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CDS Control and Monitoring Conceptual Design

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1 INTRODUCTION

1.1. Purpose

The purpose of this document is to describe the overall design of the LIGO Control and Data Systems (CDS) control and monitoring system.

1.2. Scope

CDS for LIGO has been divided, for design purposes, into two major components: Control and Monitoring and Data Acquisition. The Data Acquisition system is described in other documentation, namely the requirements in LIGO T960009-C and conceptual design in LIGO T960010-C.

This document describes a conceptual design for the infrastructure to be employed in the 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 enviroment control subsystems.

1.3. Document Overview

This document represents the conceptual design and will be "frozen" at the time of the CDS Global Design Requirements Review (DRR). This document will then be copied into and further detailed in a Preliminary Design Document (PDD), which (less the final detailed installation drawings), becomes the LIGO CDS design which will be implemented. An updated PDD and all installation plans and drawings will then become the final design package.

This document details a design which depicts what would be installed in the system if the system were to be deployed in the near term with today's technology. Since CDS involves a large amount of computer and related equipment, it is anticipated that these technologies will advance over the next two years before major purchases are made. Therefore, specific equipment selections shown in this document will change over the design phase, but the general concepts should still be valid.

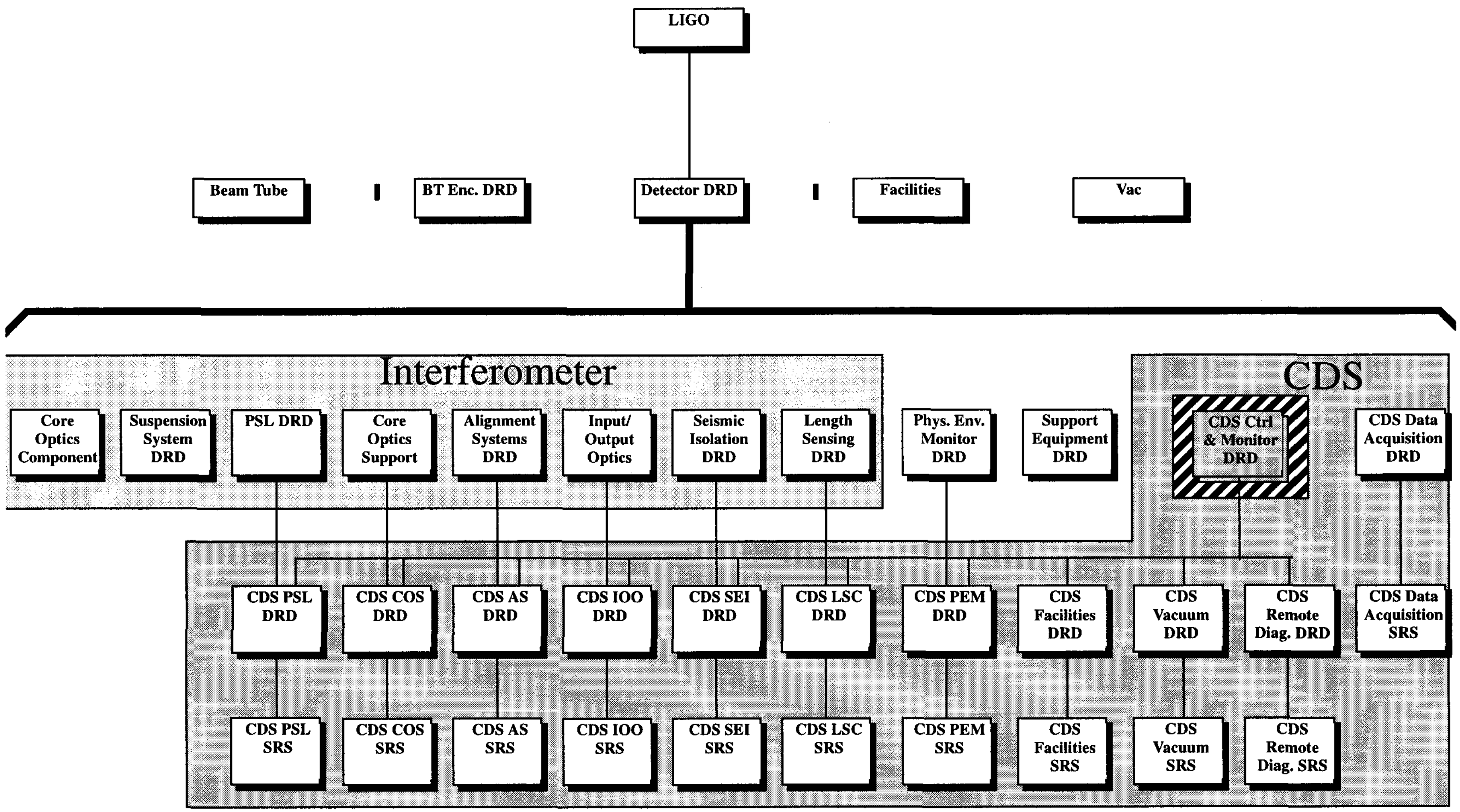


