

DEC VAXstations

MANAGEMENT SUMMARY

UPDATE: *Since we last reported on the VAXstation line, Digital Equipment Corporation has added the high-end VAXstation 8000, a 3-D graphics engine. The vendor has also enhanced the memory capacity of the low-end VAXstation 2000 and has added software that allows all models in the line to develop 3-D graphics applications.*

Industry analysts are focusing on the challenge posed to Digital Equipment Corporation's VAX superminis by IBM's new AS/400. Digital's single-user VAXstations, however, also face strong challenges in the unruly, competitive market for high-performance workstations.

According to estimates by International Data Corporation (Framingham, Massachusetts), Digital captured about 25 percent of the \$2.75 billion technical workstation market in 1987—second only to Sun Microsystems. While that showing is perfectly respectable, Digital has had to fill gaps in its product line that continued to leave it vulnerable to challenges not only from Sun, but also from Apollo Computer, Hewlett-Packard, Silicon Graphics, and even newcomers Ardent Computer (Sunnyvale, California) and Stellar (Newton, Massachusetts).

The VAXstation 8000 plugs the largest hole in Digital's line: lack of a machine capable of delivering 3-D graphics ➤



The high-end VAXstation 8000 rounds out Digital Equipment's workstation line by delivering previously absent 3-D graphics facilities. Offering some of the best graphics functionality available among comparable products, the VAXstation 8000 won't hit its full stride as a market competitor until support for the UNIX environment becomes available in the fall of 1988.

The five-model VAXstation line runs the gamut from small, diskless input stations for 2-D graphics to a 3-D realtime graphics engine. The VAXstations employ either Digital's proprietary VMS operating system or ULTRIX-32, Digital's native-mode implementation of the UNIX operating system. All VAXstations include Ethernet interfaces for configuration in multistation networks; they can also participate in Digital's VAX-cluster resource sharing schemes.

MODELS: VAXstation 2000, VAXstation II/GPX, VAXstation 3200, VAXstation 3500, and VAXstation 8000.

MEMORY: 4M to 32M bytes.

DISK CAPACITY: 0 or 42M to 560M bytes (local storage).

WORKSTATIONS: Up to three monitors and keyboards on VAXstation II/GPX.

PRICE: \$4,825 to \$89,900 (base configuration prices).

CHARACTERISTICS

VENDOR: Digital Equipment Corp. (DEC), 146 Main Street, Maynard, Massachusetts 01754-2571. Telephone (508) 897-5111.

CANADIAN ADDRESS: Digital Equipment of Canada, Ltd., P.O. Box 13000, 100 Herzberg Road, Kanata, Ontario K2K 2A6. Telephone (613) 592-5111.

DATA FORMAT

BASIC UNIT: 32-bit word.

INTERNAL CODE: ASCII for text-oriented data; binary for calculations.

MAIN STORAGE

Memory on the VAXstation II/GPX and 2000 is dynamic parity MOS RAM. Main memory cycle time is 400 nanoseconds. Main memory increments on the VAXstation II/GPX are 2M, 4M, and 8M bytes. The VAXstation 2000 is available with 4M, 6M, or 14M bytes of memory. Addressable memory on these systems is 16M bytes.

The VAXstation 3200 and 3500 each support 8M-byte memory modules which use 256K-bit ZIP DRAM-based error correction code (ECC) memory. The 3200 supports two of these modules (16 megabytes) and the 3500 supports four (32 megabytes). Addressable memory on the 3200 and 3500 is 64 megabytes. Memory boards based on 1-megabit chips will eventually be available, enabling the newer systems to take physical advantage of this increase in addressable memory. In addition, the newer memory provides ECC. ECC detects single- and double-bit errors and corrects single-bit errors; parity memory simply detects ➤

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CHART A. SYSTEM COMPARISON

MODEL	VAXstation 2000	VAXstation II/GPX	VAXstation 3200	VAXstation 3500	VAXstation 8000
SYSTEM CHARACTERISTICS					
Date of introduction	February 1987	January 1986	September 1987	September 1987	February 1988
CPU type	MicroVAX 78032	MicroVAX 78032	CVAX 78034	CVAX 78034	VAX 8250
CPU cycle time	200 ns	200 ns	90 ns	90 ns	160 ns
Operating system	VMS, ULTRIX-32	VMS, ULTRIX-32	VMS, ULTRIX-32	VMS, ULTRIX-32	VMS
Upgradable from	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Upgradable to	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Number of expansion slots	0	2 (BA23); 6 (BA123)	4	6	1
MEMORY					
Minimum capacity (bytes)	4M	5M	8M	16M	16M
Maximum capacity (bytes)	14M	16M	16M	32M	32M
DISK STORAGE					
Minimum capacity (bytes)	0 or 42M	0 or 71M	71M	159M	159M
Maximum capacity (bytes)	318M	477M	318M	560M	477M
NUMBER OF MONITORS					
COMMUNICATIONS PROTOCOLS	DECnet, TCP/IP, Ethernet, SNA, X.25	DECnet, Ethernet, SNA, X.25			
PURCHASE PRICE (Base Configurations)					
	\$4,825 to \$22,125	\$22,275 to \$65,795	\$20,725 to \$35,775	\$52,405 to \$60,405	\$89,900

▷ for intensive applications such as industrial design, architectural engineering, molecular modeling, and realtime simulation. All of Digital's major rivals already supply such machines. Digital had to start delivering a comparable system to maintain credibility in the marketplace.

Although Digital's VAXstation line has obviously sold well, the bulk of units shipped have been low-end VAXstation 2000s, which are frequently employed in diskless configurations networked around a server. Reliance on the 2000s and the more powerful 2-D stations—VAXstation II/GPX, 3200, and 3500—limited Digital's product scope and kept the company from delivering a product line that permitted a soup-to-nuts approach to application design and problem solving.

With the VAXstation 8000 in place at the high end, Digital now has an integrated line of workstations that can take full advantage of the company's vaunted networking capabilities. In a mechanical engineering application, for example, the VAXstation 2000 can be used for drafting; the design can be sent to the VAXstation 3200 or 3500 for modeling and testing and then on to the 8000 for wireframe, surface, and solids manipulation and graphic display.

The VAXstation 8000, designed in partnership with Evans and Sutherland (Salt Lake City, Utah), features Digital's VAX 8250 CPU and a specialized graphics processor. This combination allows the station to process up to 500,000 graphics vectors per second—the highest rate in the industry among comparable products—and to render 10,000 polygons per second. The graphics processor also provides an unusually high apparent screen resolution of 8,100 by 6,900 pixels.

While its graphics performance is impressive, the VAXstation 8000's pure computational power of 1.2 MIPS is a good deal lower than that of comparable machines from Sun (high-end Sun-4/200 Series processors deliver up to 10 MIPS). Digital claims to have chosen the 8250 because at the time it was the only single-board CPU—required

▶ single-bit errors. ECC is necessary to provide the higher data integrity required when using larger amounts of memory.

The VAXstation 8000 supports up to 32M bytes of memory, housed on two 16M-byte modules.

Like all VAX and MicroVAX systems, the VAXstations provide up to 4G bytes of virtual memory space.

PROCESSING COMPONENTS

The VAXstation II/GPX and 2000 employ the MicroVAX 78032 CPU, MicroVAX 78132 Floating Point Unit (FPU), and VAX instruction set. A description of these processing units and the implementation of the instruction set is provided in "DEC MicroVAX Family" (Report M09-325-101), in *Datapro Reports on Minicomputers*.

System electronics require four boards on the VAXstation II/GPX but have been reduced to one board on the VAXstation 2000 by using large-scale integration and proprietary standard cell and surface mount technologies.

The VAXstation 3200 and 3500 use the CVAX 78034 CPU chip and CVAX 78134 Floating-Point Unit. The use of CMOS technology in the CPU and FPU on the 3200 and 3500 results in a more efficient processor board layout that enables the implementation of dual-level cache memory. The CPU chip holds 1K bytes of cache memory, and an additional 64K bytes reside on the CPU board. The 3200 and 3500 CPUs feature a 90-nanosecond cycle time.

The VAXstation 8000 employs Digital's VAX 8250 CPU for applications processing. The processor board also contains 8K bytes of cache memory. (For information on the characteristics of the VAX 8250 CPU, refer to the "DEC VAX Systems" report.) Two MicroVAX II processors control input/output (I/O) to disk, tape, and input devices. A third MicroVAX II processor controls the interface to the graphics subsystem.

▶ **GRAPHICS CO-PROCESSORS:** The VAXstation 3200, 3500, and II/GPX, as well as certain configurations of the VAXstation 2000, feature the GPX graphics co-processor, which off-loads text and graphics computations from the CPU. The GPX provides a display list interface that supports a range of raster operations in hardware, including the following:

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for desktop packaging—in Digital's line that supported the VAXBI bus, which alone could deliver the data transfer speeds required for intensive graphics applications.

