LIGO Control and Data System

9 June 1994

LIGO CDS team

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LIGO PROJECT

Tasks of CDS

The tasks of the LIGO CDS are to provide the following functions to the LIGO plant:

— remote plant operation from a central control room

— acquisition and handling of physics data

— acquisition and handling of plant data

— interferometer control loops

— data archiving

— data analysis tools

CDS does not handle the following tasks:

— personnel safety

— data analysis algorithms

Physics Data

Present data rate estimate for one interferometer:

number of channels	sampling rate	data rate (ksamples/s)
132	20 kHz	2640
100	2 kHz	200
275	200 Hz	55
930	2 Hz	1.86
Total:1437		2896.86 ksamples/s (5793.72 kBytes/s)

Servo Loops

LIGO interferometers will be equipped with about 60 servo loops per interferometer:

— 6 frequency control loops

— 1 intensity stabilizing loop

— 54 attitude control loops

— 2 beam positioning control loops

Servo loops are implemented as analogue feedback loops.

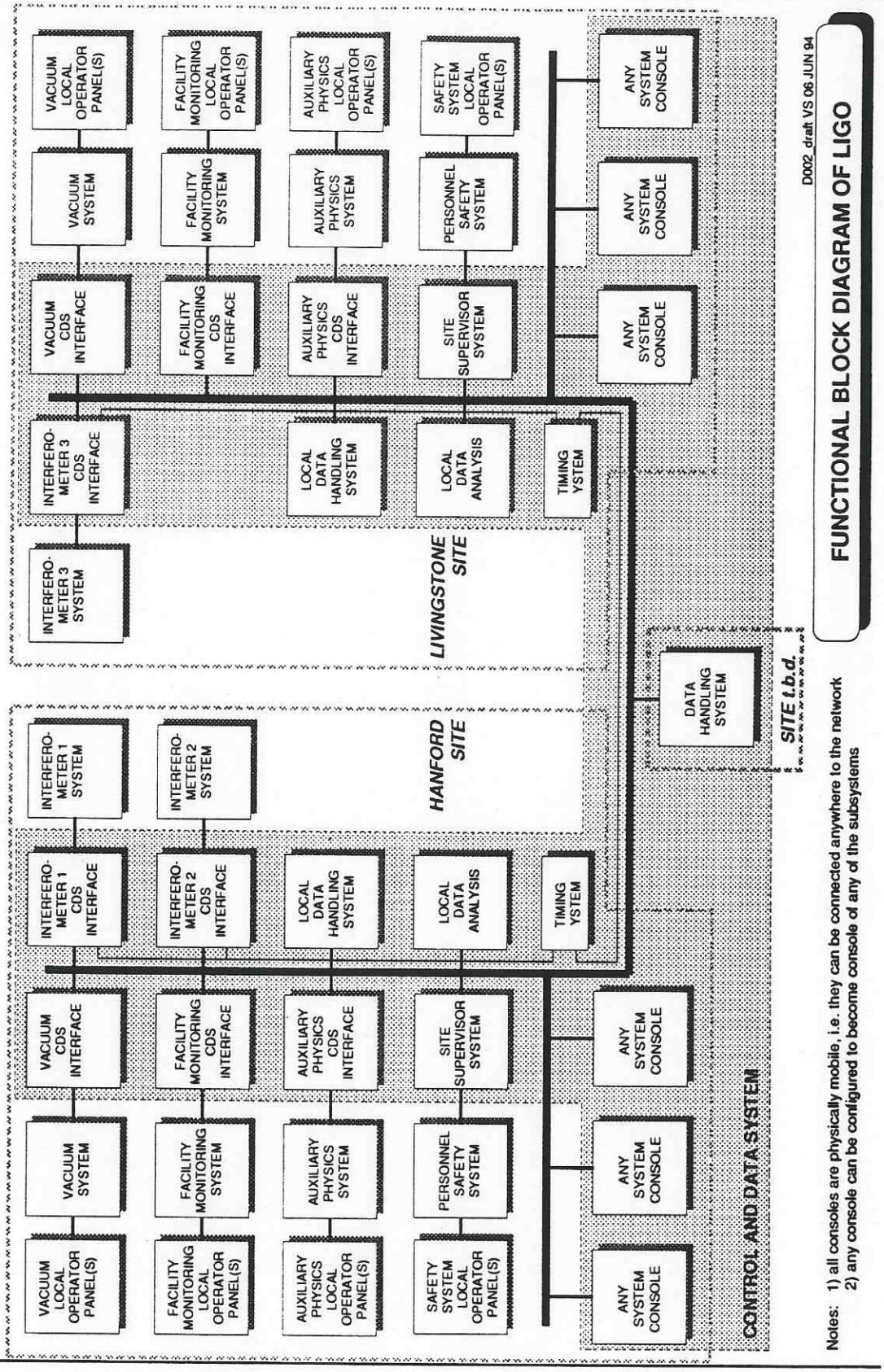
The servo loops are remotely monitored and controlled from the LIGO control rooms. This implies the following connections between the servo loop electronics and the rest of CDS:

