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- LIGO -
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CDS Control and Monitoring Final Design

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1 INTRODUCTION

1.1. Purpose

The purpose of this document is to describe the design and standards to be incorporated in the infrastructure for CDS control and monitoring systems.

1.2. Scope

CDS for LIGO has been divided, for design purposes, into three major components: Control and Monitoring, Data Acquisition and Interferometer Diagnostics. The Data Acquisition system is described in other documentation, namely the requirements in LIGO T960009-C and preliminary design in LIGO T970136-C. The IFO Diagnostics are defined in LIGO T960107-C and LIGO T960108-C.

This document describes a final design for the infrastructure to be employed in the LIGO control and monitoring system, which includes:

- LIGO control room systems, including operator consoles.
- Computer networking systems
- Timing systems to accurately timestamp LIGO data, both for control and monitoring and for LIGO data acquisition.
- Standard Input/Output (I/O) systems to be used to interface to equipment to be controlled/monitored (referred to, within this document, as front end systems).
- High level control and monitoring application and development software.

This is the highest level of CDS control and monitoring design documents, a direct outcome of the CDS Control and Monitoring Requirements Document (LIGO T950054-C), as shown in Figure 1: LIGO Requirement Specification Tree. Other CDS design documents cover specific hardware and software implementations applied to the various LIGO interferometer, vacuum and physics environment control subsystems.

1.3. Document Overview

This document represents an overview of the final design for the LIGO control and monitoring system infrastructure and basic standards which will be incorporated in all LIGO control subsystem designs. This document is essentially an update to the Control and Monitoring Preliminary Design, LIGO T960142-C, incorporating additional design details and updates and responses to action items outlined in the CDS Control and Monitoring Preliminary Design Review Report LIGO E960026-D (Excerpt attached as Appendix A to this document).

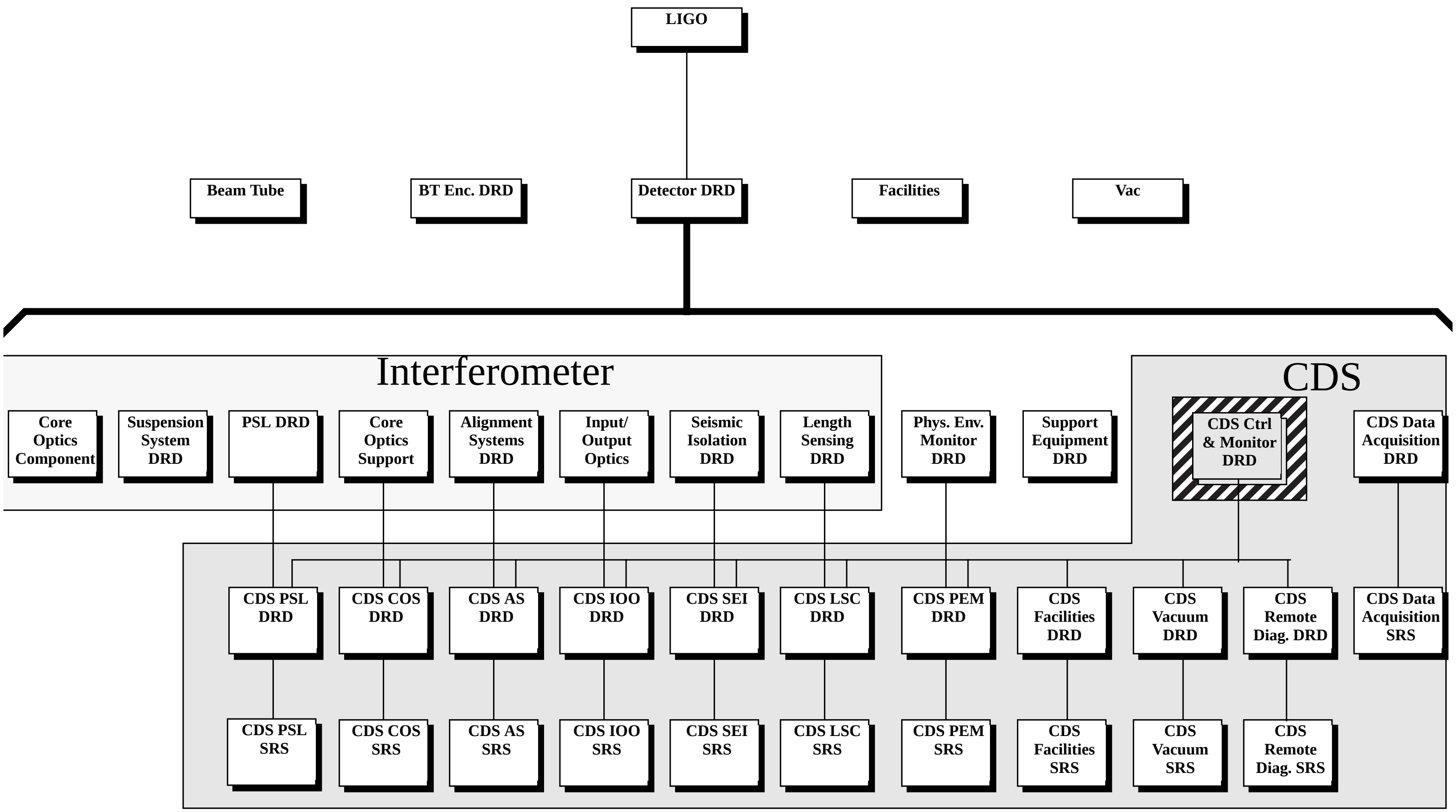


Figure 1: LIGO Requirement Specification Tree

1.4. Definitions

1.4.1. Front End Systems.

A Front End System is that part of a distributed system which interfaces with the signals to be measured. It is typically a real-time, crate based system, with direct electrical connections to the detector hardware.

1.4.2. VME.

Versa Module Eurocard, a bus based crate system allowing card based modules to communicate with each other via an arbitrated bus. Most LIGO front end systems are based on VME systems.

1.4.3. Real-Time Software.

Real-time software is that software which is deterministic in its task scheduling and duration. Throughout this document, this term refers to software which runs on a VME micro-processor under control of a real-time operating system (VxWorks).

1.4.4. Non-Real-Time Software.

Non-real-time software refers, in this document, typically to that software which runs under the UNIX operating system. This is due to the non-deterministic scheduling and task duration under this operating system.

1.5. Acronyms

- ALH - EPICS Alarm Manager
- API - Application Programmer’s Interface
- ATM - Asynchronous Transfer Mode
- CA - Channel Access
- CDS - Control and Data System
- CPU - Central Processing Unit
- DCS - Distributed Control System
- DRD - Design Requirements Document
- DSP - Digital Signal Processor
- EPICS - Experimental Physics and Industrial Control System
- FCMS - Facility Control and Monitoring System
- FCR - Facility Control Room
- GPS - Global Positioning System
- GUI - Graphical User Interface
- HMI - Human Machine Interface
- Hz - Hertz
- IFO - Interferometer
- I/O - Input/Output
- LIGO - Laser Interferometer Gravity wave Observatory
- LVEA - Laser and Vacuum Equipment Area
- MHz - Mega Hertz

- OSB - Operations Support Building
- PSL - PreStabilized Laser
- TBD - To Be Determined
- UPS - Uninterruptable Power Supplies
- VAC - Volts Alternating Current
- VDC - Volts Direct Current
- VME - Versa Modular Eurocard
- VXI - VME eXtensions for Instrumentation

1.6. Applicable Documents

- T950054-C CDS Control and Monitoring DRD
- T950120-C CDS Control and Monitoring Conceptual Design
- E960026-C CDS Control and Monitoring DRR Report LIGO
- T960142-C CDS Control and Monitoring Preliminary Design
- T960009-C CDS Data Acquisition System DRD
- T970136-C CDS Data Acquisition System Preliminary Design
- T960004-C CDS Software Development Plan and Guidelines

1.7. Drawings

The following drawings are applicable to the CDS Control and Monitoring design. Copies are included in Appendix B.

- D961395-C CDS Compute Servers and Operator Workstations
- D961396-C Facility Control Room Layout
- D961397-C Hanford Corner Station CDS Conduit Designations
- D961398-C Hanford Mass Storage Room Layout
- D970582-C Hanford Fibre Optic Plant
- D970581-C Hanford CDS Rack Assignments
- D970583-C Hanford Control and Monitoring Network

2 SYSTEM OVERVIEW

The control and monitoring systems of CDS are designed as a Distributed Control System (DCS). A basic block diagram of the hardware arrangement is shown in Figure 2: CDS Overview. The major components are:

- Operational Support: Operator stations and supporting compute and disk servers which provide:
  - Human-Machine Interfaces (HMI)
  - Control application software storage and computer boot services
  - Data archival
- Data Communications: The data networking facilities necessary for inter-processor communications.
- Timing System: Time of day and data strobing facilities
- Front End Systems: Interfaces to and real-time control of LIGO equipment

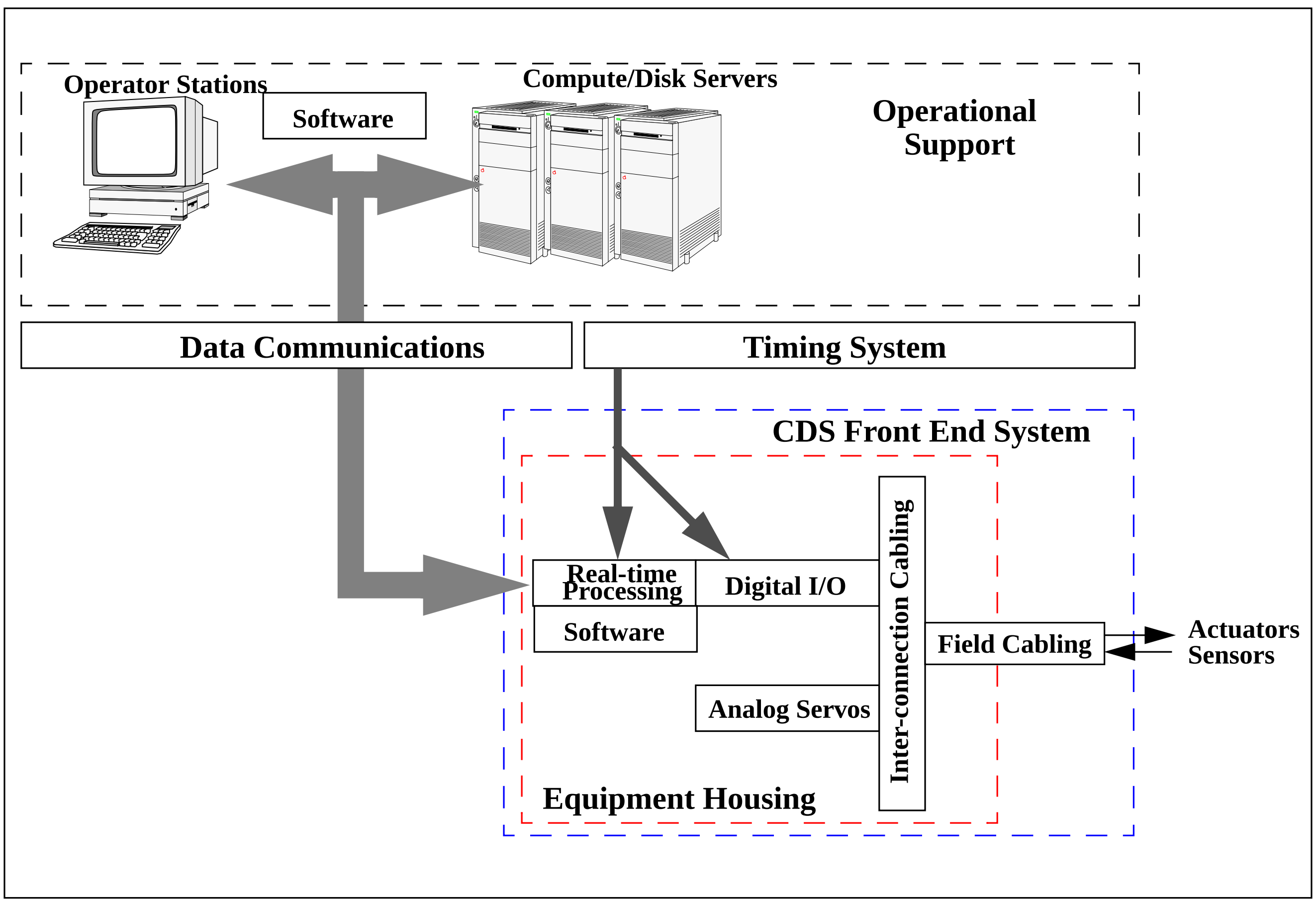


Figure 2: CDS Overview

3 FRONT END SYSTEMS

Front end systems are the field units which connect the CDS to the equipment to be controlled and/or monitored and provide for the real-time control of that equipment. The following sections describe the standard equipment to be employed in these systems.

3.1. Front End I/O Bus

The CDS will employ Versa Modular Eurocard (VME) standard crates and modules for front end I/O and processing. The VME crates meet LIGO CDS standard TBD. VME eXtensions for Instrumentation (VXI) systems may also be used in limited applications.

Any number of I/O and/or processor busses are available today which would meet LIGO needs. Some of the reasons VME is chosen over other buses are:

1. Commercial standard, with support from numerous vendors.
2. Relatively high performance / low cost.
3. Open standard architecture allowing for custom module designs.
4. High versatility. Many VME based products available, from standard I/O, to processors, to DSP modules, which allows a great flexibility for CDS design and future upgrades.

3.2. Real-time Control Processor

3.2.1. Hardware

Real-time processors fall into two categories:

- General Purpose: Provides for the bulk of real-time processing and handling of network communications.
- Digital Signal Processor (DSP): Specialized processor used to perform advanced signal processing for specific applications.

3.2.1.1 General Purpose Real-time Processor

While processor technology will have advanced prior to LIGO CDS installation, the present choice of a VME processor is a unit based on the MIPS4700. All prototype developments are presently using this processor series. Selected specifications on these processor boards are:

- Single width VME module
- IDT R4700 processor, true 64 bit, operating at 176MHz
- Performance: 87MFLOPS/sec, 120SPECint92, 90SPECfp92 (This spec is for 133MHz processor)
- 16 to 64MBytes RAM
- VME64 with board to board transfer rates to 60MByte/sec
- Two PCI Mezzanine Card (PMC) slots.
- Two serial and one ethernet (or fast ethernet) interface

3.2.1.2 Digital Signal Processor

During the design phase of individual IFO subsystems, some emphasis will be put on moving from present analog servo designs, used in previous R&D and prototype activities, to more digital implementations. For this purpose, Digital Signal Processors (DSP) may be used, if the general purpose processor cannot meet requirements and a DSP solution can meet those requirements. In those cases, a VME based DSP module would be employed, typically as a stand-alone servo controller which looks, to the general purpose processor, as a co-processor and/or standard VME module. The choice of DSP modules is TBD pending analysis of subsystem requirements, which is on going.

3.2.2. Software

Software for the realtime processing systems is described in CDS Software Development Plan and Guidlines LIGO-T960004-A.C.

3.3. Analog Servo and Signal Conditioning Hardware

Analog servo and signal conditioning units will be designed and manufactured as 6U Eurocards. These will be installed into LIGO standard Eurocard cages similar to the LIGO VME crates. However, the backplanes for these crates will only provide power connections, not digital lines. Such a crate is shown in Figure 3: CDS Eurocard Cage.

This housing has the same appearance as the CDS VME crates. However, as seen from the top view, two backplanes are installed, allowing modules to be inserted in both the front and back of the unit. Sensitive analog circuit boards would be installed in the front, with modules containing high voltage and power circuitry installed into the rear slots. Space is provided in the center between the backplanes to allow access for interface cabling.

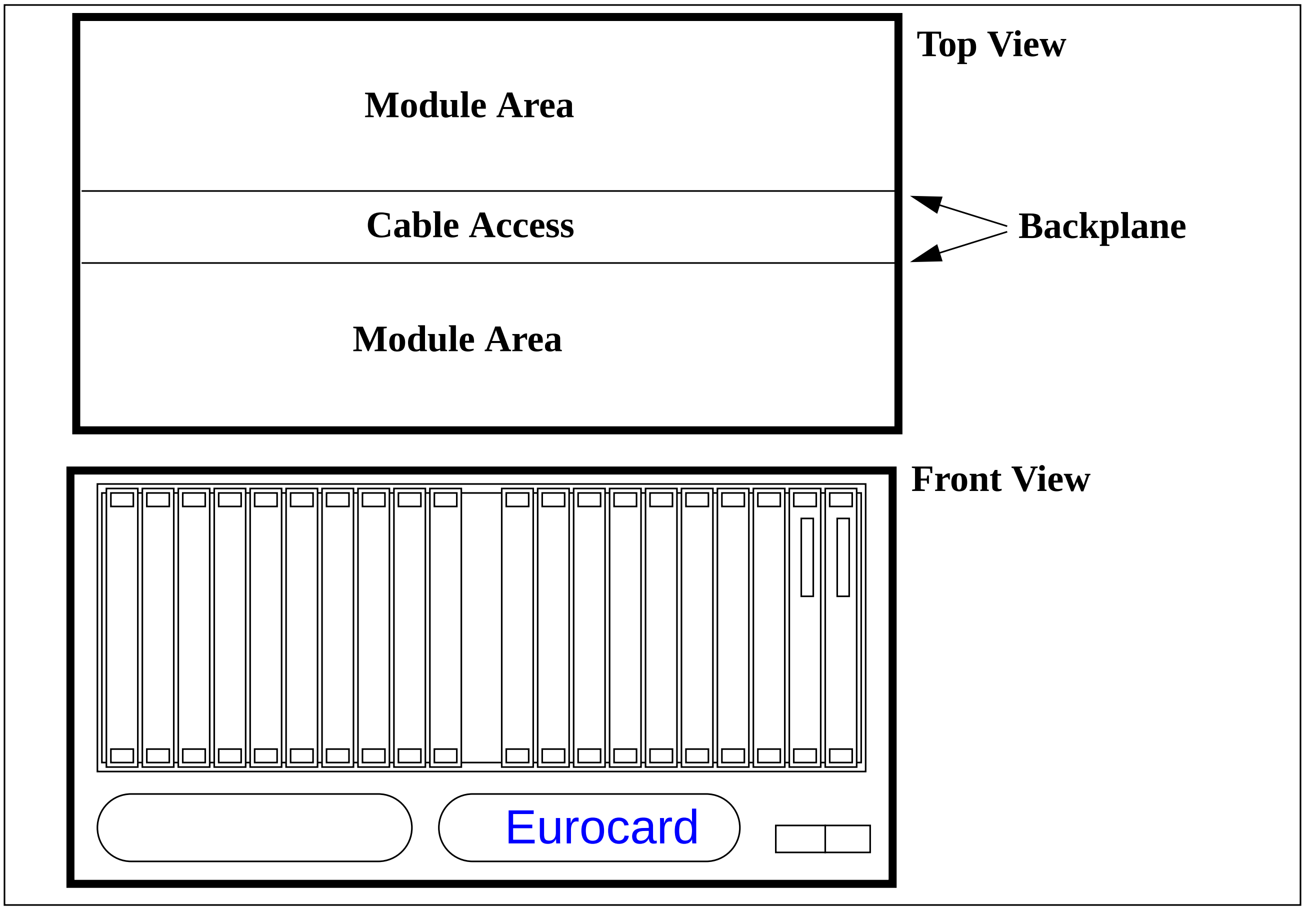
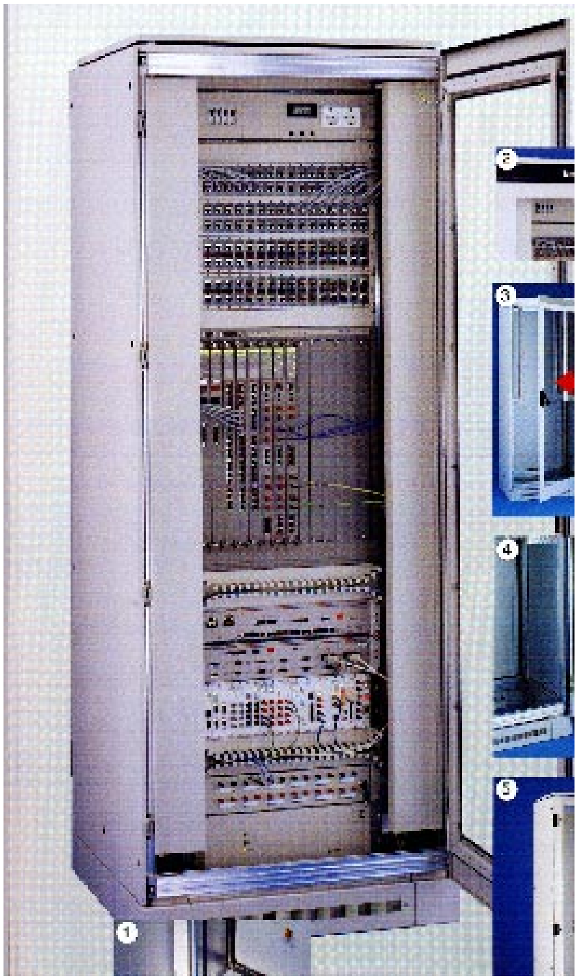


Figure 3: CDS Eurocard Cage

3.4. Equipment Housing

3.4.1. Design Specifications

CDS front end systems will be contained in standard 19” rack mounting systems. The standard rack and specifications are shown in Figure 4: CDS Rack Standard.