Figure 1: LIGO Requirement Specification Tree

1.4. Definitions

1.5. Acronyms

- ALM - EPICS Alarm Manager
- API - Application Programmer's Interface
- APS - Advanced Photon Source (Argonne National Lab)
- AR - EPICS data archiver
- ARR - EPICS archive retrieval tool
- ATM - Asynchronous Transfer Mode
- BURT - BackUp and Restore Tool
- CA - Channel Access
- CDS - Control and Data System
- CEBAF - Continuous Electron Beam Accelerator Facility
- CIM - Computer Integration and Manufacturing
- CPU - Central Processing Unit
- DCS - Distributed Control System
- DRD - Design Requirements Document
- EPICS - Experimental Physics and Industrial Control System
- EZCA - Easy Channel Access
- FC - Fiber Channel
- FCMS - Facility Control and Monitoring System
- FCR - Facility Control Room
- FDDI - Fiber Distributed Data Interface
- GPS - Global Positioning System
- GUI - Graphical User Interface
- HMI - Human Machine Interface
- HPPI - High Performance Parallel Interface
- Hz - Hertz
- IEEE - Institute of Electronic and Electrical Engineering
- IFO - Interferometer
- I/O - Input/Output
- IP - Internet Protocol
- ISO - International Standards Organization
- IXS - Information eXchange Services
- LAN - Local Area Network
- LANL - Los Alamos National Laboratory
- LIGO - Laser Interferometer Gravity wave Observatory
- LVEA - Laser and Vacuum Equipment Area
- MAC - Media Access Layer
- MEDM - Motif Epics Display Manager
- MHz - Mega Hertz
- NASA - National Aeronautics and Space Administration
- NSAP - Network Service Access Port
- OSB - Operations Support Building
- PDD - Preliminary Design Document

- PSL - PreStabilized Laser
- TBD - To Be Determined
- TCP - Transport Control Protocol
- UDP - User Datagram Protocol
- 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

