SNS ICS NETWORK STRATEGY REPORT

________________________	________________________
WBS 1.9 STL	WBS 1.9.6 Task Leader
________________________	________________________
WBS 1.9 Lead Engineer	WBS 1.9.7 Task Leader
________________________	________________________
WBS 1.9.3 Task Leader	WBS 1.9.8 Task Leader
________________________	________________________
WBS 1.9.4 Task Leader	WBS 1.9.9 Task Leader
________________________	________________________
WBS 1.9.5 Task Leader	WBS 1.8 Electrical Engineer

SNS ICS NETWORK STRATEGY

1. INTRODUCTION

The objective of this document is to develop concepts for the SNS integrated control system (ICS) network, carrying the design from the conceptual design stage to the “pre-Title I” design stage. Specific objectives include:

- Develop adequate design requirements for the start of Title I design activities.
- Develop the conceptual design to the point that interfaces with other project WBSs can be clearly understood.
- Obtain an improved cost estimate (published separately).
- Make SNS control system network needs known to both SNS and ORNL network planners.
- Present a plan for implementation of the ICS network.

The scope of this document is limited to the integrated control system network. Business, engineering, instrument data acquisition, and other SNS network requirements will be handled by others and are excluded from consideration.

This document is intended to be a one-time report, not a formally maintained document. A comprehensive report was deemed to be the best means for the SNS collaboration to reach a consensus on a starting point for the design of the ICS network. Formal documents will follow publication of this report. (See section 6 for a list of formal documentation expected).

2. ORNL NETWORK STRATEGY

ORNL has licenses for three Class B networks, offering a theoretical total of approximately 196,000 IP addresses. Around 18,000 of these IP addresses are currently being used, and the number is actually decreasing due to a shift of work to contractors.

ORNL network planners will provide adequate IP address space for the SNS project. Addresses will be assigned in a manner that ensures all SNS networks (including the ICS networks) are easily identifiable for management and administrative purposes, and in a manner which facilitates efficient implementation of IP routing, administrative policy, security policy, and network management.

Some possible scenarios include (but are not limited to) the following:

New CIDR Block - Request a new CIDR block from ESnet (Energy Sciences Network; see www.es.net) for use by the project. CIDR is an acronym for Classless Inter-Domain Routing and is described in RFC1518 and RFC1519. CIDR blocks can typically be thought of as contiguous blocks of Class C networks that are aggregated into a single routable entity.

Obtaining one contiguous block with adequate space for all SNS networks may be problematic. Obtaining separate blocks adequate for the individual SNS network entities (conventional facilities, control systems, data collection, etc.) should be feasible.

Existing Address Space - Use existing portions of class B networks already assigned to ORNL. For example, there exists one contiguous block of 12,240 unassigned addresses in one of ORNL's class B networks (134.167.0.0) that could be utilized by SNS. However, there is a potential problem with this block. Portions of this class B network are in use at the DOE Y-12 Plant, at the East Tennessee Technology Park (ETTP), and at locations at ORNL. Uncertainties in the status of ORNL's existing network service agreements (a consequence of the pending rebid of ORNL's management contract) make it difficult to predict the future use of this address space. This uncertainty will likely be resolved before IP addresses are actually required by the ICS.

Reconfiguration of existing Class B license - ORNL has embarked on a project to migrate users from an existing, flat, class B address space (128.219.0.0) into a new routed environment in the 160.91.0.0 network. This will be a lengthy project, but will eventually result in large amounts of free address space in the 128.219.0.0 network. Sufficient address space to meet all of the SNS network requirements will be available. Should the SNS project require initial IP address assignments before the migration project is completed, temporary assignments could be made from other available address pools. When the migration project is complete, SNS networks could then be assigned permanent blocks from the 128.219.0.0 address space.

In summary, obtaining a sufficient number of IP addresses should be no problem. Obtaining one contiguous block of IP addresses for all of SNS will be more difficult but should be possible.

The domain name of "sns.ornl.gov" is currently planned for SNS. Thus ICS equipment will likely be identified by the prefix "ics.sns.ornl.gov".

3. SNS CONTROL SYSTEM NETWORK REQUIREMENTS

3.1 Architectural Requirements

The SNS control system network must be compatible with the Experimental Physics and Industrial Control System (EPICS) distributed control system. Current versions of EPICS require the use of the IP communications protocol. All EPICS nodes should be within the same broadcast domain to support EPICS Channel Access broadcasts.

The SNS control system network must be separated from other SNS networks by a network segmentation device (e.g. a firewall) that controls access to the control system networks. This device should provide the capability of allowing a system manager to apply access controls to isolate the control system subnets. For example, the system manager should be able to reconfigure access controls to allow communications to continue between control system subnets and other SNS subnets, while isolating the control system subnets from the Internet or other networks external to the SNS project.

The network should be easy to maintain. Reconfiguring the network via a software database change is preferable to having to change computer configurations (IP addresses, gateway address, name servers etc.).

Network switches should be capable of implementing “virtual LANs” in order to reduce the number of switches required.

3.2 Bandwidth Requirements

We are going to forego an exhaustive analysis of bandwidth requirements for two reasons:

1) Based on the experience at APS, NSLS, and other large-scale accelerator facilities, we know that that it is possible to achieve effective accelerator operation given the bandwidth provided by standard commercially-available network hardware.

2) We aren’t going to specify requirements that can’t be met using standard commercially-available network hardware anyway. That is, for reasons of cost, reliability, etc., we must tailor requirements so that they can be met using commercially-available hardware.

None-the-less, a brief look at bandwidth goals is of some value in order to identify potential bottlenecks, etc.

3.2.1 Control Room Display Data Rates

(EPICS display updates are event-driven rather than continuous. Values are updated only if they have changed since their last report. For this reason, the rates indicated in the following table are conservative.)

Table 3-1. EPICS Display Data Rate	
Operator screens	40 screens
Points per screen	100 pts/screen
Update rate	10 Hz
Bytes per point	24 bytes/point
Bits transmitted per byte	10 bits/byte
Net bandwidth required	9.6 Mbits/sec

3.2.2 Continuously-Sampled Archived Data Rates

(EPICS archiver updates are event-driven rather than continuous. Values are updated only if they have changed since their last report. For this reason, the rates indicated in the table below are conservative.)

Table 3-2. Archive Data Rate	
Trend data archive rate	1,000 pts/sec
Update rate	10 Hz
Bytes per point	24 bytes/pt
Bits transmitted per byte	10 bits/byte
Net bandwidth required	2.4 Mbits/sec

3.2.3 IOC-to-IOC Data Rates

(EPICS IOC-to-IOC data updates are event-driven rather than continuous. Values are updated only if they have changed since their last report. For this reason, the rates indicated in the table below are conservative.)

Table 3-3. IOC-to-IOC Communications Rate, IOCs on Same Network Switch

Number of IOC-to-IOC points	1,000 pts
Update rate	10 Hz
Bytes per point	24 bytes/pt
Bits transmitted per byte	10 bits/byte
Net bandwidth required	2.4 Mbits/sec

Table 3-4. IOC-to-IOC Communications Rate, IOCs on Different Network Switches

Number of IOC-to-IOC points*	1,000 pts
Update rate	1 Hz
Bytes per point	24 bytes/pt
Bits transmitted per byte	10 bits/byte
Net bandwidth required	0.24 Mbits/sec

*Many of these will be for the run permit system

3.2.4 Video Requirements

While no video-related functions are currently identified for the ICS, it seems likely that video functionality will be required at some time in the future. Equipment selected for use in the ICS network should support industry standard multicast routing protocols and multicast group management features to facilitate future implementation of video functions.

3.3 Reliability, Availability, and Maintainability Requirements

Since SNS will not be able to operate without the EPICS subnet being fully operational, this portion of the ICS network must be extremely reliable. Vendor data, experience at other accelerator facilities, and experience in industry should be considered in the design and selection of network hardware.

