.2 Cabling in the Technical Areas of the Station Buildings

In the technical areas in the station buildings (Facility Control Room, Diagnostic Control Room, Computer Users Room, Computer and Mass Storage Room, Electronics Test and Maintenance Area, Laser and Vacuum Equipment Areas) CDS-related cabling will be installed in cable trunking. Cables will be grouped in

[3] Note that steel armouring has been dropped as mandatory requirement

[4] The rodent problem needs to be checked; other labs seem not to bother

different categories (see table below) and will be installed in separate cable ducts or in separate sections inside the same tray in order to minimize interference. The subdivision is aimed at grouping together cables which are functionally and physically similar.

It is assumed that the 120V power distribution will be separate from the CDS cable trunking.

category	usage	notes
high voltage signal	- cables with voltages >48V	shared with non-CDS usage[5]
system	- network fibre optic cables - timing fiber optic cables - network copper cables - other system related cables	
low voltage signal	- I/O cables between CDS and front-end - other signal cables - non-system-related fibre optic cables	

Table 2 Cable categories

CDS related power cables share cable trays with non-CDS cables which carry similar signals.

Attention has to be paid to the installation procedures for fibre optic cables. Depending on the cable type they may not be suitable for pulling; they need to be laid into the cable trunking (TBD: details of fibre installation in BTE)

2.4.3 Cabling in the Office Areas

CDS-related cabling in the office areas (Conference Room, offices, visitors' rooms) is limited to computer network outlets. TBD: It has to be decided which

[5] interference aspects to be checked

rooms require cable connections only (Ethernet) and which rooms require in addition fibre optic outlets (for Fibre Channel network).

3 Fire Protection

The CDS equipment of LIGO needs specific measures for fire prevention, fire alarm signalling and fire extinguishing.

Fire protection is organized in two different layers: CDS component layer, building layer.

3.1 CDS Component Fire Protection

The following features are built into CDS; they complement the building related measures described further down.

As most fires in electronic systems are caused by overheating of equipment, a very effective measure for fire prevention consists in providing an effective early-warning system for all CDS equipment.

It consists basically in a two alarm-level temperature monitoring system for all CDS cubicles:

- when the first warning threshold is exceeded, an alarm to the operator in the central control room is generated. In addition a visible signal is present on the cubicle itself.
- When the second temperature threshold is exceeded, another alarm to the operator in the central control room is generated and the power to the corresponding CDS cabinet is automatically interrupted. An alternative approach could be to make use of the remote control feature of the power distribution (see 3.2.3 below)

The alarm information should, in addition, be connected to the machine protection system (if such a system exists). In this way a second information channel which is independent of the operational status of CDS, is available to the operating crew.

3.2 Building Fire Protection System

All electrically powered CDS components in all LIGO buildings are potential fire hazards. In addition to the above described self-protection of some CDS components, the following measures are suggested. Most of these measures are not CDS-specific.

3.2.1 Fire Alarm System

The main panel of the fire alarm system (or a duplicate of it, if there are more than one) should be placed in the facility control room. It should be easily interpreted and give clear information about the physical location of the alarms.

3.2.2 Air Conditioning Control

It should be possible to remotely stop air conditioning in any part of the buildings from the facility control room. This is extremely useful in the presence of smoke which is very quickly distributed by the air conditioning.

In addition any fire alarm should stop automatically the air conditioning system.

3.2.3 Power Distribution Control

The 120V power distribution should be equipped with remote control from the facility control room in order to be able to remotely switch off electric power in the case of fire alarms.

3.2.4 TV Building Surveillance

Internal TV building surveillance is also useful in the context of fire protection, as it allows to visually identify problems.

4 Power Supply

Two aspects of the CDS power supply may influence on building aspects.

4.1 Uninterruptable Power Supply (UPS)

It still has to be decided whether parts of CDS are to be placed under a central UPS. Alternatively (and without effect on the building requirements) individual components of CDS could be connected to individual local UPS units

4.2 Structure of the Power Distribution

It still has to be decided in which way to connect CDS to the 120V supply. A possible subdivision could be to provide in each building separate 120V supplies for

- buildings (outlets, lighting, HVAC)
- vacuum equipment
- interferometers and CDS.

It may also be useful to subdivide the interferometer/CDS power supply further by separating the different interferometers at one site and possibly the interferometer from CDS system components.

4.3 Cabling and Protection

Each CDS cabinet (or equivalent unit) is connected separately to a dedicated mains power switch on the local power distribution panel. Each switch is equipped with an incorporated ground fault interrupt (GFI) circuit and thermal overload circuit breaker.

4.4 Power Load

The following table shows the total CDS-related power load at the two facilities (excluding computing stations in the Conference Room, staff offices, visitors rooms)

site	initial load (kW)	final load (kW)
WA	110.9	214.5
LA	88.3	156

5 Other Related Systems

This section lists other systems and describes their relation to CDS as they may have implications on the building requirements.

5.1 Facility Control and Monitoring System

A Facility Control and Monitoring System (FCMS) will be provided independently of CDS.

As part or all data acquired by the FCMS have to be incorporated into the LIGO data archives, this system will have an interface with CDS:

- TBD: physical implementation of the interface between CDS and FCMS.
- TBD: communication protocol between CDS and FCMS.

There is an important technical requirement which the FCMS has to fulfil: FCMS should log all status changes for motors and other rotating equipment under its control with a precision of 1 s. The absolute time base of the FCMS has to be synchronized to the absolute time base used by CDS to the same precision.