1.6.1. LIGO Documents

CDS Control and Monitoring DRD LIGO T950054-C

CDS Data Acquisition System DRD LIGO T960009-C

CDS Data Acquisition System Conceptual Design LIGOT960010-C

CDS Vacuum Cabling and Feed Through DRD LIGO T950095-C

1.6.2. LIGO Drawings

1.6.3. Non-LIGO Documents

1.6.4. Non-LIGO Drawings

2 SYSTEM OVERVIEW

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

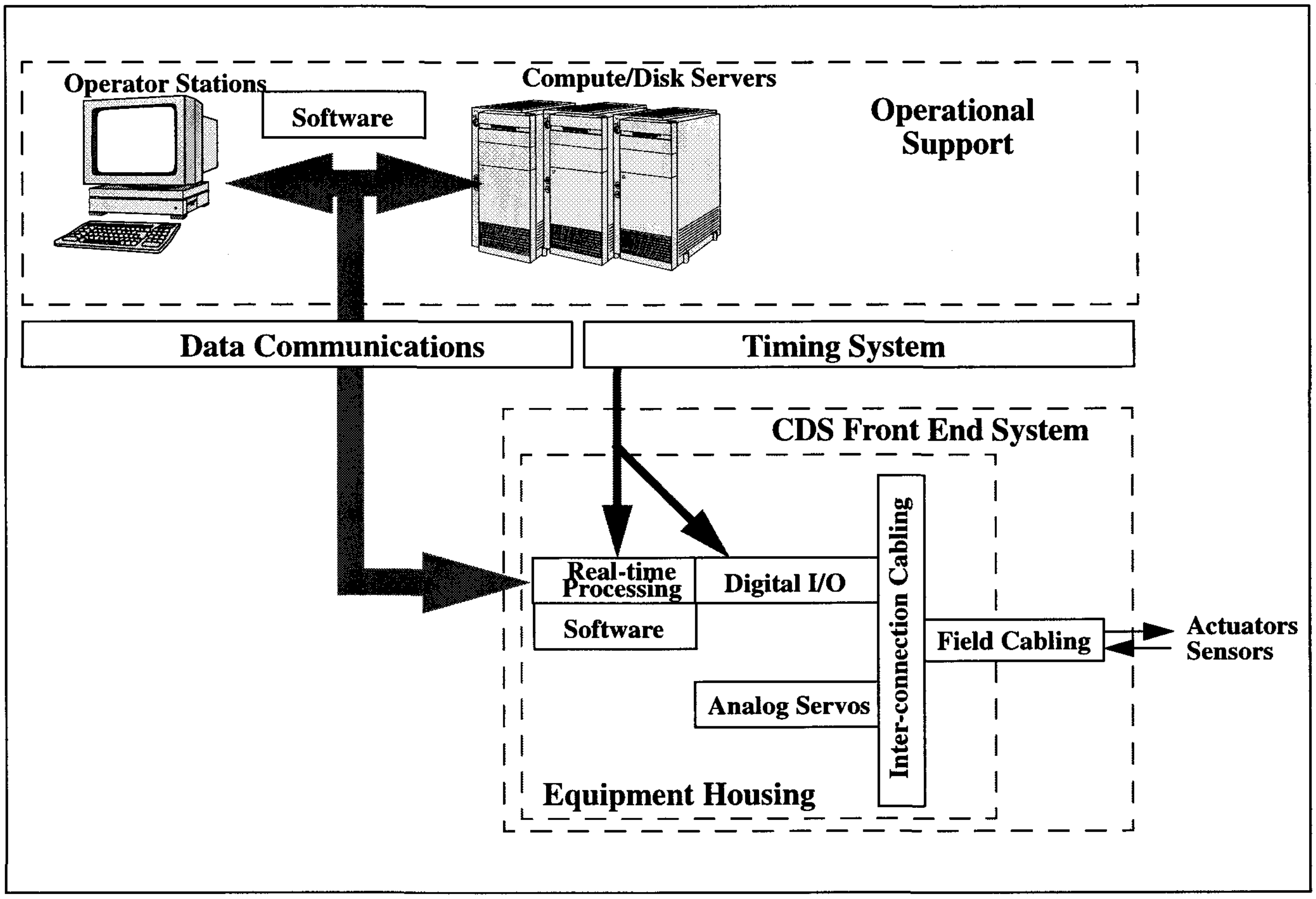


Figure 2: CDS Overview

3 FRONT END SYSTEMS

Front end systems are the field units which connect the CDS to the equipment to be controlled and/or monitored. The following sections describe the standard equipment to be employed in these systems.

3.1. Front End Processor / I/O Bus

3.1.1. Design

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 will also be used in limited applications.

As shown in the standard rack layout sketch, a VME crate will exist in each CDS rack pair (on average). The VME crate will feature a "split" backplane. Slots 0-10 will house the control and monitoring processor(s) and I/O modules. Slot 11 will not have backplane connections. Slots 12-21 will contain the CDS DAQ processor(s) and I/O modules. This is done to save on crate costs, as initial estimates indicate that separate crates would underutilize the slot space for control and monitoring and data acquisition, and therefore functions can be combined into the same crate. Estimates of VME bus usage, however, indicate that the two functions require separate backbones.

3.1.2. Design Analysis

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.

Due to its higher cost, VXI systems will be employed in a capacity limited to special test equipment setups where VXI instrumentation modules are available. This will be primarily in the realm of CDS Remote Diagnostics (described in separate documentation).

3.2. 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.