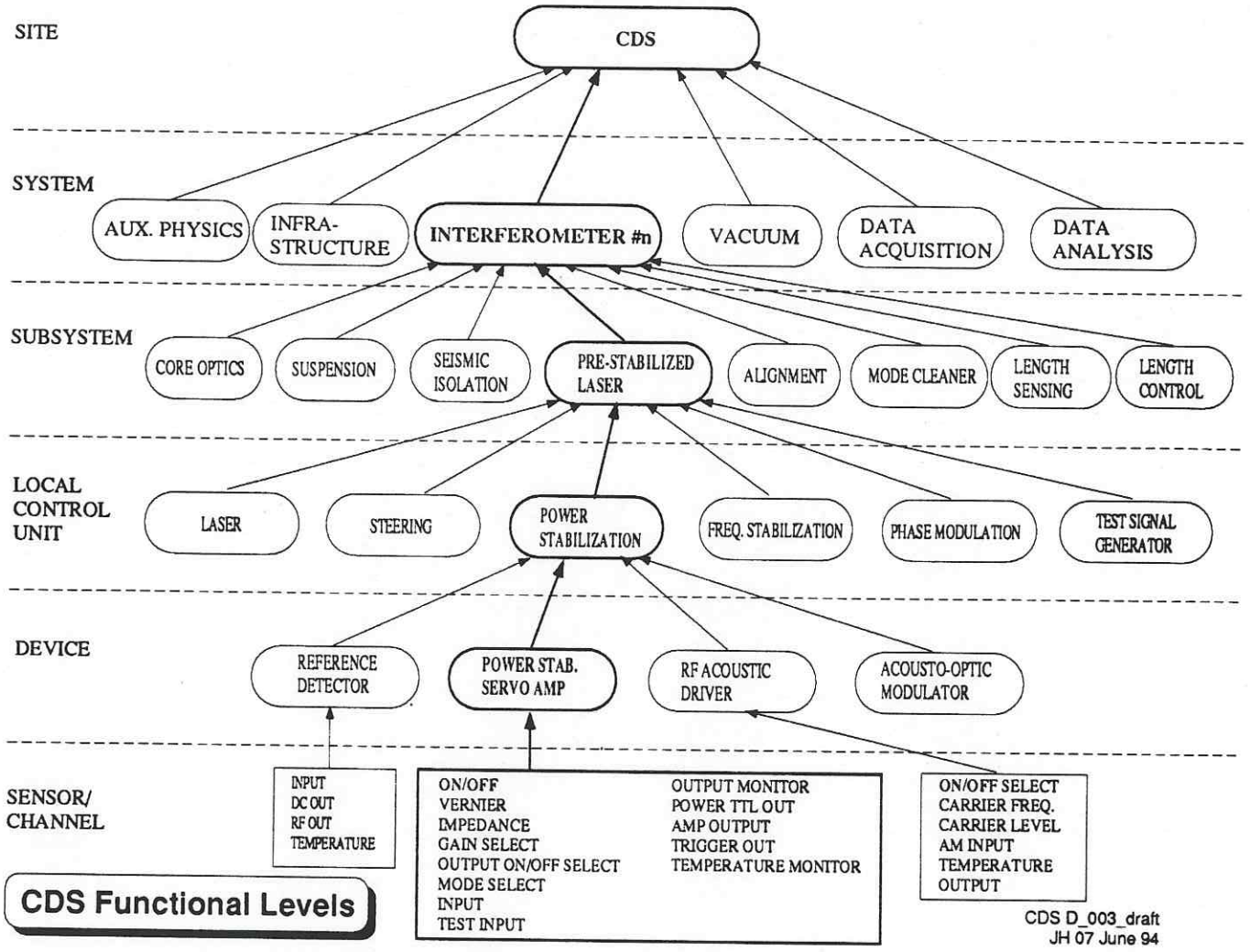
— (slow) binary control outputs from CDS