As this requirement may drive the cost of the FCMS to unacceptable levels, alternative solutions have to be studied (TBD: alternative solutions for time-logging by FCMS)

5.2 Particulate Monitoring System

LIGO may be equipped with a Particulate Monitoring System (PMS) for the monitoring of the air quality. Such a system is expected to be independent from CDS.

The central operator console for PMS (if any) will be placed in the Facility Control Room.

Data from the Particulate Monitoring System are not required to be included in the LIGO experiment data archives

There are no particular sampling speed or time resolution requirements for the PMS.

5.3 Personnel Safety and Access Control System

LIGO may require a Personnel Safety and Access Control System (PSACS). Such a system is completely independent from CDS.

The central operator console for PSACS (if any) will be placed in the Facility Control Room.

5.4 Intercom System

LIGO will require a sophisticated intercom system which will allow communication between all locations of the facility.

The intercom system must not interfere with the operation of the interferometer (this most likely excludes a radio based intercom)

The intercom system must at least be available:

- near each vacuum chamber
- near each CDS equipment cabinet
- at the operator desks in the Facility Control Room
- near the operator desks in the Diagnostic Control Room

The Intercom units must allow hands-free operation (headset/microphone sets).

The Intercom system may be part of the normal site telephone system

5.5 CCTV System

LIGO will require a Buildings' Closed Circuit TV system (BCCTVS) which will allow to view many locations in the facilities.

The BCCTVS must not interfere with the operation of the interferometer

CDS has no requirements for TV cameras as part of the BCCTVS

Please note that the BCCTVS is completely independent from the TV part of the Remote Diagnostics System which is part of CDS.

The central station of the BCCTVS will be located in the Facility Control Room

5.6 Audio System

LIGO may require a way of bringing the main interferometer output signal (and possibly a small number of other selected signals?) from each interferometer to the Facility Control Room and to the Diagnostic Control Room. These signals are required as real time audio signals.

This requirement is listed here for completeness, it is not expected to have implications on the buildings.

The Audio system will most likely be part of the remote diagnostic system inside CDS.

6 CDS-related Room Requirements

This section describes the CDS-related specific requirement for the different areas in the LIGO buildings.

CDS equipment or activities are present in the following rooms:

- Facility Control Room
- Diagnostic Control Room
- Computer Users Room
- Computer and Mass Storage Room
- Tape Room
- Electronics Test and Maintenance Area

- Conference Room
- Laser and Vacuum Equipment Areas (in all station buildings)
- Beam Tube Enclosures
- in all office locations

All rooms which house CDS equipment should have antistatic floor covering or treatment

The space requirements given in the present document reflect today's best estimate for the initial occupancy of the facilities (with 2 interferometers in at the WA facility and 1 at the LA facility) and for the final occupancy (with 6 interferometers in at the WA facility and 3 at the LA facility).

These estimates can be considered reasonably accurate for the computer & control room area (Facility Control Room, Diagnostic Control Room, Computer Users Room, Computer and Mass Storage Room, Tape Room). The space estimates for the Electronics Test and Maintenance Area and for the CDS equipment in the LVEAs have to be considered less certain.

None of the CDS-related equipment requires clean-room conditions

6.1 Facility Control Room

6.1.1 Equipment

The following table lists the equipment present in the facility control room.

function	quantities				comment
	initial		final		
	WA	LA	WA	LA	
CDS operator console screens	16	13	28	19	
local printers	3	3	5	4	on small tables
personnel protection and access monitoring system – central operator station (if any)	1	1	1	1	non-CDS
building CCTV - central operator station	1	1	1	1	non-CDS
Fire alarm system - central operator panel	1	1	1	1	non-CDS, wall mounted
Facility Control and Monitoring System – central operator station	1	1	1	1	non-CDS
Particulate Monitoring System – central operator station	1	1	1	1	non-CDS
Filing cabinets for documentation	4	3	6	5	
photocopier	1	1	1	1	

Table 3 Equipment in the Facility Control Room

6.1.2 Activities

24 hour operation of the facility

6.1.3 Adjacencies

direct	Diagnostics Control Room
indirect	Computer Users Room

6.1.4 Ambient and Space Requirements

The Facility Control Room (FCR) is to be treated as a normal office space with the following specific requirements.

- maximum occupancy: 15 persons
- normal operation occupancy: 2 persons
- The estimated electrical power usage in the FCR is given in the following table (this includes1400W for non-CDS equipment and a reserve of 500W for unspecified CDS equipment)

	WA	LA
initial	6100	5500
final	8900	6900

Table 4 Facility Control Room – installed power

- space requirements:

	WA	LA
initial	687	630
final	897	735

Table 5 Facility Control Room – space (sqft)

- A false floor is desirable. The false floor should be at least 20″ high.
- All cabling inside the FCR will be installed in pre-installed cable trays under the false floor.
- The FCR should have a minimum ceiling height of at least 10 feet (after allowing for false floor and suspended ceiling for acoustic damping and lighting)
- The FCR should be air conditioned as a normal office (taking into account the heat generated by the technical equipment in the room)
- The FCR should be made quiet by appropriate floor tile cover (carpet) and suspended ceiling construction.
- Special care should be given to the lighting in order to minimize the reflections on the computer screens.
- Light intensity in the FCR should be adjustable in intensity; independent intensity adjustment should be possible for different parts of the room (TBD: light adjustment in FCR)

6.2 Diagnostics Control Room

6.2.1 Equipment

The following table lists the equipment present in the Diagnostics Control Room (DCR).

function	quantities				comment
	initial		final		
	WA	LA	WA	LA	
Computer workstations	5	5	15	15	
local printers (on small tables)	1	1	4	4	
Filing cabinets for documentation	4	3	8	6	
photocopier	1	1	1	1	

Table 6 Equipment in the Diagnostic Control Room

6.2.2 Activities

observation of physics data from the interferometer
operation of remote diagnostics system

6.2.3 Adjacencies

direct	Facility Control Room Computer Users Room
indirect	none

6.2.4 Ambient and Space Requirements

The Diagnostic Control Room (DCR) is to be treated as a normal office space with the following specific requirements.