Apparently, Digital didn't employ the more powerful, 2.8-MIPS CVAX chip set, which anchors the new 6200 Series of multiuser VAXs, because the CVAX didn't support the VAXBI at the time the workstation was developed. (Previously employed only on the VAXstation 3200 and 3500, as well as on the MicroVAX 3500 and 3600, the CVAX set supported only the Q-bus.) Now that the CVAXs do support the VAXBI, as in the VAX 6200 Series, we assume that Digital will base future generations of the VAXstation 8000s on the CVAX/6200 implementation.

That assumes, of course, that Digital stays with proprietary technology for new high-end workstations. Digital is believed to be pursuing an agreement with MIPS Computer Systems (Sunnyvale, California) to incorporate that vendor's Reduced Instruction Set Computer (RISC) chips, which can deliver approximately 8 MIPS, into future products. Digital President Ken Olsen has also admitted that Digital is itself "half working" in RISC technologies, which could also surface in forthcoming products.

Whatever technologies it employs, Digital must certainly boost the computational power of its high-end offerings not only to compete with Sun, but also to combat incursions by so-called superworkstations—also called personal supercomputers—like Ardent's Titan and Apollo's forthcoming Series 10000, based on Apollo's Parallel Reduced Instruction Set Multiprocessing (PRISM) architecture. The computational performance of those products is measured in millions of floating-point operations per second (MFLOPS), rather than in MIPS.

Oddly enough, Digital has not yet delivered configurations of the VAXstation 8000 that run under ULTRIX-32, the company's implementation of the UNIX operating system; the 3-D machine is currently supported only under the proprietary VMS operating system, with ULTRIX availability slated for about the fourth quarter of 1988, according to sources at Digital. (We believe that Digital will actually announce the availability of ULTRIX and adjunct products as part of the DECworld exhibition in Cannes, France, in September.)

In a market where a UNIX license is an integral feature of the vast majority of units shipped, Digital's delay in delivering an ULTRIX-compatible machine automatically limits the number of sales the company can expect in the short term. (The delay certainly ties in with the availability of critical graphics facilities, as discussed below.)

Of course, not all the action in the workstation market occurs at the high end; the low-level niches are hotly contested also. Thus, Digital has increased the main memory capacity on its low-end VAXstation 2000s to 14M bytes. This enables it to compete more effectively with Sun's 386i family (which supports up to 16M bytes) in

- ▶ • Bit-plt with rotation, fractional scaling, and Boolean operations
- Vector and text drawing
- Hardware clipping, tiling (stippling), and pattern fill
- Smooth scrolling in both vertical and horizontal planes

The GPX co-processor also resolves conflicts resulting from the interaction of multiple video processes, such as CRT refresh, scrolling, and screen updates with new data. The GPX co-processor operates at speeds up to 560M bps.

The GPX graphics co-processor is closely coupled to the double-buffered video memory. Graphics information is stored in video memory rather than in system memory or on disk, resulting in faster text and graphics drawing speeds. The co-processor can also independently access display list instructions in virtual memory using Direct Memory Access (DMA). No DMA is available on the VAXstation 2000; however, video memory appears as local to the host CPU.

The GPX graphics co-processor offers either four or eight planes of display memory. The four-plane co-processor has a display capability of 16 simultaneous colors from a palette of 16 million on a color monitor or 16 simultaneous shades of gray on a monochrome monitor. (The latter is referred to as "gray-scale.") The eight-plane co-processor, available in either gray-scale or color, has a display capability of 256 simultaneous colors from a palette of 16 million. Each plane is a 1K-by-1K-by-2 video bit-map display. The "2" indicates an off-screen page that stores occluded or predrawn images.

The VAXstation 2000 also comes in monochrome configurations featuring a GPX co-processor with one plane of display memory.

The VAXstation 8000 uses a graphics subsystem jointly developed by Digital Equipment and Evans & Sutherland Corp., an interactive graphics applications developer from Salt Lake City, Utah. The graphics subsystem comprises the following six modules:

- Structure memory
- Structure walker
- Geometry pipeline
- Rendering processor
- Pixel processors
- Frame buffer

Each module is dedicated to a particular phase of 3-D graphics creation and display.

The structure of an object is defined in a hierarchical display list stored in the 4M-byte *structure memory*. Display data can be modified without rebuilding the entire structure. A transformation matrix specified on the display list corresponds to a dial on the station's dial box, allowing users to change parameters in the display list in realtime with little CPU intervention. ▶

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CHART B. DISK/DISKETTE DEVICES

MODEL	RX33	RX50	RD32	RD53	RD54	RA70
Type	Diskette	Dual diskette	Winchester	Winchester	Winchester	Winchester
Size (inches)	5.25	5.25 per diskette	5.25	5.25	5.25	5.25
Formatted capacity per drive (bytes)	1.2M	818K (409K per diskette)	42M	71M	159M	280M
Interface/controller	RQDX3; integral (VAXstation 2000)	RQDX3; KFBTA (VAXstation 8000); integral (VAXstation 2000)	KDA50			
Number of drives per interface/controller	2	4	4	4	4	4
Average access time	175 ms	264 ms	48.3 ms	38.3 ms	38.3 ms	27 ms
Data transfer rate	500K bps	250K bps	5M bps	625KB/sec	625KB/sec	1.4MB/sec
Bytes per sector/track	512/sector	512/sector	512/sector	512/sector	512/sector	512/sector
Purchase price	\$388	\$1,050 to \$1,890	\$1,615	\$4,190 to \$5,570	\$4,500 to \$5,500	\$9,000

▷ computation-intensive commercial applications—like financial analysis and sales forecasting—where larger memories are required.

COMPETITIVE POSITION

Delivery of industry-standard products is a critical issue in the workstation market, where the majority of units shipped run under operating systems derived from UNIX. Mindful of that market demand, Digital has delivered VAX PHIGS, an implementation of the popular Programmer's Hierarchical Interactive Graphics System. PHIGS is a 3-D graphics tool that provides the interface between an application program and the underlying graphics system, controlling the definition, modification, and display of hierarchical graphics data. VAX PHIGS complements Digital's Graphical Kernel System (GKS) product, which provides an interface for 2-D graphics applications.

Digital's PHIGS product, despite its usefulness, exposes some inconsistencies in the vendor's strategy for product delivery under the two operating environments it provides for the VAXstation line. GKS is currently available under both VMS and ULTRIX-32. PHIGS, on the other hand, is currently available only for VMS; UNIX implementations for ULTRIX-32 can only be obtained from third parties. According to sources at Digital, PHIGS will not be made directly available for ULTRIX-32 until ULTRIX-32 support is offered for the VAXstation 8000 in the fall of 1988.

At the same time, support for DECwindows, an implementation of the X Window Version 11 interface mechanism, will be made available for both the VMS and ULTRIX environments. The X Window system allows applications to be run on remote network nodes but displayed on a local station; DECwindows will allow users to run VMS, ULTRIX-32, and MS-DOS windows from the same workstation. This facility will provide the VAXstations with the direct MS-DOS compatibility that they lack (and which Sun has recently delivered with its 386i workstations).

Currently, windowing is provided in different ways for the two environments; X Window Version 10 is integral to

▷ The *structure walker* reads and interprets the stored display structure. It maintains a stack of graphics state information that can be saved and restored. When the data structure has been interpreted, graphics commands are passed on to the *geometry pipeline* to be processed. The geometry pipeline consists of a set of parallel processors performing standard graphics calculations. The processors also calculate depth and adjust line endpoints so that they match properly and enhance image quality. The geometry pipeline processors can perform up to 104 million arithmetic operations per second.

The output of the geometry pipeline can either be used to display wireframes or be passed through the *rendering processor*, which performs back-face removal, hidden surface testing, interpretation of lighting, and shading for a realistic interpretation of the object being modeled. A specialized 32-bit processor operating at a peak of 40 million operations per second provides the rendering processor with realtime graphics performance.

The last step for both wireframes and rendered polygons is to pass the graphics data through a set of 16 *pixel processors*, which perform antialiasing (the elimination of jagged edges from curved lines, resulting in heightened image quality), color interpolation, and parallel writes into the frame buffer. The pixel processors operate at a peak of 263 million operations per second. The result is an image with 8,100 by 6,900 pixels of apparent resolution.

The pixel processors write output to corresponding pixels on the *frame buffer*, which consists of 58 planes and 1,024 by 1,024 pixels. Of this, 1,024 by 864 lines drive the VAXstation 8000's VR290 monitor. The remaining 1,024 by 160 lines are used for off-screen storage. Ten bit planes are used for control, while the others are used for various functions, including display, buffering, and color coding.

The output of the frame buffer goes to the video control system, which converts stored digital data into analog signals for display.

INPUT/OUTPUT CONTROL

I/O on the VAXstations II/GPX, 3200, and 3500 is handled through the 22-bit extended Q-bus (also called the Q22), which provides a common communications path for the data, address, and control information passed among the CPU, memory, and device interfaces. The Q-bus provides 22-bit addressing and four interrupt levels and performs block mode DMA data transfers on a bandwidth of up to 3M bytes per second.

