

Engineering Response to the Star LSI Workstation Goals

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The *Star LSI Workstation Goals* document sets guidelines for the implementation of a low cost workstation (terminal, processor, and peripherals) for the OIS Star product. This document responds to those goals.

Version 2.0 represents current thinking concerning the design of the Star LSI Workstation. The reader is encouraged to send comments to Bob Belleville (Belleville @ ParcMaxc or 8*923*4520). This file is stored on [IRIS] <Wortstation> LsiWS 2.0 > LsiWS.press.

Prepared by Robert L. Belleville
SDD Workstation Design

Approved by Ed Miller
SDD System Design and Test

Approved by Hal Lazar
SDD Technical Program Office

Approved by David E. Liddle
SDD

XEROX

Systems Development Department
3408 Hillview Avenue
Palo Alto, California 94304

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Engineering Response to the Star LSI Workstation Goals

1. Introduction, Conclusions, and Recommendations

The *Star LSI Workstation Goals* document [reference 1] sets guidelines for the implementation of a low cost workstation (terminal, processor, and peripherals) for the OIS Star product. This document responds to those goals.

Between October 1978 and April 1979 a number of studies have been conducted to determine the most appropriate implementation for the workstation.

The October study, reference [10], made a broad investigation of possible design approaches. In addition, this study carefully evaluated a synchronous design approach, developed by Butler Lampson (PARC) reference [2], in view of the goals. The recommendation of the October study was to pursue the synchronous approach.

During January and February of 1979 additional investigations were made to understand the nature of the synchronous approach and to further refine the design approach. (references [11-24].)

A workable approach, named Dandelion, evolved from the combination of the PARC processor design, an independent display controller, an independent 8085 based low speed I/O subsystem, and an expanded memory system. This approach most nearly meets the three most important goals - Star functionality, 1981 IMO, and cost.

A number of changes have occurred since the *Goals* were written. The most important is the development of a ROS/Mohawk base LSEP which can be connected to Dandelion. The full page display and quarter page display have been replaced by the 17" large format display and the Data Terminal "B" respectively.

This document parallels the *Goals* as closely as possible. The reader is urged to refer to the *Goals* while reading this *Response*.

2. Mandatory References

[1] Ruebel, R. et. al., *Star LSI Workstation Goals*, Xerox Internal Memo, 11 September 1977.

3. Informational References

These background references provides more depth on many of the subjects covered in this document.

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- [6] Ogus, Roy C., *Xerox Wire Specification*, Systems Development Department, April 5, 1978.
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- [9] Wick, J., *D0 Timing Simulation*, Systems Development Department, October 18, 1978.
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- [11] Snow, R., *Experience with MIDAS*, Systems Development Department (Memo), January 3, 1979. Filed on [IRIS] <Workstation> Snow> Midas.memo
Note: References [12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24] are contained in a single printable file [IRIS] <Workstation> Notes> WS-Summary.press (62 pages).
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- [17] Crane, R., *Low Speed Printer Interface*, Systems Development Department (Memo), January 27, 1979. Filed on [IRIS] <Crane> LSEP.press
- [18] Crane, R., *Workstation Display*, Systems Development Department (Memo), February 8, 1979. Filed on [IRIS] <Workstation> Notes> WSDisplay.press
- [19] Purcell, S., *Sumit Flexibility*, Systems Development Department (Memo), February 1, 1979. Filed on [IRIS] <Workstation> Notes> Flexibility.memo
- [20] Purcell, S., *Low Speed Electronic Printing and Sumit Workstation*, Systems Development Department (Memo), December 1, 1978. Filed on [IRIS] <Workstation> Notes> LSEP-

WS.memo

- [21] Fairbairn, D., *NoteTaker System Manual*, Palo Alto Research Center/SSL, December 1979. (Note: logic drawings also available)
- [22] Ogus, R., *Workstation Low-Speed Processor*, Systems Development Department (Memo), February 6, 1979. [IRIS] <Workstation> Notes> LSProc.memo
- [23] Crane, R., *64K Memory Reliability*, Systems Development Department (Memo), February 9, 1979. Filed on [IRIS] <Workstation> Notes> WSMemRel.press
- [24] Garner, R., *ALU Timing*, Systems Development Department (Memo), February 15, 1979. Filed on [IRIS] <Workstation> Notes> ALUTiming.press
- [25] Miller, E. and R. Belleville, *Workstation Structure*, Systems Development Department (Memo), February 23, 1979. Filed on [IRIS] <Workstation> Notes> WS-StudyII.Memo
- [26] Crane, R., *Dandelion Memory System*, Systems Development Department (Memo), April 9, 1979. Filed on [IRIS] <Workstation> Notes> WSMemSys.press
- [27] Hruschak, J. and S. Marshall, *Star/Mohawk control interface*, M&OED/SI/IOT (Memo), April 30, 1979.
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4. General Requirements