- occupancy up to 20 persons

- The estimated installed electrical power in the DCR is given in the following table (this includes a reserve of 500W for unspecified CDS equipment)

	WA	LA
initial	1700	1700
final	4300	4300

Table 7 Diagnostic Control Room installed power

- space requirements:

	WA	LA
initial	338	338
final	631	607

Table 8 Diagnostic Control Room – space (sqft)

- A false floor is desirable. The false floor should be at least 20″ high.
- All cabling inside the DCR will be installed in pre-installed cable trays under the false floor.
- The DCR should have a minimum ceiling height of at least 10 feet (after allowing for false floor and suspended ceiling for acoustic damping and lighting)
- The DCR should be air conditioned as a normal office (taking into account the heat generated by the technical equipment in the room)
- The DCR should be made quiet by appropriate floor tile cover (carpet) and suspended ceiling construction.
- Special care should be given to the lighting in order to minimize the reflections on the computer screens.
- Light intensity in the DCR should be adjustable in intensity; independent intensity adjustment should be possible for different parts of the room (TBD: light adjustment in DCR)

6.3 Computer User Room

The computer user room is not strictly related to CDS. It is included in this document for completeness as it house the same type of equipment as the Facility and Diagnostics Control Rooms.

6.3.1 Equipment

The following table lists the equipment present in the computer user room.

function	quantities				comment
	initial		final		
	WA	LA	WA	LA	
Computer workstations	5	3	10	6	
local printers (table top printers)	1	1	2	2	
A size plotter	1	1	1	1	
Filing cabinets for documentation	3	2	6	3	

Table 9 Equipment in the Computer Users Room

6.3.2 Activities

use of special computer equipment
data analysis of interferometer data
plotting of large drawings

6.3.3 Adjacencies

direct	Diagnostic Control Room
indirect	Facility Control Room

6.3.4 Ambient and Space Requirements

The Computer User Room (CUR) is to be treated as a normal office space with the following specific requirements.

- occupancy up to 15 persons

- The estimated installed electrical power in the CUR is given in the following table (this includes a reserve of 500W for unspecified equipment)

	WA	LA
initial	1900	1500
final	3100	2300

Table 10 Computer Users Room – installed power

- space requirements:

	WA	LA
initial	382	316
final	457	376

Table 11 Computer Users Room – space (sqft)

- The total space requirement for the CUR is 457 sqft at the WA facility and 376 sqft at the LA facility (including 200 sqft walking space)
- A false floor is desirable. The false floor should be at least 20″ high.
- All cabling inside the CUR will be installed in pre-installed cable trays under the false floor.
- The CUR should have a minimum ceiling height of about 10 feet (after allowing for false floor and suspended ceiling for acoustic damping and lighting)
- The CUR should be air conditioned as a normal office (taking into account the heat generated by the technical equipment in the room)
- The CUR should be made quiet by appropriate floor tile cover (carpet) and suspended ceiling construction.
- Special care should be given to the lighting in order to minimize the reflections on the computer screens.

6.4 Computer and Mass Storage Room[6]

6.4.1 Equipment

The Computer and Mass Storage Room (CMSR) houses the following equipment:

- compute servers

[6] a.k.a. Computer Room, Computer Equipment Room

- mass storage units (disk units, manual tape unit(s), robotic tape unit)
- telecommunications equipment for computers
- Personnel Safety and Access Control System – Central Unit (if any)
- telephone system central unit

6.4.2 Activities

regular change of tapes (about once an hour)
occasional interaction with the computer sysrtem

6.4.3 Adjacencies

direct	Tape Room
indirect	none

6.4.4 Ambient and Space Requirements

The Computer and Mass Storage Room (CSMR) is located near the CFR in order to facilitate cabling.

- permanent occupancy: 0
- temporary occupancy: 2 persons
- The CMSR is not permanently manned.
- The estimated installed electrical power in the CMSR is given in the following table.

	WA	LA
initial	2300	2300
final	4300	3800

Table 12 Computer and Mass Storage Room installed power

- space requirements:

	WA	LA
initial	360	310
final	480	400

Table 13 Computer and Mass Storage Room – space (sqft)

- The total space requirement for the CMSR is about 480 sqft at the WA facility and 400 sqft at the LA facility (including 20 sqft for non-CDS equipment and 250/200 sqft walking space)
- It should be equipped with a false floor for easy cabling. The false floor should be at least 20″ high.
- All cabling inside the CMSR will be installed in pre-installed cable trays under the false floor.
- The CMSR should be air conditioned to maintain the following conditions:
  a. temperature: 22C +/-2C
  b. relative humidity 40% ... 60%
  c. dust should be filtered as for normal computer rooms

6.4.5 Special Requirements

6.4.5.1 Temperature Monitoring

An excess temperature (measured about 6′ above the floor) in the CMSR should trigger the following two-stage alarm procedure:

- first level alarm (>26C) triggers an audible and visible operator alarm in the FCR
- the second level alarm (>30C) shuts the power to computers off and raises an audible and visible alarm in the FCR

6.4.5.2 Smoke detection

Early fire protection is necessary in an unmanned computer room. Appropriate smoke detectors will detect fire in an early stage. The following alarm procedure is proposed:

- A single detector alarm is only signaled in the FCR (audible and visible alarm)

- If more than one detector detects smoke, an alarm is raised immediately in the FCR and a siren is operated inside and outside the computer room.
- If the fire alarm is not reset within two minutes according to an approved procedure, electric power is automatically interrupted in the CMSR and an inert gas (Halon successor) is released.