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CHART C. GRAPHICS MONITORS

MODEL	VR150/VR260	VR160/VR290
DISPLAY PARAMETERS		
Screen size (inches)	15 (VR150); 19 (VR260)	15 (VR160); 19 (VR290)
Tilt/swivel screen	Standard	Standard
Total colors/no. simult. displayed	16 (4-plane) or 256 (8-plane) simultaneous shades of gray	16 million/16 (4-plane), 256 (8-plane)
Resolution (pixels)	1,024 x 864, 100/78 pixels per inch	1,024 x 864, ¹ 100/78 pixels per inch
KEYBOARD PARAMETERS		
Style	Typewriter	Typewriter
Character/code set	ASCII	ASCII
Detachable	Yes	Yes
Program function keys	20	20
PURCHASE PRICE	\$1,200 (VR150); \$2,300 (VR260)	\$2,000 (VR160); \$6,300 (VR290)

¹Effective resolution on the VAXstation 8000's VR290 is 8,192 x 6,912.

the ULTRIX Worksystem Software (UWS) delivered on the ULTRIX-based VAXstations, while a different windowing system is incorporated into the VMS Workstation Software (VWS) provided for machines running in the proprietary operating environment.

As a competitive necessity, Digital must make the software offerings for both environments symmetrical. Needless to say, the company has to deliver a PHIGS version compatible with UNIX to compete with Sun. That competition in delivery of graphics products takes on added intensity because of the two companies' struggle for control of the direction—and installed base—of UNIX products: Sun is working with AT&T to develop the next release of System V and Digital is a sponsoring partner in the Open Software Foundation (OSF). To be taken seriously as a committed UNIX vendor for the workstation market, Digital must deliver ULTRIX PHIGS ASAP.

Delivery of DECwindows for the VMS environment is similarly urgent. PHIGS and X Windows Version 11 have both been announced as standards that OSF intends to follow. As has been reasonably rumored, Digital intends to make its VMS environment adhere to the IEEE's POSIX standard—with which the OSF's operating environment will comply. In that case, Digital will have to deliver standards compliant VMS products that dovetail with the OSF's offerings and with those available for the ULTRIX environment, which should be made POSIX-compliant this summer.

On the price front, Digital should decrease the price of the VAXstation 8000 to compete more evenly with comparable Sun offerings. Sun's new 7-MIPS 4/150CXP (for mechanical CAD and architecture, engineering, and construction applications) costs approximately \$6,400 per MIPS, compared to a far higher \$74,900 per MIPS for the 1.2-MIPS VAXstation. One can argue that the vastly greater graphics functionality of the VAXstation 8000 justifies its higher price; after all, the 500,000-vector-per-second capabilities of the VAXstation dwarf the 150,000-vector-per-second capability of the Sun machine. Digital must cut this price difference, however, to fully exploit the attractiveness of its graphics capabilities in the marketplace.

The VAXstation 2000, like the MicroVAX 2000, employs a busless architecture and has no expansion slots. It is equipped with a modified Small Computer Systems Interface (SCSI) port designed to connect the expansion cabinet housing a TK50 tape drive and additional disk drive.

Because it is essentially a specialized VAX 8250 system, the VAXstation 8000 employs a single 13.3M-byte VAXBI bus as both system and I/O bus. For details on the VAXBI, refer to the "DEC VAX Systems" report. The VAXBI on the VAX 8000 supports three MicroVAX-based controllers: the KFBTA disk controller; the DEBNK, which handles tape devices and the interface to the Ethernet network; and the graphics subsystem interface, which synchronizes the mapping of graphics data between VAX virtual memory and the graphics subsystem. It also manages input from the keyboard, mouse, and dial box, which allows a user to manipulate an image on a screen by mapping control attributes such as rotation, scaling, and translation to the dials with little CPU intervention.

The VAXstation 8000 employs a peripheral repeater box that serves as a central connection point for the monitor and the input devices, simplifying cable management.

CONFIGURATION RULES

Since ULTRIX-32 software is available only on tape, ULTRIX-32 systems that are not networked require a TK50 tape drive. An ULTRIX-32 system without a TK50 must be networked to another ULTRIX-32 system running Remote System Manager (RSM) V1.1 to support downline loading of the operating system.

A VMS system without a TK50 or an RX50 diskette must be networked to another VMS system running RSM V1.1 to support downline loading of the operating system.

The VAXstation 2000 is housed in a compact system box but maintains hardware and software compatibility with the larger VAXstation members. The VAXstation 2000 is available in a number of kernel configurations, to which options can be added. The kernels are designated as diskless kernels, as RD53 kernels that include a 71M-byte RD53 disk, or as RD54 kernels that include a 159M-byte RD54 disk drive. Each of the kernels includes 4M, 6M, or 14M bytes of memory; a 15- or 19-inch monochrome or color monitor; a ThinWire Ethernet interface; documentation; and VMS, VMS Workstation Software (VWS), DE-Cnet, and Local Area VAXcluster (LAVC) licenses or ULTRIX-32 and ULTRIX Worksystem Software (UWS), Network File System (NFS), ULTRIX C, VAX C, ULTRIX Fortran, and ULTRIX Pascal licenses.

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CHART D. PRINTERS

MODEL	LA75	LA210	LN03	LN03 Plus
Type	Dot matrix	Dot matrix	Laser	Laser
Speed	32/42/125/250 cps	40/240 cps; 80 cps opt.	8 ppm	8 ppm
Bidirectional printing	Yes	Yes	Not applicable	Not applicable
Paper size	4.25 to 10.0 in. wide	3.5 to 14.9 in. wide	8.5 x 11.0 in.	8.5 x 11.0 in.
Character formation	36 x 18/36 x 17/24 x 9/12 x 9 dot matrix	33 x 18/7 x 9 dot matrix; 33 x 9 opt.	300 x 300 dots/in.	300 x 300 dots/in.
Horizontal character spacing (char./inch)	10.0, 12.0, 16.5, 17.1, or 5.0, 6.0, 8.25, 8.55	Variable	Variable	Variable
Vertical line spacing (lines/inch)	2, 3, 4, 6, 8, 12	Variable	Variable	Variable
Character set	ASCII, 8 others	94 ASCII; Courier, VT100 line-drawing std.; others opt.	ASCII; 16 resident Courier/Elite fonts	ASCII; technical; 17 resident fonts
Controller/interface	RS-423	RS-232-C std.; Centronics parallel opt.	RS-232-C	RS-232-C
No. of printers per controller/interface	1	1	1	1
Printer dimensions, in. (h x w x d)	4.8 x 16.8 x 13.6	5.0 x 21.5 x 13.5	15.0 x 21.0 x 23.5	15.0 x 21.0 x 23.5
Graphics capability, dots per inch	180 x 144	132 x 72	Not applicable	300 x 300
Comments	Built-in LA50, LA100, LA210, IBM Pro-printer emulation	Compatible with IBM PC/XT/AT	Prints in landscape and portrait modes	Provides bit-mapped, Tektronix 4010/4014-compatible graphics
Purchase price	\$835	\$1,760	\$2,895	\$3,995

➤ The VAXstation 2000s are faced with a similar challenge at the low end of the line. For example, the 3-MIPS Sun 386i/150—targeted for similar electronic publishing, financial services, financial analysis, sales forecasting, and other commercial applications—prices out to about \$2,700 per MIPS, compared to \$5,100 per MIPS for a comparably configured 0.9 MIPS VAXstation 2000. If Digital can't deliver better bang with its low-end machines, it must try for better bucks.

ADVANTAGES AND RESTRICTIONS

Digital offers innovative networking schemes for its VAXstations and other computers, and that's a significant advantage in environments where sharing computational and peripheral resources is critical. Up to 42 VAXstation and MicroVAX nodes can be connected over Ethernet in a configuration called a Local Area VAXcluster (LAVC). In LAVCs, servers provide boot services, including computational facilities and disk storage far in excess of those available to individual stations. (For example, Digital's VAXservers—specially configured MicroVAXs—can support almost 2G bytes of disk storage, compared to the 560M-byte limit on any single VAXstation.)

In addition, through a scheme that Digital calls LAVC Phase II (LAVC 2), LAVCs can access the far greater storage and computational facilities of VAXclusters incorporating Digital's VAX superminis and Hierarchical Storage Controllers (HSCs). VAXclusters can incorporate the recently introduced Symmetrical Multiprocessor (SMP) VAX computers and the 9.7G-byte SA600 Storage Array, four of which can be supported per HSC, providing up to 37.8G bytes of online storage on each controller. (For details on VAXclusters, refer to the "DEC VAX Systems" report on Page M11-325-501 in *Datapro Reports on Mini-computers*.)