- Aluminum and sheet steel
- Dimensions: 31.5” x 35.4” x 84”
- Doors: Front/Rear/Side
- Side cable feed base
- 41U installation area (71.75”)

Figure 4: CDS Rack Standard

3.4.2. Typical Layout

A typical front end rack layout for interferometer control subsystems is shown in Figure 5: CDS Standard Front End Rack Assembly (LVEA). This rack contains:

1. A 1U top panel (Service Panel), which includes:
   - Panel breaker(s) for rack power
   - 10baseT connector which provides an ethernet connection to the CDS networks. This allows for connection of a laptop PC for local operation/maintenance.

- Phone jack

2. Two 1U 24VDC power supplies. +/-24VDC will be the CDS standard for binary I/O operation, such as relays, switches, contacts, etc. These are also the standard supplies for CDS analog servo circuit boards.
3. VME and Eurocard crates
4. Wiring cross connect systems
5. Phone

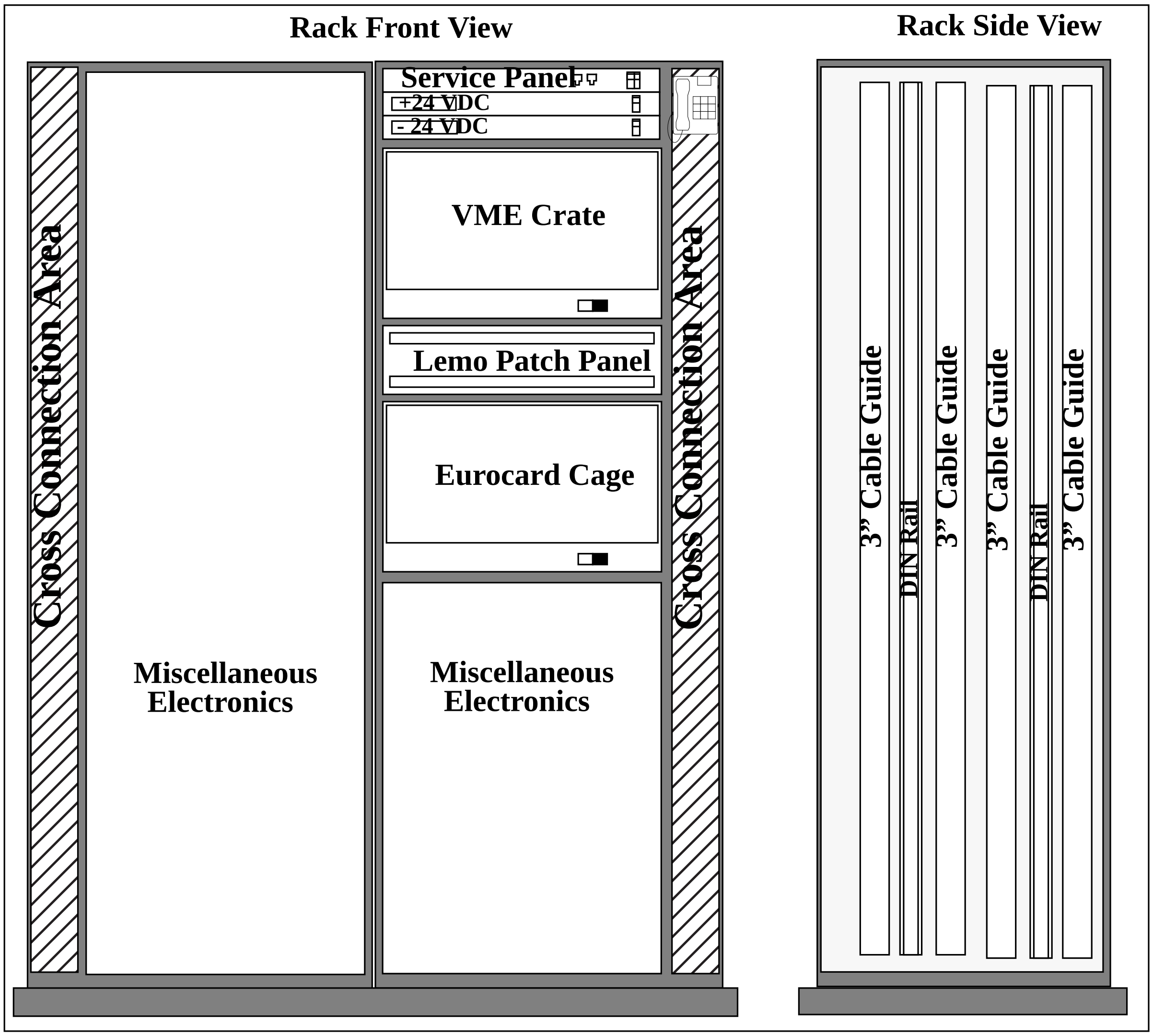


Figure 5: CDS Standard Front End Rack Assembly (LVEA)

3.5. Inter-connection wiring

Three general schemes will be used to interconnect CDS modules and CDS to external equipment:

1. Coax wiring through a Lemo patch panel.
2. Interconnect wiring through DIN rail mounted discreet or mass termination blocks.

3. Signal cables designated as “critical” due to signal levels, noise levels, allowed lengths, etc., will be run directly from the CDS interface module(s) to the equipment involved.

As shown in the previous rack layout sketch, a Lemo patch panel will exist between the control and monitoring and DAQ crates. This will be the primary interface point to control signals which must be acquired and archived by the DAQ system. This panel will also provide the connection point for signals interfaced via coaxial cable to field equipment and provide some standard test point signals for o’scope connection.

As can be seen in Figures 4 and 5, the CDS racks are oversized in width and generally installed in pairs. This allows field cabling to enter from the bottom sides of racks and terminate into side mounted DIN equipment. This method is shown in Figure 6: CDS Cable Interconnect System. This cross connect area contains alternating 3” cable guide and DIN rails. The DIN rails will be used to mount Phoenix (or equivalent) mass termination blocks for connection of multi-conductor ribbon cable from VME I/O modules to field devices and single point termination blocks for distribution of power and similar types of signals. The standard mass termination cable is a twisted, shielded, round ribbon type, with flat ribbon breakouts at 2 meter intervals for the standard ribbon connectors. The routing of cable from the VME and other front panel electronics to the cross connect area will be via punchouts in the 3” cable guide areas through the rack side wall into the main rack area.

Cable routing into/out of the racks will be via the bottom of the rack. In LIGO equipment buildings, cabling will be through a toe base into a floor-mounted cable tray. Those racks located within the control areas of the OSB will be via openings in the raised floors.

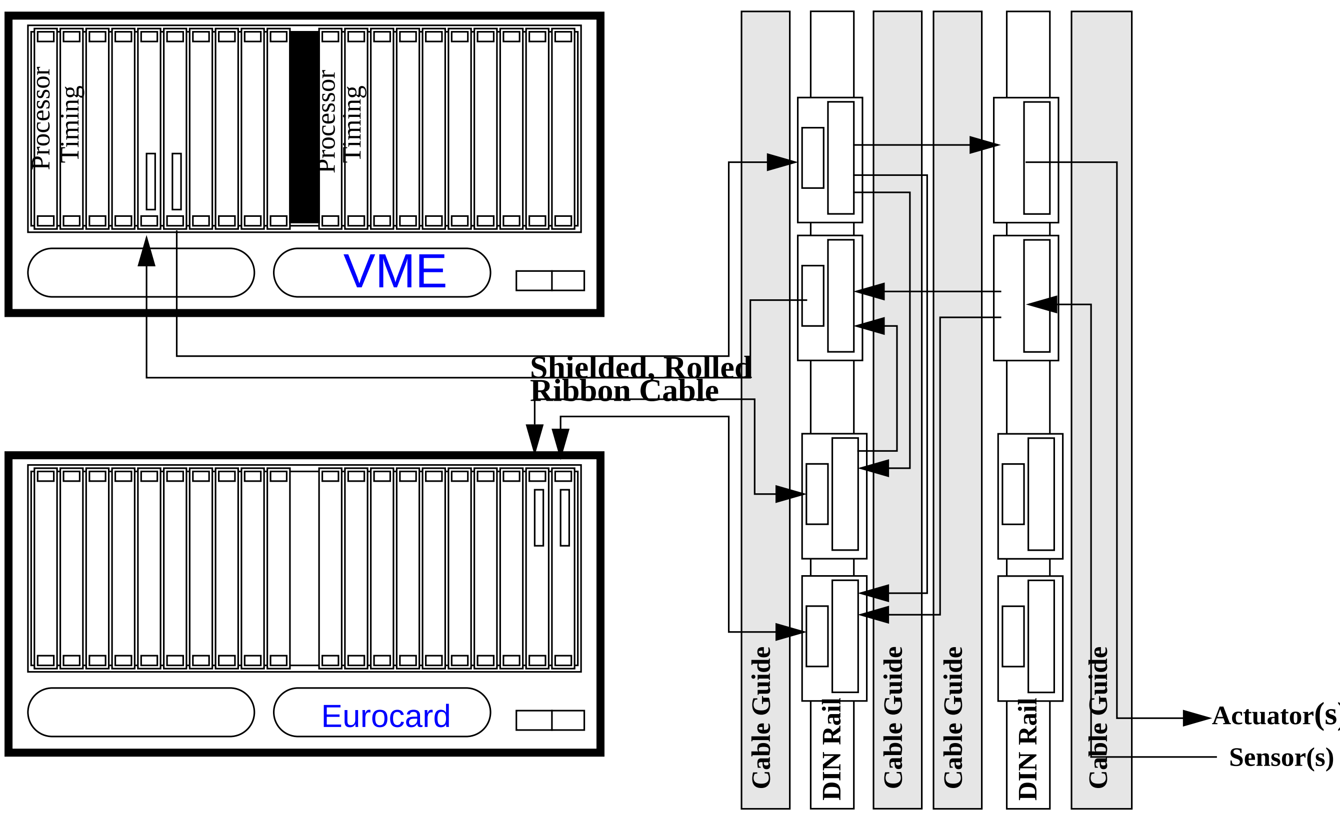


Figure 6: CDS Cable Interconnect System

3.6. Interfaces

The following figure shows the interfaces to CDS front end system racks. These are further described in the following subparagraphs.

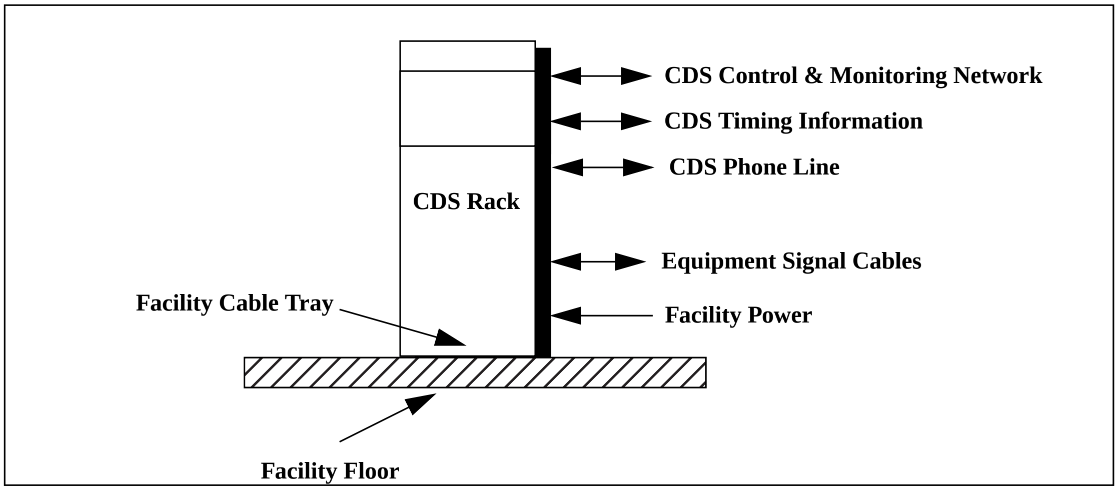


Figure 7: CDS Front End Rack Interfaces

3.6.1. Rack Placement

CDS rack placements for the LVEA and mid and end stations are depicted in LIGO D960073-E, Chamber and Rack Designations. Rack assignments by CDS subsystem and preliminary labouts are shown in LIGO-D970581-00-C. Note that the rack layouts shown in this referenced drawing are only preliminary. Detailed, final rack layouts will be produced as separate drawings as part of the subsystem designs.

3.6.2. Cable Raceways

Cable trays will be provided (by others) under the beam tubes for the routing of CDS cables. These trays will be subdivided into three parts to provide separation of cables by function:

- Analog signal cables
- Digital cables
- Power cables
- RF cables.

Short tray stubs will be provided at each rack location to get from the main cable trays to entry at the rack bases.

3.6.3. Cable in Vacuum

CDS must provide certain cables into the LIGO vacuum chambers. All cabling within vacuum will meet the Vacuum Cabling and Feedthrough (VCF) requirements as outlined in LIGO T950095-C.

3.6.4. Facility Power

Two 110VAC/15A service lines will be provided to each CDS rack. This service will be brought through conduits encased in the concrete flooring from 15A breaker panels on the building walls at various locations. CDS rack power feed locations are shown in LIGO D960073-E.

3.6.5. Grounds

Common grounds will be carried to all CDS racks from the technical ground bus bars located in the building walls. These grounds will be carried via the power conduits which extend from the power feed locations in the facility walls, through the concrete floor and into the CDS racks.

Detailed grounding schemes for electronics for CDS subsystems will be developed as part of the detailed subsystem designs and presented in the associated design documents.

4 TIMING SYSTEM

4.1. Design

The CDS timing system is based on the Global Positioning System (GPS). A GPS antenna and receiver will be located at each mid and end station, along with two at the corner station area to serve the LVEA and OSB.

The system layout is shown in Figure 8: Timing System Overview. At each LIGO building area, a GPS antenna will be mounted on the roof and connected via a coax line to a VME based GPS receiver module in one of the CDS VME crates in the area. All other VME crates within the building/corner station area will house GPS slave modules. The actual receiver circuitry is housed in the antenna unit. The difference between the VME receiver module and the slaves is only in that the receiver module has the added connections to accept the antenna inputs.

Once the receiver is powered up, it takes up to 30 minutes (<5 min. typical) to acquire enough satellite information to get accurate time information (time dependent on how long the system has been off). Once time information is acquired, it is available:

1. To the VME processor over the backplane via direct memory locations.
2. To VME slave units via IRIG-B connections.

In addition to time-of-day information, the receiver and slave VME units produce selectable phase-locked TTL clock outputs with frequencies of 2^n Hz, from 1Hz to 4MHz. These clocks will be used as synchronization inputs to DAQ modules and control and monitoring signal digitizers.

The GPS module design also allows VME interrupts to be generated at these clock frequencies. These will be used to synchronize time critical software events.

At the present time, CDS is awaiting delivery of the first article units. Exact system specifications and layouts will be prepared following tests of these units.

4.2. Interfaces

Interfaces to the timing system are:

1. At the VME backplane connection to the receiver/slave modules.
2. At the timing clock output jack on the module front panel.