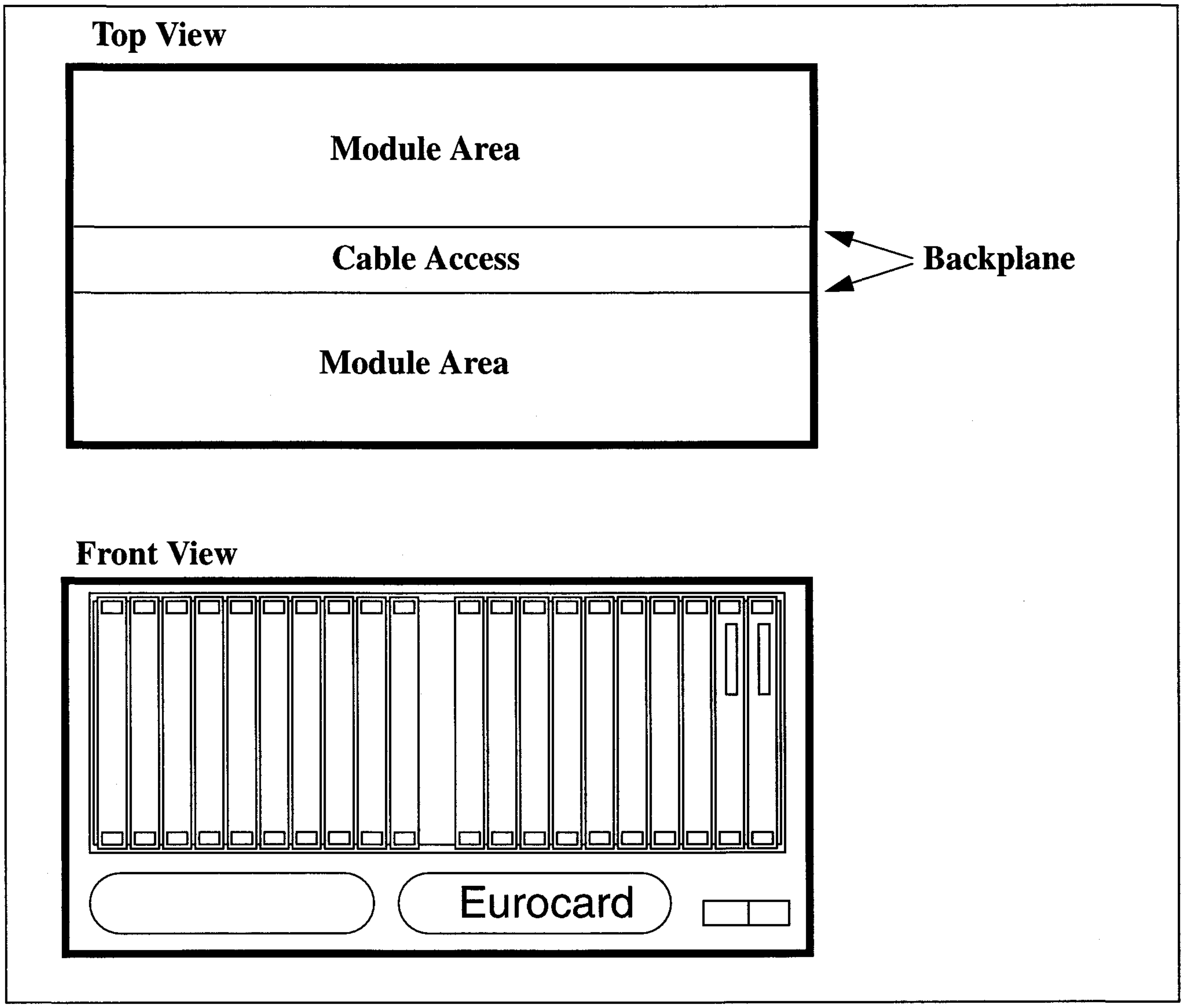
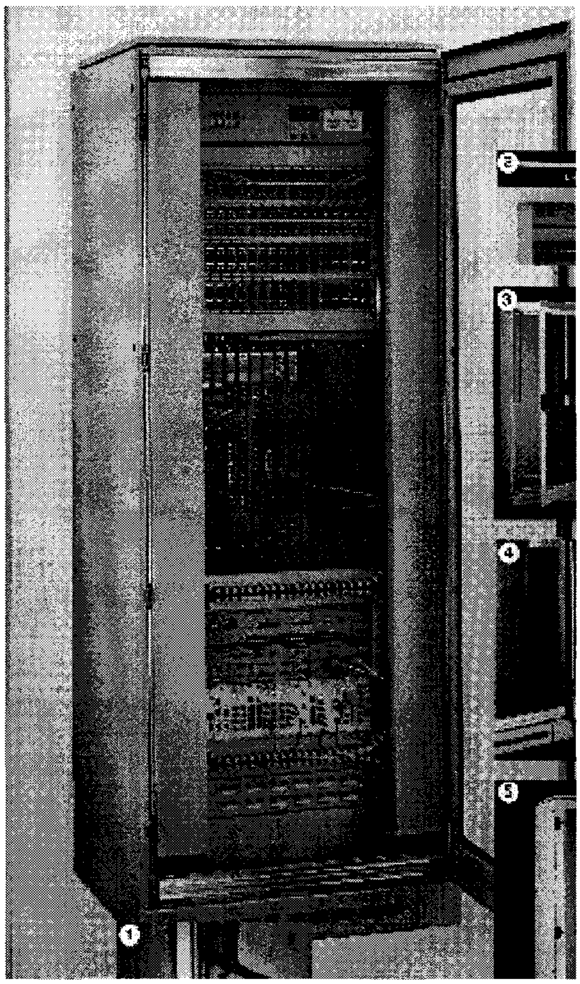


Figure 3: CDS Eurocard Cage

3.3. Equipment Housing

3.3.1. 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: 27.6" x 31.5" x 84"
- Doors: Front/Rear/Side
- Side cable feed base
- 41U installation area (71.75")
- Load Capacity: 225 lbs.
- Power dissipation: 700W max.

Figure 4: CDS Rack Standard

3.3.2. Typical Layout

A typical front end rack layout 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.