6.5 Tape Room[7]

The tape room is the on-site repository for all data tapes from the LIGO instrument at the site. (A second, independent tape room off-site houses copies of the tapes)

6.5.1 Activities

regular access (about once an hour) to deposit or retrieve tapes

6.5.2 Adjacencies

direct	Computer and Mass Storage Room
indirect	none

6.5.3 Ambient and Space Requirements

- permanent occupancy: 0
- temporary occupancy: 2 persons
- The Tape Room is not permanently manned
- there is no electrical equipment in the Tape Room
- The Tape Room should have at least 400 sqft of floor space
- The tapes are housed in appropriate metal cabinets with fire retardant properties; alternatively the entire room could be fire protected
- The Tape Room should be air conditioned to maintain the following conditions:

  a. temperature: 22C +/-2C
  b. relative humidity 40% ... 60%
  c. dust should be filtered as for normal computer rooms

7 a.k.a. Tape Vault

6.5.4 Special Requirements

6.5.4.1 Temperature

An excess temperature in the Tape Room should trigger an operator alarm in the FCR.

6.5.4.2 Smoke detectors

Automatic fire protection is required. Appropriate smoke detectors will detect fire in an early stage. The following alarm procedure is proposed:

A single detector alarm is only signaled in the FCR (audible and visible alarm)

If more than one detector detects smoke, an alarm is raised in the FCR and a siren is operated inside and outside the tape room.

If the fire alarm is not reset within two minutes according to an approved procedure, an inert gas (Halon successor) is released.

6.6 Electronics Test and Maintenance Area[8]

At each facility there is the need for a test and maintenance area for electronic components (ETMA). The ETMA provides the means for on-site testing of electronic components in case of equipment failures. The test equipment is geared towards providing rapid functional tests which are important in maintenance situations when a quick decision is needed in order to identify faulty components. The test equipment will also be used to execute acceptance tests on incoming equipment on first delivery or on return from repair.

In addition the ETMA provides the space for the electronic component store for the site. One of the technicians present in the ETMA acts also as storeman for the equipment store on site.[9]

[8] a.k.a. Electronic Shop/Data Lab

[9] Large CDS-related items (VME crates, power supplies, electronic cabinets) will be stored in the Long-Term Storage Room

During Installation and commissioning the ETMA will also house partial or complete CDS systems prior to their installation in the field.

The ETMA will be equipped as a general electronics lab facility.

function	quantities				comment
	initial		final		
	WA	LA	WA	LA	
Engineer's office ("glass cage")	1	1	1	1	
Technician's desk	2	2	2	2	
Electronic workbench	4	4	6	6	
Storage units for small components	5	5	10	8	
Storage units for electronic modules	4	4	8	8	
printer (table top laser printers)	2	2	3	3	
A size plotter[10]	1	1	1	1	
Filing cabinets for documentation	6	6	12	12	
test area (300 sqft)	1	1	1	1	

Table 14 Equipment in the Electronics Test and Maintenance Area

6.6.1 Activities

work on small electronic modules (benchtop activities, typical for an electronic shop
electronic system tests (the equipment is composed of an electrocnic rack and a computing workstation)
combined alectronic and optic tests (the equipment is composed of an electrocnic rack, a computing workstation, and some opto/mechanical components)
"small" electronic items store (from electronic components to electronic modules)

[10] in addition to or as alternative to the plotter in the Computer Users Room

6.6.2 Adjacencies

direct	optical shop
indirect	mechanical shop, vacuum prep/assembly lab

6.6.3 Ambient and Space Requirements

- permanent occupancy: 3 persons
- temporary occupancy: 10 persons
- a separate "glass cage" is required as office space inside this area
- The estimated installed electrical power in the ETMA is given in the following table.

	WA	LA
initial	12100	12100
final	18900	18900

Table 15 ETMA – installed power

- space requirements:

	WA	LA
initial	1045	1045
final	1291	1291

Table 16 ETMA – space (sqft)

- The ETMA should be air conditioned to maintain the following conditions:
  a. temperature: 22C +/- 2C
  b. relative humidity 40% ... 60%
- The ETMA should be equipped with overhead and wall-mounted cable support for easy installation and modification of test setups.

6.6.4 Special Requirements

The ETMA requires compressed air. (TBD: details of compressed air in the ETMA)

6.7 Long-term Storage Room

CDS is one of the customers of the Long-term Storage Room (LTSR). This chapter deals only with the CDS-related requirements.

Equipment which CDS intends to store in the LTSR includes:

- VME crates
- power supply units
- empty 19" instrument cabinets
- cable trunking pieces
- transformers
- cable drums
- shipping containers
- ...

6.7.1 Activities

irregular access to store or retrieve large items

6.7.2 Adjacencies

direct	none
indirect	EMTA

6.7.3 Ambient and Space Requirements

- occupancy: 0
- no special electrical connections are required
- CDS requires TBD sqft of floor space in the LTSR[11].
- Many items are bulky and/or heavy and require transportation with a pallet dolly
- The CDS equipment stored in the LTSR does not require particular conditions:
  a. temperature: 5 to 40C
  b. relative humidity 20% to 90% (non condensing

[11] estimate: 200 sqft

6.7.4 Special Requirements

Pallet dolly transportation of equipment to the Test and Maintenance Area is required. Connecting doors should be at least 1.5m wide and 2.75m high

6.8 Active Storage Room

CDS is one of the customers of the Active Storage Room (ASR). This chapter deals only with the CDS-related requirements.

