Engineering Response to the Star LSI Workstation Goals

Version 2.0
May 1979

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.
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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 The full page display and quarter page display have been replaced by the 17" large format display and the Data Terminal "B" respectively.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

3. Informational References

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


WS.memo


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 Transceiver
- Character Printer - Diablo's Beach printer
The Dandelion System

Central Processor
- Processor (2901 based)
- Mesa Emulator
- Xerox Wire and controller
- Rigid Disk and controller
- LSEP controller
- Processor (8085 based)
- Floppy Disk
- Keyboard
- Pointer
- Bell
- RS-232-C
- Character Printer
- Character Displays
- Maintenance Panel

Memory System
- Additional Memory
- Memory (64K by 16)
- Memory (64K by 16)
- Display Controller
- Monitor

Input/Output Processor

Large Format Display

DandeLion-Block.sii
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.)

Power Supply

AC Power Filter

Cooling

DC Power Distribution

AC Power Distribution

Slot 0 - Additional Memory
96K Additional Storage (16K LSI memory parts) necessary until 64K LSI memory parts become available

Slot 1 - Memory and Memory Control
32K Storage (16K LSI memory parts)
128K (64K LSI memory parts)
Single bit error correction, Double bit detection
Memory Controller

Slot 2 - High Speed I/O
Display Controller OR LSEP Controller
SA1000 rigid disk controller OR SA4000 controller
Xerox Wire Controller
System Clocks

Slot 3 - CPU
ALU
Control Store

Slot 4 - IOP
8085 MPU, RAM, and PROM
CPU control
Writable control store interface
IBM Floppy Disk Controller
Keyboard and Pointer Controllers
Speaker
Time of day clock
2 Channel RS-232C (DCE interface)
Maintenance Panel, Reset, and Alt. Boot Buttons

Slot 5 - IOP Options
850 Format Floppy Disk
Additional channels of RS-232C (DCE interface)
Communication RS-232C (DTE interface)
RS-366 (Auto Dial)
Additional RAM or PROM for IOP

Backplane

Maintenance Panel

Connector Panel for Options

Keyboard
Speaker
Large Format Display
Character Printer (RS-232C DCE)
LSEP (RS-232C DCE)
Xerox Wire Tranceiver

Logic-Configuration.Sil
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.
Workstation PD UMC Estimate  
(1982 Economics)

O Console - Material Breakdown

<table>
<thead>
<tr>
<th>Printed Wiring Board Assemblies</th>
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<th>Labor &amp; Overhead</th>
<th>DMF</th>
<th>Total</th>
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Console Subtotal $3008

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</table>

Character Printer $891

Peripheral Equipment Subtotal $1606

Complete Workstation Configuration with Character Printer $4614
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<td><strong>$2386</strong></td>
</tr>
</tbody>
</table>

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      |                   |                  |     | 891    |

**Peripheral Equipment Subtotal $1606**

**Complete Workstation Configuration with Character Printer $4614**