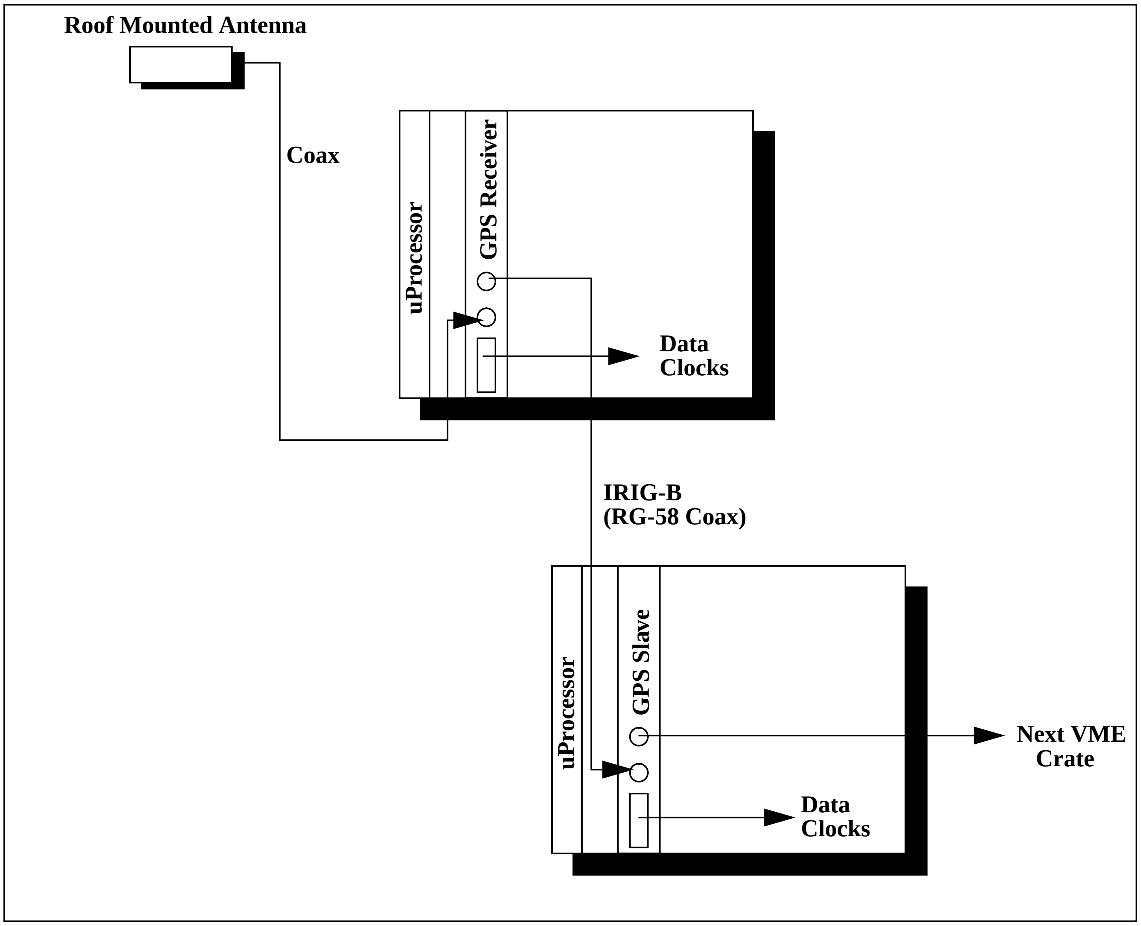


Figure 8: Timing System Overview

5 COMMUNICATIONS

5.1. Networking

To meet the computer networking demands of CDS, several networks will be provided. These are as follows:

1. CDS Control and Monitoring Network (CMN): This is the general data network of CDS and will provide standard control and monitoring, video and burst data networking facilities.
2. Data Acquisition System (DAQS) Network: This is to be a private, high performance network to provide the high bandwidth needs of moving data from DAQS data collection units to the DAQS framebuilders.
3. Real-time Network (RTN): This network (or networks) will provide for real-time network demands which may be placed on CDS for closed loop control which requires communication between multiple processors, such as for the ASC/LSC.

Of these networks, only the first (CMN) is within the scope of this document. The DAQS network is described in the DAQS Preliminary Design T970136-00-C. Additional real-time networks will be described in individual subsystem documentation as private networks. To support these latter two, the CDS Control & Monitoring system need only provide the transmission media (fibre optics), as described in section 5.3.

CMN is the primary backbone structure which will be provided to meet the General Controls, Burst Data and Video network data communication requirements. The Hanford site Control and Monitoring Network Drawing (D970583-00-C) depicts the layout and further detail of this system. Key components are:

1. ATM Backbone: The backbone of the CMN is a 155Mbit/sec OC-3 ATM network. This backbone is controlled by a Fore Systems ASX-1000 ATM switch. The specifications for the initial switch to be installed are:
   - Switching speed: 5Gbit/sec (unit is expandable to 10Gbit/sec)
   - Switch controllers: Two, based on i960 processors
   - Power supplies: Dual, redundant
   - Ports: 32 OC-3 ports, 8 with medium range (10km) single mode transceivers, 24 with short range multi-mode transceivers. This can be expanded to 64 ports in the ASX-1000.
2. Ethernet Switches: Ethernet provides the primary connections to control and data acquisition processors for the purposes of booting systems and “slow” data traffic, such as message passing and data updates to operator control panels. Ethernet switches are used to provide these connections to control processors throughout the site, as well as to DAQS framebuilder processors and control room peripheral equipment. These switches are Fore Systems model ES-3810 units, which contain 24 ethernet ports (expandable to 72 ports) and a 155Mbit/sec ATM uplink. This provides a dedicated 10Mbit/sec ethernet link to all connected devices. These units are capable of switching speeds to 2.5Gbit/sec.
3. Video convertors: Video to ATM transmitters will be used to transfer video images from cameras located throughout the site. These units provide inputs for up to six video cameras, along with outputs to control camera pointing, focus, etc. The video is captured and transmitted via an ATM uplink, which connects to the ATM switch. This video can then be displayed on any workstation connected to the CDS network.

With this architecture, the network bandwidth figures would be:

- Aggregate bandwidth: Up to 5Gbits/sec (ATM Switch performance limit)
- Maximum bandwidth between two processors: 155Mbit/sec (Both processors directly connected to ATM backbone switch)
- Minimum bandwidth between two processors: 10Mbit/sec (Both processors connected to Ethernet switch)

5.2. Phone Service

CDS is to provide the cable infrastructure for phone service in specified areas of the LVEA and mid and end stations. For the mid and end stations, CDS will run 6 pair conductor, buried along with the network fibre optics, from the OSB. For the LVEA, CDS will run phone lines via OSB/LVEA conduit CY7 and appropriate cable trays to the following LVEA racks:

- 1X2
- 1X6
- 1X9
- 1Y9
- 2X8
- 2X4
- 2X1
- 2Y2
- 1Y16
- 1X10
- 1X15

5.3. Communications Cable Plant

The cable plant for networking equipment will be a combination of fibre optics and CAT5-UTP cable. The fibre optics cable plant is shown in Hanford Fibre Optic Plant (D970582-00-C). CAT5 cables are shown in the Hanford Control and Monitoring Network drawing, D970583-00-C.

6 OPERATIONS SUPPORT

Two spaces are provided at each facility for CDS equipment: a Facility Control Room (FCR) and a Mass Storage Room (MSR), where networking and compute server equipment are housed.

6.1. Facility Control Room

A floor plan for the FCR is shown in FCR Layout drawing LIGO D961398-00-C. The layout includes seven operator consoles/stations. During the LIGO commissioning phase, the seven consoles provide space for the larger engineering and scientific staff typically involved in commissioning activities. As LIGO moves into more steady-state operations, two stations are intended as the main consoles for the two LIGO operators on shift, with the other five remaining consoles available for additional staff performing machine studies and tuning activities. Two large screen (120” diagonal) projection systems also provide for viewing of operator selectable display screens and video throughout the room.

Computing facilities and connections for the FCR are shown in D961395-C.

6.2. Operator Stations

The CDS will provide three types of operator stations:

- Operator Consoles at the FCR
- Single, fixed/portable workstation locations at various points throughout the Ligo laser/vacuum equipment buildings.
- Portable laptop stations

6.2.1. FCR Consoles

The operator console enclosures are low bay 19” rack units (24”W x 46”H x 48D”). Each console will have up to four bays for mounting of high resolution monitors, telephones, test equipment, and book storage.

The core of each console is a Sun UltraSparc2 workstation, with two or three 20” high resolution color monitors, single keyboard, mouse and knob box. These units have four S-bus slots, with three devoted to graphics monitors and the fourth for an ATM network interface card.

Four personal computer (PC) stations are also permanently mounted in designated consoles. These units provide the interfaces to the Facility Monitoring and Control System (FMCS), the RGA software for the PEM system, and CDS databases.

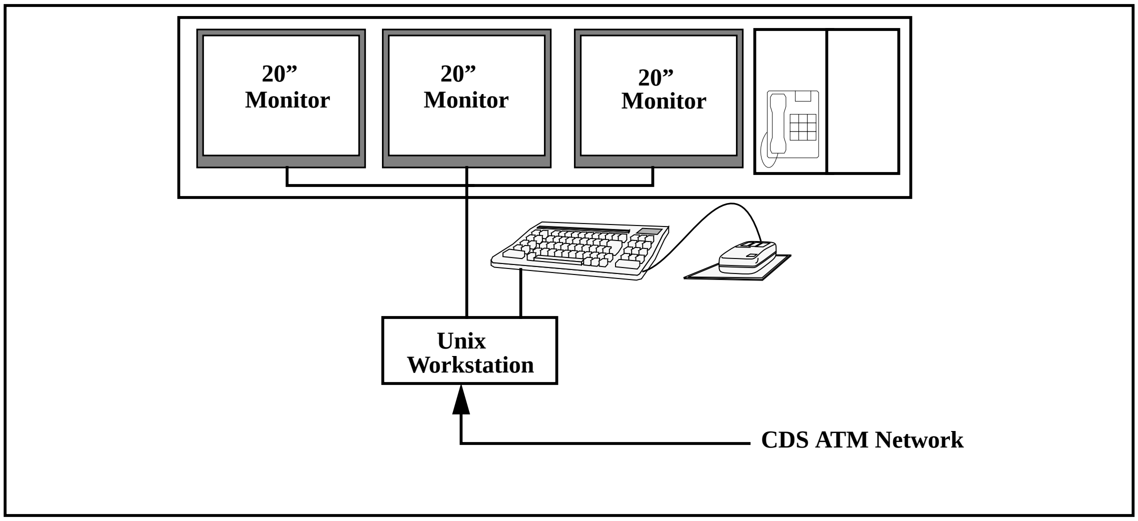


Figure 9: Operator Console Computer Equipment

6.2.2. Fixed/Portable Workstations

To meet the requirements of stand-alone operation of the Vacuum Control and Monitoring System (VCMS) during vacuum equipment acceptance testing, VCMS racks will be equipped with single Sparc5 workstations. After the acceptance tests, these workstations will be mounted to portable carts for use as local operator stations for interferometer system commissioning and maintenance.

6.2.3. Portable Laptop Stations

For operation local to the equipment being controlled/monitored, the CDS racks provide an ethernet connection for use by lap top personal computers. These computers will be provided with networking and X window software to allow viewing of any CDS displays available on the network.

6.2.4. Remote Access

A separate workstation class computer will be provided as a “firewall” to the CDS networks. This computer will provide for access to CDS information to outside computers at a lower priority to ensure the CDS system does not become overburdened by external systems and data requests. This computer will be equipped with one network interface connection to CDS networks and an additional separate network interface module connected to the general computing and data analysis networks.

6.2.5. General Computing

Two workstations will be provided in the FCR which connect to the site general computing network. These stations are provided to allow operators access to LIGO general computing facilities.

6.3. Computer/Mass Storage Area

The Computer/Mass Storage (CMS) area will house the control and monitoring and data acquisition compute servers, mass storage units, networking equipment, and other CDS support equipment. The preliminary layout of this room is shown in D961398-C.

6.3.1. Control and Monitoring Server

The control and monitoring server will consist of:

- Two UltraSparc2 server computers
- Two 50 GByte Disk Arrays
- A tape backup unit, which is a 20 tape (8mm) robot unit with dual drives (3MByte/sec/drive)

6.3.2. Uninterruptable Power Supplies (UPS)

UPS will be provided as necessary to keep the following operational during a power outage for up to 30 minutes:

- Control and Monitoring and Data Acquisition System servers
- Network hubs
- One operator console and its associated equipment

For real-time front end processors, their criticality will be analyzed as part of the subsystem design, and UPS provided if deemed necessary and appropriate.

6.4. Software

Operational support software, in the context of this document, is that software which provides SCADA functions on non-real-time platforms. This software is run primarily under Unix and includes :

- HMI
  - Sammi
  - Medm
  -
- Data Archival and Retrieval
  - DAQS developed software for standard FRAME formats
- Alarm Management
  - ALH
- System parameter save and restore
  - BURT
- Application Programmer’s Interface
  - Channel Access (CA)
  - Easy Channel Access (EZCA)

Further information on CDS software can be found in CDS Software Development Plan and Guidelines LIGO-T960004-A-C.

APPENDIX A CONTROL AND MONITORING PDR ACTION ITEMS

The following action items are reproduced from the Control and Monitoring PDR, along with the actions taken.

RECOMMENDED ACTION ITEMS

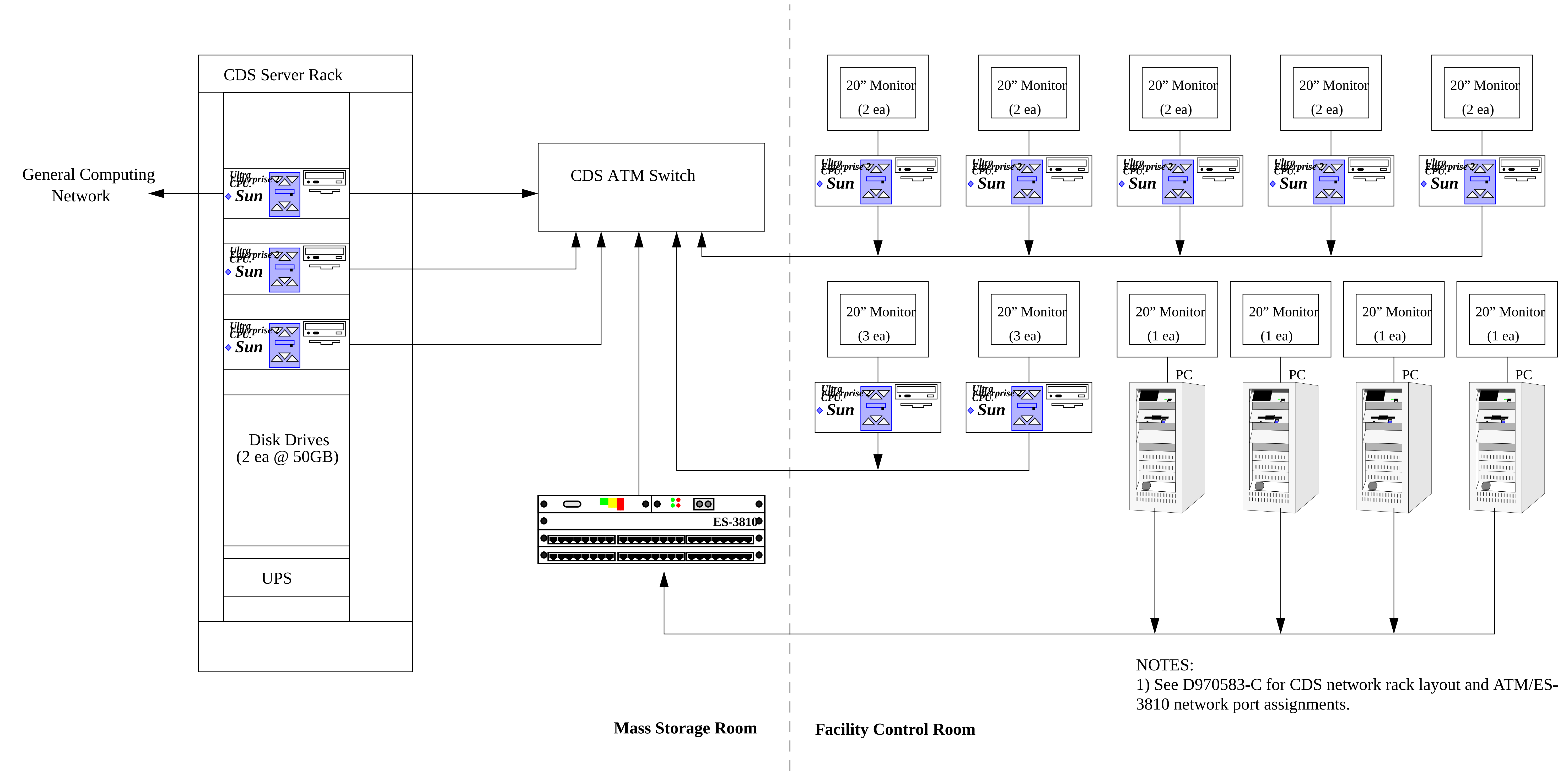
PRELIMINARY DESIGN

1. ***Concern***: The sparcstation 20” monitors may produce electromagnetic radiation that exceeds the electromagnetic limit imposed on CDS equipment in the EMC plan.
   Action: Determine the electromagnetic emission from the monitors and, if required, consider LCD dispays as an alternative.
   Action Taken: No monitors will be permanently mounted in CDS equipment racks in VE areas.
2. ***Concern***: Hardware reset of a processor using network monitoring watchdog should be explicitly required.
   Action: Add to the design requirements.
   Action Taken: Added to requirements; WDT module has been designed and implemented.
3. ***Concern***: The proposed control room layout does not appear to use the available floor space judiciously.
   Action: Revise the layout to conserve available floor space for operators, while allowing reasonable access for cabling and maintenance and repair activities (in the rear of the operator consoles/stations).
   Action Taken: Control room layout revised.
4. ***Concern***: No mention of spares and support equipment.
   Action: Present a recommended spares list and a support equipment list (OTDR, bus analyzers, etc.) at the FDR.
   Action Taken: List developed.
5. ***Concern***: Lack of C-code design/writing standards or style guidance.
   Action: Develop a C-code specification which (among other requirements) calls for ANSII standard code.
   Action Taken: Software Development Plan (LIGO-T960004-C) updated to reflect style guidelines and standards.
6. ***Concern***: There is a need to define an exception handler to trap, log and recover from error conditons.
   Action: Define the exception handler.
   Action Taken: Exception handlers have been added to the system requirements.
7. ***Concern***: The requirements for science data analysis and display capabilities are incomplete and as a consequence the proposed approach of using DaDisp or similar analysis/display package cannot be evaluated.
   Action: The science and operations groups should define analysis and display needs for the cDS-CM system. Based on these requirements, the science and operations groups should recommend/evalute one or mor packages (DaDisp, PVWave, Matlab, etc.) to be accessible within the CDS-CM framework. The need for any glue software (e.g. for import/export of data) should be identified.

Action Taken: Still Open.

8. ***Concern***: The latency of an ATM network may not support high rate servo loops.
   Action: Evaluate (through test if necessary) the expected latency on the ATM network and determine if this will support LSC and ASC requirements.
   Action Taken: ATM backbone was never intended to act as the realtime network to meet the needs of ASC/LSC closed loops. Those will be handled with private networks (reflected memory/fibre channel).
9. ***Concern***: The network bandwidth requirement table (as summarized on slide 14 of the viewgraph presentation) does not include the suspension (SUS) subsystem.
   Action: Verify that the requirements include all interferometer subsystems.
   Action Taken: Bandwidth requirements have been verified to include all LIGO systems.
10. ***Concern***: The open interface nature of the proposed CDS networks appear to allow “unauthorized” code to read/write to real-time control systems; this risk should be precluded.
    Action: Define a means of controlling access to the CDS network by uncontrolled/unreviewed sofware (e.g. developed by scientists involved in interferometer debug).
    Action Taken: In accordance with the software development plan, a software librarian will be the only person allowed to release code for use in the system. A “firewall” computer has been added to the CDS architecture which will restrict access from outside users.
11. ***Concern***: Only 50% spare capacity (18 fibres total) are proposed for the fibre-optic cabling along the interferometer arms.
    Action: Consider increasing the initial spare capacity to 24 or 36 fibres.
    Action Taken: Fibre optic plant design modified to include 24 fibres per mid and end station VE areas.

APPENDIX B DRAWINGS



NOTES:
1) See D970583-C for CDS network rack layout and ATM/ES-3810 network port assignments.