— (slow) binary status input to CDS

— (slow) analogue setpoint outputs from CDS

— (fast) data acquisition input to CDS


FUNCTIONAL BLOCK DIAGRAM OF LIGO
D002_draft VS 06 JUN 94
LIVINGSTONE SITE
HANFORD SITE
SITE t.b.d.
CONTROL AND DATA SYSTEM
INTERFERO-METER 3 SYSTEM
INTERFERO-METER 3 CDS INTERFACE
INTERFERO-METER 1 SYSTEM
INTERFERO-METER 2 SYSTEM
INTERFERO-METER 1 CDS INTERFACE
INTERFERO-METER 2 CDS INTERFACE
VACUUM SYSTEM
FACILITY MONITORING SYSTEM
AUXILIARY PHYSICS SYSTEM
PERSONNEL SAFETY SYSTEM
VACUUM CDS INTERFACE
FACILITY MONITORING CDS INTERFACE
AUXILIARY PHYSICS CDS INTERFACE
SITE SUPERVISOR SYSTEM
LOCAL DATA HANDLING SYSTEM
LOCAL DATA ANALYSIS
TIMING YSTEM
DATA HANDLING SYSTEM
VACUUM LOCAL OPERATOR PANEL(S)
FACILITY MONITORING LOCAL OPERATOR PANEL(S)
AUXILIARY PHYSICS LOCAL OPERATOR PANEL(S)
SAFETY SYSTEM LOCAL OPERATOR PANEL(S)
ANY SYSTEM CONSOLE
Notes: 1) all consoles are physically mobile, i.e. they can be connected anywhere to the network
2) any console can be configured to become console of any of the subsystems


SITE
CDS
SYSTEM
AUX. PHYSICS
INFRA-STRUCTURE
INTERFEROMETER #n
VACUUM
DATA ACQUISITION
DATA ANALYSIS
SUBSYSTEM
CORE OPTICS
SUSPENSION
SEISMIC ISOLATION
PRE-STABILIZED LASER
ALIGNMENT
MODE CLEANER
LENGTH SENSING
LENGTH CONTROL
LOCAL CONTROL UNIT
LASER
STEERING
POWER STABILIZATION
FREQ. STABILIZATION
PHASE MODULATION
TEST SIGNAL GENERATOR
DEVICE
REFERENCE DETECTOR
POWER STAB. SERVO AMP
RF ACOUSTIC DRIVER
ACOUSTO-OPTIC MODULATOR
SENSOR/ CHANNEL
INPUT
DC OUT
RF OUT
TEMPERATURE
ON/OFF
VERNIER
IMPEDANCE
GAIN SELECT
OUTPUT ON/OFF SELECT
MODE SELECT
INPUT
TEST INPUT
OUTPUT MONITOR
POWER TTL OUT
AMP OUTPUT
TRIGGER OUT
TEMPERATURE MONITOR
ON/OFF SELECT
CARRIER FREQ.
CARRIER LEVEL
AM INPUT
TEMPERATURE
OUTPUT
CDS Functional Levels
CDS D_003_draft
JH 07 June 94