Equipment which CDS intends to store in the ASR includes:

- VME crates
- power supply units
- full 19" instrument cabinets
- cabinets accessories
- cable trunking accessories
- transformers
- cable drums
- packaging materials
- ...

6.8.1 Activities

irregular access to store or retrieve large items

6.8.2 Adjacencies

direct	none
indirect	EMTA

6.8.3 Ambient and Space Requirements

- occupancy: 0
- no special electrical connections are required
- CDS requires TBD sqft of floor space in the LTSR[12].
- Some items are bulky and/or heavy and require transportation with a pallet dolly
- The CDS equipment stored in the ASR does not require particular conditions:
  a. temperature: 5 to 40C
  b. relative humidity 20% to 90% (non condensing

6.8.4 Special Requirements

Pallet dolly transportation of equipment to the Test and Maintenance Area is required. Connecting doors should be at least 1.5m wide and 2.75m high

6.9 Conference Room

The conference room is not strictly related to CDS. It is included in this document for completeness as it houses some CDS-related equipment.

6.9.1 Equipment

The following table lists the CDS-related equipment present in the computer user room.

function	quantities				comment
	initial		final		
	WA	LA	WA	LA	
Workstations with videoconferencing attachments	1	1	1	1	
table top laser printer	1	1	1	1	

Table 17 Equipment in the facility computer user room

[12] estimate: 200 sqft

6.10 Office Space Requirements

6.10.1 Requirements for CDS Personnel

CDS activities at the site require permanent office space for two professionals and two technicians (excluding operators).

The two technicians will permanently occupy two desks in the Electronics Test and Maintenance Area (see Table14)

An HW engineer will be placed in a "glass cage"-type office inside the Electronics Test and Maintenance Area (see Table 14)

A SW engineer will be placed in a normal office.

6.10.2 General Requirements for all Office-type Spaces

All office-type spaces (including administrative assistant, visitors) will require computer network connection. The network connection will connect the office with the Computer and Mass Storage Room.

6.11 Laser and Vacuum Equipment Areas

The bulk of the CDS equipment will be installed in the Laser and Vacuum Equipment Areas (LVEA) in all station buildings (Corner Stations, Mid Stations in WA, End Stations).

The layout and the quantity of CDS equipment in these areas is less well defined than in the other areas described so far. Therefore this section will have many uncertainties.

6.11.1 Layout

CDS cabinets will typically be associated with a vacuum module or a small group of adjacent modules, or with a laser. The CDS cabinets will be placed in the vicinity of the module(s) or lasers.

The following is an estimate of CDS equipment in Laser and Vacuum Equipment Areas in the various buildings.

area		WA facility		LA facility	
		initial	final	initial	final
corner station	cabinets	30	60	25	50
	workstations	3	3	3	3
endstation (each)	cabinets	3	7	2	4
	workstations	1	1	1	1
midstation (each)	cabinets	3	7	1	1
	workstations	1	1	1	1

Table 18 CDS equipment allocation in the LVEAs

There are two major layout issues to be considered:

- access for people
- cabling

A layout has to be found which allows access to all cabinets at all times compatible with the operation of LIGO. This involves inventing a scheme of walkways which enable easy crossing of the beam tubes for pedestrians and for light trolleys (e.g. an oscilloscope trolley). The scheme has to be modular and expandable to accommodate future components.

Many of the CDS cabinets have to be very close (<6ft) from the corresponding local equipment or vacuum chamber.

CDS cabling in the LVEAs has to provide for each cabinet:

- network connections
- signal cable connection to vacuum chamber(s) or laser
- 120V power
- higher voltage signal connections (up to 800V) in some cases
- intercom/telephone connection
- some cabinets may require video connections

It still has to be defined whether all cabinets are floor mounted, or whether there will also be cabinets mounted on raised platforms.

Floor mounted cabinets require cable entry from the top; this suggests to mount cable trays and supports above the top of the cabinets at about 8′ to 9′ from the floor.

If cabinets are mounted on platforms, then cable entry could be from the bottom of the cabinets with the corresponding mounting of the cable trays and supports below the platform level, possibly even below the beam tube

~~A third, less preferred possibility is the use of trenches in the floor.~~

Grounding in the LVEA requires special attention

6.11.2 Activities

no regular activities during normal instrument operation

6.11.3 Adjacencies

direct	none
indirect	none

6.11.4 Ambient and Space Requirements

The following tables give the space and power requirements for the CDS equipment in the LVEAs in all LIGO station buildings. These figures do not include walking space; they only contain the immediate access space for cabinets.

building	space	installed power	
		initial	final
WA corner building	1365sqft	63.6kW	123.6kW
WA end stations (each)	172sqft	6.7kW	14.7kW
WA mid stations (each)	172sqft	6.7kW	14.7kW
total WA	2053sqft	90.4kW	182.4kW

Table 19 CDS-related space and power requirements in the LVEAs in the WA facility

building	space	installed power	
		initial	final
LA corner building	1115sqft	53.6kW	103.6kW
LA end stations (each)	115sqft	4.7kW	8.7kW
LA mid pumping stations (each)	44sqft	2.7kW	2.7kW
total WA	1433sqft	68.4kW	126.4kW

Table 20 CDS-related space and power requirements in the LVEAs in the LA facility

The CDS requirements for air conditioning in the LVEAs are as follows:

- temperature: 22C +/- 2C
- relative humidity 30% ... 70% (non condensing)

6.11.5 Special Requirements

6.11.5.1 Grounding

CDS signal connections require special attention as far as grounding is concerned.