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TWO PLACE DECIMAL ±
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CDS Compute Servers and Operator Workstations

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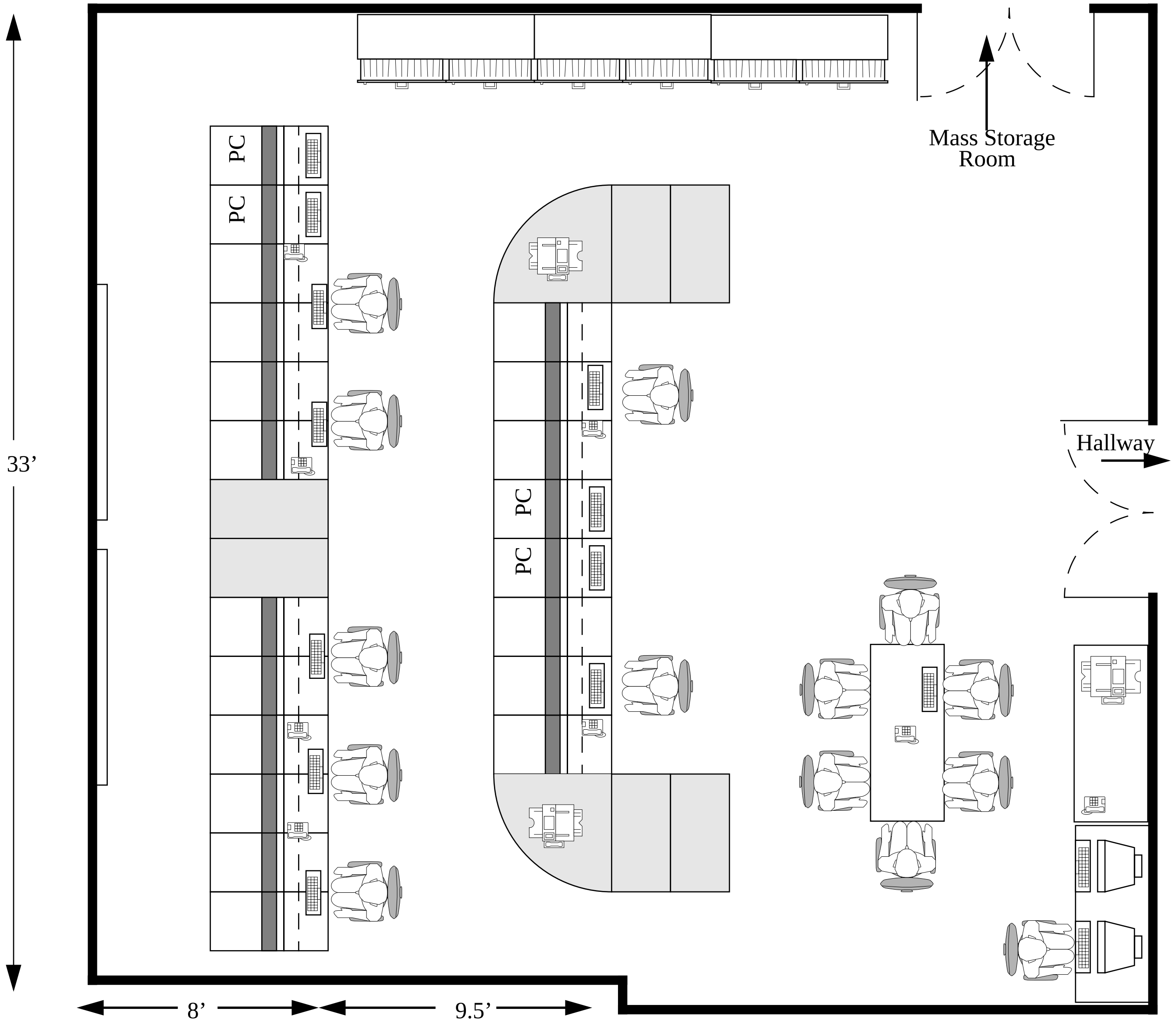
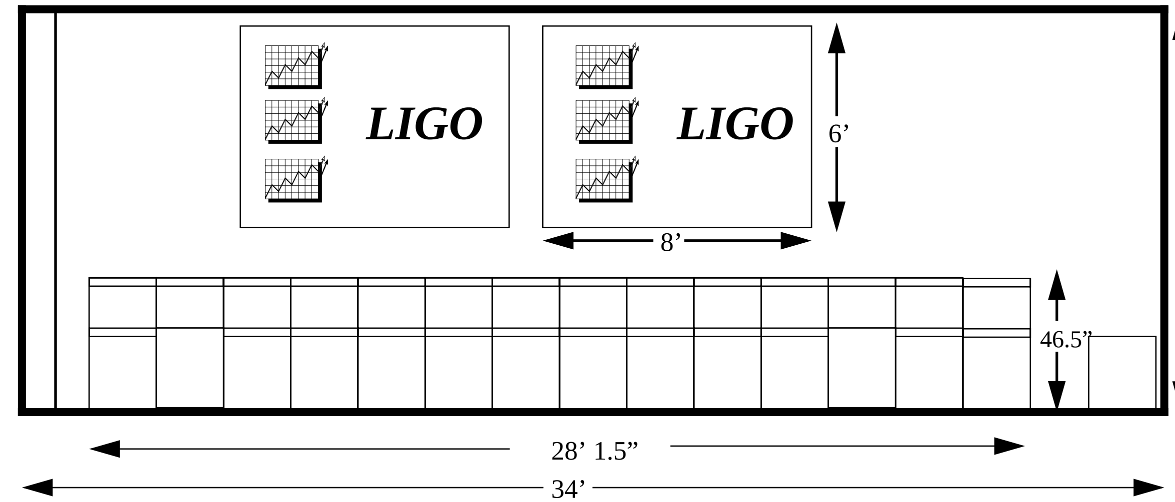
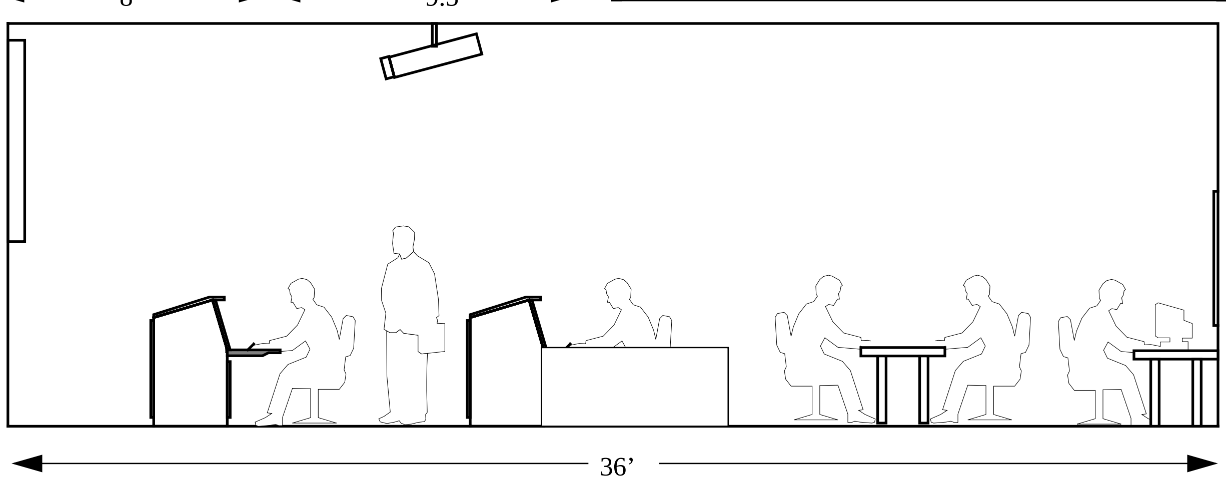
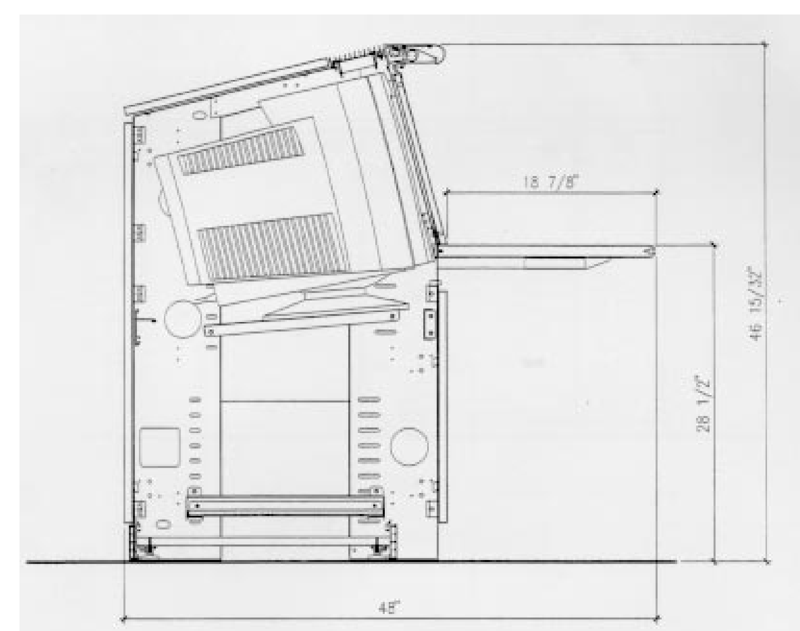
CAD FILE | SCALE | SHEET **1 of 1** | STD | VER. 01







Console Detail



NOTES:

1) Console locations marked PC are personal computer locations for monitoring of FCMS, RGA control and CDS database information; all other console locations consist of a Sun Ultrasparc driving two/three 20” monitors for MMI into CDS control, monitoring and data acquisition systems.

2) Computer terminals shown in bottom, left corner of FCR are to be general computing workstations.

3) Wall mounted computer video projection screens are 6’ by 8’ (120” diagonal viewing area).

4) Console detail shown is correct except that top of console is to be flat and not slanted.

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THREE PLACE DECIMAL ±
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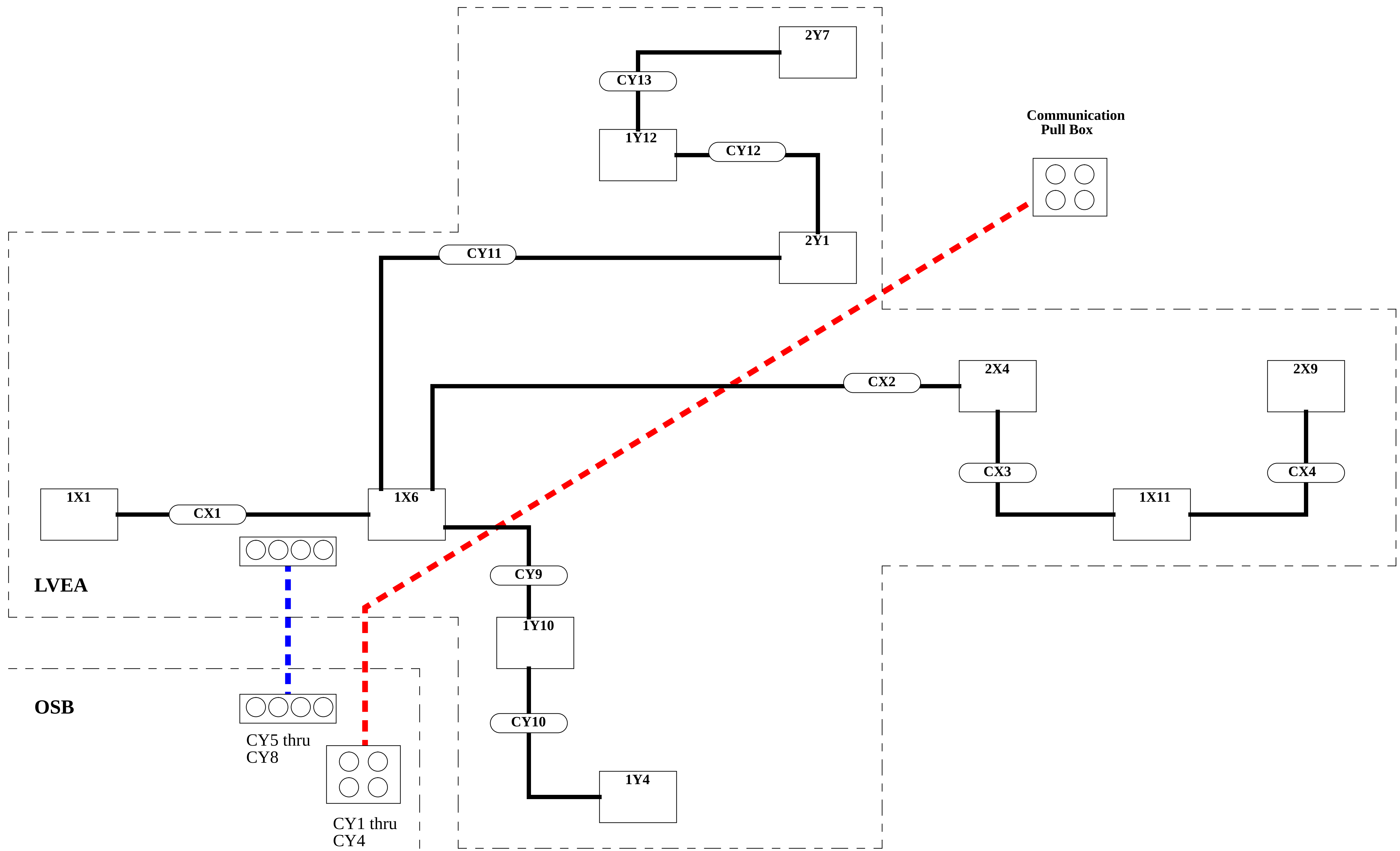
Facility Control Room Layout

SCALE | SIZE B | DWG. NO. **D961396-00-C** | REV. **00**

CAD FILE | SCALE | SHEET **1 of 1** | STD | VER. 01



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FINISHED SURFACE RMS
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Hanford Corner Station
CDS conduit designations

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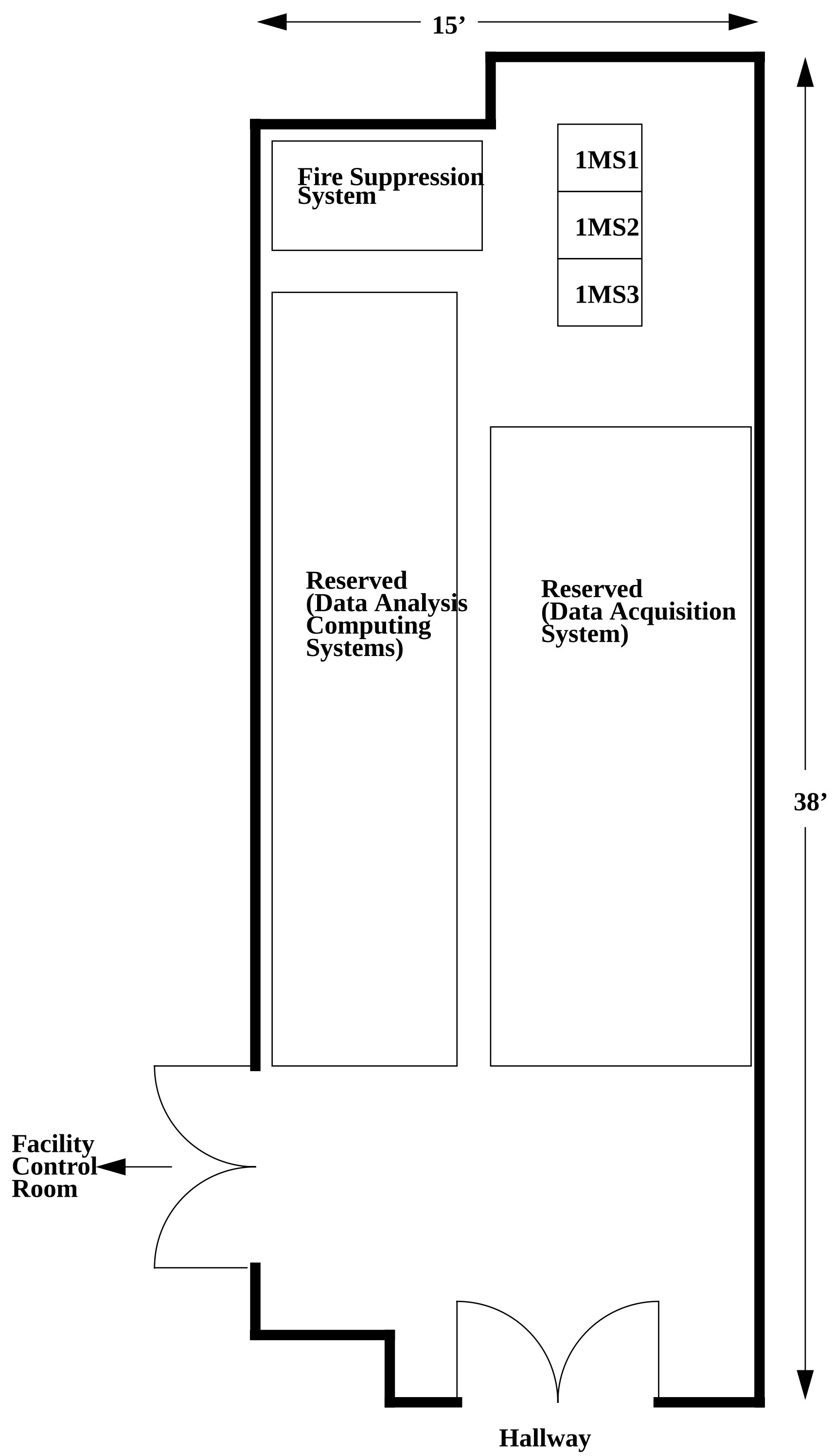