➤ Each VAXstation 2000 kernel supports the following options:

- A keyboard.
- A pointing device (mouse or tablet).
- A four-plane graphics co-processor for monochrome, gray-scale, or color display.
- An eight-plane graphics co-processor for gray-scale or color display.
- Two half-height storage devices that can be added to the diskless configurations. These include the 1.2M-byte RX33 diskette drive and a 42M-byte RD32 disk drive. (Only one of each can be configured and both must be housed in the system box; these devices are not supported under the ULTRIX-32 operating system.)
- The TK50 tape drive, available only in the BA40A expansion box.
- A second full-height RD53 or RD54 disk that can be added to the RD53 and RD54 kernels; this requires the BA40A expansion adapter. The BA40A expansion adapter houses both a TK50 tape drive and an RD53 or RD54 disk drive. If both a second disk and the TK50 are added, only one expansion adapter need be ordered.

In June 1988, Digital added six diskless configurations to the VAXstation 2000 line. These kernels include the four- or eight-plane graphics co-processor, keyboard, and mouse that are offered only as options on the other VAXstation 2000s. These configurations also come with 6M or 14M bytes of system memory, a 15- or 19-inch color monitor, Ethernet controller, and ULTRIX or VMS license.

➤ The VAXstation II/GPX is housed in either the BA23 (four-plane) or BA123 (eight-plane) enclosure. It includes the MicroVAX II CPU and FPU and supports up to three graphics co-processors, three 19-inch monochrome or color

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CHART D. PRINTERS (Continued)

MODEL	ScriptPrinter (LNO3R)	LCG01	LJ250/LJ252	PrintServer 40 (LPS40)
Type	Laser	Color	Color	Laser
Speed	8 ppm	1 page per 2 min.	20-167 cps NLQ; 1 page per 2-4 min. graphics	40 ppm
Bidirectional printing	Not applicable	Yes	Yes	Not applicable
Paper size	8.5 x 11.0 in. or 8.3 x 11.7 in.	8.5 x 11.0 in.	8.5 x 11.0 in.	7.5 to 11.0 in. wide; 10.5 to 17.0 in. long
Character formation	300 x 300 dots/in.	Inkjet	Thermal inkjet drop-on-demand	Electrophotographic
Horizontal character spacing (char./inch)	Variable	Variable	10, 12, 18	Variable
Vertical line spacing (lines/inch)	Variable	Variable	2, 3, 4, 6, 8, 12	Variable
Character set	ASCII, technical; 29 resident fonts	Variable	Variable	29 resident typefaces
Controller/interface	RS-232-C	RS-232-C, RS-422, 20 mA	Serial (LJ250) or parallel (LJ252)	—
No. of printers per controller/interface	1	1	1	—
Printer dimensions, in. (h x w x d)	15.0 x 21.0 x 23.5	8.5 x 24.0 x 24.25	3.65 x 17.5 x 12.25	40.4 x 60.0 x 28.4
Graphics capability, dots per inch	300 x 300	154 x 154	90 x 90 or 180 x 180	300 x 300
Comments	Includes PostScript Interpreter; prints ANSI/sixel, ReGIS, and Tektronix 4010/4014 files	Supports ReGIS, NAPLPS, and Bit Map Image protocols; up to 216 shades	Includes HP-PCL support; supports ReGIS graphics	Ethernet print server; uses PostScript; includes ANSI/sixel-, ReGIS-, Tektronix-to-PostScript translators
Purchase price	\$5,495	\$17,490	\$1,695	\$49,900

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

➤ In fact, all models of the VAXstation line incorporate Digital's DECnet and LAVC software licenses in the basic configuration prices, so the networking functionality is available with each system at no extra cost. The UWS workstation software on the ULTRIX-32-based workstations provides compatibility with Sun Microsystems' Network File Systems (NFS), so those stations have access to a de facto industry standard for multivendor networking. Moreover, DECnet-ULTRIX networking software, available for the workstations that run under UNIX, allows access to TCP/IP networks, which are heavily employed in the UNIX workstation environment.

Digital also offers diskless configurations of its workstations, saving users the cost of storage hardware that they may not need if they intend to configure the stations in networks or LAVCs. Use of diskless stations can also enhance security in environments where data is critical or sensitive by allowing a central, more easily monitored storage facility.

USER REACTION

Datapro recently spoke to two VAXstation users at the University of Pennsylvania's Wharton School of Business Administration. Wharton was suggested to us as a site by the Digital Equipment Computer Users Society (DECUS).

Wharton employs seven VAXstation 2000s, all running the VMS operating system. Two VAXstations are employed in the Systems Group, which provides computing services to the faculty and administration through Digital Equipment, Floating Point Systems (FPS), and IBM equipment. Three VAXstations are in faculty offices in

➤ monitors, and three keyboards and mice. The system supports up to 16M bytes of memory (up to two memory modules can be configured per system); 477M bytes of disk storage through three 159-megabyte RD54 disks in a desk-side enclosure; and the DEQNA or DELQA Ethernet interface. System purchase includes a VMS or ULTRIX-32 license containing all the components cited above for the VAXstation 2000.

The VAXstation II/GPX is available in diskless configurations, in two-user configurations, and in packaged systems that include basic disk storage facilities. The system can support four- and eight-plane graphics co-processors. Also supported are the 71M-byte RD53 disk drive and the TK50 tape drive.

A special configuration of the VAXstation II/GPX is available for artificial intelligence (AI) applications. Housed in the BA123 enclosure, it includes 16M bytes of memory, two RD54 disk drives, a TK50 tape drive, a VR290 19-inch color monitor, an eight-plane graphics co-processor, mouse, keyboard, DEQNA Ethernet interface, VAX/Lisp, and VMS and VWS or ULTRIX-32 and UWS licenses.

The VAXstation 3200, housed in the BA23 pedestal enclosure, is available in diskless configurations as well as in configurations with integral storage. It comes in either four-plane gray-scale or eight-plane color versions.

➤ A basic 3200 configuration includes the CMOS CPU and FPU, 8M bytes of memory, a four- or eight-plane graphics co-processor, a 19-inch monochrome or color monitor, a DELQA Ethernet interface, documentation, and one-year hardware and software warranty. A VMS-based system includes the VMS operating system, VWS, LAVC, and DECnet end node software licenses. A system based on ULTRIX—Digital's version of the Berkeley UNIX operating system—includes ULTRIX-32, UWS, Fortran, VAX-C, and Pascal licenses.

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▷ the Decision Sciences department. Those five stations are networked through an Ethernet-based LAVC with a MicroVAX II as a server. The other two VAXstations are used by the school's administration and are networked to another MicroVAX.

Wharton's VAXstations can also access the resources of the school's VAX 8700-based VAXcluster through the Ethernet network.

Currently, Wharton is evaluating both a MicroVAX 3500 and a 3600 as servers; an ULTRIX-32-based VAXserver 3500 is also on order.

The first user we spoke to is a systems programmer. He primarily uses the multiwindowing facilities of VMS Workstation Software (VWS) on his VAXstation 2000 for remote login over Ethernet to the VAXcluster system and other network nodes. He tells us that a recent power outage caused a problem with VWS: the software crashes whenever the station is started. While awaiting repair, he and another programmer have been using a PC that permits only a single-screen image; they find the PC far inferior to the VAXstation, which boasts a 19-inch screen in addition to the windowing facilities. In his words, "We've been spoiled. . . . If somebody tries to take my station away, they're going to have a fight on their hands."

When queried about Digital's response to problems like the one described, he says that the field service unit is very responsive. He is, he says, "very pleased" with Digital's support.

This user makes an interesting observation about how Wharton uses the VAXstation 2000s. Although each is configured with a 42M-byte RD32 disk drive, the Systems Group recommends that the faculty clients use the local disks only for paging and swapping files; critical applications and data are stored on a 456M-byte RA81 drive attached to the MicroVAX II server. The reason for that guideline is twofold. First, the professors who use the VAXstations normally require more storage than is provided by the local disks; secondly, using a central disk resource for significant data simplifies backup.

The second user we interviewed is Morris Cohen, professor of Decision Sciences. Cohen employs his VAXstation 2000 in three ways. He uses it as a standalone computer to work on manufacturing planning, simulation, and optimization models. He also uses the station to "exploit the transparency" that Ethernet provides among the VAXstations, the VAXcluster, and other processors on the network. The station serves as a platform from which he can tie into multiple processors on the network and run different variants of a problem simultaneously.

In addition, Cohen occasionally uses his station simply as a terminal, sending print jobs to laser printers attached to the VAXcluster and tying into ARPANET and other networks on and off campus for electronic mail and to exchange professional information.

▶ The VAXstation 3200 supports an additional 8M bytes of memory, for a total of 16M bytes. (Up to two memory modules can be configured per system.) The system also supports up to 318M bytes of disk storage (two 159M-byte RD54 drives). The system will accommodate an internal, 95M-byte TK50 tape drive; it also supports the 296M-byte TK70 tape drive.