Front-end Hardware

— VME and/or VXI for physics data acquisition

— industrial PLC or VME for plant monitoring and control (not yet decided)

— VME or VXI (t.b.d.) for servo loop front-end

Networking

Three level network hierarchy:

— Fiber Channel (255 Mbit/s per channel) for all high data rate connections

— Ethernet (10 Mbit/s) for control and monitoring between subsystems and between subsystems and operator consoles

— (vendor specific) field bus (about 1mbit/s) for economic front end connection to plant control equipment

Computers

— UNIX workstations as operator consoles

— UNIX stations as general purpose computing servers

— Motorola 68000 based VME controllers

— VME DSP (digital signal processor) boards for signal analysis

— commercial PLC front end

Operating Systems

— UNIX for workstations

— VXworks for VME controllers

— proprietary software for PLCs

EPICS

EPICS (Experimental Physics and Industrial Control System) is a set of software tools and applications jointly developed by

— Los Alamos National Laboratory

— Argonne National Laboratory

for the purpose of controlling Particle Accelerators and other Large Physics Experiments.

Present and future development is being done cooperatively by:

— Argonne (ANL),

— Los Alamos National Laboratory (LANL),

— Lawrence Berkeley Laboratory (LBL),

— the Continuous Electron Beam Facility (CEBAF)

— DESY (Deutsches Elektronen-Synchrotron).

— and others

(EPICS continued)

EPICS provides:

— Interfaces to instrumentation from data acquisition, supervisory control, and steady-state control through a table entry, distributed database.

— Operator interface to all control system parameters through interactive displays.

— Data logging through a table entry archiving file.

— Alarm management through a table entry alarm file.

— Sequential control through a state definition language with convenient database interface routines.

— Channel access routines for interfacing the control system data to data analysis, third party software packages, adaptive control algorithms and any other functions not provided in the control system.

The basic components needed are

— the Operator Interface (OPI),

— Input Output Controller (IOC),

— and a Local Area Network (LAN) which allows the OPI and IOC to communicate.

Servo Loops

— Servo loop electronics will be implemented on semi custom VME (or possibly VXI) modules.

— Each module consists of two half boards:

— — a standard backplane interface with a set of components:

- 16 bit slow, binary input
- 16 bit slow, binary output
- 8 20kHz, 16bit analogue-to-digital converters
- 8 slow, 16bit digital-to-analogue converters

— — the specific servo loop components

— servo loops are operated exclusively via CDS, thew do not have "front panels" for manual setting

Timing

The timing system has to provide

— precision time marks (1 microsecond)