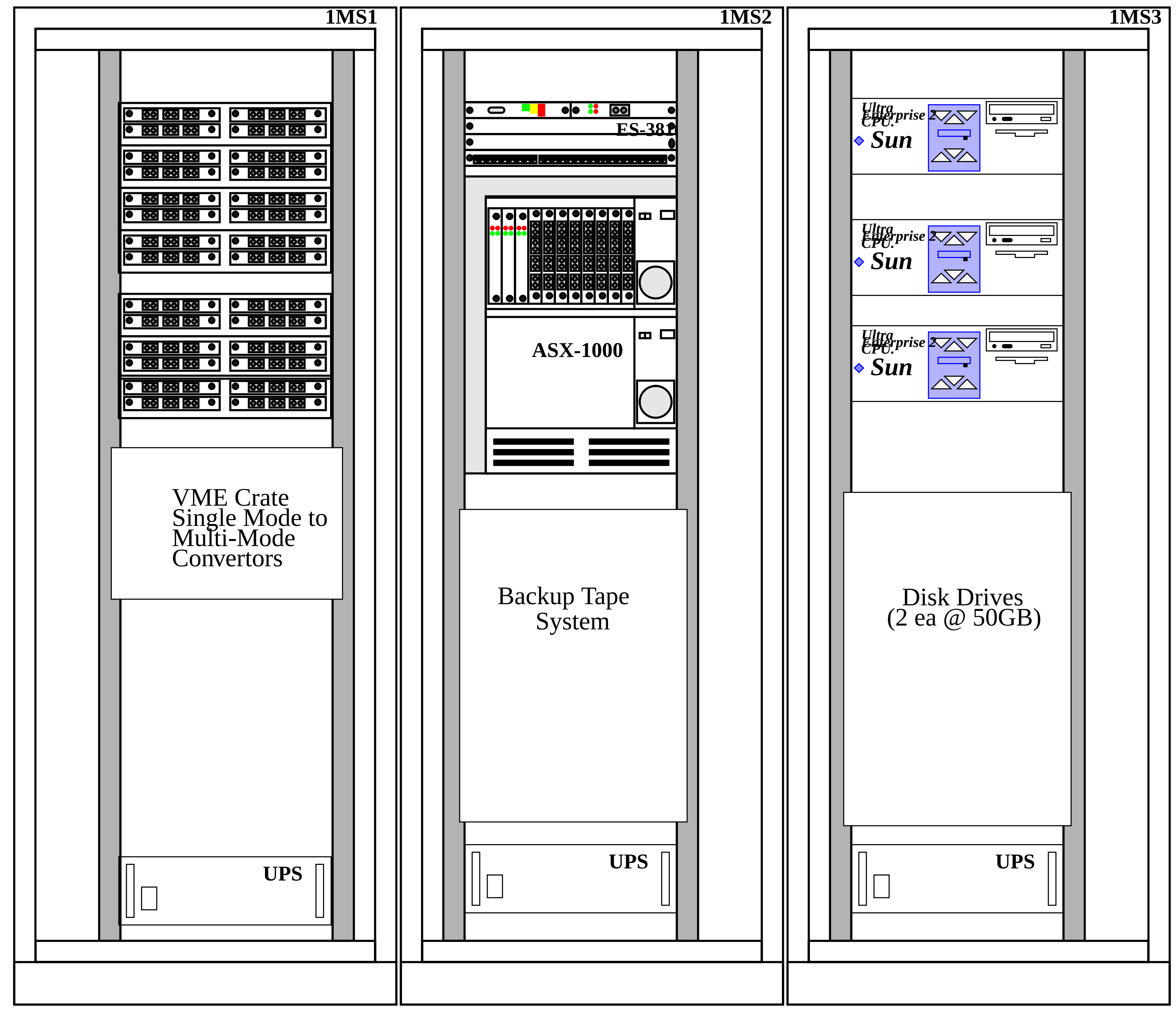

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Mass Storage Room Layout

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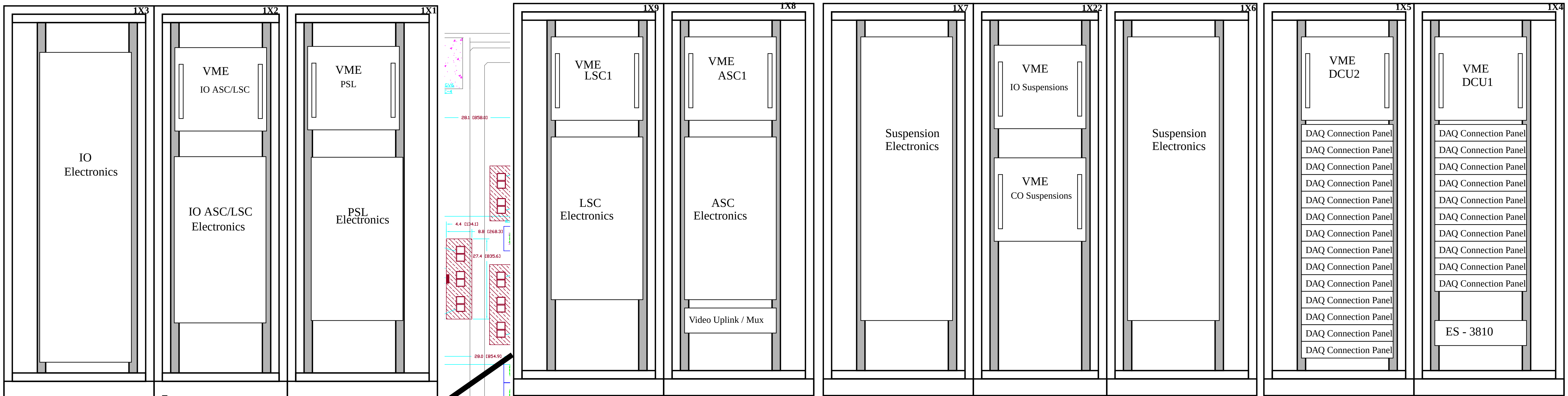

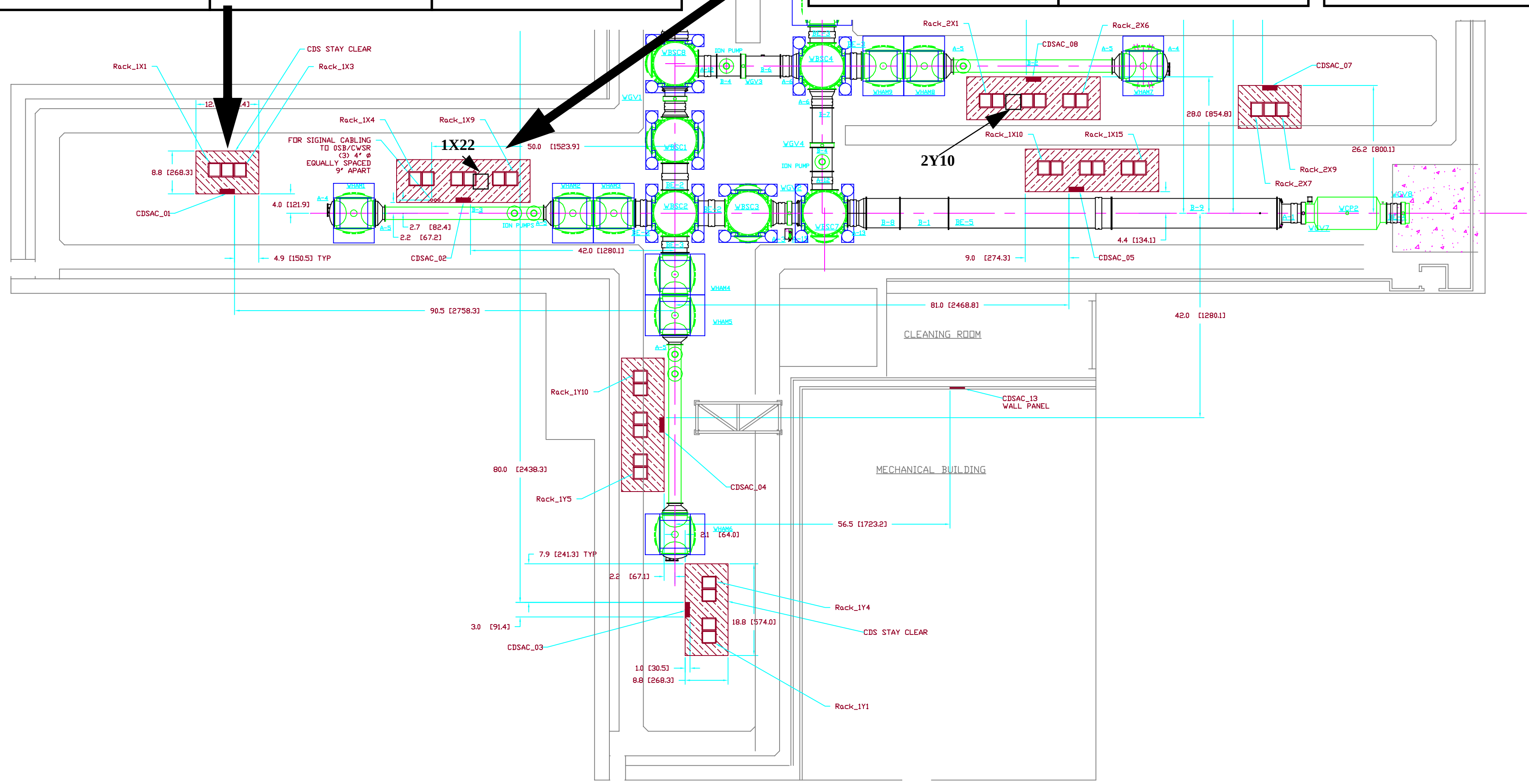

Notes:

1) This drawing is intended solely to depict rack locations and subsystem assignments. For detailed rack equipment layouts, see appropriate CDS subsystem drawings.

2) Additional racks have been added to this drawing which are not yet reflected in Chamber and Rack Designations (D960073-00-E). These are:

- Rack 1X22, between 1X7 and 1X8.
- Rack 2X10, between 2X2 and 2X3.

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Hanford Rack Assignments
Control and Data Systems

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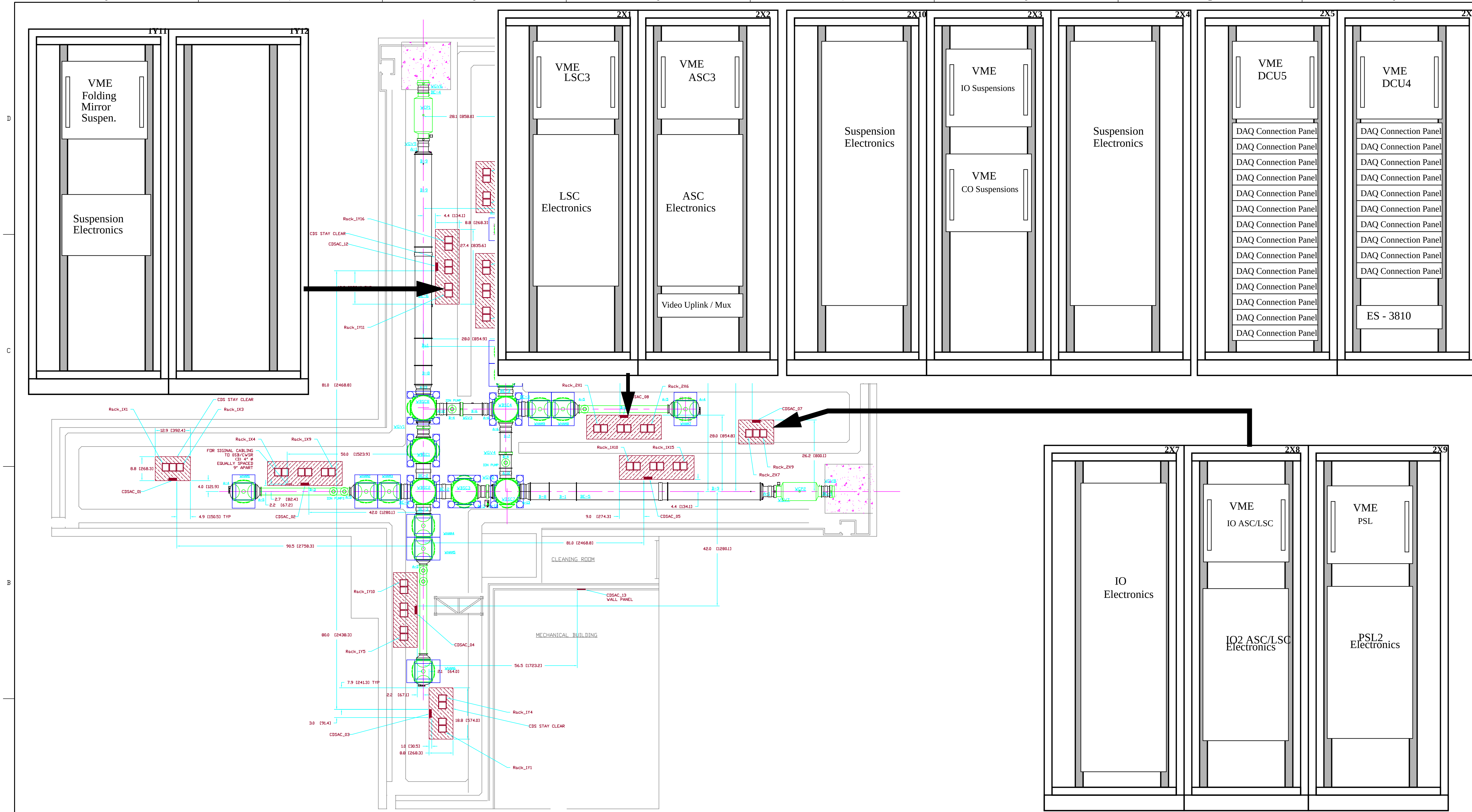
SCALE | SHEET 1 of 5



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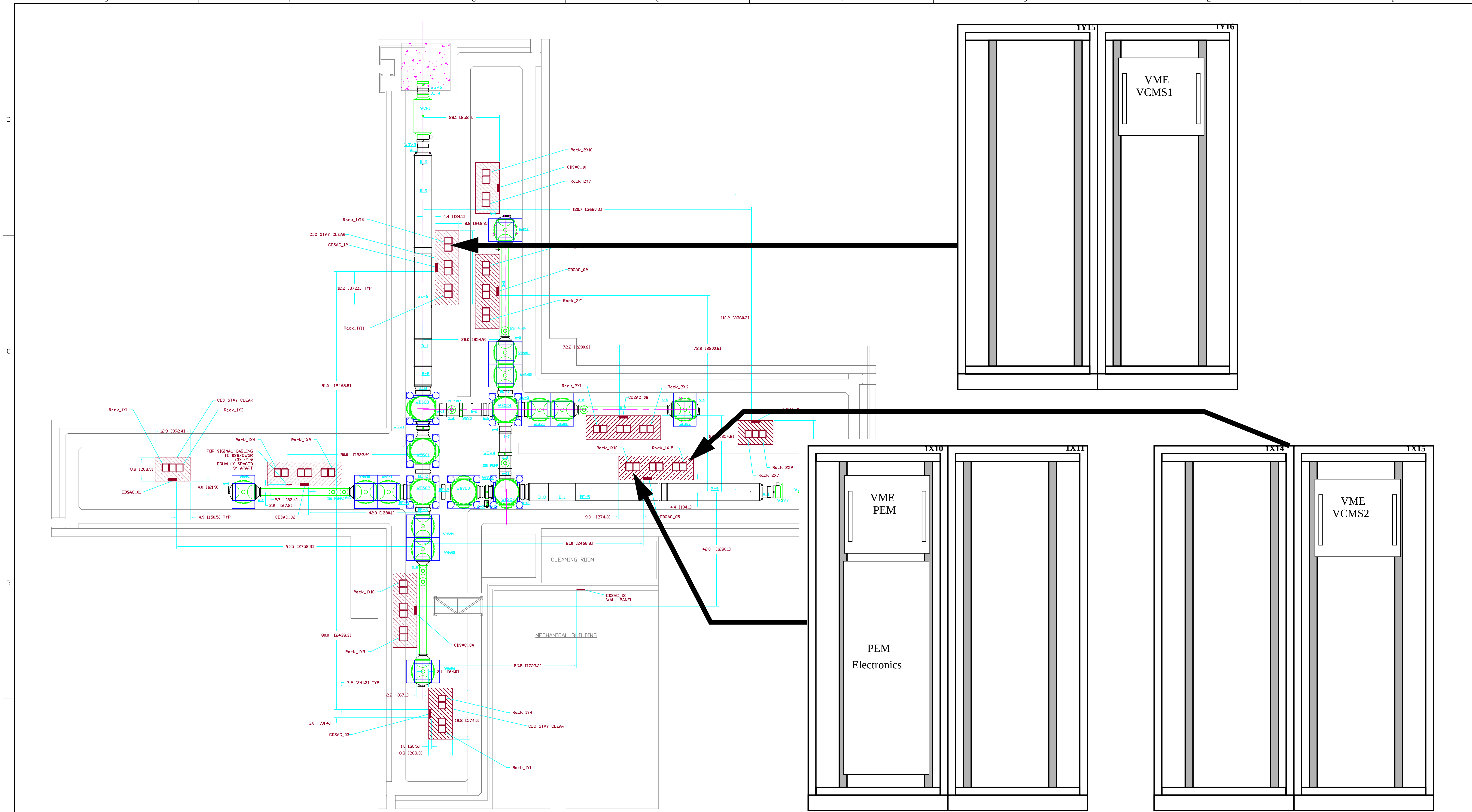

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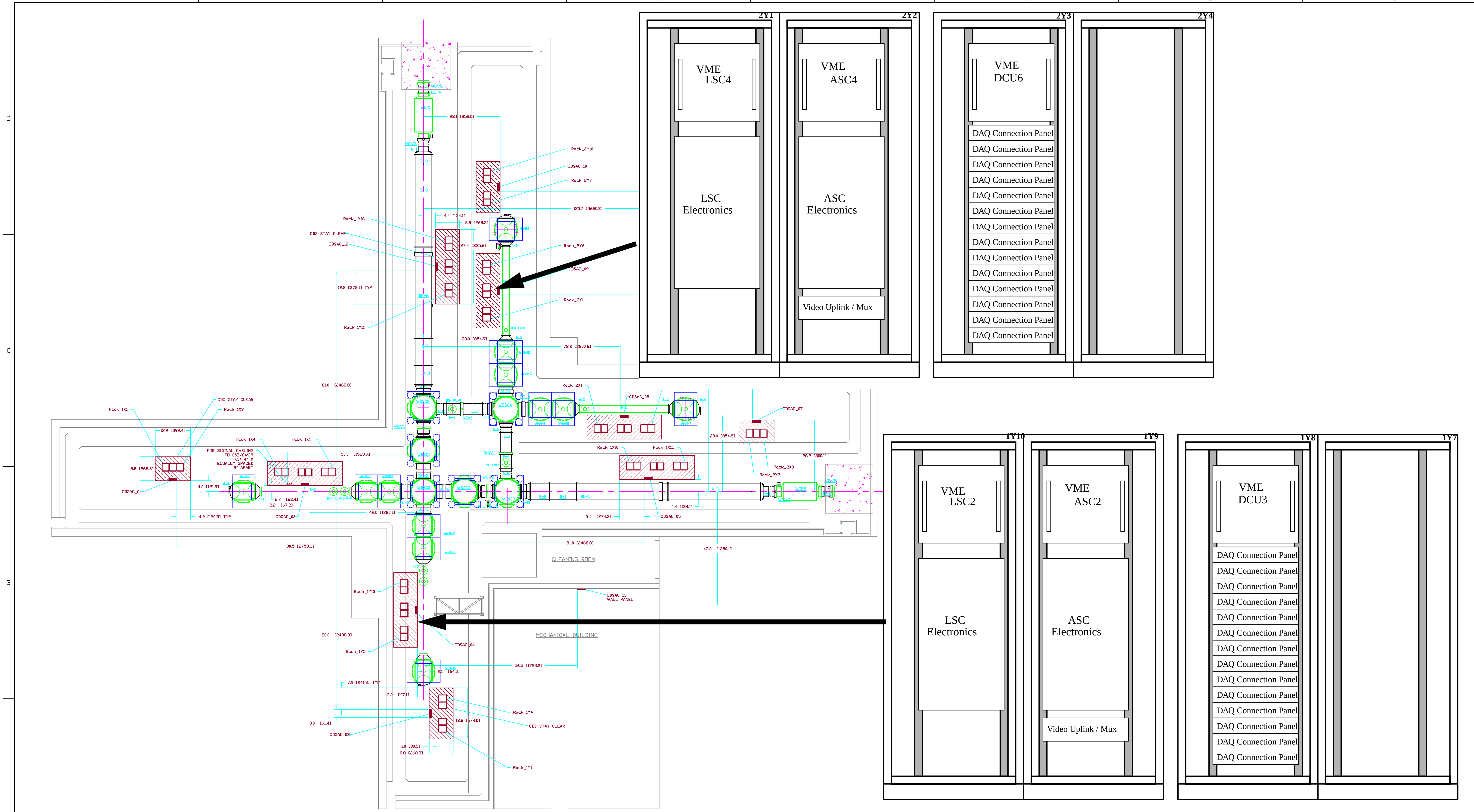
SCALE | SHEET 3 of 5



