

SURFACE VEHICLE RECOMMENDED PRACTICE

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RECOMMENDED PRACTICE FOR THE SELECTION OF ENGINEERING WORKSTATIONS

FOREWORD

The development of cost effective engineering workstations has resulted in a marketplace with many vendors, each offering a myriad of options or configurations. This proliferation has created confusion for the potential user who is seeking a degree of standardization for selection given a particular application level. The engineer needs a better definition of supported functions that should be expected from the workstation vendors. A functionality definition is required that describes performance and capacity ranges, and sets specific standards in the following areas:

Hardware

System Software

Communications

Graphics Display

This document, therefore, defines the range of these workstation requirements for the engineer. These Engineering Workstation specifications are based on the commitment to existing and emerging industry standards. This commitment facilitates the following:

Portability of application software from one vendor's workstation to another.

A "single point of access" to compute resources.

A consistent "user interface".

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FOREWORD (Continued)

Virtual "seamless" communications across local and wide area networks serving a diverse hardware environment.

Full support for a diverse application environment.

1. SCOPE:

This SAE Recommended Practice defines a guideline to help engineering users in workstation selection by specifying engineering workstation configurations in terms of vendor supported functionality for several levels of performance and capacity. These workstations will satisfy different engineering applications while maintaining interoperability. The objective is to specify a set of standards, not a single workstation, which must be addressed by the Engineering Workstation vendors to meet the hardware and operating environment needs of engineers in their CAD, CAM, CAE and other engineering activities.

2. REFERENCES:

2.1 Applicable Documents:

2.1.1 ANSI Documents:

ANSI X3.9-1978 1978 ANSI standard "Programming Language FORTRAN"

ANSI X3.64 Current ANSI standard "Additional Controls for Use with American National Standard Code for Information Interchange"

ANSI X3.144 Current ANSI standard "Information Systems - Computer Graphics - Programmer's Hierarchical Interactive Graphics System (PHIGS) Functional Description, Archive File Format, Clear-Text Encoding of Archive File"

ANSI X3.159 Current ANSI standard "Programming Language C"

2.1.2 Other Documents:

CCITT X.25 CCITT Recommendation "Interface Between DTE and DCE for Terminals Operating in the Packet Mode on Public Data Networks"

CCITT X.400 CCITT Recommendation "Message Handling Systems: System Model - Service Elements"

CCITT V.35 CCITT Recommendation "Data Transmission at 48 KBPS Using 60 - 108 KHz Group Band Circuits" for data communication over the telephone network

2.1.2 (Continued):

EIA-232-D	Current ANSI/EIA standard "Interface Between Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary Data Interchange" (revision of standard RS-232-C)
EIA-343-A	Current EIA standard "Electrical Performance Standards for High Resolution Monochrome Closed Circuit Television Camera"
EIA-449	Current ANSI/EIA standard "General Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange"
IEEE 488.1	Current ANSI/IEEE standard "IEEE Standard Digital Interface for Programmable Instrumentation"
IEEE 488.2	Current ANSI/IEEE standard "IEEE Standard Codes, Formats, Protocols, and Common Commands" (For Use with ANSI/IEEE Standard 488.1-1987 IEEE Standard Digital Interface for Programmable Instrumentation)
IEEE 770X3.97	Current ANSI/IEEE standard "Pascal Programming Language"
IEEE 802.3	Current ANSI/IEEE standard for Local Area Networks "CSMA/CD Media Access Method"
IEEE 802.4	Current ANSI/IEEE standard for Local Area Networks "Token-Passing Bus Access Method and Physical Layer Specifications"
IEEE 802.5	Current ANSI/IEEE standard for Local Area Networks "Token Ring Access Method and Physical Layer Specifications"
IEEE 1003.1	Current IEEE standard "Portable Operating System Interface for Computer Environments"
RS-232-C	See EIA-232-D
RS-449	See EIA-449
XPG3	X/OPEN Company Limited, Portability Guide Issue 3, December 1988

2.2 Glossary of Acronyms/Terms:

ADA: High level computer programming language named after Lady Ada Lovelace, Charles Babbage's computer programmer.

ANSI: American National Standards Institute.