Because of power and cooling restrictions, a VAXstation 3200 configuration (the VS315) that includes the RD54 disk can accommodate only 8M bytes of memory if both disk and tape are added internally.

The *VAXstation 3500* is housed in the BA213 pedestal enclosure and comes with the CMOS CPU and FPU, 16M bytes of memory, a four- or eight-plane graphics co-processor, a 19-inch monochrome or color monitor, a DELQA Ethernet interface, a 280M-byte RA70 disk drive, a 296M-byte TK70 tape drive, documentation, and one-year hardware and software warranty.

A VMS-based 3500 system includes VMS, VWS, LAVC, and DECnet end node software licenses; an ULTRIX-based system includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses.

The VAXstation 3500 supports an additional 16M bytes of memory (i.e., two 8M-byte memory modules can be added to the integral system memory), for a total of 32M bytes. An additional RA70 disk drive can be configured in the pedestal enclosure for a total of 560M bytes of disk storage.

The gray-scale version of the VAXstation 3200 and 3500 includes a four-plane graphics co-processor and a monochrome monitor; the color version includes an eight-plane graphics co-processor and color monitor. The keyboard, mouse or tablet, and power cord must be ordered separately.

The *VAXstation 8000* includes 16M bytes of memory; 58-plane, 3-D graphics subsystem; RD54 159M-byte disk drive; VR290 19-inch color monitor; keyboard/mouse; eight-knob dial box; DELQA Ethernet controller; 95M-byte TK50 tape unit; VMS, High-Performance Workstation Software (HPWS, incorporating Digital's implementation of the X Window system) and DECnet licenses. The VAXstation 8000 features one expansion slot. The system supports two additional RD54 disk drives. Up to 16M bytes of memory can be added through 4M-byte or 16M-byte increments. The standard Digital graphics tablet can be added to the VAXstation 8000.

VAXstations are available in special VMS- and ULTRIX-based configurations for development of artificial intelligence applications. The *AI VAXstation 2000, 3200, and 3500* include a Lisp license. A license for the OPS5 AI language is also included with VMS-base AI VAXstations.

Specialized VMS-based realtime workstation systems, called *VAXlabs*, are offered for laboratory data acquisition and experiment control applications. The VAXlab/GPX, 2000, and 3200 include the following facilities:

- Subroutine libraries for realtime I/O, mathematical and statistical analysis, signal processing, and scientific graphics
- Realtime support for analog I/O, digital I/O, IEEE 488 realtime clock, and serial I/O options

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Like the systems programmer to whom we spoke earlier, Cohen says that he likes the large screen and VWS windowing facilities that his monochrome station provides—particularly the latter facility, because it allows him to initiate multiple jobs simultaneously.

Cohen says that, as much as he likes the VAXstation 2000, he finds it somewhat slow, particularly when compared to Digital's multiuser VAXs. "I'm impressed that the little box on my desk equals one eighth of an 8700, but it's still only one eighth." [*Editor's Note: Digital actually rates the VAXstation 2000 at about one seventh the power of the VAX 8700.*] Cohen would eventually like a station that delivers more power for his modeling and analysis work. □

- ▷ • Special interface panels for connecting laboratory instruments

Specialized configurations of Digital's MicroVAX systems, called *VAXservers*, are available as boot nodes and resource servers for distributed workstations in network and Local Area VAXcluster environments. (For details on LAVCs, see the SOFTWARE section below.) The three servers are the VAXserver 3500, based on the MicroVAX 3500, and the MicroVAX 3600-based VAXserver 3600 and 3602; the 3602 is a dual-CPU implementation.

The *VAXserver 3500* includes the following components:

- CVAX 78034 CPU and CVAX 78134 FPU
- 16M-byte ECC memory (expandable to 32M bytes)
- BA213 pedestal enclosure
- Console terminal cable
- TK70 296M-byte cartridge tape drive
- KDA50 disk controller
- RA70 280M-byte disk drive
- DELQA Ethernet controller
- VMS or ULTRIX-32 operating system license. (The VMS license includes VMS file and application server, DECnet full-function, and LAVC licenses; the ULTRIX-32 license includes one to two user operating systems, DECnet end node, and ULTRIX server licenses.)

A console terminal must be configured for the system to function. Up to two 8M-byte memory boards can be added to the base configuration, as can an additional RA70 disk drive. Up to five Q-bus interface options can be added to the VAXserver 3500; however, each additional memory board reduces the number of configurable Q-bus options by one. Ethernet options can also be added.

The *VAXserver 3600* provides essentially the same components as the VAXserver 3500, substituting a 622M-byte RA82 disk drive for the RA70. This server also employs a different cabinet: the 40-inch-high H9644, which includes a BA213 chassis.

The VAXserver 3600 can support an additional tape drive—either the 1600/6250 bpi, 40M-/145M-byte TU81E (also called the TU81-Plus) or the 1600 bpi, 40M-byte

TSV05. Up to three of the following disk devices can be added to the VAXserver 3600:

- 205M-byte RA60-CA removable drive with cabinet (up to one)
- 205M-byte RA60-AA removable drive without cabinet (up to two)
- 280M-byte RA70E-SA internal fixed disk drive (up to two)
- 456M-byte RA81-CA fixed disk drive with cabinet (up to one)
- 456M-byte RA81-AA fixed disk drive without cabinet (up to two)
- 622M-byte RA82-CA fixed disk drive with cabinet (up to one)
- 622M-byte RA82-AA fixed disk drive without cabinet (up to two)
- Two RA82 drives in cabinet (RA82-DA), counting as two options
- Three RA82 drives in cabinet (RA82-EA), counting as three options

An RA81-CA, RA82-CA, RA82-DA, TU81E, or TSV05 is prerequisite for RA81-AA and RA82-AA units. RA60s do not fit in TU81E or system cabinets.

Up to two 8M-byte memory boards can be added to the VAXserver 3600. Systems with TSV05 or TU81E tapes can support up to four Q-bus options; however, each additional memory board reduces the number of options by one. Systems without TSV05 or TU81E units can support up to five Q-bus options; again, each additional memory board reduces by one the number of available options.

A console terminal must be added for the server system to function. As with the VAXserver 3500, Ethernet options can also be added.

As mentioned previously, the *VAXserver 3602* employs two CPUs. CPU 1 includes the following components:

- CVAX 78034 CPU and CVAX 78134 FPU
- 16M-byte ECC memory (expandable to 32M bytes)
- 40-inch 9644 cabinet, including a BA213 enclosure
- Console terminal cable
- TK70 296M-byte cartridge tape drive with TQK70 controller
- KDA50 disk controller
- RA82 622M-byte disk drive
- DELQA Ethernet controller
- VMS or ULTRIX-32 operating system license. (The VMS license includes VMS file and application server, ▶

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► DECnet full-function, and LAVC licenses; the ULTRIX-32 license includes one to two user operating systems, DECnet end node, and ULTRIX server licenses.)

CPU 2 includes the same CPU, FPU, memory, disk controller, Ethernet controller, and enclosure facilities as CPU 1. The same software licenses are available, except the DECnet license under VMS is an end node license.

The two CPUs share the dual-ported RA82 disk drive and the TK70 tape drive, both of which reside in the CPU 1 cabinet.

A TU81E or TSV05 tape drive can be added to the VAXserver 3602; the TSV05 must be mounted in the CPU 2 cabinet.

Up to three shared RA Series disks can be added; configuration limits are those specified above for the VAXserver 3600, except that up to three RA70E-SA drives can be added to the 3602.

Each CPU on the VAXserver 3602 supports up to three additional RA Series disks minus the number of shared RA disks added. Options for individual CPUs are the RA70E, RA81, and RA82 disk drives in the models listed above for VAXserver 3600.

For systems without a TSV05, one RA81-AA or RA82-AA mounts in the CPU 2 cabinet. One RA81-AA or RA82-AA mounts in the TU81E cabinet. An RA81-CA or RA82-CA is prerequisite for each two RA81-AAs or RA82-AAs. An RA60-CA is prerequisite for RA60-AA; RA60s do not fit in TU81E or system cabinets.

Up to two 8M-byte memory boards can be added to each CPU. On CPU 1, up to five Q-bus interface options can be added to systems without the TU81E or TSV05 and up to four can be added to systems with those tape units; however, each memory board added to CPU 1 reduces the number of configurable Q-bus options by one. CPU 2 supports up to six Q-bus options, minus the number of additional memory boards configured.

Like the other servers, the VAXserver 3602 allows configuration of Ethernet options.

A VT330 or VT340 is recommended as a shared console for the VAXserver 3602 because each possesses a split screen capability. If another type of terminal is selected, one console terminal is required for each CPU. (For specifications and prices on the VT300 Series of terminals, refer to the "DEC VAX Systems" report on Page M11-325-501.)

INPUT/OUTPUT UNITS

Refer to Chart B for disk and diskette devices, to Chart C for graphics monitors, and to Chart D for printers.

Note: The following items are options, unless otherwise noted.