A graded approach should be taken in the application of redundancy to increase network availability. In general, redundancy should be applied to equipment whose failure impacts a large number of users. For example, core switches should be fully redundant. Redundant power sources should be considered for all switches. Where full redundancy cannot be provided initially, the system should be designed so that redundancy can be added at a later date should reliability requirements dictate it.

Network hardware shall be powered from an uninterruptible power supply.

Areas where network equipment is located (communications closets, etc.) must have adequate air conditioning.

Where electrical interference and grounding pose potential problems, fiber optics should be used. Fiber should be used for all backbone network connections. Fiber optic cables should not be run in high- or moderate-radiation areas to avoid problems of radiation-induced opacity in the fibers.

The support staff should be capable of monitoring and diagnosing network problems remotely. Remote connections to network switch console ports should be independent of the EPICS network so that when the EPICS network goes down the cause can still be diagnosed remotely. Remote access should include access from homes to facilitate network maintenance during off-hours.

4. SURVEY OF OTHER FACILITIES

4.1 Advanced Photon Source (APS)

The APS control system is based on EPICS. A standard Ethernet-based LAN is used to connect EPICS nodes. Some highlights of the APS control system network follow.

There are 5 control system subnets, each with a maximum of 254 hosts. One subnet contains the approximately 170 EPICS nodes (IOCs, OPIs, and servers). The other four subnets are connected to terminal servers (which are used for remote access to console ports, etc.).

APS is in the process of upgrading their network. The FDDI backbone will be replaced with redundant gigabit Ethernet and all 10-MB hubs will be replaced with 10/100 Ethernet switches. Figure 4-1 shows a schematic of the planned network.

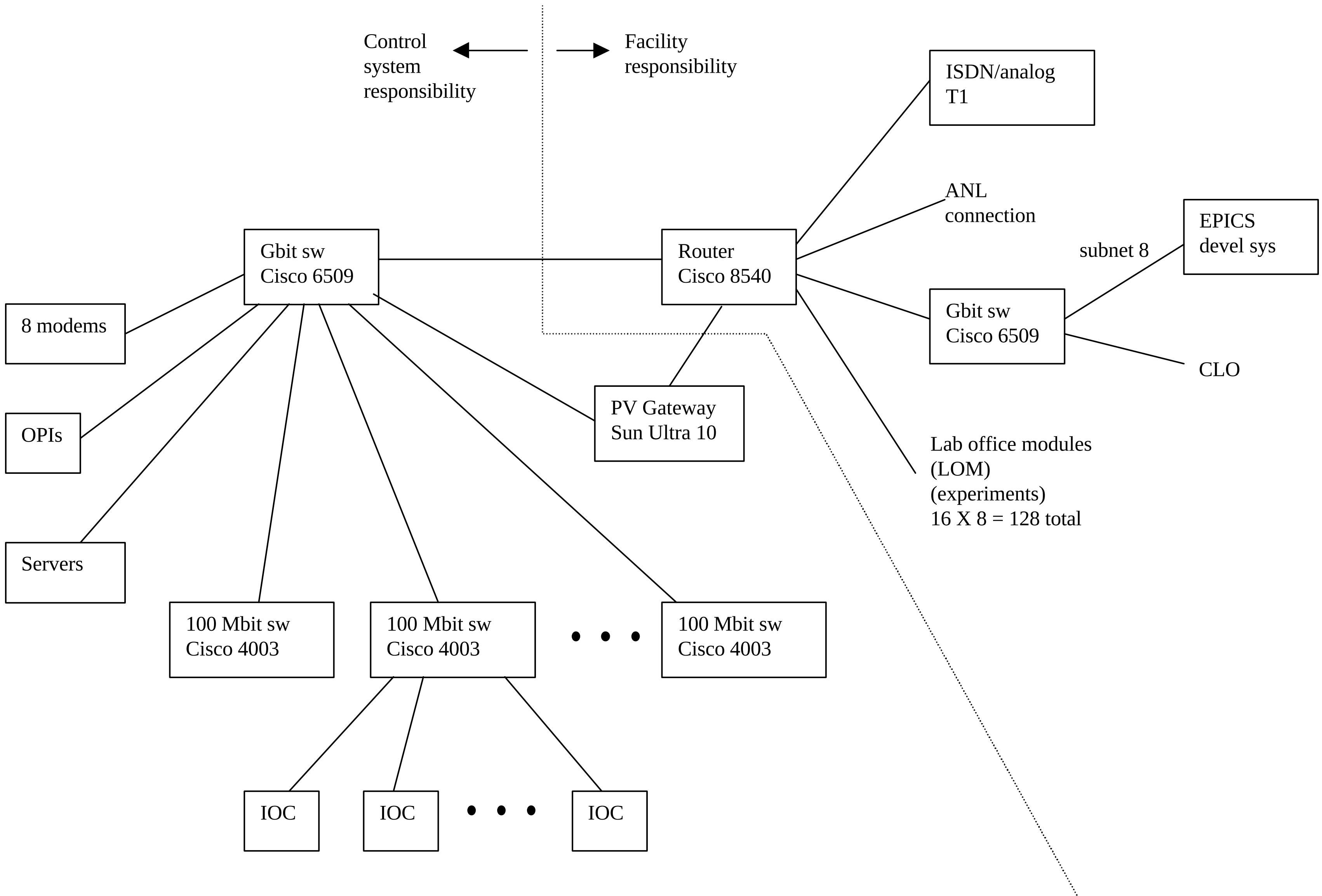


Fig. 4-1. Schematic of Planned APS Network Upgrade

APS uses redundant fiber-optic Ethernet connections to IOCs. A schematic of the architecture used to obtain redundant communications channels to IOCs is shown in figure 4-2. Redundant Ethernet switch ports are used to present each IOC with two network connections. In some cases the redundant Ethernet links go to the same switch, while others go to separate switches. (For example, storage ring network switches are spaced around the ring, so one link goes to the nearest switch in the clockwise direction while the other goes to the nearest switch in the counterclockwise direction). A "redundant transceiver" at each IOC handles the decision of which fiber to logically connect to the IOC at a given time. The Cabletron Systems model FOT DF24 transceiver is used; see http://www.cabletron.com/products/items/mconvert_trans/ for additional information.

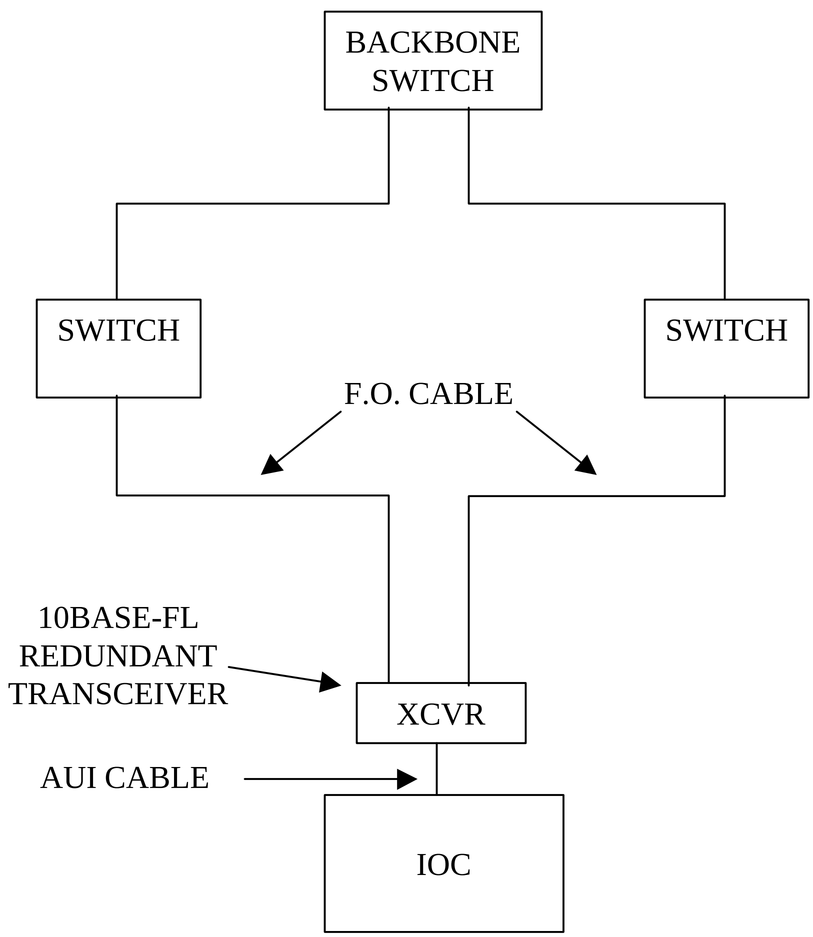


Fig. 4-2. Redundant network architecture for IOCs used at APS

Terminal server connections to IOC console ports. APS has two IP addresses for each IOC CPU module: one for the Ethernet connection and one for the serial console port. They use reverse terminal servers to connect to each console port. The terminal servers are connected to subnets which are separate from the EPICS channel access subnet.