The Goals[1] require the following general considerations:

1. The Workstation is a multinational product. It is designed to adhere to Multinational Standards 1-8. It is assumed that the program will be single point design and single point manufacture.
2. The Workstation is designed to meet the Star Product Functions Specification for release 1 as well as releases 2 and 3.

An additional goal is to use standard peripherals developed by Xerox OEM suppliers and other programs.

5. System Concepts

The system combines both a high performance processor, developed at the Palo Alto Research Center, a low cost "off the shelf" LSI microprocessor, and standard peripherals to produce a cost effective solution to the problems presented by Star application software.

The Dandelion processor must:

- a. Support the OIS software language - Mesa.
- b. Drive a crt display with more than a full page of multi-font text and graphics.
- c. Interface with high performance peripherals such as the 10 million bit per second Xerox Wire communication network.
- d. Support a range of slow devices such as keyboard, pointer, floppy disk, and serial communication.

To meet these needs, Dandelion is designed from four subsystems shown in the diagram.

The central processor section is specially designed from commercially available, high performance, bit-slice, microprocessor components. It executes Mesa programs and directly interfaces to the rigid disk, Xerox Wire, and the Low Speed Electronic Printer (LSEP).

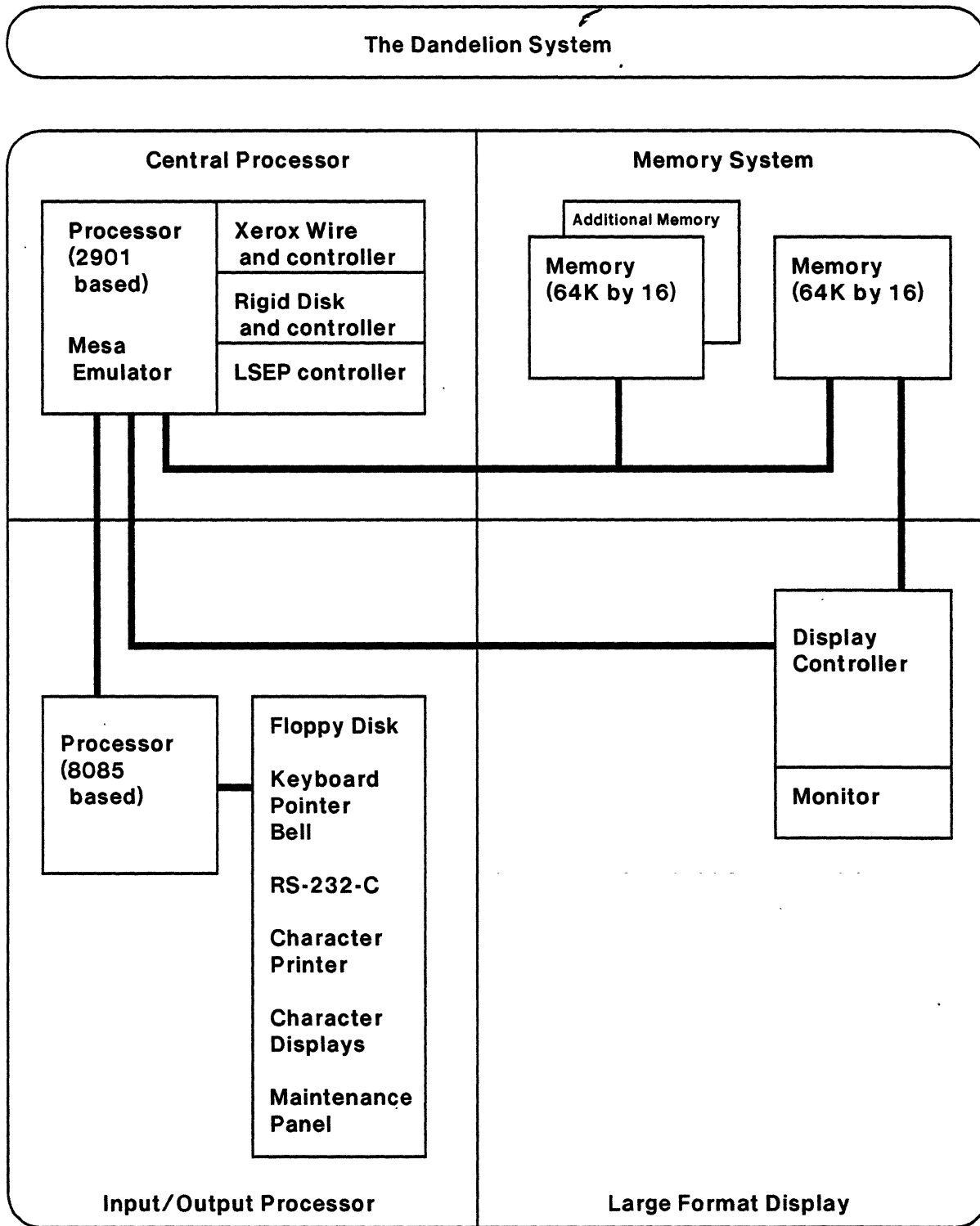
Because the image on the crt is large (1024 dots wide by 809 dots high) and must be refreshed nearly 40 times a second to produce a flicker free image, a separate display controller is included to send 50 million bits per second from the display memory to the crt.