2.2 (Continued):

ANTI-ALIASING: A technique used to provide a greater apparent resolution on the screen of a graphics display without the cost of a higher resolution display.

BSD 4.3: Berkeley Software Distribution (version 4.3).

C: High level programming language (see ANSI X3.159).

CCITT: Comite Consultatif International de Telegraphique et Telephonique (an international consultative committee that sets international communications usage standards).

CPU: Central Processing Unit.

CRAY STATION: CRAY Research, Inc.'s proprietary remote job scheduling products.

CSMA/CD: Carrier Sense Multiple Access with Collision Detection.

DCE: Data Communications Equipment.

DEC VT-100: Digital Equipment Corporation proprietary ASCII text terminal emulation products.

DEC VT-2xx: Digital Equipment Corporation proprietary graphics terminal emulation products.

DEPTH QUENING: Graphics display technique in which an object being displayed that is farther from the viewer is darker; the closer an object, the brighter it is.

DOUBLE BUFFERING: The concept of using two buffer registers between a computer's central processing unit and an input/output device in which one buffer is being refreshed while the other is being used for the input (or output) operation thereby resulting in increased performance and reduced flicker between screen updates.

DTE: Data Terminal Equipment.

EIA: Electronics Industries Association.

FORTRAN-77: High level computer programming language for FORMula TRANslation - 1977 version; (see ANSI X3.9-1978).

GB: Gigabyte; billions of bytes.

GOURAUD: Shading technique used for the display of objects in which varying degrees of light intensity are calculated across each polygonal surface making up the object. This technique provides a more realistic image than constant shading but a somewhat less realistic image than provided by Phong shading.

2.2 (Continued):

IBM LU 6.2: International Business Machines Corporation's Logical Unit type 6.2 proprietary format operating under SNA for application to application program communications across a network.

IBM 3179/3279G: International Business Machines Corporation's proprietary SNA terminal with vector data stream products.

IBM 3279: International Business Machines Corporation's proprietary SNA vector graphics terminal products.

IBM 5080: International Business Machines Corporation's proprietary high performance graphics terminal emulation products.

IEEE: The Institute of Electrical and Electronic Engineers, Inc.

IEEE 802.3: Local area network standard based on CSMA/CD Ethernet technology over various media (see IEEE 802.3).

IEEE 802.4: Local area network based on token bus over broadband technology (see IEEE 802.4).

IEEE 802.5: Local area network based on token ring technology (see IEEE 802.5).

IEEE 1003: See "POSIX" (see IEEE 1003.1).

I/O: Input/output.

ISO/OSI: International Organization for Standardization/Open Systems Interconnection.

LAN: Local area network.

LISP: LISP Processing programming language widely used in artificial intelligence applications.

MAP/TOP: Manufacturing Automation Protocol/Technical Office Protocol.

MB: Megabyte; millions of bytes.

MEGAPIXEL: Millions of graphics display picture elements.

MFLOPS: Millions of floating point operations per second (see Argonne National Laboratory report "Performance of Various Computers Using Standard Linear Equations Software in a FORTRAN Environment", Table 1, "Solving a System of Linear Equations with LINPACK in Full Precision using All FORTRAN").

MIPS: Millions of instructions per second executed by a computer's central processing unit.

2.2 (Continued):

MS DOS: Microsoft Corporation's Disk Operating System for personal computers.

NFS: SUN Microsystems, Inc.'s Network File System specification.

Non-interlaced: In raster graphics display tubes, every scanning line is refreshed for each sweep down the display as opposed to the interlace method used in standard television in which every other scanning line is refreshed during each sweep thereby requiring two sweeps to completely refresh the display.

NTSC: National Television Standards Committee.

NURBS: Non-Uniform Rational B-spline Surfaces.

OSF/Motif: Open Software Foundation X-Window based user interface product.

Pascal: High level computer programming language named after Blaise Pascal (see IEEE 770X3.97).

PC-DOS: IBM Personal Computer Disk Operating System.

PEX: PHIGS+ Extensions to X-window.

PHIGS: Programmer's Hierarchical Interactive Graphics System (see ANSI X3.144).

PHONG SHADING: A compute-intensive shading technique used in the display of objects whereby the light intensity for every point on the object is calculated to obtain a very realistic image.