Terminal server RS-232 links are in general implemented via fiber optics. The terminal servers are Xyplex model “Maxserver 1640”, which have fiber-optic receiver/transmitters. At IOCs, they use a custom VME board to convert from fiber-optics back to RS-232.

Software development system requirements: For APS the level of software development activities changed during the life of the project, ramping to a maximum and then dropping off to a maintenance level. The maximum level of activity was twice what it is now (where “now” is the fully-developed operational phase of the facility). APS currently has 4 EPICS software development labs, each with a couple of VME crates (typically mounted in a 19” wide by 6 ft high relay rack), at least one PC, and one Sun (or other Unix) workstation. In some labs additional PCs and workstations are needed. This amounts to approximately 6 nodes per lab, or 24 total. A total of IP 48 addresses were needed at time of maximum effort.

See the references listed in Appendix D.1 for more information on the APS control system network.

4.2 National Synchrotron Light Source (NSLS)

The National Synchrotron Light Source has recently upgraded their network to incorporate Ethernet switches. They use Cisco 5000 series switches which have either a 5 or 13 slot chassis and hold either three or 10 I/O boards. An I/O board can be a 48 port 10Mhz switched Ethernet board, a 12 port 10/100Mhz board, and recently a multi-port gigabit Ethernet board has been announced. Each system has an ATM uplink to an ATM switch.

5. ICS NETWORK STRATEGY

5.1 General Description

See figure 5.1 for a high-level block diagram of the ICS network. A more detailed block is provided in Appendix B.1. The ICS network architecture will consist of three subnets:

1) A subnet supporting EPICS channel access for controls,
2) A subnet for system maintenance, which provides remote access to programming ports of programmable equipment (e.g. to network switches, IOCs, and PLCs).
3) A subnet for software and hardware development systems.

The first subnet is restricted to EPICS channel access communications in order to prevent competition for network bandwidth from other less-critical functions. The two subnets for development and maintenance (items 2 and 3 above) are separated due to differing security requirements.

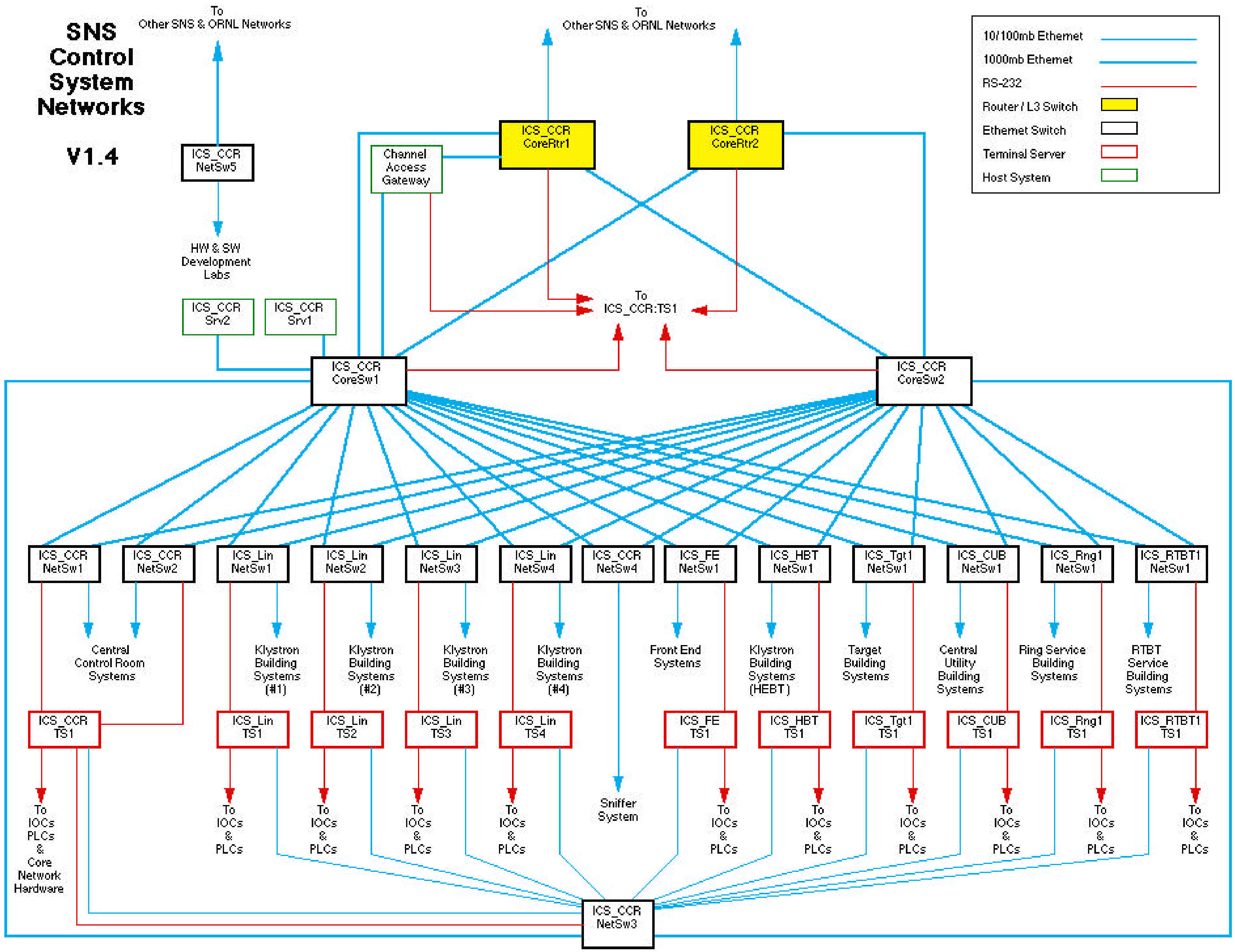


Figure 5.1 – ICS Network Block Diagram

Each subnet will have the following features:

- Fully switched
- 100 MHz Ethernet used for most network node connections.
- Most communication links to IOCs are 100BaseTX. Some links are 100BaseFX, primarily where distance and high EMI levels might affect reliability (e.g. in the klystron building).
- Gigabit Ethernet (redundant, fiber optic) used for backbone communications

The transfer of process variable data between the ICS channel access subnet and other SNS networks will take place through a channel access gateway.

5.2 Control System Node Count

An estimate of the number of SNS control system network nodes has been prepared and is included as Appendix A. The current estimate is approximately 786 IP addresses total (with no contingency factor applied).

Some comments on the estimate follow.

- **Software development system.** The level of software development activities is likely to change during the life of the project, ramping to a maximum and then dropping off to a maintenance level. (e.g. APS ramped up to a maximum of ~48 nodes and then dropped back down to ~24 nodes). This could be different for SNS since much of the software development will be done off-site. An estimated maximum number of nodes (i.e. 48) is shown in the estimate.

- **Temporary OPI connections.** The design shown provides an extra network connection at each IOC (e.g. for a temporary OPI). In general, there are no provisions for temporary network connections anywhere else. (One exception is that 8 drops are shown for temporary connections in the Target Building, since all IOCs in that building are located in the control room).