The memory system, which is designed from LSI memory components, provides the system with 128K words (16 bits wide) of main memory. Error correction for single bit errors is fully automatic. (K=1024)

To interface to a several slow devices, an Input/Output Processor (IOP) is included. The processor is an Intel 8085 which is currently used in several Xerox products. LSI controllers connect directly to the 8085 to dramatically reduce the cost and complexity of the whole system.

Standard peripheral devices are used to the greatest extent possible in the workstation. The following devices are described in their *Requirements Specification*:

- CRT Display - Large Format Display
- Rigid Disk - either Shugart's SA100X or SA400X
- Floppy Disk - either Shugart's SA800 or SA850
- Xerox Wire Tranceiver
- Character Printer - Diablo's Beach printer



6. Workstation Configuration

The preliminary workstation configuration is shown in the figure on page 8. Please refer to this drawing while reading the following section.

The 64K LSI memory parts which are needed for the lowest cost implementation of the workstation may not be available in sufficient quantity, at the right price, to support the early (1980/1981) production requirements. To reduce risk two separate memory systems are being designed - one using 16K LSI memory parts and a second using 64K parts. Unfortunately, the 16K design requires a two module implementation. The design is proceeding in such a way that when the single module, 64K systems become available the second module can be dropped with no change to the backplane.

In addition to the storage of 128K 16-bit words of information, the memory system provides for fully automatic correction of single bit errors and the detection of double bit errors.

The processor and high speed I/O are housed on the next two modules. The CPU module contains the ALU (Arithmetic Logic Unit), micro-instruction control storage, and related logic.

The high speed I/O module contains the controllers for the rigid disk, large format display, Xerox Wire, and the LSEP (Low Speed Electronic Printer). Effort will be made to insure that the least number of configurations of this module need be designed; however, because of board space limitations the following 4 modules will probably be needed:

1. Display, SA1000, Xerox Wire
2. Display SA4000, Xerox Wire
3. LSEP, SA1000, Xerox Wire
4. LSEP, SA4000, Xerox Wire

The IOP module supports the basic low speed devices needed for Star functionality. In addition this module, which includes a 8085 microprocessor, controls the central processor during startup. The diagnosability of the whole system is also enhanced by this independent module. The peripherals supported in the standard configuration are:

- IBM compatible floppy disks, single and dual density/sided
- Keyboard, pointer (mouse), and speaker
- Time of day clock
- Maintenance panel, reset and alternate boot buttons
- 2 independent channels of RS-232-C DCE interface

The alternate boot button provides a means for the system to be coldstarted, from a device other than the rigid disk, without the need for a keyboard. This allows a workstation-based, LSEP server to be started from floppy disk, for example.