All signal paths should be parallel to corresponding Ground conductors. The Ground conductors should be tree structured.

If one assumes that all CDS cabinets are connected with each other only via fibre optic connections, the grounding problem (for CDS) is reduced to the grounding aspects between the individual vacuum chamber and the corresponding set of CDS cabinets. Electrical signal connections connecting different cabinet groups have to be dealt with on an individual basis. It can be assumed that no requirements on the buildings flow from these connections.

(TBD: Grounding details)

6.11.5.2 Electro-magnetic Interference

CDS equipment is susceptible to EMI and produces EMI. It seems that these aspects have no effect on the building requirements.

(TBD: EMI interference from VME equipment)

6.11.5.3 Acoustic noise

CDS equipment produces acoustic noise.

(TBD: acoustic noise from crates)

It has to be investigated to which extent building related measures can help in the reduction of noise transmission from CDS equipment.

6.12 Beam Tube Enclosures / Mid-Pumping Stations

Initially, the Beam Tube Enclosures (BTEs) will not contain active CDS components. Besides cables the Beam Tube Enclosures will initially contain only passive measurement heads like thermometers and hygrometers.

When the additional pumping stations (250m stations) are added, CDS components will most likely be placed at them. These will be housed in cabinets technically very similar to the ones mentioned before, but reduced in height.

The Mid-Pumping Stations at the LA facility will most likely house repeaters for the Fibre Channel fast network.

6.12.1 Ambient and Space Requirements

The CDS requirements are presented separately for the Beam Tube Enclosures, the Mid-Pumping Stations and the (future) Additional Pumping Stations.

6.12.1.1 Beam Tube Enclosures

The Beam Tube Enclosures carry the CDS long-range fibre-optic cabling.

A budget space requirement for CDS on the BTE runs is one cable tray 300 mm wide by 100 mm high. It is strongly desirable, to have a second tray of the same dimensions installed as a spare.

The cable trays should be arranged in such a way that cables can easily be routed to the future additional pumping stations (250m intervals)

6.12.1.2 Mid-Pumping Stations

6.12.1.2.1 Space At each of the mid-pumping stations at the Louisiana facility one CDS cabinet will be installed. It requires a floor space of 23″ wide by 120″ deep (20 sqft). The vertical space should be 6.5′ (high enough for a person to work).

6.12.1.2.2 Electrical Power At each of the mid-pumping stations there should be 2kW of electrical power (120V) available.

6.12.1.2.3 Ambient Requirements

- temperature between +5C and 40C
- relative humidity 25% to 90% non condensing.

6.12.1.2.4 Fire protection Cabinets placed at the mid-pumping stations will have to be connected to the remote monitoring scheme in exactly the same way as any other CDS cabinet.

It can be expected that the normal overheat detection mechanism described above for all CDS cabinets can be considered sufficient for the protection of the cabinets in the mid-pumping stations.

Smoke detectors will certainly be present as described above. It has to be checked whether any active fire extinguishing measures are to be considered, as a fire in one of the cabinets could easily destroy also the long-range cabling in the nearby cable trays.

6.12.1.3 Additional Pumping Stations

6.12.1.3.1 Space At each of the future additional pumping station there should be enough space provided to install one cabinet. This will require a floor space of 23″ wide by 120″ deep (20 sqft). The vertical space should be 6.5′ (high enough for a person to work).

6.12.1.3.2 Electrical Power At each of the future additional pumping stations there should be 2kW of electrical power (120V) available.

6.12.1.3.3 Ambient Requirements During the first phase (no active components present) there are no particular ambient requirements by CDS components. In the second (active component) phase the equipment will put certain limits on the ambient conditions:

- temperature between +5C and 40C
- relative humidity 25% to 90% non condensing.

6.12.1.3.4 Fire protection Cabinets placed at the additional pumping stations will have to be connected to the remote monitoring scheme in exactly the same way as any other CDS cabinet.

It can be expected that the normal overheat detection mechanism described above for all CDS cabinets can be considered sufficient for the protection of the cabinets in the BTEs.

Smoke detectors will certainly be present as described above. It has to be checked whether any active fire extinguishing measures are to be considered, as a fire in one of the cabinets could easily destroy also the long-range cabling in the nearby cable trays.

6.13 Building Requirements on CDS

6.13.1 Mobile Consoles

Mobile consoles must be compatible with transportation by overhead crane.

6.13.2 Cables

All CDS-cables must be noncombustible or have flame spread rating of 25 or less in accordance with ASTM E84.

Appendix A: Power Consumption and Space Calculations

The following four tables show the full calculation of CDS related space and power requirements for both sites.

power consumption per unit

"screen"	200
printer	200
server	500
tape unit	500
cabinet	2000
workbench	1000

WA initial

FCR				
16	"screen"	200	3200	
3	printer	200	600	
1	access console	200	200	
1	TV console	1000	1000	
1	fire alarm stn	200	200	
1	FCMS	200	200	
1	PMS	200	200	
1	various	500	500	
	subtotal		0	6100
DCR				
5	"screen"	200	1000	
1	printer	200	200	
1	various	500	500	
	subtotal		0	1700
CUR				
5	"screen"	200	1000	
1	printer	200	200	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	1900
computer room			0	
2	server	500	1000	
1	tape unit	500	500	
1	acc.ctl.comp.	300	300	
1	various	500	500	
	subtotal		0	2300
test&maintenace			0	
5	"screen"	200	1000	
3	cabinet	2000	6000	
4	workbench	1000	4000	
2	printer	200	400	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	12100
laser and vacuum equipment area			0	
30	cabinet	2000	60000	
3	"screen"	200	600	
1	various	3000	3000	
	subtotal			63600
endstation (each)			0	
1	"screen"	200	200	
3	cabinet	2000	6000	
1	various	500	500	
	subtotal		0	6700
midstation/mid pumping station (each)			0	
1	"screen"	200	200	
3	cabinet	2000	6000	
1	various	500	500	
	subtotal			6700
Total per site	(kwatts)			110.9
LVEAs only	(kWatts)			90.4