PIXEL: The smallest addressable picture element of a graphics display.

POSIX: Portable Operating System Interface for "X" computer environment (see IEEE 1003.1).

POSTSCRIPT: Adobe Systems Incorporated's proprietary device-independent, high-level, interpretive programming language with extensive graphics capabilities. It is primarily used to describe the appearance of text, geometric shapes and sampled images on printed pages.

PU: Physical Unit.

QWERTY: A standard keyboard named because the letters 'qwerty' appear in order in the row of keys directly above the keyboard left hand home row.

2.2 (Continued):

RGB Output: An output model for specifying a color, or a gray-scale, as a combination of the three primary colors of light (red, green and blue) in particular concentrations. The intensity of each primary color is specified by a number in the range of 0 to 1. If all three colors have equal intensity, the perceived result is a pure gray on the scale from black to white. (see EIA-343-A).

RJE: Remote Job Entry.

RS-232: Serial interface specification (see EIA-232-D).

RS-449: Serial interface specification (see EIA-449).

TCP/IP: Transmission Control Protocol/Internet Protocol.

TEKTRONIX 4XXX: Tektronix Inc.'s proprietary graphics terminal products.

UNIX SYSTEM V: Current version of the portable computer operating system developed by Bell Laboratories of AT&T.

WAN: Wide area network.

X/OPEN GUI: X/OPEN Corporation specification for a graphical user interface (future).

X-WINDOW SYSTEM: Massachusetts Institute of Technology's defacto standard portable distributed windowing system.

X.25: CCITT Recommendation "Interface Between DTE and DCE for Terminals Operating in the Packet Mode on Public Data Networks" (see CCITT X.25).

V.35: CCITT Recommendation "Data Transmission at 48 KBPS Using 60 - 108 KHz Group Band Circuits" for data communication over the telephone network (see CCITT V.35).

X.400: CCITT Recommendation "Message Handling Systems: System Model - Service Elements" (see CCITT X.400).

Z BUFFERING: Technique used in hidden-surface algorithms in which the z-depth value of each pixel being examined is compared against the value stored in the buffer to see which pixel is closer to the viewer. The pixel closest to the viewer is then displayed. High depth z buffering is accomplished by using additional bits in the z-buffer (24 bit).

2.3 Trademarks:

Ethernet - Trademark of Xerox Corporation

Motif - Trademark of Open Software Foundation

Network File System - Trademark of Sun Microsystems, Inc.

NFS - Trademark of Sun Microsystems, Inc.

OSF - Trademark of Open Software Foundation

2.3 (Continued):

POSIX - Trademark of the Institute of Electrical and Electronic Engineers
Postscript - Registered trademark of Adobe Systems, Inc.
Unix - Registered trademark of AT&T
X/Open - Registered trademark of X/Open Company, Ltd.
X Window System - Trademark of Massachusetts Institute of Technology

3. TECHNICAL COMPLIANCE MATRIX:

The workstation specifications are contained in the Technical Compliance Matrix, which is divided into two sections: (1) Standard Workstation Characteristics (see Table 1); and (2) Minimum Performance and Capacity Ranges (see Table 2). These two sections are described below.

3.1 Technical Compliance Matrix - (see Table 1):

Table 1 contains the standard workstation characteristics that must apply to all workstations claiming compliance with this document. This section is organized into four categories:

- a. Hardware: Workstation CPU, I/O, memory, addressing hardware.
- b. System Software: Operating systems, languages, file system and windowing support.
- c. Communications: LAN, WAN, gateways, and emulators.
- d. Graphics Display: Display size, resolution, and graphics performance features.

Each category contains three columns of information: Characteristic items, Base System specifications or standards, and User Option specifications or standards.

- (1) Characteristic: This column briefly describes each workstation attribute.
- (2) Base System: The features indicated in the base system specification for each item are those features which a workstation vendor must provide as standard features on all workstations. It is anticipated that users would require all of these features on an engineering workstation. The base system specifications would typically define the minimum in the range of performance for any workstation.
- (3) User Options: User Options are those features which could be purchased as required for specific tasks and needs. However, the workstation vendor must supply and support all of the user options. Third party products could meet the user option requirements if they are supplied and supported by the workstation vendor. Each user option is marked to indicate whether it must be available from the workstation vendor on all workstation models, or available on at least one model within a product family.