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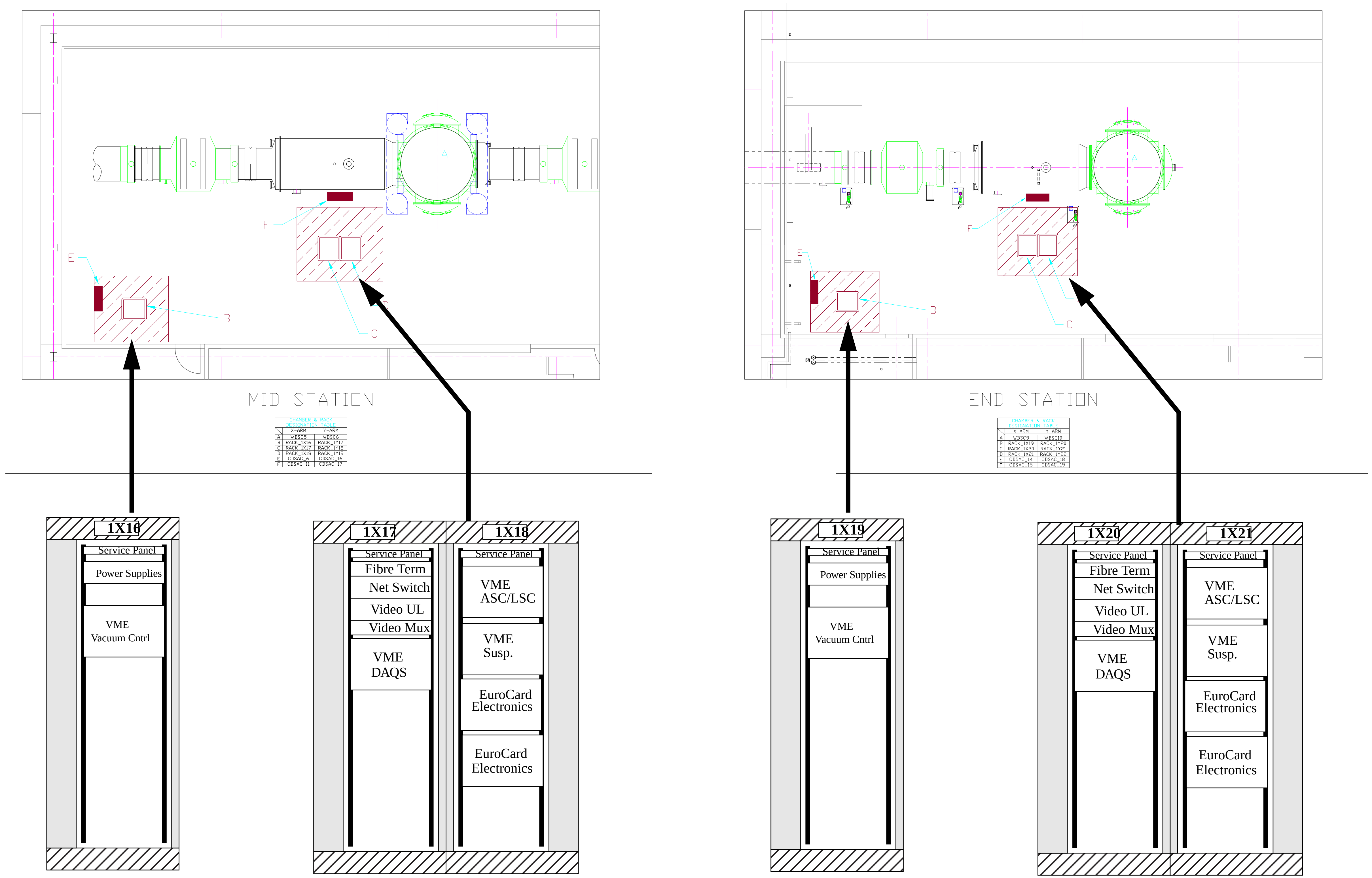
SCALE | SHEET 4 of 5



CHAMBER & RACK DESIGNATION TABLE (MID STATION)

	X-ARM	Y-ARM
A	WBSC5	WBSC6
B	RACK_1X16	RACK_1Y17
C	RACK_1X17	RACK_1Y18
D	RACK_1X18	RACK_1Y19
E	CDSAC_6	CDSAC_16
F	CDSAC_11	CDSAC_17

CHAMBER & RACK DESIGNATION TABLE (END STATION)

	X-ARM	Y-ARM
A	WBSC9	WBSC10
B	RACK_1X19	RACK_1Y20
C	RACK_1X20	RACK_1Y21
D	RACK_1X21	RACK_1Y22
E	CDSAC_14	CDSAC_18
F	CDSAC_15	CDSAC_19

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

REFERENCE DRAWINGS

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Hanford Rack Assignments
Control and Data Systems

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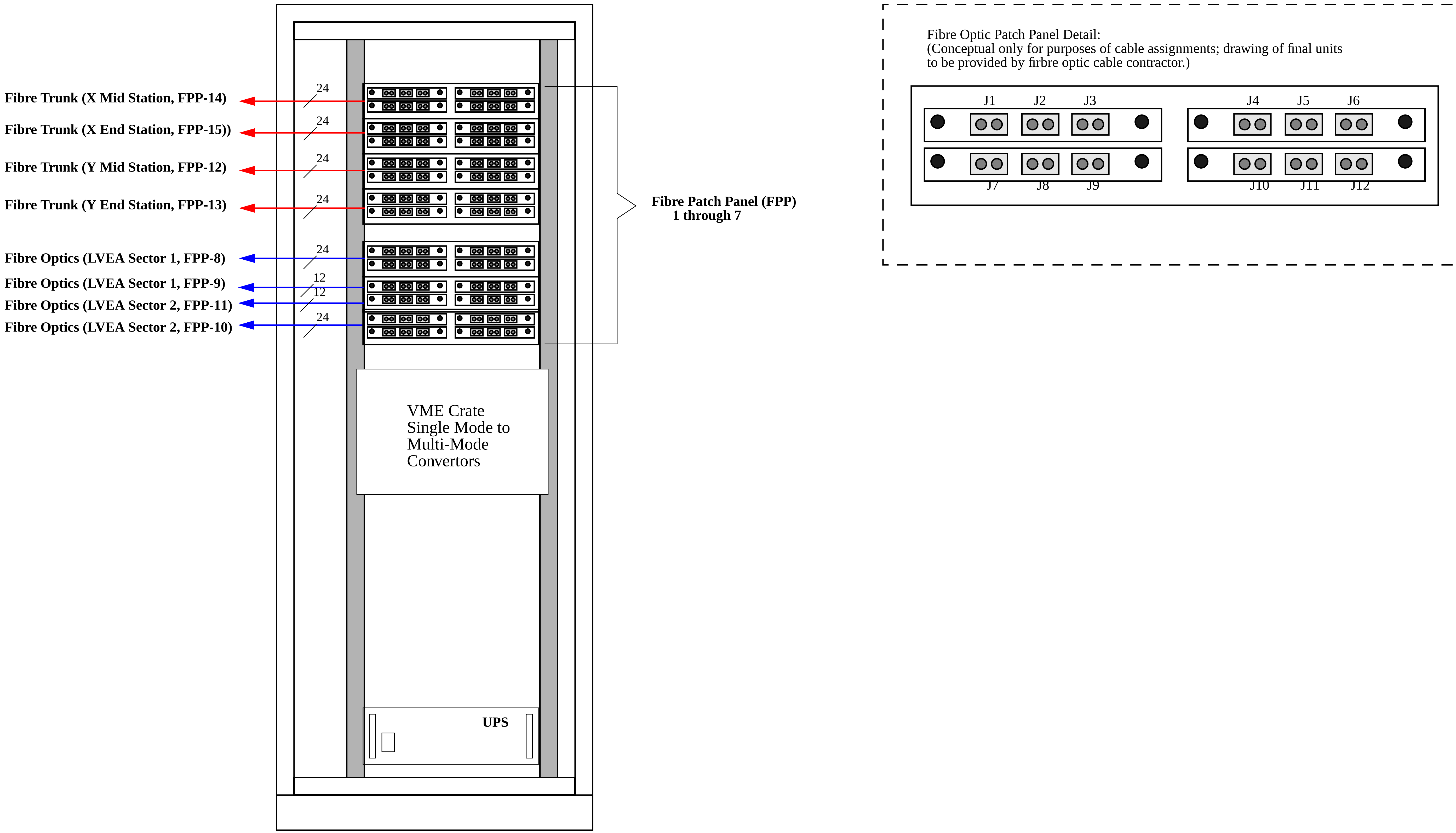
CAD FILE | SCALE | SHEET 5 of 5 | STD | VER. D1



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Hanford Fibre Optic Plant
(Main Trunk Termination Rack)

SCALE | SIZE B | DWG. NO. D970582-00-C | REV.
CAD FILE | SCALE | SHEET 1 of 6 | STD | VER. 01

FPP-1 Connection Assignments (24 fibre trunk to FPP-14):

FPP Connection	Cable Number	To Rack	To Device
J1 - J3			Spare
J4 - J6			Spare
J7			Spare
J8		IMS-1	SM/MM Conv. 1
J9		IMS-1	SM/MM Conv. 2
J10		IMS-1	SM/MM Conv. 3
J11		IMS-2	ASX1000/NIM1/J1
J12		IMS-2	ASX1000/NIM2/J1

FPP-3 Connection Assignments (24 fibre trunk to FPP-12):

FPP Connection	Cable Number	To Rack	To Device
J1 - J3			Spare
J4 - J6			Spare
J7			Spare
J8		IMS-1	SM/MM Conv. 1
J9		IMS-1	SM/MM Conv. 2
J10		IMS-1	SM/MM Conv. 3
J11		IMS-2	ASX1000/NIM1/J1
J12		IMS-2	ASX1000/NIM2/J1

FPP-2 Connection Assignments (24 fibre trunk to FPP-15):

FPP Connection	Cable Number	To Rack	To Device
J1 - J3			Spare
J4 - J6			Spare
J7			Spare
J8		IMS-1	SM/MM Conv. 1
J9		IMS-1	SM/MM Conv. 2
J10		IMS-1	SM/MM Conv. 3
J11		IMS-2	ASX1000/NIM1/J1
J12		IMS-2	ASX1000/NIM2/J1

FPP-4 Connection Assignments (24 fibre trunk to FPP-13):

FPP Connection	Cable Number	To Rack	To Device
J1 - J3			Spare
J4 - J6			Spare
J7			Spare
J8		IMS-1	SM/MM Conv. 1
J9		IMS-1	SM/MM Conv. 2
J10		IMS-1	SM/MM Conv. 3
J11		IMS-2	ASX1000/NIM1/J1
J12		IMS-2	ASX1000/NIM2/J1

FPP-5 Connection Assignments

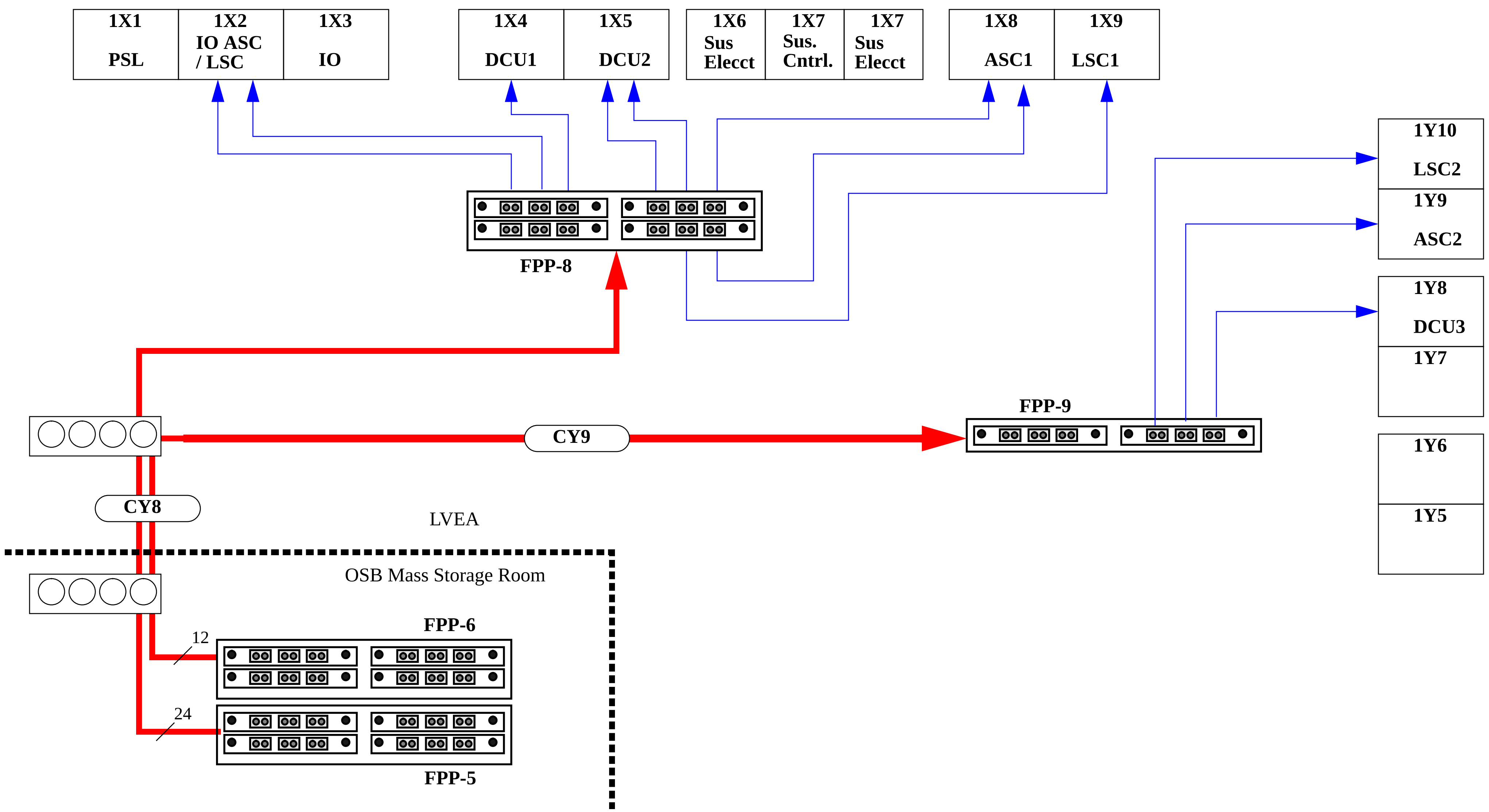
FPP Connection	Cable Number	To Rack	To Device
J1			TBD LSC
J2			TBD ASC
J3		IMS-3	TBD DAQ
J4		IMS-3	TBD DAQ
J5		IMS-2	ASX1000/NIM1/J2
J6			TBD ASC
J7			Spare
J8			Spare
J9			Spare
J10			Spare
J11			TBD LSC
J12		IMS-2	ASX1000/NIM1/J3

FPP-6 Connection Assignments :

FPP Connection	Cable Number	To Rack	To Device
J1			Spare
J2			Spare
J3			Spare
J4			TBD LSC
J5			TBD ASC
J6		IMS-3	TBD DAQ
J7			Spare
J8			Spare
J9			Spare
J10		IMS-4	TBD DAQ
J11			TBD ASC
J12			TBD LSC

FPP-7 Connection Assignments :

FPP Connection	Cable Number	To Rack	To Device
J1			TBD LSC
J2			TBD ASC
J3		IMS-2	ASX1000/NIM2/J3
J4		IMS-4	TBD DAQ
J5		IMS-4	TBD DAQ
J6		IMS-2	ASX1000/NIM2/J2
J7			Spare
J8			Spare
J9			Spare
J10			Spare
J11			TBD ASC
J12			TBD LSC



FPP-8 Connection Assignments:

FPP- 8 Connection	Cable Number	To Rack	To Device
J1		1X2	IO LSC Refl. Mem.
J2		1X2	IO ASC Refl. Mem.
J3		1X4	DAQ Refl. Mem.
J4		1X5	DAQ Refl. Mem.
J5		1X5	ES-3810 (ATM)
J6		1X8	ASC Refl. Mem.
J7			Spare
J8			Spare
J9			Spare
J10			Spare
J11			LSC Refl. Mem.
J12			AVA-300 (Video)

FPP-9 Connection Assignments:

FPP- 9 Connection	Cable Number	To Rack	To Device
J1			Spare
J2			Spare
J3			Spare
J4		1Y10	LSC Refl. Mem.
J5		1Y9	ASC Refl. Mem.
J6		1Y8	DAQ Refl. Mem.