  While not included in the current cost estimate, it has been suggested that network connections be provided in the tunnels for intermittent use (e.g. during troubleshooting). This warrants further investigation. One low-cost option might be to install wireless LANs for remote communications in tunnels and elsewhere. This has been tried at other facilities without much success. However, wireless network equipment has likely improved since then and this option should be revisited.

- **Instruments.** Local area networks for neutron instruments will be provided by others. Neutron instrument equipment (including EPICS-based controls) will not be directly connected to the ICS subnets. There will be cases where information will need to be exchanged between the instruments and the ICS. This exchange will be implemented using a channel access gateway rather than via a direct network connection.

- **PLC Interfaces.** The standard method of interfacing IOCs to PLCs has not been determined yet. The design shown assumes that PLC connections are via ethernet direct to IOCs.

Another option would be to connect PLC ethernet links through ethernet switches. Changing to this option would increase the number of switch channels required.

5.3 IP Address Strategy

Table 5-1 shows the numbers of IP addresses identified to date for each subnet (ref. estimate in Appendix A), as well as the maximum numbers of addresses to be assigned to each subnet.

Table 5-1. ICS Subnet

Subnet Description:	# IP addr*.:	Max. # IP addr:
Channel Access Subnet	305	2046
PLC connections (no subnet)	94	510
Terminal Server Subnet	339	2046
Development System Subnet	48	510

*No contingency applied

5.4 Cable Plant

A hierarchical "star" cable topology will be used to facilitate network management and upgrades. Network communications hardware will be physically located in communications closets and equipment rooms. (A preliminary layout of communication room locations is available from SNS conventional facilities design personnel).

Backbone communications cabling (i.e. cabling between communications rooms) for the control system network is provided by conventional facilities WBS 1.8.3.x.2.5. Control system backbone network fibers may be physically in the same multi-fiber cable as other SNS network fibers. However the control system networks will be connected to other SNS networks only through a router.

The design shown assumes that network equipment will be spaced closely enough to allow the use of multi-mode fiber for the gigabit ethernet backbone. (This assumption could become invalid depending on the final location of the main distribution center. Gigabit ethernet standards specify that equipment handle a minimum distance of 550 meters on multimode fiber. The actual supported distance varies from vendor to vendor. Some network backbone distances could exceed 550 meters if the main distribution center is placed at one end of the facility).

Network switches will be located close enough to network nodes that 100BaseTX connections can be used. (While some connections to IOCs will be made via 100BaseFX fiber optic connections, having the switches close keeps our options open).

5.5 Interface with Other SNS WBSs

Interface documents will be developed after this report is issued. Interface issues to be addressed include the following:

- Space requirements, e.g.:
  - Space for ICS network equipment racks in communications closets.
  - Space in IOC racks for connector panels. For IOCs with copper links, the cost estimate shows a 1-3/4" tall rack-mounted patch panel. For IOCs with fiber optic links, the cost estimate shows a 3-1/2" high rack-mounted connector panel for fiber optic connectors plus a surface-mounted outlet box for each PLC connected.
  - Space in PLC cabinets. The cost estimate shows a surface-mounted outlet box for PLCs.
- Equipment environmental requirements (max. operating temp., humidity, etc.)
- Electrical power requirements (two independent circuits, one of which is fed from a UPS; single point instrument-grade ground; "clean" power; etc.)
- Raceway requirements
- Backbone cable plant requirements. Where our cables/equipment end and where conventional-facilities-supplied cables/equipment begin.
- Cable interface with other WBS 1.9 subsystems, e.g.:
  - If PLC ethernet link runs directly to IOC cabinet (per baseline design strategy): WBS 1.9.2.1 is responsible for providing a patch panel in the IOC cabinet. The WBS 1.9.x or 1.x system owning the PLC is responsible for running the ethernet cable from the PLC to the IOC cabinet and terminating it at the patch panel.
  - If PLC ethernet link runs to a network switch: WBS 1.9.2.1 could be responsible for putting an outlet box in the PLC cabinet and running the cable from the PLC to the switch. (This scenario is not currently in the baseline design).
- Functional interface between the ICS network and other SNS networks.

5.6 Security

The ICS subnets will be separated from other SNS networks by a firewall. The firewall will include access controls that allow a system manager to restrict access to ICS networks if threatened.

5.7 Reliability, Availability, and Maintainability Features

5.7.1 General

Backbone network cabling and the central switches will be redundant. (See block diagram in Appendix B.1 for a schematic).

Remote network access to ICS equipment for programming and maintenance will be provided. ORNL is currently evaluating means for providing secure remote access to internal network resources. Commercially-available Virtual Private Network (VPN) technology is likely to be a good method of providing this functionality.

Terminal servers will be used to provide remote connection to programming or console ports of programmable devices (e.g. IOCs, PLCs). The console ports of each network switch will be also be connected to these terminal servers. The terminal servers will be on a separate subnet from the channel access subnet in order to allow troubleshooting remotely when the channel access subnet fails. CAT5 unshielded, twisted-pair cable will be used for RS-232/RS-422 terminal server links; this will allow the possibility of upgrading to ethernet later.

Network switches on the channel access subnet will have the capability of configuring a channel to mirror any other channel on the switch. A “mirror channel” from each switch will be routed to a central network switch. A network sniffer connected to this central switch can then monitor any switch channel in the ICS network. This capability should aid in troubleshooting network problems.

A network management station will be provided. To facilitate network management, only hardware supporting the Simple Network Management Protocol (SNMP) will be used in the ICS network.

An extra network connection will be installed in each IOC cabinet to allow the use of portable OPIs during system start-up and troubleshooting. (Where a number of IOCs are located in close proximity, only one connection will be provided).

Each network switch will have redundant AC-to-DC power supplies. Each of these power supplies will be powered via a separate AC power circuit (i.e. two power circuits per switch), one of which is fed from the facility UPS.

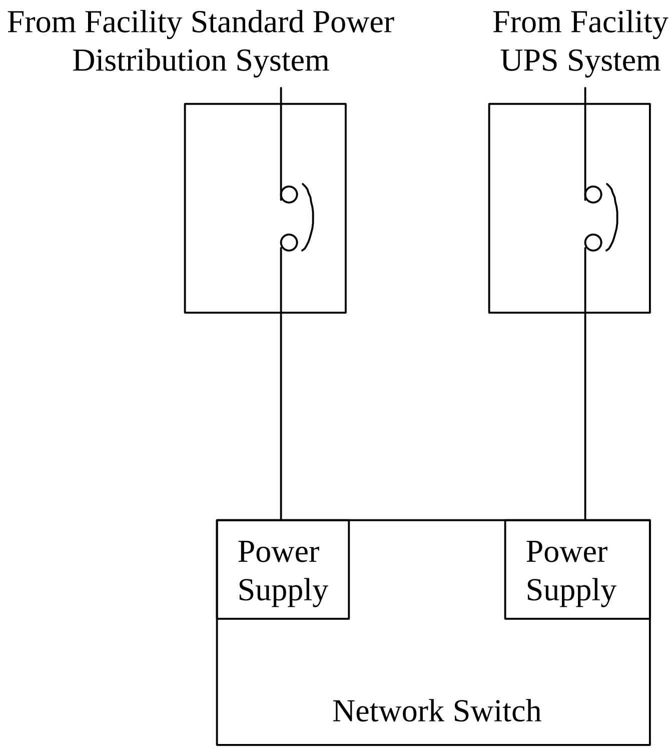


Fig. 5-2. Typical Switch Power Supply Circuits

5.7.2 IOC Communications

Redundant IOC communications (as implemented at APS) were considered during the network development activities leading to this report. However, this option has now been dropped, primarily for reasons of cost. Experience at other facilities (e.g. AGS / RHIC) indicates that standard 100BaseTX and 100BaseFX communications can work reliably in our application.

For the sake of completeness, information on how a redundant link would be implemented is included below.