OTHER PERIPHERALS: The TK70 streaming cartridge tape drive, bundled with the VAXstation 3500 and also supported on the VAXstation 3200, has a 5¼-inch form factor. The TK70 uses 296M-byte CompacTape-II tape cartridges (developed by Digital in conjunction with 3M Company), which hold the entire contents of the 280M-byte RA70 disk drive. The TK70 transfers data at 90K bytes per second and features ECC, CRC, and a read-after-write procedure to verify data.

The TK50 streaming tape drive—bundled with the VAXstation II/GPX and 8000 and optional on the VAXstation 2000 and 3200—is a ½-inch cartridge unit that uses CompacTape cartridges; a single cartridge can back up any of the Winchester disks used on a VAXstation II/GPX, 2000, or 3200. This Q-bus drive, which uses a microprocessor-based controller, has a maximum storage capacity of 95M bytes and achieves a read/write speed of 75 ips in streaming mode. The TK50 has a peak data transfer rate of 62.5K bytes per second (45K bytes per second for user data). Recording density is 6667 bpi. The TK50 also features read-after-write operation and emulates reel-to-reel tape drive operation. The TK50 is not supported by the VAXstation 3500; however, the TK70 supported by that system can read tapes written on a TK50.

The RRD50 CD reader, an optical disk device supported on all VAXstations except the 2000, can randomly access 600M bytes of formatted user data from a Compact Disk Read-Only Memory (CD-ROM). The drive has an access time of 1.5 milliseconds and a data transfer rate of 150K bytes per second. The RRD50 employs the Philips/Sony standard for compact disks, as well as the Uni-File data format. The RRD50 comes with a one-year on-site hardware warranty.

The three-button *mouse*—a standard feature on the VAXstations—provides X and Y relative displacement and a 100-pulse-per-inch output rate. The VAXstations also support an optional *digitizing tablet* with light pen or cross-haired puck.

COMMUNICATIONS

The DELQA Ethernet interface, included with the VAXstation 3200, 3500, and 8000, as well as with certain configurations of the II/GPX, connects these systems to Ethernet V2.0 or IEEE 802.3 LANs. DELQA provides on-board Maintenance Operation Protocol (MOP), which offers enhanced network management features, including remote circuit loopback, system identification messages, remote booting or diskless systems, and maintenance of data link counters.

Via the DEQNA Ethernet interface, the VAXstation II/GPX can be connected to local and wide area networks and share resources with systems running VMS and UNIX operating systems and systems running on SNA and X.25 networks. The interface operates at 10M bps and is supported under DECnet Phase IV software. DEQNA allows a system to communicate with up to 1,023 addressable devices on an Ethernet LAN.

The DESVA synchronous controller connects the VAXstation 2000 to ThinWire or standard Ethernet LANs. (Support for standard Ethernet is available only in DESVAs built after January 15, 1988.)

This IEEE 802.3-compliant device operates at 10M bits per second and provides both Ethernet data link layer functions and a portion of physical channel functions. The DESVA is supported under DECnet Phase IV software.

Also configurable on the VAXstation family is the H4000 Ethernet Transceiver, detailed in the "DEC VAX Systems" report.

The ThinWire Ethernet Multiport Repeater (DEMPR) provides eight ports for connecting eight ThinWire Ethernet segments and one port for connecting to an H4000 transceiver. As a repeater, the DempR extends the length, ►

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► topology, or interconnection of the physical network medium beyond the limits imposed by a single segment. Each segment can have 29 stations, for a total of 232 stations.

The *ThinWire Ethernet Single-Port Repeater (DESPR)* connects a single ThinWire segment to a standard Ethernet network. The ThinWire segment can be up to 600 feet (185 meters) long and can accommodate up to 29 stations. The DESPR connects to standard Ethernet using an H4000 transceiver or a DELNI eight-device concentrator. When the DESPR/DELNI combination is used, the DELNI must be connected to the standard Ethernet using an H4000-BA transceiver. The DESPR must be counted as a repeater when configuring a standard Ethernet network.

The *ThinWire Ethernet Station Adapter (DESTA)* is an Ethernet/IEEE 802.3 transceiver that connects a single Ethernet station to ThinWire cabling. The DESTA has two ports: one connects to the T-connector attached to ThinWire, while the other leads to a station. The DESTA can be attached to current Ethernet controllers, such as the DELQA, allowing UNIBUS, Q-bus, and Pro 380 devices to connect to ThinWire Ethernet. The DESTA also allows Digital's Ethernet communications and terminal servers to connect to ThinWire Ethernet.

SOFTWARE

SYSTEM SOFTWARE: The VAXstations run the VMS and ULTRIX-32 operating systems, described in detail in the "DEC VAX Systems" report.

The VMS operating system for the VAXstations (and for the MicroVAX supermicros as well) is the same as that which runs on the VAX superminis. Previously, a subset of VMS was offered for the VAXstation and the MicroVAX; the microsystems could not support full-sized VMS due to limitations of system disk size and distribution media. Digital has now removed those constraints. Because the operating environments are fully compatible, VAXstations and MicroVAXs can run the same system and applications software as the larger VAX computers without recompilation or relinking, subject to the limitations of peripheral support.

Version 5.0, the most recent release of VMS, includes support for Local Area VAXcluster Systems Phase II, described later in this section.

VMS Workstation Software (VWS) is a layered product that provides graphics support for the VAXstations. VWS provides multiple, overlapping windowing capabilities; VT220 emulation with technical character set; Tektronix 4014 emulation; a mouse-based interface for window manipulation; a graphics programming interface; a device driver interface to graphics hardware; and hard copy graphics support.

On VAXstations configured in an LAVC, VWS runs on the workstation itself, but is stored on and loaded from the server.

The workstation software features a Graphical Kernel System (GKS) library, a layered product that includes a high-level graphics and text programming interface; ANSI standard level 0b is provided, with GKS output directed through the windowing system. VT102 and Tektronix 4014 emulators running through the X Window server allow many applications to run unchanged in a windowed environment. A low-level graphics programming interface allows direct procedural access to hardware for customized applications requiring higher graphics speeds. VAX GKS Version 3 conforms to level 2c of the ANSI/ISO GKS

standard for two-dimensional, device-independent graphics. Applications developed with VAX GKS software on the VAXstation will run on all other VMS-based systems.

ULTRIX-32, Digital's derivative of UNIX, is based on Berkeley 4.2 BSD UNIX. It includes extensions from 4.3 BSD and AT&T UNIX System V. It does not comply fully with AT&T's System V Interface Definition (SVID). *ULTRIX-32* does, however, comply with the IEEE's 1003.1 standard for a portable environment (POSIX) and with the National Bureau of Standards' interim Federal Information Processing Standard (FIPS).

ULTRIX-32 supports workstation configurations with a server and up to 26 diskless stations. The server provides centralized system management and remote restarting for client systems. The server downloads the operating system and applications onto the diskless workstation clients; it can also install software over the network for disk-based clients.

Equipped with the *ULTRIX Worksystem Software V1.1 Server Kit*, the server can install the graphics subsystem, including software libraries and commands for the client stations. (Details on UWS are provided below.) The server can also execute graphics applications and display them on the client devices.

Users can configure the client systems to share local area network resources, such as printers, disk storage, and CPU facilities. Central file resources can also be shared to reduce disk space requirements and to simplify file administration.

ULTRIX-32 permits applications to be ported from one VAX system—workstation, supermicro, or supermini—to another without modification or recompilation.

ULTRIX-32 Worksystem Software (formerly called *ULTRIX-32w*) provides windowing and graphics capabilities under *ULTRIX-32*. UWS also supports diskless VAXstations and Sun Microsystems workstations through the virtual disk operation. The virtual disk facility allows users to connect lower-priced diskless workstations into existing networks and access the disk storage on other systems in the network. Both *ULTRIX-32* and UWS are fully compatible with Sun Microsystems' Network File System, allowing VAXstations to coexist in multivendor networked environments and to access files transparently over an Ethernet network.

The *ULTRIX Window Manager (UWM)* provides a multi-window environment, including support for resizing, restacking, moving, and iconifying windows.

Windowing facilities are provided in different ways for *ULTRIX-32* and VMS. The X Window System Version 10—based on the X Window package developed by MIT's Project Athena and the MIT Laboratory for Computer Science—is integral to UWS. A different windowing system is provided in the VWS for the proprietary VMS environment. A network-based facility, the X Window System provides workstations with remote graphics windowing. Users can run applications on remote nodes and have the graphics output presented transparently on their local workstations. The X Window System also supports multiple view ports that can overlap and run even while occluded by another window.

The enhanced X Window System Version 11 will be available for both *ULTRIX-32* and VMS in the latter part of 1988 in a product called *DECwindows*, which will provide

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► network-transparent interactions with applications. DEC-windows will enable users to run VMS, ULTRIX-32, and MS-DOS windows on their workstations simultaneously and with a consistent interface.