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

REFERENCE DRAWINGS

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DIMENSIONS ARE IN INCHES
TOLERANCES:
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THREE PLACE DECIMAL ±
FINISHED SURFACE RMS
BREAK CORNERS IN: OUT:
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Hanford Fibre Optic Plant
(LVEA Sector 1 Fibres)

SCALE | SIZE B | DWG. NO. D970582-00-C | REV.
CAD FILE | SCALE | SHEET 4 of 6 | STD | VER. D1

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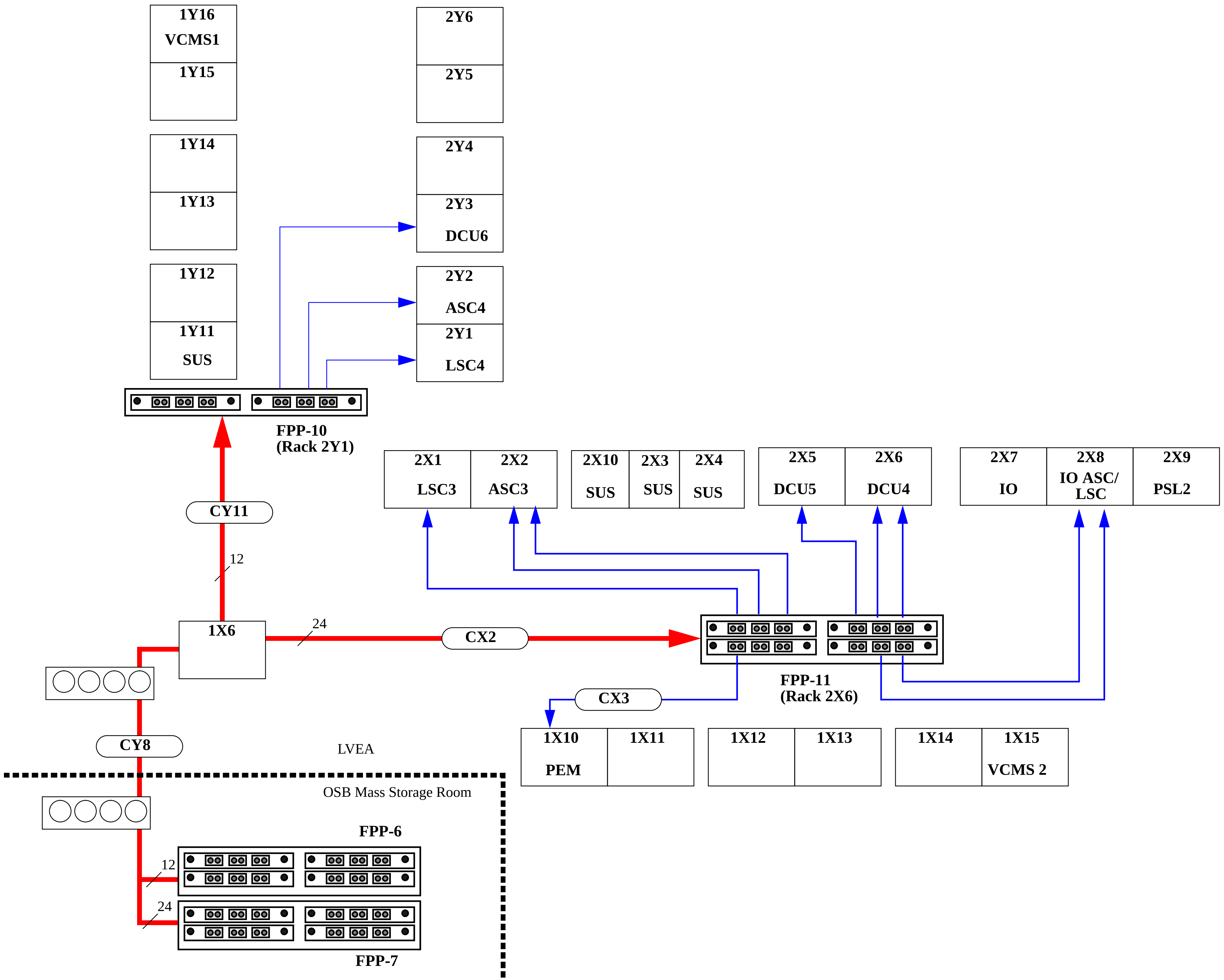

FPP-11 Connection Assignments:

FPP- 11 Connection	Cable Number	To Rack	To Device
J1		2X1	LSC Refl. Mem.
J2		2X2	ASC Refl. Mem.
J3		2X2	AVA-300 (Video)
J4		2X5	DAQ Refl. Mem.
J5		2X6	ES-3810 (ATM)
J6		2X6	DAQ Refl. Mem.
J7		1X10	DAQ Refl. Mem.
J8			Spare
J9			Spare
J10			Spare
J11		2X8	IO LSC Refl. Mem.
J12		2X8	IO ASC Refl. Mem.

FPP-10 Connection Assignments:

FPP- 10 Connection	Cable Number	To Rack	To Device
J1			Spare
J2			Spare
J3			Spare
J4		2Y3	DAQ Refl. Mem.
J5		2Y2	ASC Refl. Mem.
J6		2Y1	LSC Refl. Mem.

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION

REFERENCE DRAWINGS

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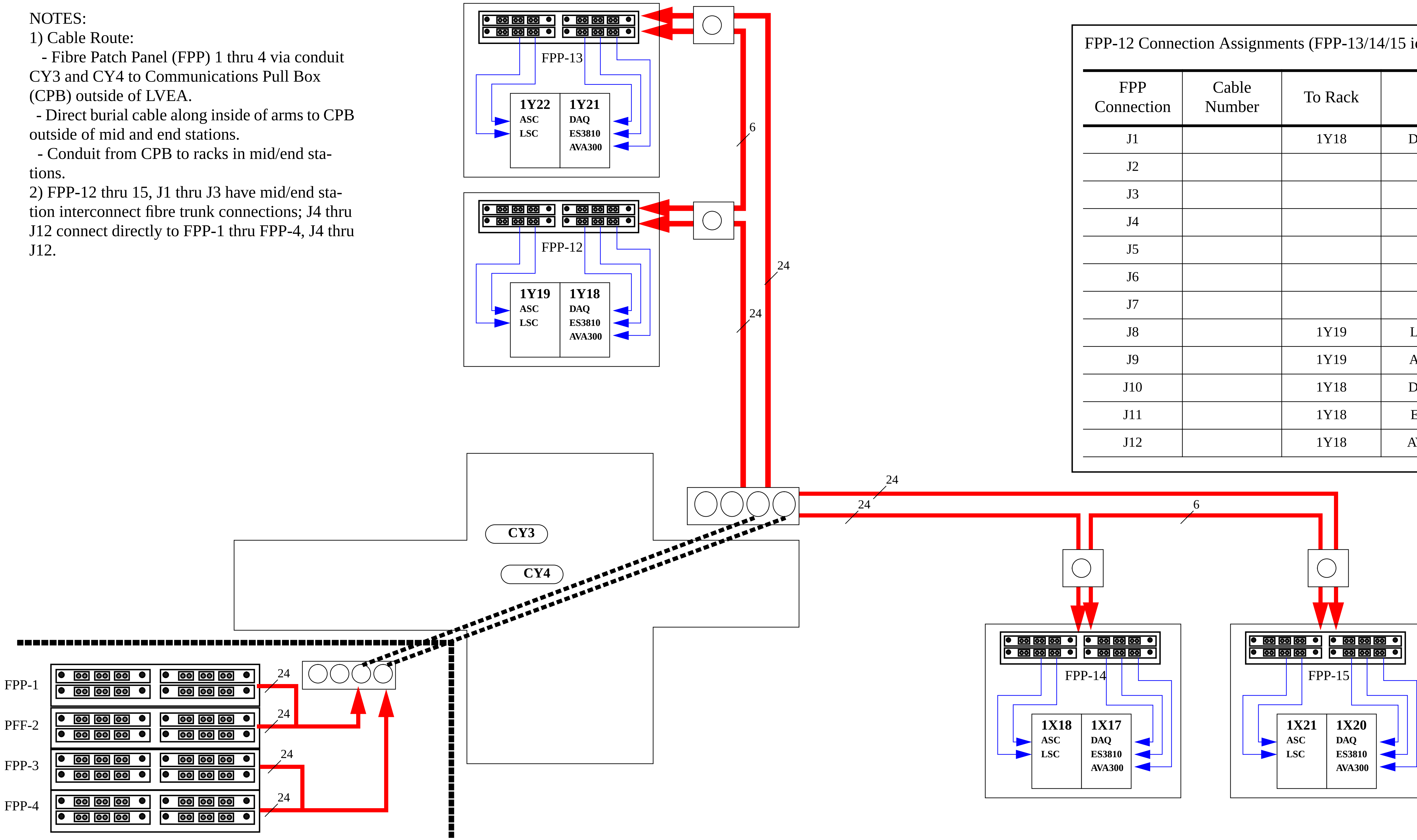
Hanford Fibre Optic Plant
(LVEA Sector 2 Fibres)

SCALE | SIZE B | DWG. NO. D970582-00-C | REV.
CAD FILE | SCALE | SHEET 5 of 6 | STD | VER. 01

NOTES:
1) Cable Route:
- Fibre Patch Panel (FPP) 1 thru 4 via conduit CY3 and CY4 to Communications Pull Box (CPB) outside of LVEA.
- Direct burial cable along inside of arms to CPB outside of mid and end stations.
- Conduit from CPB to racks in mid/end stations.

2) FPP-12 thru 15, J1 thru J3 have mid/end station interconnect fibre trunk connections; J4 thru J12 connect directly to FPP-1 thru FPP-4, J4 thru J12.



FPP-12 Connection Assignments (FPP-13/14/15 identical):

FPP Connection	Cable Number	To Rack	To Device
J1		1Y18	DAQ Refl. Mem.
J2			Spare
J3			Spare
J4			Spare
J5			Spare
J6			Spare
J7			Spare
J8		1Y19	LSC Refl. Mem.
J9		1Y19	ASC Refl. Mem.
J10		1Y18	DAQ Refl. Mem.
J11		1Y18	ES-3810 (ATM)
J12		1Y18	AVA-300 (Video)

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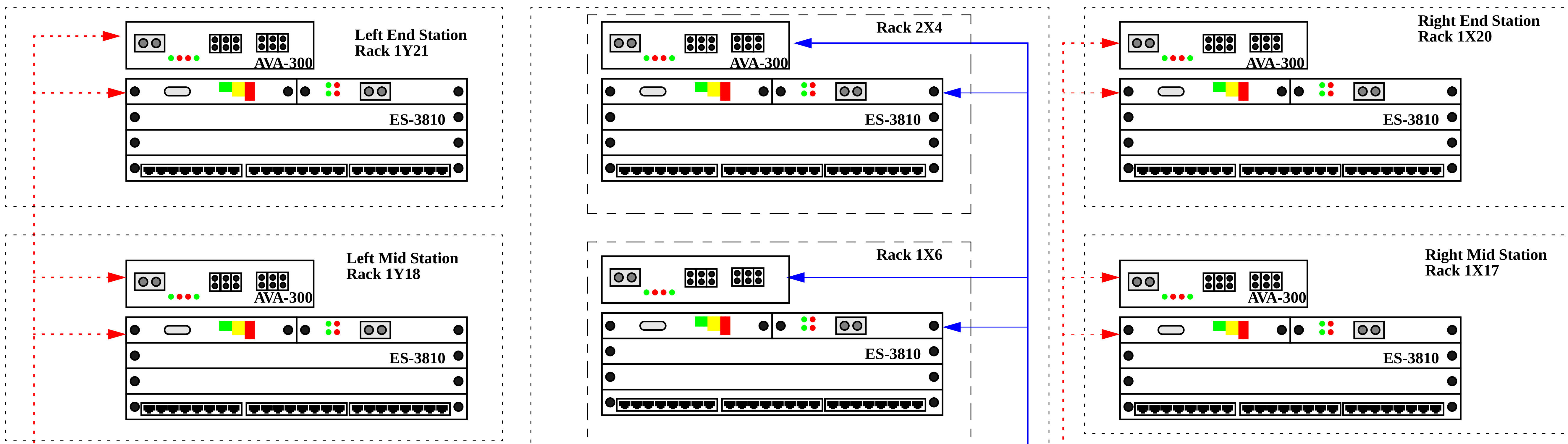
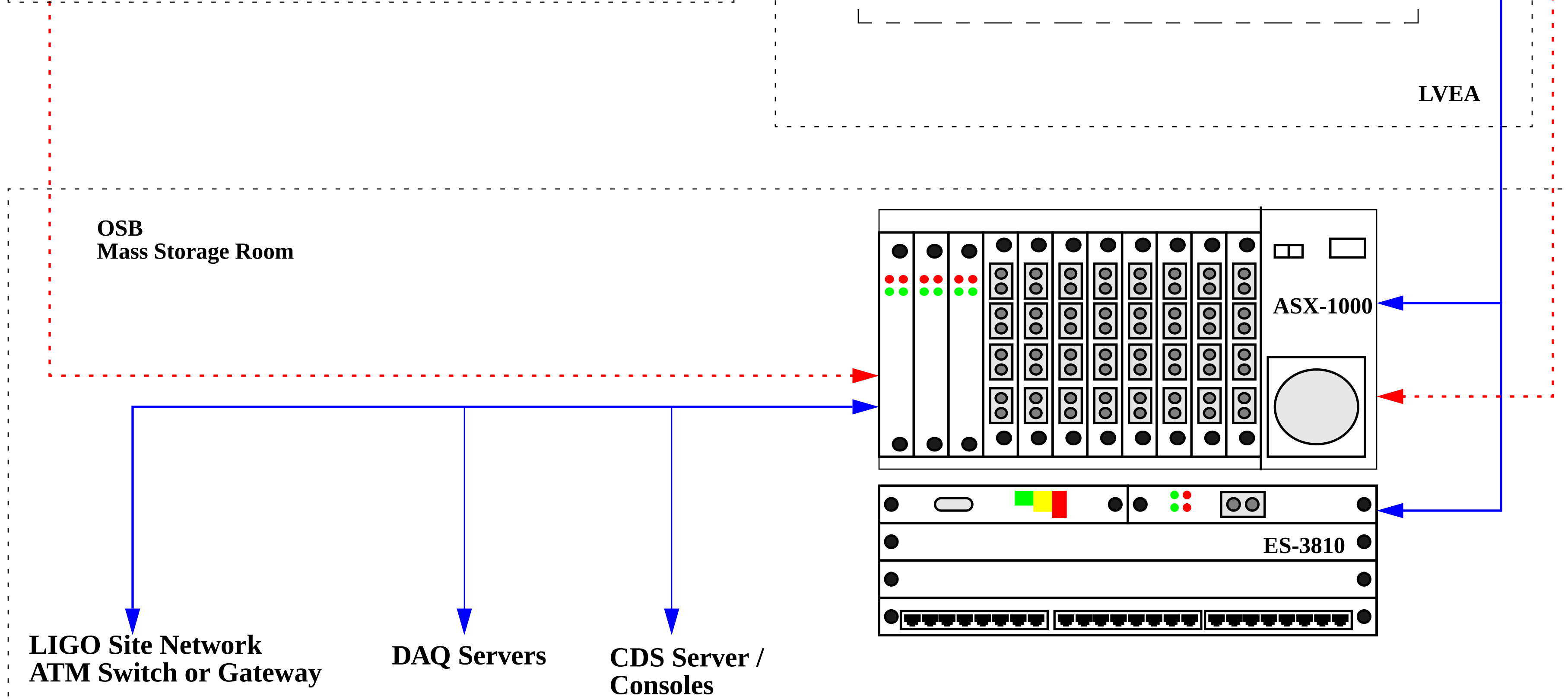
Hanford Fibre Optic Plant
(Mid and End Station Fibres)

DWG. NO. D970582-00-C





Notes:
1) All connections to mid and end stations via single mode fibre optics (red / dotted lines).
2) Connections within LVEA and OSB via multi-mode fibre optics (blue / solid lines).

Equipment:
1) ASX-1000: ATM backbone switch w/two controllers and power supplies, 8 OC-3 interface modules. Each interface module contains one long range, single mode fibre transceiver and three short range, multi-mode fiber transceivers.
2) ES-3810: Ethernet switch unit, with one 155Mbit/sec OC-3 uplink to the ATM switch and 24 ethernet ports for connection to local processors.
3) AVA-300: Video interface unit, with one 155Mbit/sec OC-3 uplink to the ATM switch and six ports for video camera connections.

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION
D970100-C	Hanford Network Cable Plant		

REFERENCE DRAWINGS

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FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
FINISHED SURFACE RMS
BREAK CORNERS IN. OUT.
REMOVE ALL BURRS

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Hanford Control & Monitoring Network
(Overview)

SCALE | SIZE B | DWG. NO. D970583-00-C | REV.
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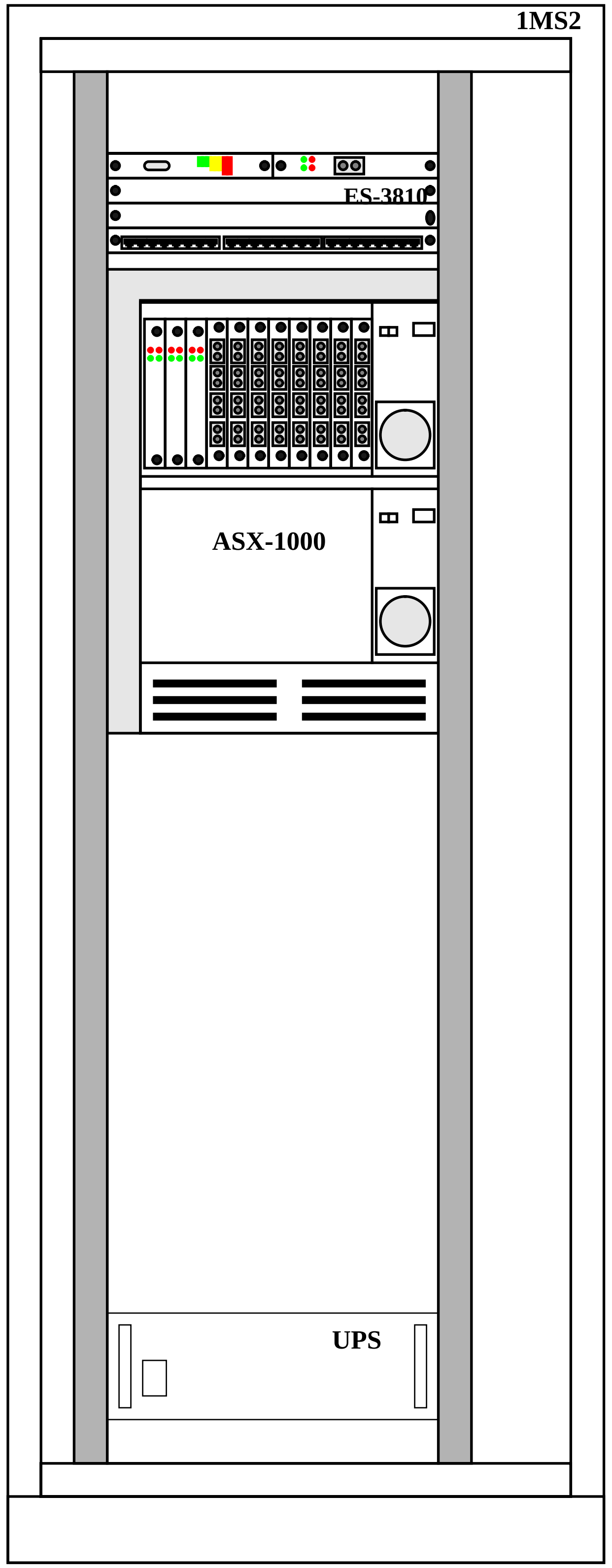

ASX-1000 NIM/Channel Assignments (NIM 1 thru 4)

ASX-1000		Destination		
NIM-Chan.	Fibre Type	Bldg.	Rack	Device
1-1	SM	Mid X	1X17	ES-3810
1-2	MM	LVEA	1X5	ES-3810
1-3	MM	LVEA	1X8	AVA-300
1-4	MM			
2-1	SM	Mid X	1X17	AVA-300
2-2	MM	LVEA	2X6	ES-3810
2-3	MM	LVEA	2X2	AVA-300
2-4	MM			
3-1	SM	End X	1X20	ES-3810
3-2	MM	OSB		DAQ Svr 1
3-3	MM	OSB		DAQ Svr 2
3-4	MM	OSB		CDS Svr 1
4-1	SM	End X	1X20	AVA-300
4-2	MM	OSB		CDS Svr 2
4-3	MM	OSB		CDS FWall
4-4	MM	OSB		ES-3810

ASX-1000 NIM/Channel Assignments (NIM 5 thru 8)

ASX-1000		Destination		
NIM-Chan.	Fibre Type	Bldg.	Rack	Device
5-1	SM	Mid Y	1Y18	ES-3810
5-2	MM	OSB		FB-1
5-3	MM	OSB		FB-2
5-4	MM			
6-1	SM	Mid Y	1Y18	AVA-300
6-2	MM			
6-3	MM			
6-4	MM	OSB	Console 7	UltraSparc
7-1	SM	End Y	1Y20	ES-3810
7-2	MM	OSB	Console 1	UltraSparc
7-3	MM	OSB	Console 2	UltraSparc
7-4	MM	OSB	Console 3	UltraSparc
8-1	SM	End Y	1Y20	AVA-300
8-2	MM	OSB	Console 4	UltraSparc
8-3	MM	OSB	Console 5	UltraSparc
8-4	MM	OSB	Console 6	UltraSparc

Notes:
1) Equipment to be housed in rack 1MS2 (in Mass Storage Room), adjacent to Fibre Optic Trunk Rack 1MS1.
2) ES-3810 provides 24 switched ethernet ports to CDS computers in OSB. Port assignments are TBD.