TABLE 1 - Section I. Standard Workstation Characteristics

Hardware

Characteristic	Base System Requirements	User Option Availability	All Models	Some Model(s)
CPU	32 bit			
Bus Structure	Open, specifications published			
Random Access Memory	Minimum of 8 MB with error correction or detection			
Virtual Addressing	64 MB per process	2 GB per process		X
I/O Support	RS-232C or EIA-232-D	V.35 or RS-449		X
	3 Button Mouse			
	QWERTY Keyboard			
		Removable Media - tape, floppy, disk	X	
Physical Environment	Normal office environment (e.g. power, heat, noise)	Digitizing Device		X
Printer Support		Parallel Interface-Centronics or IEEE 488.2	X	
Server Capability		See Note 1		X

System Software

Characteristic	Base System Requirements	User Option Availability	All Models	Some Model(s)
Operating System	IEEE 1003 POSIX Compliance			
		BSD 4.3 Extensions	X	
		UNIX System V Extensions	X	
		PC-DOS or MS-DOS		X
Language Support		FORTAN 77 (ANSI X3.9-1978)	X	
		C (ANSI X3.159)	X	
Distributed File System		NFS Version 2	X	
Windowing System	X-Window Version 11.3			
	Multiple Processes			
	X server with support for graphics hardware			
	Xlib & Xtintrinsics			
	Libraries supporting PHIGS (ANSI X3.144)			
		MURBS Support		X
		Phong Shading		X
	X/OPEN GUI or OSF/Motif (w/ window manager and libraries)			
Hardcopy support		Postscript		X

TABLE 1 (Continued)

Communications

Characteristic	Base System Requirements	User Option Availability	All Models	Some Model(s)
Local Area Network	IEEE 802.3 or IEEE 802.5	IEEE 802.3	X	
	TCP/IP			
	BSD 4.3 network extension services			
	ISO/OSI commitment			
		MAP/TOP specification		X
Wide Area Network, Gateways, Emulators		ANSI X3.64 support	X	
		IBM 3x78 emulator with file transfer	X	
		IBM 3274 PU type 2.X plus C library		X

Graphics Display

Characteristic	Base System Requirements	User Option Availability	All Models	Some Model(s)
Display Characteristics	Non-interlaced Monitor	Monochrome		X
		Grayscale		X
		Color	X	
	12" display size (minimum)	12"-16" screen	X	
		At least 19" screen	X	
		Flat-faced		X
		RGB output		X
Display Resolution	0.7 megapixel display area (minimum)	See Section II		
High Performance Graphics Hardware		Hidden line & surface removal		X
		Z buffering (16 bit)		X
		High depth Z buffering (24 bit)		X
		Double buffering		X
		Depth queing		X
		Anti-aliasing (4K by 4K addressable)		X
		Overlay Plane facilities		X
		Gouraud Shading		X

3.2 Technical Compliance Matrix (see Table 2):

Table 2 contains performance and capacity ranges that will distinguish different models of workstations and/or different levels of user requirements. These individual items are divided into three categories:

- a. Processor performance requirements.
- b. Graphics display hardware capabilities.
- c. Memory and disk capacity requirements.

The level of each of the individual items in Table 2 should be specified independently of the other items listed. Vendors should specify the highest level, for each item, that a particular workstation model meets or exceeds.

3.3 Technical Compliance Matrix Notes:

3.3.1 Note 1: "Server" products consistent with family architecture capable of supporting shared work-group resources such as auxiliary storage, communications and peripherals. The requirement is to provide functionality sufficient to address all of the system administration issues present in a network environment. The detail-level implementation and richness of this functionality will be a significant factor in the selection of workstation strategic suppliers. Specific features should include (but not be limited to) the following list:

- a. Network initial program load (IPL) capability (i.e., the ability to "boot" a remote workstation of the same product family). The economy, data control, and reliability features available via the implementation of diskless workstation nodes drive this requirement.
- b. Computational serving ability
- c. Communications gateway ability
- d. Peripheral manager providing control of shared local area network (LAN) resources such as printers, plotters, disks, etc.
- e. Additional interface ports/slots
- f. Rack mountable with other devices capability