— time base

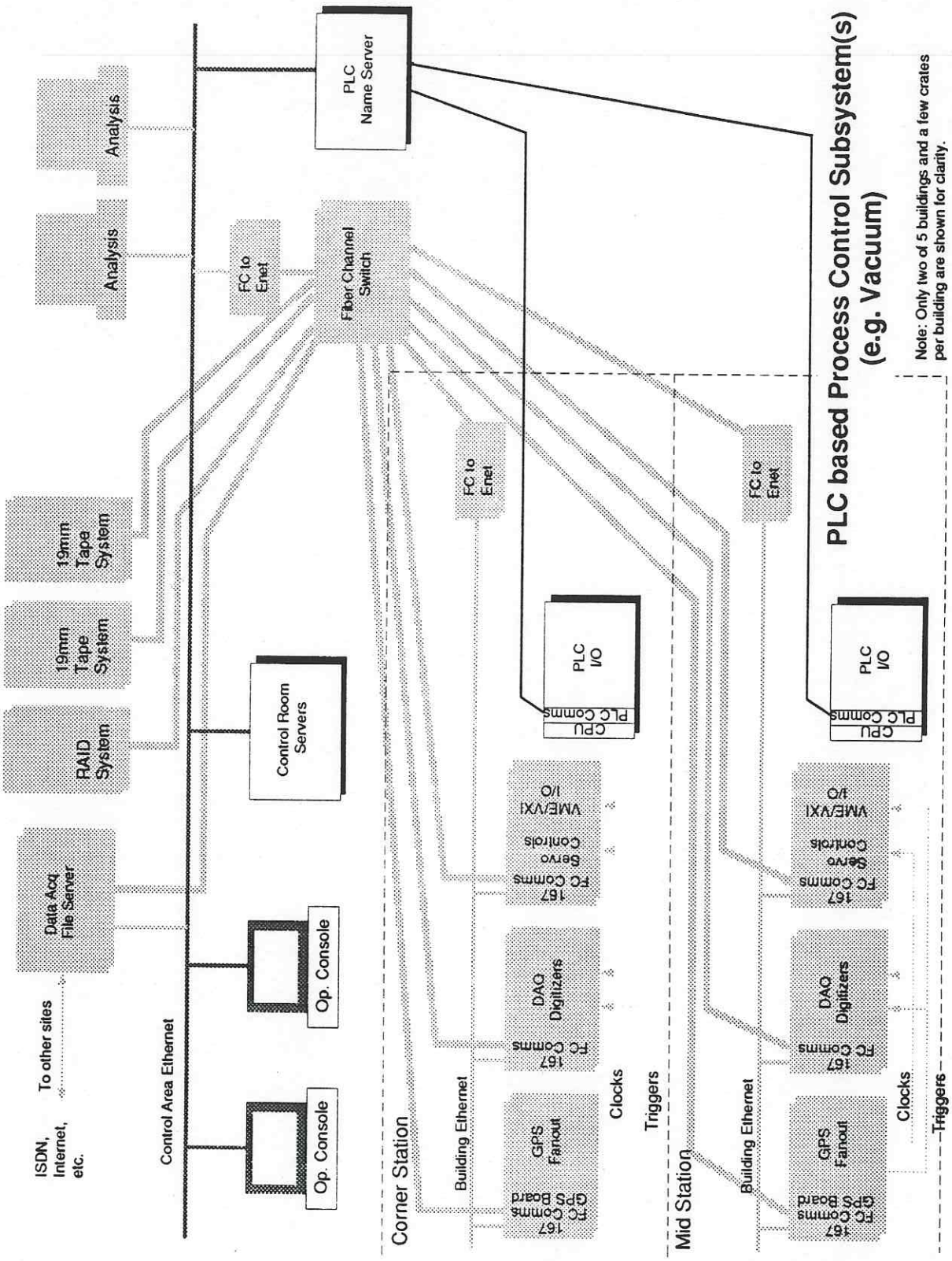
to data acquisition front-end hardware at both sites with relative precision of about 1 microsecond