Structured Graphics Routines (SGRs)—supported only on the VAXstation 8000—and *VAX Programmer's Hierarchical Interactive Graphics System (PHIGS)*, Digital's implementation of the ANSI draft standard for three-dimensional, device-independent graphics software, provide facilities for development and display of 3-D graphics applications.

The VAXstations support the same *database management, communications facilities, applications, tools and utilities, and languages* as the MicroVAXs. Descriptions of the software supported are provided in the "DEC MicroVAX Family" report (Page M09-325-101). Some programs, such as the Remote System Manager (RSM), allow a VAXstation to function as a client but not as a server in a distributed processing environment. Unless noted, details on the software referenced in this section are also the same as those presented in the "DEC VAX Systems" report. Further details on VAX and MicroVAX software can be found in the *Datapro Directory of Software* and the *Datapro Directory of Microcomputer Software*.

The VAXstations also support the facilities of Digital's *DECtp* transaction processing environment, announced July 19, 1988.

Local Area VAXcluster (LAVC) software allows the interconnection through Ethernet of up to 42 VAXstation and MicroVAX systems. At least one system must serve as a boot node; all others can be configured as satellites. The LAVC creates a unified system, allowing all participating nodes to remain independent while equally sharing resources, such as disks, tapes, and printers, and to employ a single distributed file system that manages access of files at the record level.

Version 5.0 of VMS provides support for *LAVC Phase II* (also called LAVC 2), in which the LAVCs can be connected over Ethernet to VAXclusters of VAX superminis and Hierarchical Storage Controllers (HSCs) linked by Digital's Computer Interconnect (CI). The workstations and supermicros thus have access to the far greater computational and storage facilities offered by the larger VAX systems.

LAVC 2 creates a so-called mixed interconnect VAXcluster in which the CI- and HSC-connected VAX systems service boot and I/O requests from the computers in the LAVC.

APPLICATIONS: More than 3,000 VAX applications can run unmodified on the VAXstations. Digital also depends very heavily on third-party software vendors to provide specialized applications software for various industries and marketplaces. Digital enters into Cooperative Marketing Program (CMP) relationships with firms that are leading application solutions suppliers in specific vertical market segments. System Cooperative Marketing Program (SCMP) participants are OEMs that offer their applications products in combination with Digital hardware. CMPs and SCMPs currently offer over 130 applications packages tailored for the VAXstation product line, including the following products:

- Applix, Inc. *Alis* office automation software
- Autodesk, Inc. *AutoCAD* design and drafting software

- Auto-trol Technology *Graphics Systems*
- BBN Software Products *RS/1*, *RS/Explore*, *RS/Discover*, and *QCA* data analysis software
- Biosym Technologies, Inc. *Insight* 3-D graphics and *Discover* molecular dynamics and simulation software
- CADcentre, Inc. *Plant Design Management System (PDMS)* 3-D modeling software for plant engineering projects
- Cadre Technologies Inc. *Teamwork* CASE tools
- Cognos, Inc. *PowerHouse* application development language
- Combustion Engineering, Inc. *Plant View* 3-D modeling software for process and power plants
- GE Calma *Prism/DDM* and *DIMENSION III* CAE/CAD/CAM software
- Impell Computer Systems *Re:Vision* and *Re:Design* engineering drawing tools
- Index Technology Corp. *Excelsator* CASE tools
- Interleaf, Inc. *Interleaf* electronic publishing software
- Matra Datavision *Euclid-IS* CAD/CAM/CAE software
- Racal-Redac, Inc. *VISULA* CAE/CAD software
- Structural Dynamics Research Corp. (SDRC) *I-DEAS* MCAE software
- Sierra Geophysics, Inc. *MIMIC*, *QUIKLOG*, *STRAT-LOG*, *QUIKRAY*, *QUIKSHOT*, *QUIKVSP*, *QUIKCDP*, *RAYMAP*, *SIVA*, *VESPA*, and *STATIX* seismic processing software
- Signal Technology, Inc. *ILS* laboratory signal processing software
- Tektronix CAE Systems *PCB*, *Gate Array*, and *Full Custom Logic WorkSystems*
- Tripos Associates, Inc. *Sybylset* molecular modeling software

Allied with third-party software vendors, Digital has designed, has configured, and has tested fully integrated systems, called VAX Solution Systems, for specific industry applications, such as artificial intelligence, electronics design, computer-integrated manufacturing, mechanical design and analysis, and electronic publishing. A number of these packages incorporate hardware configured in LAVCs.

OPERATING ENVIRONMENT

The dimensions of the VAXstation 2000 are the same as those provided for the MicroVAX 2000 in the "DEC MicroVAX Family" report. The VAXstation 2000's operating environment differs slightly from that of its multiuser counterpart, however; the operating temperatures for the VAXstation 2000 range from 60 to 90 degrees Fahrenheit (15.5 to 35.5 degrees Celsius) at 40 to 80 percent relative humidity, noncondensing. ►

► The VAXstation II/GPX is housed in the same BA23 and BA123 enclosures as the MicroVAX II. The VAXstation 3200 is housed in the BA23 enclosure, while the VAXstation 3500 uses the BA213 enclosure. The dimensions and operating environments of these system units are described in the "DEC MicroVAX Family" report cited earlier.

The VAXstation 8000 is housed in a caster-mounted, desk-side pedestal cabinet that stands 25.5 in. (64.7 cm.) high, 14.25 in. (36.2 cm.) wide, and 29.5 in. (74.9 cm.) deep. It weighs 200 pounds (91 kg.). The cabinet contains all system components: CPU, peripheral controllers, memory, hard disk, cartridge tape, graphics subsystem, power supplies, and blower. It meets Class B heat, noise, and power specifications for office environments. Acoustic noise is less than 6.2 dB.

The VAXstation 8000 requires 120-V, 60-Hz, single-phase power. Maximum power consumption is 1200 W, with frequency tolerance of 47 to 63 Hz. Operating temperature is 50 to 90 degrees Fahrenheit (15 to 32 degrees Celsius) at relative humidity of 10 to 80 percent, noncondensing.

SUPPORT SERVICES

DOCUMENTATION: Hardware documentation is included with each VAXstation. The documentation consists of Owner and Technical Manuals. Documentation Kits are optionally available for selected software packages; the kits include Reference Manuals, User's Guides, and other instructional materials.

TRAINING/EDUCATION: Digital maintains over 25 training centers worldwide. Courses cover both equipment and non-product-related topics. A variety of teaching methods is used, including instructor-led courses and self-paced instruction. Digital's Educational Services division publishes a digest listing available courses four times a year. On-site training at the customer's installation can also be provided.

WARRANTY: The VAXstations, as well as all peripherals, are covered by a one-year warranty. Warranty coverage can be extended for up to three years.

MAINTENANCE: Digital's Field Service organization offers both on-site and off-site support services for the VAXstations. Standard on-site services include the Basic Service Agreement, the extended DECservice Agreement, and Per Call service. Off-site maintenance is available through Digital's Customer Returns Center, Product Repair Center, and Digital Servicenters, which are all equipped with parts inventories, special diagnostic systems, and repair kits. Details of Digital's service programs and of

software support services available are provided in the "DEC VAX Systems" report referenced earlier.

Two other types of integrated service are offered for the VAXstations. Basic System Service (BSS) is offered on systems used as LAVC boot nodes or as standalone systems. Basic Node Service (BNS) is offered on systems used as LAVC nodes only. Both plans provide On-site Basic Hardware Service and Right to Use Updates. BSS also provides Digital Software Information Network, as well as Hardware and Software Telephone Support through the System Administrator.

PRICING

POLICY: Digital provides the VAXstations on a purchase basis with separately priced maintenance agreements beyond the initial one-year warranty period. Leasing arrangements are available through Digital's U.S. Customer Finance Group.

Digital software is licensed rather than sold. Users purchase licenses and distribution rights separately. Customers ordering ULTRIX-32 software receive a UNIX operating system binary license directly from Digital. For new VAXstation purchasers, an ULTRIX-32 license is included in the price of the system. Current users of Digital's VMS operating system and VAX users with third-party UNIX licenses can order the ULTRIX-32 license as an add-on product.

A software license can either be purchased outright or obtained through Digital's Periodic Payment License (PPL) option, through which the user pays an initial license fee and then makes monthly payments thereafter. The software is licensed with a 90-day cancellation option.

The price of a VAXstation includes operating system and DECnet licenses. The PPL option for those products includes the initial license charge and 12 months of PPL fees for both products.

Digital also offers VAXcluster software pricing options based on system capacity ratings for VMS layered software. Those ratings equalize the cost between a standalone computer and a VAXcluster of equivalent capacity. Under this scheme, the cost of a layered software product used in a VAXcluster does not increase incrementally as new processors are added.

Digital's Volume Software Pricing programs are available for VAXstation users. A description of these programs is provided in the "DEC MicroVAX Family" report previously cited.