TABLE 2 - Section II. Performance and Capacity Ranges

Processor	Performance Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
CPU (in MIPS)	2 to < 5	5 to < 10	10 to < 20	20 to < 50	50 or more
Floating Point Operations (in MFLOPS)	0.2 to < 0.4	0.4 to < 1.0	1.0 to < 2.5	2.5 to < 5.0	5.0 or more

Graphics Display	Capability Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Display Area (in megapixels)	0.7 to < 1.0	1.0 to < 1.3	1.3 to < 4.0	4.0 or more	
Display bit planes - See (in bits per pixel) Note 3	1 to 7	8 to 23	24 to 39	40 or more	
Color Palette	< 256 K	256 K to < 16M	16 M or more		
Refresh-3D (in Kvectors/second)	< 10	10 to < 100	100 to < 300	300 to < 1000	1000 or more
Refresh-2D (in Kvectors/second)	< 100	100 to < 300	300 to < 1000	1000 or more	
Gouraud Shading (in Kpolygons/sec)	0 to < 1	1 to < 5	5 to < 20	20 to < 100	100 or more

Memory	Capacity Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Random Access Memory (in MB)	8 to < 16	16 to < 32	32 to < 64	64 to < 128	128 or more
Local Disk Capacity (in MB)	0 to < 300	300 to < 1000	1000 to < 5000	5000 or more	

See Note 2 for performance test specifications

- 3.3.2 Note 2: The performance test measurements for Table 2 of the Technical Compliance Matrix should be performed according to accepted industry practice. However, some of these tests will yield results that are not fully equivalent from one workstation family to another. In subsequent versions of this document, it is intended that these specifications will be changed to reflect the work of the Systems Performance Evaluation Cooperative (SPEC) and the NCGA Graphics Performance Characterization (GPC) committee. Other graphics display performance tests, such as flat shading or raster painting speeds, will be considered for inclusion in a future version.

The Floating Point Operations measurement should be performed using the LINPACK benchmark test from Argonne National Labs with FORTRAN in full (double) precision.

- 3.3.3 Note 3: Display Bit Planes include Z buffer and translucency bits.

3.4 Options Not in Technical Compliance Matrix:

The following list of items, which are not included in the Technical Compliance Matrix, is intended to convey valid user requirements which are not presently universal enough to be specified as mandatory. However, these items are suggested for consideration as value-added options, may be specified in acquisition documents and may become items in the Technical Compliance Matrix at a later date.

3.4.1 Hardware Options and Peripherals:

- a. NTSC video support
- b. Scanners
- c. Audio

3.4.2 Communications/Emulations:

- a. LAN
 - (1) High speed node-to-node (50 MB+)
- b. WAN/Gateway/Emulation Products
 - (1) IBM 3179G/3279G supporting vector data stream
 - (2) IBM 3174 controller emulation
 - (3) IBM LU 6.2 peer-to-peer communications
 - (4) RJE (56 Kb)
 - (5) IBM 5080 remote emulation
 - (6) DEC VT-100 emulation
 - (7) DEC VT-2XX emulation
 - (8) Tektronix 4XXX emulation
 - (9) CRAY station support
 - (10) CCITT X.400 electronic mail
- c. Network administration tools

3.4.3 Operating Environment:

- a. Operating System
 - (1) Real-time UNIX/POSIX support
- b. DOS under UNIX/POSIX
 - (1) VGA or EGA graphics in a variable size window up to full screen
- c. Language Support
 - (1) Ada
 - (2) BASIC
 - (3) LISP
 - (4) Object oriented C
 - (5) Pascal
- d. Windowing System
 - (1) 3D extensions (PHIGS in an X Window or PEX)
- e. Distributed Processor System Support
- f. User Interface - IEEE P1201 Committee Standard when adopted

4. EXAMPLES:

Examples of possible workstation configurations are shown for various application areas, using Table 2 of the Technical Compliance Matrix. The shaded areas represent the approximate level requirement for that particular range. These examples do not represent a standard for a particular workstation, and some application areas cover a wide range of requirements.