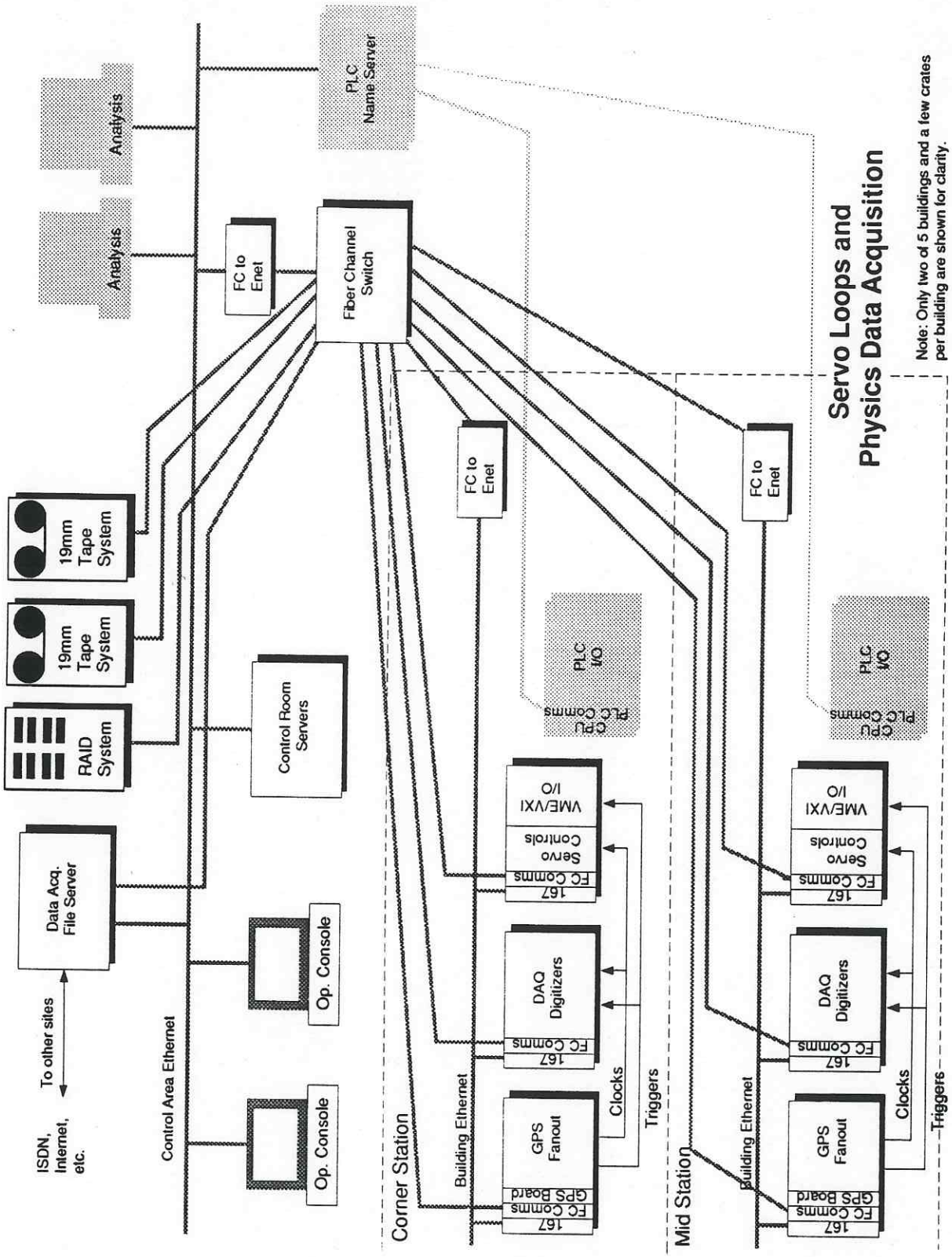
A GPS (General Positioning System) based system can provide the necessary signals with off the shelf components:

— Each building of each site (i.e. 5 per site) would have it's own GPS based timing system similar to the following

— Commercial modules are available that track 6 to 8 satellites and guarantee +/- 1 microseconds accuracy to Universal Time

— Modules have programmable clock outputs from 1 Hz to 1 MHz.


PLC based Process Control Subsystem(s)
(e.g. Vacuum)
Note: Only two of 5 buildings and a few crates per building are shown for clarity.
PLC Name Server
Analysis
Analysis
FC to Enet
Fiber Channel Switch
19mm Tape System
19mm Tape System
RAID System
Control Room Servers
Data Acq File Server
Op. Console
Op. Console
ISDN, Internet, etc.
To other sites
Control Area Ethernet
Corner Station
Mid Station
FC to Enet
FC to Enet
PLC I/O
CPU
PLC Comms
PLC I/O
CPU
PLC Comms
VME/VXI I/O
167 FC Comms
Servo Controls
VME/VXI I/O
167 FC Comms
Servo Controls
DAQ Digitizers
167 FC Comms
DAQ Digitizers
167 FC Comms
GPS Fanout
167 FC Comms GPS Board
GPS Fanout
167 FC Comms GPS Board
Building Ethernet
Building Ethernet
Clocks
Clocks
Triggers
Triggers