Transceivers are available to connect a device with a 100BaseTX interface to redundant fiber links. An example device is the Lancast Redundant Twister product. Other manufacturers have similar devices. In this configuration, an end node would connect to the redundant converter with a CAT 5 patch cable and fiber links would run to ports on separate switch boards within a switch chassis. Chassis-based switches are available now that support 24 100BaseFX connections per card. Higher densities will be available soon.

A diagram of the redundant configuration is shown in the figure below. The cost of the redundant converters is currently about $600.

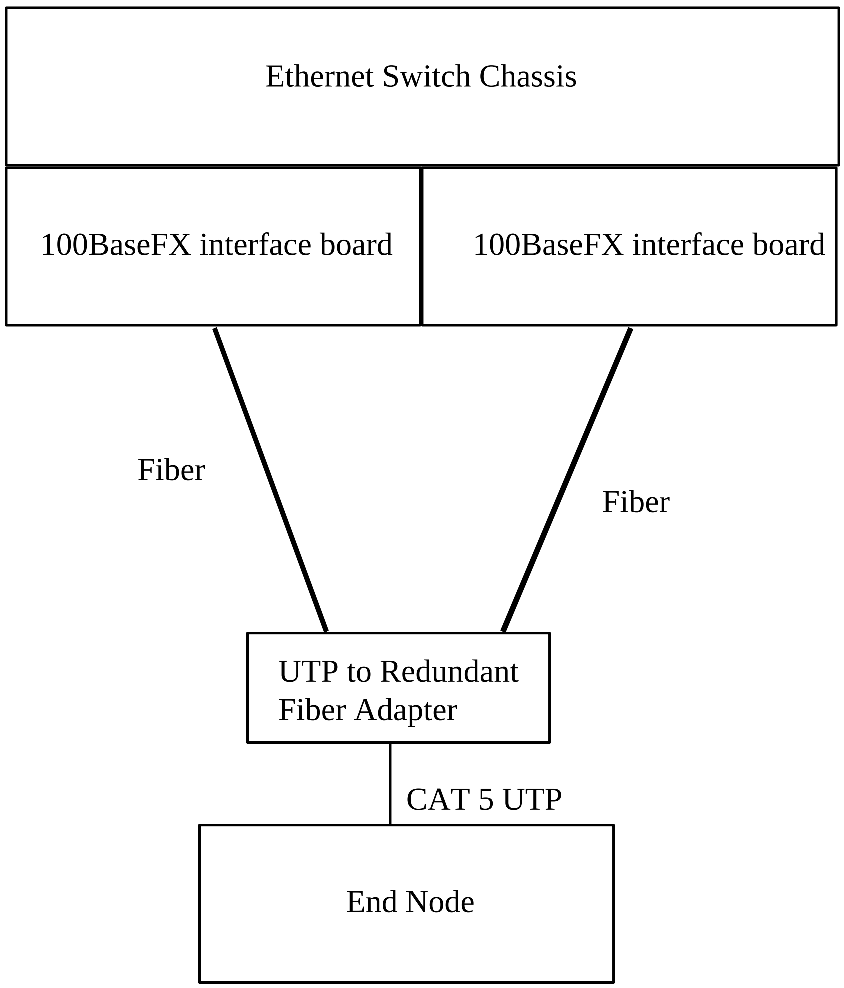


Fig. 5-3. IOC redundant communications (NOTE: Not currently planned for SNS).

6. IMPLEMENTATION PLAN

The following table reflects current plans for implementation of the ICS network.

Table 6-1. Implementation Plan		
Activity	**Performed by:**	**Oversight by:**
Interface & Project Mgmt.	SNS Controls Group	-
Preliminary Design	SNS Controls Group (ORNL CIND consulting)	-
Title I Design	SNS Controls Group (ORNL CIND consulting)	-
Title II Design	SNS Controls Group (ORNL CIND consulting)	-
Title III Design	SNS Controls Group (ORNL CIND consulting)	-
Procurement	SNS Controls Group (ORNL CIND consulting)	-
Construction Mgmt.	CM	SNS Controls Group
Construction: cabling & racks	Qualified contractor	SNS Controls Group
Installation of equipment in racks	SNS technicians	SNS Controls Group
Start-up and checkout	SNS Controls Group, ORNL CIND	-
Maintenance	SNS Controls Group, ORNL CIND	-

AE = Architect/Engineer (Knight Engineering)
CIND = Computing, Information, and Networking Division
CM = Construction Manager (Sverdrup)

Table 6-2 lists design documents that will be required to implement the control system network.

Table 6.1-1. Document Plan

Conceptual Design:
WBS 1.9.2.1 Descriptor Form
SNS ICS Network Strategy Report (this document)

Preliminary (title I) design documents:
System Requirements Document
Interface Documents (WBS 1.9.2.1 – WBS 1.9.x; WBS 1.9.2.1 – WBS 1.8)
Block diagrams / schematic representations
Preliminary location plan
Equipment list/database
Updated schedule and cost estimate

Detailed (title II) design documents:

- Procurement specifications
- Configuration tables/database (e.g. channel assignments, IP address assignments, etc.)
- Detailed location plans
- Cable tables/database for host-to-communication-room cables
- Cable installation documents
- Test plans
- Panel layouts and bills of material (Or alternatively, these could be provided by equipment supplier)
- Updated schedule and cost estimate

Title III design documents:

- Procedures for post-construction inspection and start-up tests
- As-built drawings, databases, etc.

APPENDIX A - ICS CONTROL NETWORK NODE COUNT

Key:
# CA IP addr = "Number of channel access IP addresses"
# Dev. IP addr = "Number of development system IP addresses"
# PLC IP addr = "Number of PLC IP addresses"
# sw. ports = "Number of 100 Mbit switch ports"
# TS IP addr = "Number of terminal server (i.e. maintenance subnet) IP addresses"
IOC = EPICS I/O controller
OPI = EPICS operator interface
Prn = Printer
Rtr = Router
Srvr = server
Sw = Ethernet switch
TS = Terminal server

The numbers in the following table match the quantities shown on the block diagrams in Appendix B.1.

Qty.	Node Type	# CA IP addr	# PLC IP addr	# TS IP addr	# Dev. IP addr	# sw. ports	Description
Central Control Building Equipment:							
2	Srvr	2		2		2	Central file server
12	OPI	12		12		12	Central control room
2	Rtr	4		2			Router
1	Srvr	1		1		1	Channel access gateway
2	Sw			2			Network switch, for CCR bldg equip
2	Sw			2			Network switch, central (backbone)
4	Prn	4				4	Printer and/or print servers, in control room
1				1			Network management station
1	Sw			1			Network switch, for connecting mirrored ports to sniffer
1	Sw			1			Network switch, for connecting to terminal servers
1	IOC	1		1		1	Run permit system
1	IOC	1		1		1	Fast protect system
1	IOC	1		1		1	Timing system master
1				1			Terminal server (for IOC console ports)
(For conventional facilities & PPS:)							
1			1	1			Elec. pwr. SCADA sys.
1	IOC	1		1		1	Elec. pwr. SCADA sys. & Fire Protect Sys I/F
1	IOC	1		1		1	PPS I/F
4	PLC	__	4	4	__	__	PPS PLCs
39		28	5	35	0	24	Subtotal
Central Control Building Equipment, Development & Maintenance Systems:							