"screen" 200
printer 200
server 500
tape unit 500
cabinet 2000
workbench 1000

WA final

FCR				
28	"screen"	200	5600	
5	printer	200	1000	
1	access console	200	200	
1	TV console	1000	1000	
1	fire alarm stn	200	200	
1	FCMS	200	200	
1	PMS	200	200	
1	various	500	500	
	subtotal		0	8900
DCR				
15	"screen"	200	3000	
4	printer	200	800	
1	various	500	500	
	subtotal		0	4300
CUR				
10	"screen"	200	2000	
2	printer	200	400	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	3100
computer room			0	
5	server	500	2500	
2	tape unit	500	1000	
1	acc.ctl.comp.	300	300	
1	various	500	500	
	subtotal		0	4300
test&maintenace			0	
8	"screen"	200	1600	
6	cabinet	2000	12000	
4	workbench	1000	4000	
3	printer	200	600	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	18900
laser and vacuum equipment area			0	
60	cabinet	2000	120000	
3	"screen"	200	600	
1	various	3000	3000	
			0	
	subtotal			123600
endstation (each)			0	
1	"screen"	200	200	
7	cabinet	2000	14000	
1	various	500	500	
	subtotal		0	14700
midstation/mid pumping station (eac			0	
1	"screen"	200	200	
7	cabinet	2000	14000	
1	various	500	500	
	subtotal			14700
Total per site	(kwatts)			214.5
LVEAs only	(kWatts)			182.4

Figure 1 Calculation of the CDS-related power requirement for the WA facility

power consumption per unit

"screen"	200
printer	200
server	500
tape unit	500
cabinet	2000
workbench	1000

LA initial

FCR				
13	"screen"	200	2600	
3	printer	200	600	
1	access console	200	200	
1	TV console	1000	1000	
1	fire alarm stn	200	200	
1	FCMS	200	200	
1	PMS	200	200	
1	various	500	500	
	subtotal		0	5500
DCR				
5	"screen"	200	1000	
1	printer	200	200	
1	various	500	500	
	subtotal		0	1700
CUR				
3	"screen"	200	600	
1	printer	200	200	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	1500
computer room			0	
2	server	500	1000	
1	tape unit	500	500	
1	acc.ctl.comp.	300	300	
1	various	500	500	
	subtotal		0	2300
test&maintenace			0	
5	"screen"	200	1000	
3	cabinet	2000	6000	
4	workbench	1000	4000	
2	printer	200	400	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	12100
laser and vacuum equipment area			0	
25	cabinet	2000	50000	
3	"screen"	200	600	
1	various	3000	3000	
			0	
	subtotal			53600
endstation (each)			0	
1	"screen"	200	200	
2	cabinet	2000	4000	
1	various	500	500	
	subtotal		0	4700
midstation/mid pumping station (ea			0	
1	"screen"	200	200	
1	cabinet	2000	2000	
1	various	500	500	
	subtotal			2700
Total per site	(kwatts)			88.3
LVEAs only	(kWatts)			68.4

LA final

FCR				
19	"screen"	200	3800	
4	printer	200	800	
1	access console	200	200	
1	TV console	1000	1000	
1	fire alarm stn	200	200	
1	FCMS	200	200	
1	PMS	200	200	
1	various	500	500	
	subtotal		0	6900
DCR				
15	"screen"	200	3000	
4	printer	200	800	
1	various	500	500	
	subtotal		0	4300
CUR				
6	"screen"	200	1200	
2	printer	200	400	
1				
1	various	500	500	
	subtotal		0	2100
computer room			0	
4	server	500	2000	
2	tape unit	500	1000	
1	acc.ctl.comp.	300	300	
1	various	500	500	
	subtotal		0	3800
test&maintenace			0	
8	"screen"	200	1600	
6	cabinet	2000	12000	
4	workbench	1000	4000	
3	printer	200	600	
1	plotter	200	200	
1	various	500	500	
	subtotal		0	18900
laser and vacuum equipment area			0	
50	cabinet	2000	100000	
3	"screen"	200	600	
1	various	3000	3000	
			0	
	subtotal			103600
endstation (each)			0	
1	"screen"	200	200	
4	cabinet	2000	8000	
1	various	500	500	
	subtotal		0	8700
midstation/mid pumping station (ea			0	
1	"screen"	200	200	
1	cabinet	2000	2000	
1	various	500	500	
	subtotal			2700
Total per site	(kwatts)			156
LVEAs only	(kWatts)			126.4

Figure 2 Calculation of the CDS-related space requirement for the LA facility

space requirement per unit (sqft)