The two RS-232-C DCE interfaces can be used in a number of ways. One of the connectors includes the LSEP interface as well as the RS-232-C connection.

RS-232-C provides for two types of equipment to be interfaced, data terminal equipment (DTE) and data communication equipment (DCE). In short, one DTE can be plugged into one DCE. The character printer (Beach), the digital terminal (Beehive "B"), and the Aux. Media are all designed to meet RS-232-C DTE specifications. Modems, on the other hand, are DCE.

Only one LSEP can be connected to the workstation at a time. This leaves a free DCE port for a

digital terminal, Aux. Media, or character printer. If no LSEP is connected then the port is free for use with terminal, Aux. Media, or character printer. (This configurability refers to hardware only. Software limitation may also apply.)

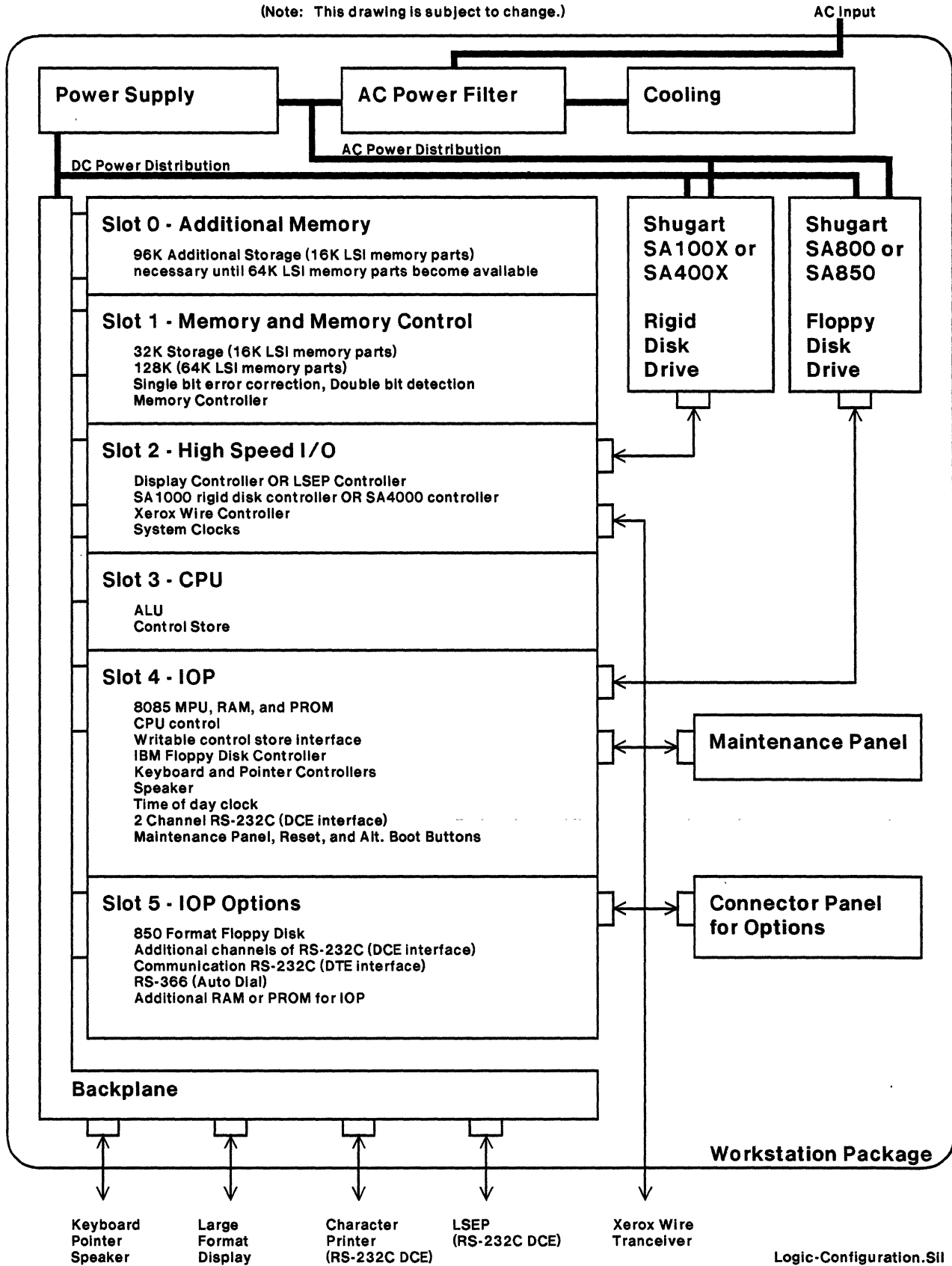
If additional RS-232-C DCE connections are needed for digital terminals these can be provided on the IOP option module. Also RS-232-C DTE connections to a external communication system are also housed on the IOP option module. Connection to the IOP options are made on a connector panel located at the rear of the package.