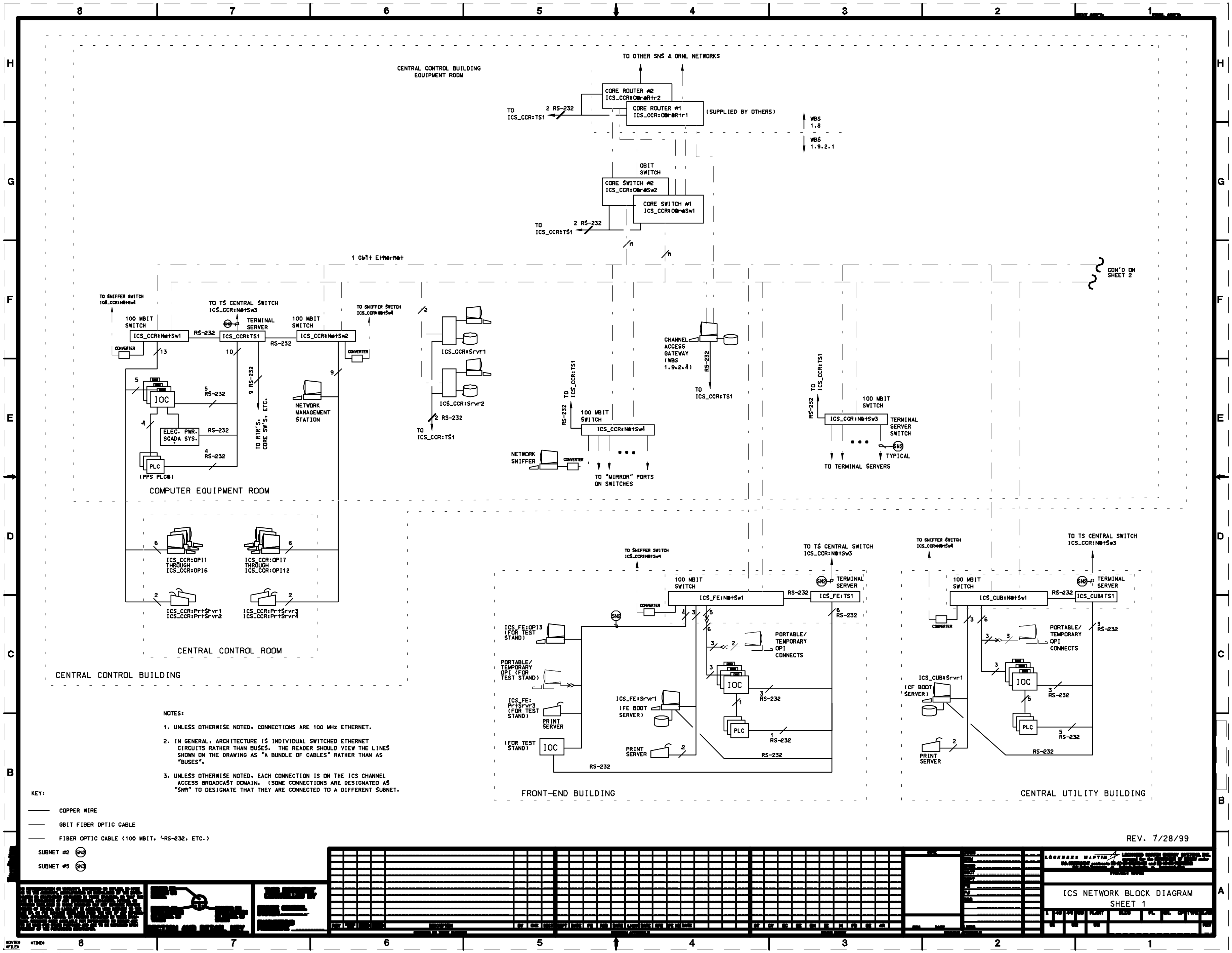
Qty.	Node Type	# CA IP addr	# PLC IP addr	# TS IP addr	# Dev. IP addr	# sw. ports	Description
1	Srvr				1	1	S/W devel. sys. server
16	OPI				16	16	S/W devel. sys. OPIs
16	IOC				16	16	S/W devel. sys. IOCs
4	PLC				4	4	S/W devel. sys. PLCs
2	Prn				2	2	S/W devel. sys. printer and/or print servers
1	Sw				1		Network switch, for development systems
2	IOC				2	2	Hardware lab IOC
6	Misc.	__	__	__	6	6	Hardware lab workstations, etc.
48		0	0	0	48	47	Subtotal
Front End Building:							
1	Srvr	1		1		1	FE Boot Server (serves as OPI also)
1	OPI	1		1		1	Test stand
1	PLC		1	1			Vacuum system
3	IOC	3		3		3	Misc.
1	TS			1			Terminal server (for IOC console ports, PLC I/F, etc.)
2	OPI	2				2	Temporary / portable OPIs
1	OPI	1				1	Temporary / portable OPI for test stand
2	Prn	2				2	Printer and/or print server
1	Prn	1				1	Printer and/or print server for test stand
1	Sw			1			Network switch
1	IOC	1	__	1	__	1	IOC for test stand
15		12	1	9	0	12	Subtotal
Klystron Building:							
1	Srvr	1		1		1	Linac Boot Server (serves as OPI also)
36	OPI	36				36	Temporary / portable OPIs
4	IOC	4		4		4	Vacuum systems
6	PLC		6	6			Vacuum systems
4	IOC	4		4		4	Cooling water systems
7	PLC		7	7			Cooling water systems
5	IOC	5		5		5	Power supplies
9	PLC		9	9		9	Power supplies
55	IOC	55		55		55	Diagnostics
1	IOC	1		1		1	Chopper
34	IOC	34		34		34	LLRF systems
34	IOC	34		34		34	HPRF Subsystems
40	PLC		40	40		40	HPRF systems
8	Prn	8				8	Printers and/or print servers
4	Sw			4			Network switch
4	TS			1			Terminal server (for IOC console ports, PLC I/F, etc.)
(For conventional facilities:)							
1	IOC	1		1		1	Confinement HVAC
1	PLC	1	__	1	__	0	Confinement HVAC
254		184	62	207	0	232	Subtotal

Qty.	Node Type	# CA IP addr	# PLC IP addr	# TS IP addr	# Dev. IP addr	# sw. ports	Description
HEBT Service Area (in east end of Klystron Bldg.):							
9	IOC	9		9		9	Misc.
6	PLC		6	6			Vacuum, power supplies, etc.
4	OPI	4		4		4	Temporary / portable OPIs
1	TS			1			Terminal server (for IOC console ports, PLC I/F, etc.)
2	Pr	2				2	Printers and/or print servers
1	Sw	__	__	1	__	__	Network switch
23		15	6	21	0	15	Subtotal
Ring Service Building:							
1	Srvr	1		1		1	Ring Boot Server (serves as OPI also)
13	IOC	13		13		13	Misc.
6	PLC		6	6			Vacuum
1	OPI	1		1		1	Ring control room
4	OPI	4				4	Temporary / portable OPIs
2	Prn	2				2	Printers and/or print servers
1	Sw	1		1			Network switch
1	TS			1			Terminal server (for IOC console ports, PLC I/F, etc.)
(For conventional facilities:)							
1	IOC	1		1		1	Confinement HVAC
2	PLC	2	__	2	__	2	Confinement HVAC
32		25	6	26	0	24	Subtotal
RTBT Service Building:							
9	IOC	9		9		9	Misc.
6	PLC		6	6			Vacuum
4	OPI	4				4	Temporary / portable OPIs
2	Prn	2				2	Printers and/or print servers
1	Sw			1			Network switch
1	TS	__	__	1	__		Terminal server (for IOC console ports, PLC I/F, etc.)
23		15	6	17	0	15	Subtotal
Target Building:							
1	Srvr	1		1		1	Target Boot Server (serves as OPI also)
8	OPI	8				8	Temporary / portable OPIs
1	OPI	1		1		1	Target control room, double-headed workstation
3	IOC	3		3		3	Misc.
3	PLC		3	3			Misc.
2	Prn	2				2	Printers and/or print servers
1	Sw			1			Network switch