"screen"	15
printer	15
server	30
tape unit	30
cabinet	19
workbench	36

WA initial

FCR				
16	"screen"	15	240	
3	printer	15	45	
1	walking space	250	250	
1	access console	20	20	
1	TV console	20	20	
1	FCMS	20	20	
1	PMS	20	20	
6	filing cabinets	12	72	
	subtotal		0	687
DCR				
5	"screen"	15	75	
1	printer	15	15	
1	walking space	200	200	
4	filing cabinets	12	48	
	subtotal		0	338
CUR				
5	"screen"	15	75	
1	printer	15	15	
1	walking space	200	200	
1	plotter	20	20	
6	filing cabinets	12	72	
	subtotal		0	382
computer room			0	
2	server	30	60	
1	tape unit	30	30	
1	acc.ctl.comp.	20	20	
1	walking space	250	250	
	subtotal		0	360
test&maintenace			0	
5	"screen"	15	75	
4	workbench	36	144	
8	filing cabinet	12	96	
7	component storage	15	105	
5	module storage	12	60	
1	plotter	15	15	
1	test area	300	300	
1	walking space	250	250	
	subtotal		0	1045

space requirement per unit (sqft)

"screen"	15
printer	15
server	30
tape unit	30
cabinet	19
workbench	36

LA initial

FCR				
13	"screen"	15	195	
3	printer	15	45	
1	walking space	250	250	
1	access console	20	20	
1	TV console	20	20	
1	FCMS	20	20	
1	PMS	20	20	
5	filing cabinets	12	60	
	subtotal		0	630
DCR				
5	"screen"	15	75	
1	printer	15	15	
1	walking space	200	200	
4	filing cabinets	12	48	
	subtotal		0	338
CUR				
3	"screen"	15	45	
1	printer	15	15	
1	walking space	200	200	
1	plotter	20	20	
3	filing cabinets	12	36	
	subtotal		0	316
computer room			0	
2	server	30	60	
1	tape unit	30	30	
1	acc.ctl.comp.	20	20	
1	walking space	200	200	
	subtotal		0	310
test&maintenace			0	
5	"screen"	15	75	
4	workbench	36	144	
8	filing cabinet	12	96	
7	component storage	15	105	
5	module storage	12	60	
1	plotter	15	15	
1	test area	300	300	
1	walking space	250	250	
	subtotal		0	1045

Figure 3 Calculation of the CDS-related space requirement for the initial LIGO

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space requirement per unit (sqft)

"screen"	15
printer	15
server	30
tape unit	30
cabinet	19
workbench	36

WA final

FCR

28	"screen"	15	420	
5	printer	15	75	
1	walking space	250	250	
1	access console	20	20	
1	TV console	20	20	
1	FCMS	20	20	
1	PMS	20	20	
6	filing cabinets	12	72	
	subtotal		0	897

DCR

15	"screen"	15	225	
4	printer	15	60	
1	walking space	250	250	
8	filing cabinets	12	96	
	subtotal		0	631

CUR

10	"screen"	15	150	
1	printer	15	15	
1	walking space	200	200	
1	plotter	20	20	
6	filing cabinets	12	72	
	subtotal		0	457

computer room 0

5	server	30	150	
2	tape unit	30	60	
1	acc.ctl.comp.	20	20	
1	walking space	250	250	
	subtotal		0	480

test&maintenace 0

8	"screen"	15	120	
6	workbench	36	216	
12	filing cabinet	12	144	
10	component stora	15	150	
8	module storage	12	96	
1	plotter	15	15	
1	test area	300	300	
1	walking space	250	250	
	subtotal		0	1291

laser and vacuum equipment area 0

60	cabinet	19	1140	
3	"screen"	15	45	
15	filing cabinet	12	180	
			0	
	subtotal			1365

endstation (each) 0

1	"screen"	15	15	
7	cabinet	19	133	
2	filing cabinet	12	24	
	subtotal		0	172

midstation/mid pumping station (each 0

1	"screen"	15	15	
7	cabinet	19	133	
2	filing cabinet	12	24	
	subtotal			172

Total CDS requirement at WA site	(sqft)	5465
LVEAs only	(sqft)	2053

space requirement per unit (sqft)

"screen"	15
printer	15
server	30
tape unit	30
cabinet	19
workbench	36

LA final

FCR

19	"screen"	15	285	
4	printer	15	60	
1	walking space	250	250	
1	access console	20	20	
1	TV console	20	20	
1	FCMS	20	20	
1	PMS	20	20	
5	filing cabinets	12	60	
	subtotal		0	735

DCR

15	"screen"	15	225	
4	printer	15	60	
1	walking space	250	250	
6	filing cabinets	12	72	
	subtotal		0	607

CUR

6	"screen"	15	90	
2	printer	15	30	
1	walking space	200	200	
1	plotter	20	20	
3	filing cabinets	12	36	
	subtotal		0	376

computer room 0

4	server	30	120	
2	tape unit	30	60	
1	acc.ctl.comp.	20	20	
1	walking space	200	200	
	subtotal		0	400

test&maintenace 0

8	"screen"	15	120	
6	workbench	36	216	
12	filing cabinet	12	144	
10	component stora	15	150	
8	module storage	12	96	
1	plotter	15	15	
1	test area	300	300	
1	walking space	250	250	
	subtotal		0	1291

laser and vacuum equipment area 0

50	cabinet	19	950	
3	"screen"	15	45	
10	filing cabinet	12	120	
			0	
	subtotal			1115

endstation (each) 0

1	"screen"	15	15	
4	cabinet	19	76	
2	filing cabinet	12	24	
	subtotal		0	115

midstation/mid pumping station (each 0

1	"screen"	15	15	
1	cabinet	19	19	
1	various	10	10	
	subtotal			44

Total CDS requirement at LA site	(sqft)	4683
LVEAs only	(sqft)	1433

Figure 4 Calculation of the CDS-related space requirement for the final LIGO

TBD pointers