Extra interface hardware required by the non-standard 850 format floppy disk can also be included in the IOP option module.

In addition to the electronics, a DC power supplies provides about 350 watts to the logic. Filtered AC is distributed to the disks, power supply and fans. Effort will be taken to insure that the system can be operated from a standard 15 Amp outlet (i.e. total rating not to exceed 12 Amps.)

Preliminary Workstation Configuration

(Note: This drawing is subject to change.)



7. UMC Estimate

The chart on page 10 shows an estimate of the UMC of the workstation and related optional equipment.

8. Performance/Physical Characteristics

The workstation processor system is designed to meet Star functional requirements. Performance has been carefully examined and the results are reported in references [12] and [13].

Reference [13] estimates that the workstation processor should display a full page of multi-font text in less than 2 seconds. This must be accomplished with the display processor running. The workstation is designed to meet this requirement.

Care has been taken to insure that diagnostics and maintenance can be performed quickly and effectively. The packaging takes both servicability and cooling as principal concerns. Individual logic modules are functionally split to assist in fault isolation. MTBF and MTTR cannot be estimated at this time.

Multi-national Standards are being followed.

9. Graphic Output

The character printer is directly supported in the standard workstation configuration. The electrical interface provided by the workstation is RS-232-C DCE. A specification of that interface is included in reference [28].

The Versatec electrostatic plotter is not included in the workstation design at this time.

An interface to a ROS/Mohawk LSEP is included in the basic workstation. The interface specification is detailed in reference [27]. When a workstation is configured to include an LSEP, no display controller (for the large format display) is included. An RS-232-C DCE interface is available to drive a digital terminal; however. Performance data on driving the ROS/Mohawk is given in reference [20].

10. IMO

Work is now underway to insure that the workstation meets a 1Q81 IMO. Detail Schedule information is given in the *Star Engineering Support Plan*.

11. Cost of Ownership

The design of the workstation has been aimed at producing a functional processor system for Star which will be efficient and reliable.

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**Workstation PD UMC Estimate
(1982 Economics)**

O Console - Material Breakdown

Printed Wiring Board Assemblies

PWBs, Backplane, and Interconnect	-	-	-	-	-	-	-	-	-	-	400	
Miscellaneous LSI parts	-	-	-	-	-	-	-	-	-	-	155	
System RAM	-	-	-	-	-	-	-	-	-	-	190	
Control RAM	-	-	-	-	-	-	-	-	-	-	147	
Miscellaneous MSI/SSI parts	-	-	-	-	-	-	-	-	-	-	220	
Structure	-	-	-	-	-	-	-	-	-	-	148	
Power Supply	-	-	-	-	-	-	-	-	-	-	300	
SA 800 Floppy Disk Drive	-	-	-	-	-	-	-	-	-	-	180	
SA 1000 Rigid Disk Drive	-	-	-	-	-	-	-	-	-	-	480	
Other	-	-	-	-	-	-	-	-	-	-	166	
											<u>2386</u>	
											Total Material	\$2386

<u>Material</u>	<u>Material Overhead</u>	<u>Labor & Overhead</u>	<u>DMF</u>	<u>Total</u>
2386	263	221	138	

Console Subtotal \$3008

	<u>Material</u>	<u>Material Overhead</u>	<u>Labor & Overhead</u>	<u>DMF</u>	<u>Total</u>
O Display	342	38	25	30	435
O Keyboard	137	15	10	10	172
O Pointer	62	7	20	19	108
O Character Printer					891

Peripheral Equipment Subtotal \$1606

Complete Workstation Configuration with Character Printer \$4614