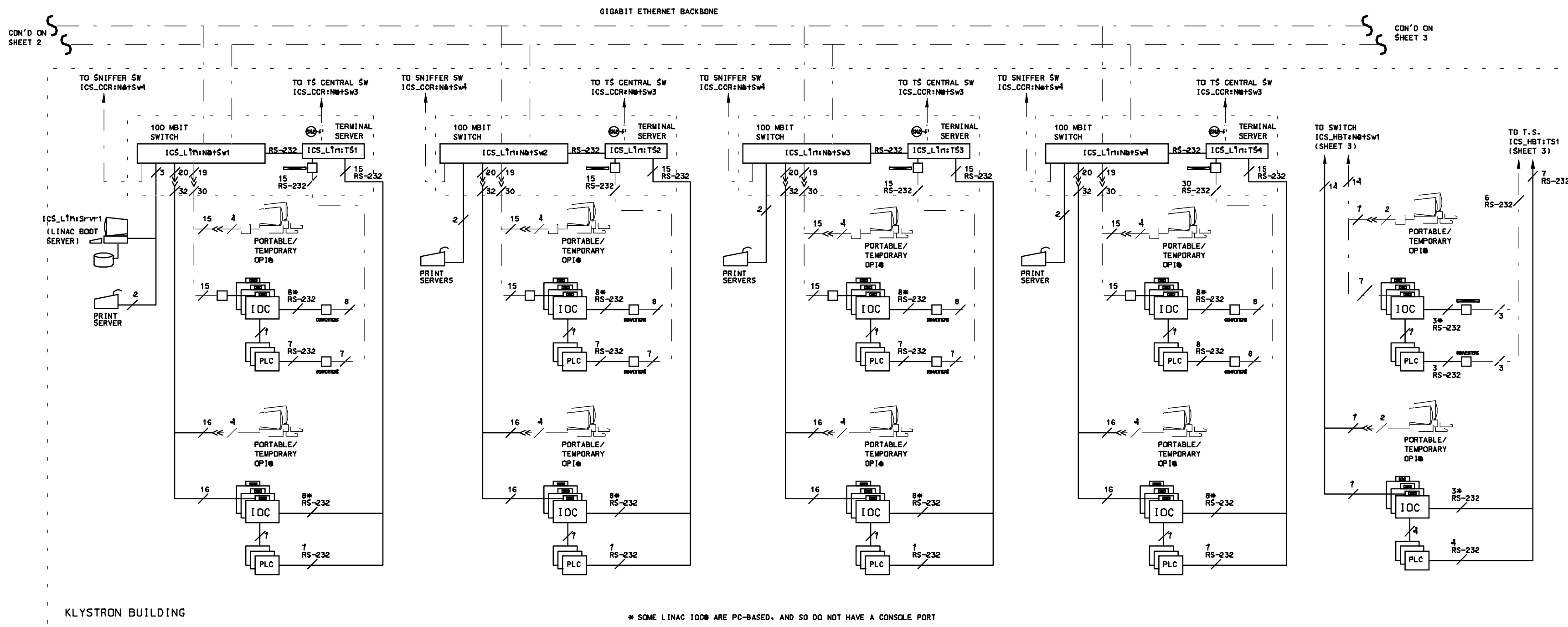
Qty.	Node Type	# CA IP addr	# PLC IP addr	# TS IP addr	# Dev. IP addr	# sw. ports	Description
1	TS			1			Terminal srvr. (for IOC console ports, PLC I/F, etc.)
(For conventional facilities:)							
1	IOC	1		1		1	Confinement HVAC
1	PLC	1		1		1	Confinement HVAC
1	PLC	1	__	1	__	1	Waste system controls
23		18	3	13	0	18	Subtotal
Central Utility Building:							
1	Srvr	1		1		1	Conv. Fac. Boot Server (serves as OPI also)
3	IOC	3		3		3	Mech. systems
5	PLC		5	5			Mech. systems
1	TS			1		1	Terminal srvr. (for IOC console ports, PLC I/F, etc.)
2	Prn	2				2	Printers and/or print servers
1	Sw			1			Network switch
3	OPI	2	__	__	__	3	Temporary OPIs, workstations, etc.
16		8	5	11	0	10	Subtotal
Grand Totals:							
473		305	94	339	48	397	Total with no contingency

APPENDIX B - ICS NETWORK DRAWINGS

Reduced-size copies of ICS Network drawings follow. Larger size copies are available on request.



CENTRAL CONTROL BUILDING
EQUIPMENT ROOM
TO OTHER SNS & ORNL NETWORKS
CORE ROUTER #2
ICS_CCR:CoreRtr2
CORE ROUTER #1
ICS_CCR:CoreRtr1
(SUPPLIED BY OTHERS)
TO ICS_CCR:TS1
2 RS-232
WBS 1.8
WBS 1.9.2.1
GBIT SWITCH
CORE SWITCH #2
ICS_CCR:CoreSw2
CORE SWITCH #1
ICS_CCR:CoreSw1
1 Gbit Ethernet
CON'D ON SHEET 2
TO SNIFFER SWITCH ICS_CCR:NetSw4
TO TS CENTRAL SWITCH ICS_CCR:NetSw3
TERMINAL SERVER
100 MBIT SWITCH
ICS_CCR:NetSw1
ICS_CCR:TS1
ICS_CCR:NetSw2
CONVERTER
IOC
ELEC. PWR. SCADA SYS.
PLC
(PPS PLCs)
TO RTR'S, CORE SW'S, ETC.
NETWORK MANAGEMENT STATION
COMPUTER EQUIPMENT ROOM
ICS_CCR:Srvr1
ICS_CCR:Srvr2
CHANNEL ACCESS GATEWAY (WBS 1.9.2.4)
ICS_CCR:NetSw4
NETWORK SNIFFER
TO "MIRROR" PORTS ON SWITCHES
ICS_CCR:NetSw3
TERMINAL SERVER SWITCH
TYPICAL
TO TERMINAL SERVERS
ICS_CCR:OPI1 THROUGH ICS_CCR:OPI6
ICS_CCR:OPI7 THROUGH ICS_CCR:OPI12
ICS_CCR:PrtSrvr1
ICS_CCR:PrtSrvr2
ICS_CCR:PrtSrvr3
ICS_CCR:PrtSrvr4
CENTRAL CONTROL ROOM
CENTRAL CONTROL BUILDING
ICS_FE:NetSw1
ICS_FE:TS1
ICS_FE:OPI3 (FOR TEST STAND)
PORTABLE/TEMPORARY OPI (FOR TEST STAND)
ICS_FE:PrtSrvr3 (FOR TEST STAND)
PRINT SERVER
ICS_FE:Srvr1 (FE BOOT SERVER)
(FOR TEST STAND)
PORTABLE/TEMPORARY OPI CONNECTS
FRONT-END BUILDING
ICS_CUB:NetSw1
ICS_CUB:TS1
ICS_CUB:Srvr1 (CF BOOT SERVER)
CENTRAL UTILITY BUILDING
NOTES:
1. UNLESS OTHERWISE NOTED, CONNECTIONS ARE 100 MHz ETHERNET.
2. IN GENERAL, ARCHITECTURE IS INDIVIDUAL SWITCHED ETHERNET CIRCUITS RATHER THAN BUSES. THE READER SHOULD VIEW THE LINES SHOWN ON THE DRAWING AS "A BUNDLE OF CABLES" RATHER THAN AS "BUSES".
3. UNLESS OTHERWISE NOTED, EACH CONNECTION IS ON THE ICS CHANNEL ACCESS BROADCAST DOMAIN. (SOME CONNECTIONS ARE DESIGNATED AS "SNn" TO DESIGNATE THAT THEY ARE CONNECTED TO A DIFFERENT SUBNET.
KEY:
COPPER WIRE
GBIT FIBER OPTIC CABLE
FIBER OPTIC CABLE (100 MBIT, RS-232, ETC.)
SUBNET #2 SN2
SUBNET #3 SN3
REV. 7/28/99
ICS NETWORK BLOCK DIAGRAM
SHEET 1
Seed Date: Feb 1, '97