Processor	Performance Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
CPU (in MIPS)	2 to < 5	5 to < 10	10 to < 20	20 to < 50	50 or more
Floating Point Operations (in MFLOPS)	0.2 to < 0.4	0.4 to < 1.0	1.0 to < 2.5	2.5 to < 5.0	5.0 or more

Graphics Display	Capability Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Display Area (in megapixels)	0.7 to < 1.0	1.0 to < 1.3	1.3 to < 4.0	4.0 or more	
Display bit planes (in bits per pixel)	1 to 7	8 to 23	24 to 39	40 or more	
Color Palette	< 256 K	256 K to < 16M	16 M or more		
Refresh-3D (in Kvectors/second)	< 10	10 to < 100	100 to < 300	300 to < 1000	1000 or more
Refresh-2D (in Kvectors/second)	< 100	100 to < 300	300 to < 1000	1000 or more	
Gouraud Shading (in Kpolygons/sec)	0 to < 1	1 to < 5	5 to < 20	20 to < 100	100 or more

Memory	Capacity Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Random Access Memory (in MB)	8 to < 16	16 to < 32	32 to < 64	64 to < 128	128 or more
Local Disk Capacity (in MB)	0 to < 300	300 to < 1000	1000 to < 5000	5000 or more	

FIGURE 1 - Example Performance and Capacity Ranges
Technical Publishing Workstation

Processor	Performance Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
CPU (in MIPS)	2 to < 5	5 to < 10	10 to < 20	20 to < 50	50 or more
Floating Point Operations (in MFLOPS)	0.2 to < 0.4	0.4 to < 1.0	1.0 to < 2.5	2.5 to < 5.0	5.0 or more

Graphics Display	Capability Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Display Area (in megapixels)	0.7 to < 1.0	1.0 to < 1.3	1.3 to < 4.0	4.0 or more	
Display bit planes (in bits per pixel)	1 to 7	8 to 23	24 to 39	40 or more	
Color Palette	< 256 K	256 K to < 1M	16 M or more		
Refresh-3D (in Kvectors/second)	< 10	10 to < 100	100 to < 300	300 to < 1000	1000 or more
Refresh-2D (in Kvectors/second)	< 100	100 to < 300	300 to < 1000	1000 or more	
Gouraud Shading (in Kpolygons/sec)	0 to < 1	1 to < 5	5 to < 20	20 to < 100	100 or more

Memory	Capacity Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Random Access Memory (in MB)	8 to < 16	16 to < 32	32 to < 64	64 to < 128	128 or more
Local Disk Capacity (in MB)	0 to < 300	300 to < 1000	1000 to < 5000	5000 or more	

FIGURE 2 - Example Performance and Capacity Ranges
Drafting and Layout Workstation

Processor	Performance Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
CPU (in MIPS)	2 to < 5	5 to < 10	10 to < 20	20 to < 50	50 or more
Floating Point Operations (in MFLOPS)	0.2 to < 0.4	0.4 to < 1.0	1.0 to < 2.5	2.5 to < 5.0	5.0 or more

Graphics Display	Capability Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Display Area (in megapixels)	0.7 to < 1.0	1.0 to < 1.3	1.3 to < 4.0	4.0 or more	
Display bit planes (in bits per pixel)	1 to 7	8 to 23	24 to 39	40 or more	
Color Palette	< 256 K	256 K to < 16M	16 M or more		
Refresh-3D (in Kvectors/second)	< 10	10 to < 100	100 to < 300	300 to < 1000	1000 or more
Refresh-2D (in Kvectors/second)	< 100	100 to < 300	300 to < 1000	1000 or more	
Gouraud Shading (in Kpolygons/sec)	0 to < 1	1 to < 5	5 to < 20	20 to < 100	100 or more

Memory	Capacity Requirement				
	Level 1	Level 2	Level 3	Level 4	Level 5
Random Access Memory (in MB)	8 to < 16	16 to < 32	32 to < 64	64 to < 128	128 or more
Local Disk Capacity (in MB)	0 to < 300	300 to < 1000	1000 to < 5000	5000 or more	

FIGURE 3 - Example Performance and Capacity Ranges
Wireframe and Surfaces Workstation