Servo Loops and
Physics Data Acquisition
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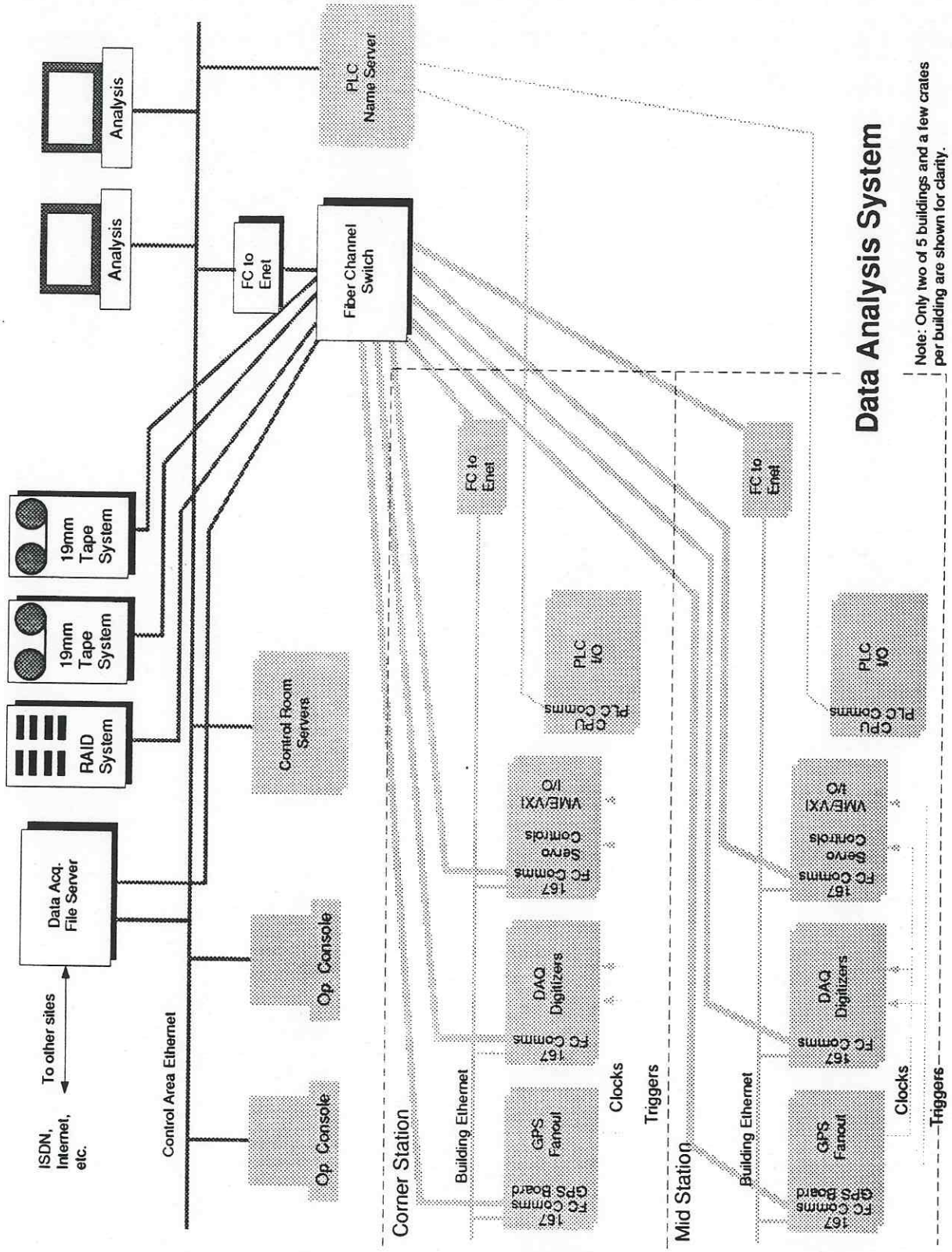
Data Analysis System