DWG. NO.	DESCRIPTION
D970100-C	Hanford Network Cable Plant

REFERENCE DRAWINGS

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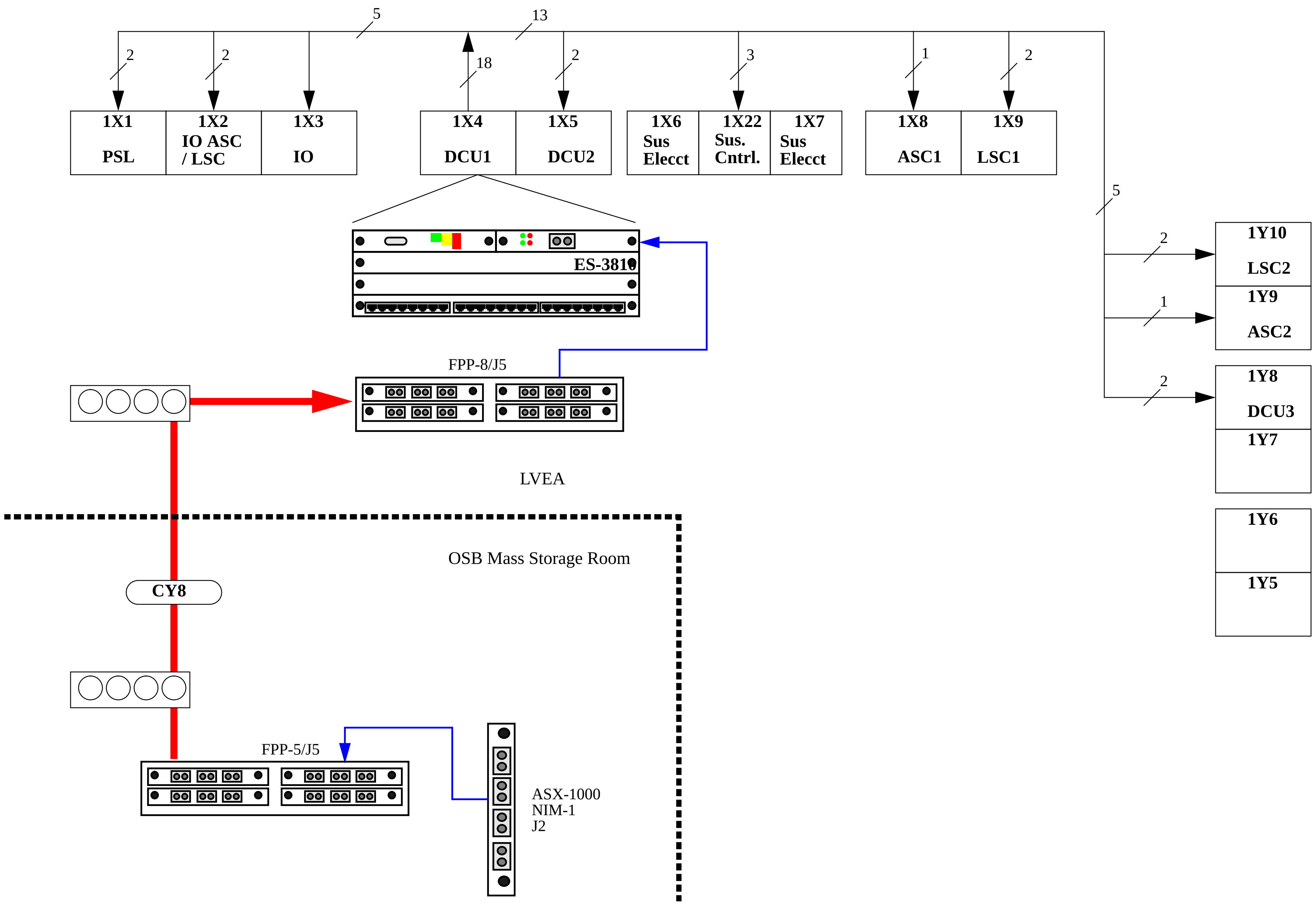
Hanford Control & Monitoring Network
Main Networking Rack / ATM Connections)

SIZE B DWG. NO. D970583-00-C



ES-3810 (LVEA Sector 1) Connection Assignments:

ES-3810 Connection	Cable Number	To Rack	To Device
J1		1X1	PSL Processor
J2		1X1	Rack Outlet
J3		1X2	IO ASC Processor
J4		1X2	IO LSC Processor
J5		1X3	Rack Outlet
J6			Spare
J7		1X4	DAQ Processor
J8		1X5	DAQ Processor
J9		1X5	Rack Outlet
J10		1X22	IO Processor
J11		1X22	CO Processor
J12		1X22	Rack Outlet
J13		1X8	ASC Processor
J14		1X9	LSC Processor
J15		1X9	Rack Outlet
J16		1Y10	LSC Processor
J17		1Y10	Rack Outlet
J18		1Y9	ASC Processor
J19		1Y8	DAQ Processor
J20		1Y8	Rack Outlet
J21			Spare
J22			Spare
J23			Spare
J24			Spare

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ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
FINISHED SURFACE RMS
BREAK CORNERS IN. OUT.
REMOVE ALL BURRS

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Hanford Control & Monitoring Network
LVEA Sector 1

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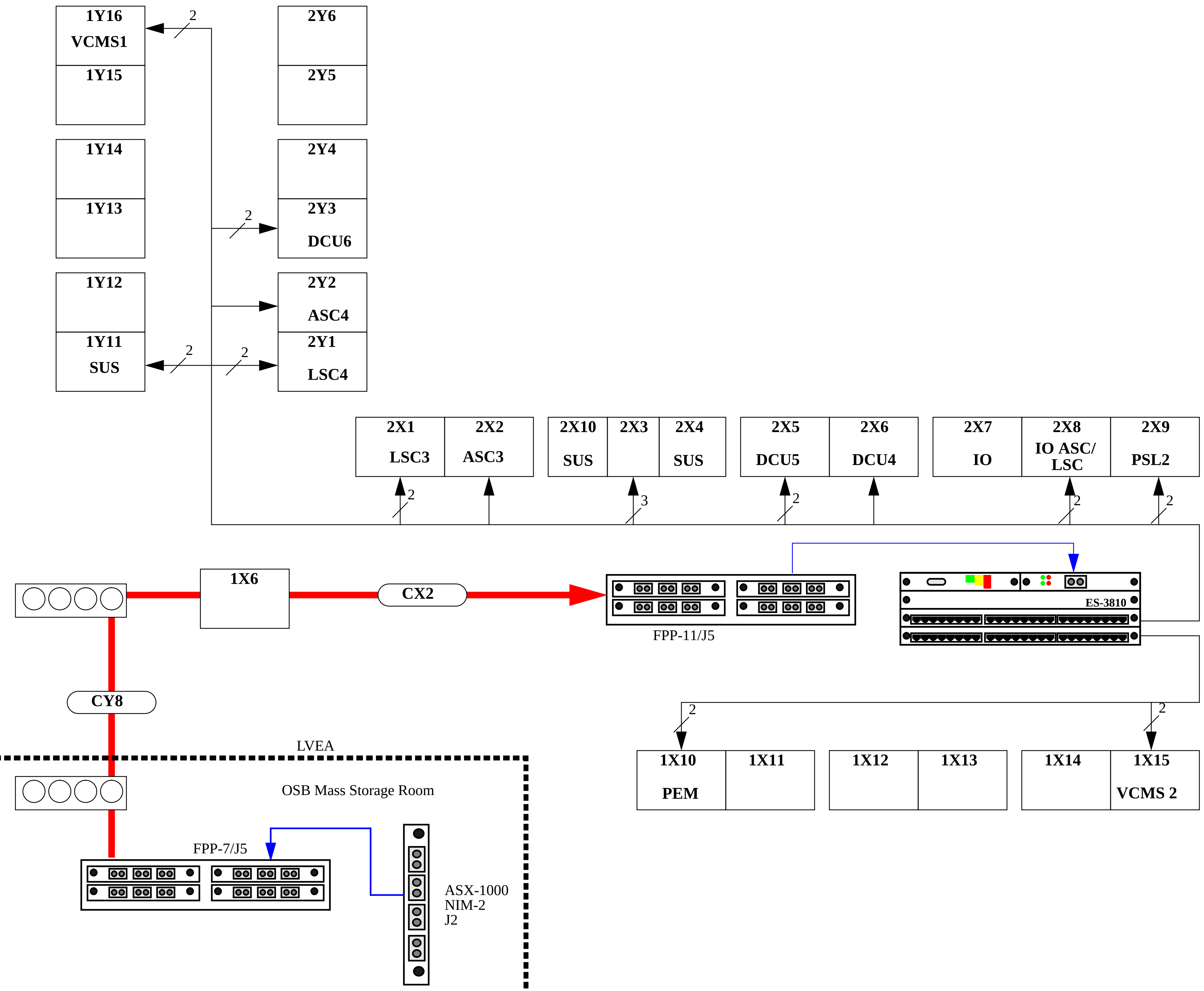

ES-3810 (LVEA Sector 2) Connection Assignments:

ES-3810 Connection	Cable Number	To Rack	To Device
J1		2X9	PSL Processor
J2		2X9	Rack Outlet
J3		2X8	IO ASC Processor
J4		2X8	IO LSC Processor
J5		2X6	DAQ Processor
J6		2X5	DAQ Processor
J7		2X5	Rack Outlet
J8		2X3	IO Processor
J9		2X3	CO Processor
J10		2X3	Rack Outlet
J11		2X2	ASC Processor
J12		2X1	LSC Processor
J13		2X1	Rack Outlet
J14		2Y1	LSC Processor
J15		2Y1	Rack Outlet
J16		2Y2	ASC Processor
J17		2Y3	DAQ Processor
J18		2Y3	Rack Outlet
J19		1Y11	Fold Mirror Susp.
J20		1Y11	Rack Outlet
J21		1Y16	VCMS1 Processor
J22		1Y16	Rack Outlet
J23		1X15	VCMS2 Processor
J24		1X15	Rack Outlet
J25		1X10	PEM DAQ Processor
J26		1X10	Rack Outlet
J27-J48			Spares

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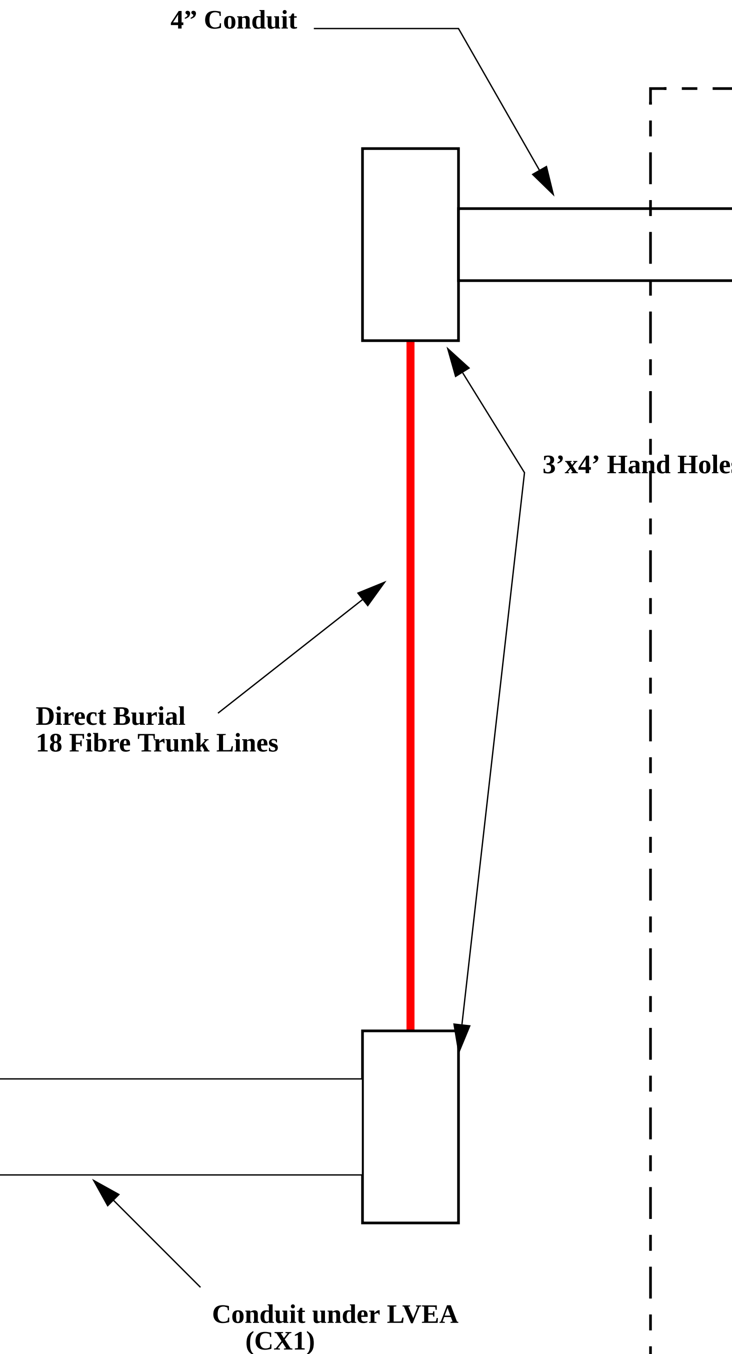
Hanford Control & Monitoring Network
LVEA Sector 2

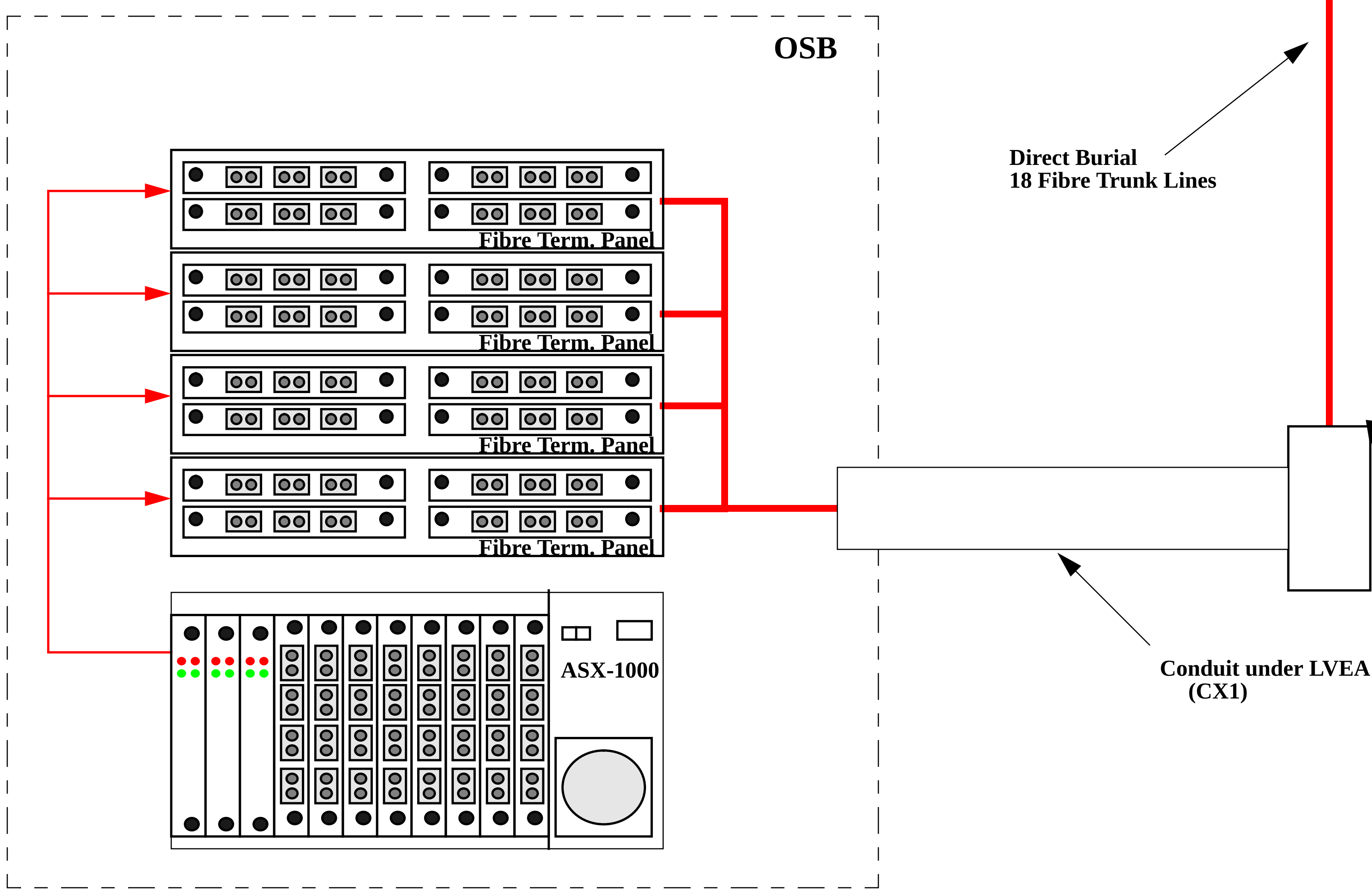
SIZE B DWG. NO D970583-00-C REV. 0

SHEET 4 of 5

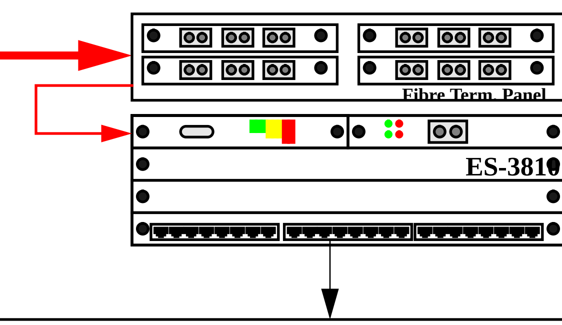
Notes:

1) See Fibre Optic Plant drawing D97xxxx-00-C for fibre termination points.
2) Mid station on X arm will also contain an ethernet hub which connects port J11 of the ES-3810 to another hub midway down the X1 beam tube enclosure for purposes of connecting an RGA controller.





Typical Mid/End Station Connections



ES-3810 (Mid/End Station) Connection Assignments:

ES-3810	Cable Number	To Rack	To Device
J1		A	VCMS Processor
J2		A	Rack Outlet
J3		B	DAQ Processor
J4		B	PEM Processor
J5		B	Rack Outlet
J6		C	LSC Processor
J7		C	ASC Processor
J8		C	CO Susp. Processor
J9		C	Rack Outlet
J10		TBD	FCMS
J11-J24			Spares

Rack Designations

Rack	X Mid	X End	Y Mid	Y End
A	1X16	1X19	1Y17	1Y20
B	1X17	1X20	1Y18	1Y21
C	1X18	1X21	1Y19	1Y22

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Hanford Control & Monitoring Network
Mid & End Stations

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