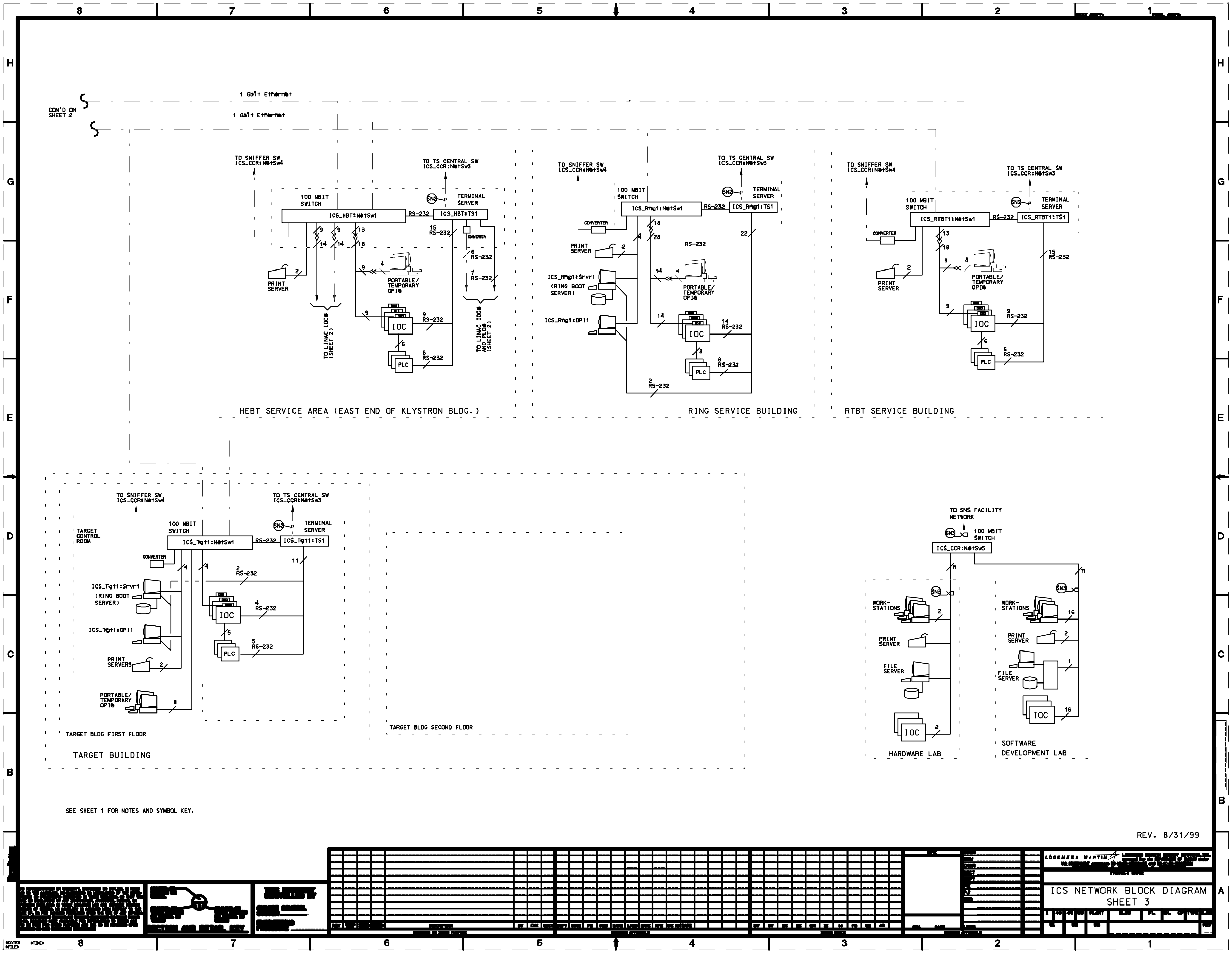
* SOME LINAC IOCs ARE PC-BASED, AND SO DO NOT HAVE A CONSOLE PORT

SEE SHEET 1 FOR NOTES AND SYMBOL KEY

REV. 8/31/99

LOCKHEED MARTIN

ICS NETWORK BLOCK DIAGRAM
SHEET 2



1 Gbit Ethernet
1 Gbit Ethernet
CON'D ON SHEET 2
TO SNIFFER SW ICS_CCR:NetSw4
TO TS CENTRAL SW ICS_CCR:NetSw3
100 MBIT SWITCH
ICS_HBT:NetSw1
TERMINAL SERVER
ICS_HBT:TS1
RS-232
CONVERTER
PRINT SERVER
PORTABLE/ TEMPORARY OPIs
IOC
PLC
TO LINAC IOCs (SHEET 2)
TO LINAC IOCs AND PLCs (SHEET 2)
HEBT SERVICE AREA (EAST END OF KLYSTRON BLDG.)
ICS_Rng1:NetSw1
ICS_Rng1:TS1
ICS_Rng1:Srvr1 (RING BOOT SERVER)
ICS_Rng1:OPI1
RING SERVICE BUILDING
ICS_RTBT1:NetSw1
ICS_RTBT1:TS1
RTBT SERVICE BUILDING
TARGET CONTROL ROOM
ICS_Tgt1:NetSw1
ICS_Tgt1:TS1
ICS_Tgt1:Srvr1 (RING BOOT SERVER)
ICS_Tgt1:OPI1
PRINT SERVERS
TARGET BLDG FIRST FLOOR
TARGET BLDG SECOND FLOOR
TARGET BUILDING
TO SNS FACILITY NETWORK
ICS_CCR:NetSw5
WORK-STATIONS
FILE SERVER
HARDWARE LAB
SOFTWARE DEVELOPMENT LAB
SEE SHEET 1 FOR NOTES AND SYMBOL KEY.
REV. 8/31/99
LOCKHEED MARTIN
ICS NETWORK BLOCK DIAGRAM
SHEET 3

APPENDIX C - DRAFT EQUIPMENT SPECIFICATIONS

Network switches:

For Basic Switch:
- 10BaseT and 100BaseTX supported.
- Redundant 1000baseX gigabit backbone.
- Performance specifications…
- Reliability specifications…
- Environmental specifications…
- Virtual network support
- Port mirroring, remotely configurable
- SNMP support
- Provisions to support future addition of video functions
- Redundant power supplies, with provisions for each power supply to be powered via a separate 120 VAC circuit.
- Suggested vendor & model: Cisco 4003

When 100 Mbit fiber optic connections (100BaseFX) to hosts are required, add the following:
- 100BaseFX supported.
- SC or MT-RJ fiber optic connections
- Suggested vendor & model: Cisco 6509

For Core switches, add the following:
- 1000BaseX supported
- SC or MT-RJ fiber optic connections
- Suggested vendor & model: Cisco 6509

Sniffer
(APS uses Network Associates Co. sniffers)

Channel Access Gateway
Suggested vendor & model: Sun Ultra 10

APPENDIX D - REFERENCES

D.1 APS

1. APS control system network topology diagram, available at: http://www.aps.anl.gov/asd/controls/network.html.

2. "An Accelerator Controls Network Designed for Reliability and Flexibility", W.P. McDowell and K.V. Sidorowicz, APS, available at: http://www.aps.anl.gov/icalepcs97/paper97/p115.pdf

3. "The APS Control System Network", K.V. Sidorowicz and W.P. McDowell, ANL, available at: http://adwww.fnal.gov/www/icalepcs/abstracts/PDF/m3ad.pdf

D.2 BNL SNS CONTROLS GROUP

1. "SNS Networking at BNL", John Smith, BNL, available at http://server.ags.bnl.gov/bnlags/bnlsns/sns.html under "SNS Technical Notes" item #56.

D.3 PRODUCT INFORMATION

1. Cisco Systems, http://www.cisco.com/public/pubsearch.html

2. LANCAST, Inc., fiber optic connectivity products, http://www.lancast.net/

Contributors:

Jeff Cleveland, ORNL / LMES Engineering
John Cobb, ORNL
Bill DeVan, ORNL
Chuck Fisher, ORNL
Dave Gurd, LANL
John Hammonds, ANL
Steve Lewis, LBNL
Bill McDowell, ANL
John Munro, ORNL
Ray Shanlever, ORNL / LMES Engineering
John Smith, BNL
Randall Wetherington, ORNL I&C Div.
Bobby Whitus, ORNL I&C Division