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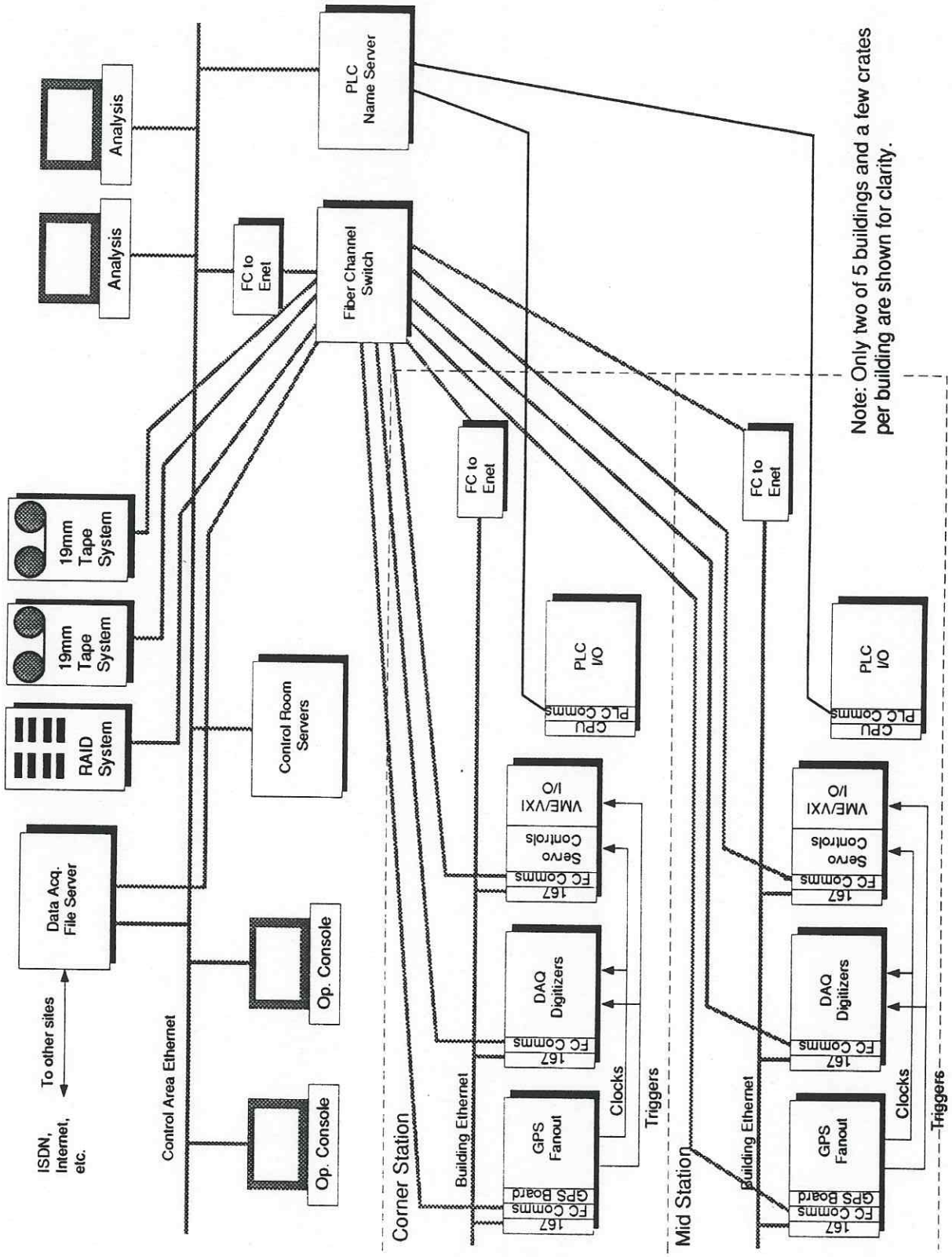
Triggers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