Pricing for VAXstation hardware and related software are provided in the following list. ►

DEC VAXstations

EQUIPMENT PRICES

VAXSTATION 2000		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)	Basic Node Service (Monthly) (\$)	Basic System Service (Monthly) (\$)
VS450-DA(D3)	MicroVAX II CPU/FPU; 4M bytes of main memory; 19-in. monochrome monitor; ThinWire Ethernet interface; English hardware documentation, one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	5,625	64	76	50	64
VS450-EA(E3)	Same as VS450-DA(D3) except with 6M bytes of memory	7,925	64	76	50	64
VS450-FA(F3)	Same as VS450-DA(D3) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	5,625	64	76	50	64
VS450-GA(G3)	Same as VS450-FA(F3) except with 6M bytes of memory	7,925	64	76	50	64
VS451-DA(D3)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. monochrome monitor, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	4,825	58	69	45	58
VS451-EA(E3)	Same as VS451-DA(D3) except with 6M bytes of memory	7,125	58	69	45	58
VS451-FA(F3)	Same as VS451-DA(D3) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	4,825	58	69	45	58
VS451-GA(G3)	Same as VS451-FA(F3) except with 6M bytes of memory	7,125	58	69	45	58
VS452-DA(D3)	MicroVAX II CPU/FPU, with 4M bytes of memory, 19-in. monochrome monitor, RD53 71M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	8,425	102	121	88	102
VS452-EA(E3)	Same as VS452-DA(D3) except with 6M bytes of memory	10,725	102	121	88	102
VS452-FA(F3)	Same as VS452-DA(D3) except bundled software includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	8,425	102	121	88	102
VS452-GA(G3)	Same as VS452-FA(F3) except with 6M bytes of memory	10,725	102	121	88	102
VS453-DA(D3)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. monochrome monitor, RD53 71M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	7,625	96	114	83	96
VS453-EA(E3)	Same as VS453-DA(D3) except with 6M bytes of memory	9,925	96	114	83	96
VS453-FA(F3)	Same as VS453-DA(D3) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	7,625	96	114	83	96
VS453-GA(G3)	Same as VS453-FA(F3) except with 6M bytes of memory	9,925	96	114	83	96
VS454-DA(D3)	MicroVAX II CPU/FPU with 4M bytes of memory, 19-in. monochrome monitor, RD54 159M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	10,625	127	151	113	127
VS454-EA(E3)	Same as VS454-DA(D3) except with 6M bytes of memory	12,925	127	151	113	127
VS454-FA(F3)	Same as VS454-DA(D3) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	10,625	127	151	113	127
VS454-GA(G3)	Same as VS454-FA(F3) except with 6M bytes of memory	12,925	127	151	113	127
VS455-DA(D3)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. monochrome monitor, RD54 159M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	9,825	121	144	108	121
VS455-EA(E3)	Same as VS455-DA(D3) except with 6M bytes of memory	12,125	121	144	108	121
VS455-FA(F3)	Same as VS455-DA(D3) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	9,825	121	144	108	121
VS455-GA(G3)	Same as VS455-FA(F3) except with 6M bytes of memory	12,125	121	144	108	121
VS460-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 19-in. color monitor, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	12,125	134	160	105	134
VS460-EA(E3/E4)	Same as VS460-DA(D3/D4) except with 6M bytes of memory	14,425	134	160	105	134

NA—Not applicable.
 NC—No charge.

DEC VAXstations

		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)	Basic Node Service (Monthly) (\$)	Basic System Service (Monthly) (\$)
VAXSTATION 2000 (Continued)						
VS460-FA(F3/F4)	Same as VS460-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C and Pascal	12,125	134	160	105	134
VS460-GA(G3/G4)	Same as VS460-FA(F3/F4) except with 6M bytes of memory	14,425	134	160	105	134
VS461-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. color monitor, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	8,125	113	135	88	113
VS461-EA(E3/E4)	Same as VS461-DA(D3/D4) except with 6M bytes of memory	10,425	113	135	88	113
VS461-FA(F3/F4)	Same as VS461-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	8,125	113	135	88	113
VS461-GA(G3/G4)	Same as VS461-FA(F3/F4) except with 6M bytes of memory	10,425	113	135	88	113
VS462-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 19-in. color monitor, RD53 71M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	14,925	172	205	143	172
VS462-EA(E3/E4)	Same as VS462-DA(D3/D4) except with 6M bytes of memory	17,225	172	205	143	172
VS462-FA(F3/F4)	Same as VS462-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	14,925	172	205	143	172
VS462-GA(G3/G4)	Same as VS462-FA(F3/F4) except with 6M bytes of memory	17,225	172	205	143	172
VS463-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. color monitor, RD53 71M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	10,925	151	180	126	151
VS463-EA(E3/E4)	Same as VS463-DA(D3/D4) except with 6M bytes of memory	13,125	151	180	126	151
VS463-FA(F3/F4)	Same as VS463-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	10,925	151	180	126	151
VS463-GA(G3/G4)	Same as VS463-FA(F3/F4) except with 6M bytes of memory	13,225	151	180	126	151
VS464-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 19-in. color monitor, RD54 159M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	17,125	197	235	168	197
VS464-EA(E3/E4)	Same as VS464-DA(D3/D4) except with 6M bytes of memory	19,425	197	235	168	197
VS464-FA(F3/F4)	Same as VS464-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	17,125	197	235	168	197
VS464-GA(G3/G4)	Same as VS464-FA(F3/F4) except with 6M bytes of memory	19,425	197	235	168	197
VS465-DA(D3/D4)	MicroVAX II CPU/FPU with 4M bytes of memory, 15-in. color monitor, RD54 159M-byte disk drive, ThinWire Ethernet interface, hardware documentation, and one-year hardware/software warranty; bundled software licenses include VMS, VWS, LAVC, and DECnet	13,125	176	210	151	176
VS465-EA(E3/E4)	Same as VS465-DA(D3/D4) except 6M bytes of memory	15,425	176	210	151	176
VS465-FA(F3/F4)	Same as VS465-DA(D3/D4) except bundled software licenses include ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal	13,125	176	210	151	176
VS465-GA(G3/G4)	Same as VS465-FA(F3/F4) except with 6M bytes of memory	15,425	176	210	151	176
VS460-JA(J3/J4)	MicroVAX II CPU/FPU with 14M bytes of memory, 19-in. color monitor, 4-plane graphics co-processor, keyboard and mouse, Ethernet controller, VMS license	19,125	—	—	—	—
VS460-KA(K4)	Same as VS460-JA(J3/J4) but with ULTRIX-32 license	19,125	—	—	—	—
VS461-JA(J3/J4)	Same as VS460-JA(J3/J4) but with 15-in. color monitor	15,125	—	—	—	—
VS461-KA(K3/K4)	Same as VS461-JA(J3/J4) but with ULTRIX-32 license	15,125	—	—	—	—

NA—Not applicable.
NC—No charge.

DEC VAXstations

		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)	Basic Node Service (Monthly) (\$)	Basic System Service (Monthly) (\$)
VAXSTATION 2000 (Continued)						
VS470-EA(E3/E4)	MicroVAX II CPU/FPU with 6M bytes of memory; 8-plane-graphics co-processor; 19-in. color monitor; keyboard and mouse; Ethernet controller; VMS license	17,425	—	—	—	—
VS470-GA(G3/G4)	Same as VS470-EA(E3/E4), but with ULTRIX-32 license	17,425	—	—	—	—
VS470-JA(J3/J4)	Same as VS470-EA(E3/E4), but with 14M bytes of memory	22,125	—	—	—	—
VS470-KA(K3/K4)	Same as VS470-GA(G3/G4), but with 14M bytes of memory	22,125	—	—	—	—
VS471-EA(E3/E4)	MicroVAX II CPU/FPU; 6M bytes of memory; 8-plane graphics co-processor; 15-in color monitor; keyboard and mouse; Ethernet controller; VMS license	13,425	—	—	—	—
VS471-GA(G3/G4)	Same as VS471-EA(E3/E4), but with ULTRIX-32 license	13,425	—	—	—	—
VS471-JA(J3/J4)	Same as VS471-EA(E3/E4), but with 14M bytes of memory	18,125	—	—	—	—
VS471-KA(K3/K4)	Same as VS471-GA(G3/G4), but with 14M bytes of memory	18,125	—	—	—	—
VAXSTATION II/GPX SYSTEMS						
VS230-F3(F4/FA)	Color system; includes 5M bytes of main memory; BA23 enclosure; 19-in. color monitor; eight-plane graphics co-processor; DELQA; documentation; VMS, VWS, DECnet end node, and LAVC licenses; one-year hardware/software warranty; must order keyboard, pointing device, and power cord	22,275	239	285	199	239
VS230-G3(G4/GA)	Same as VS230-F3(F4/FA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses	22,275	239	285	199	239
VS230-H3(H4/HA)	Same as VS230-F3(F4/FA), but also includes RD54 159M-byte disk drive	29,325	318	379	278	318
VS230-J3(J4/JA)	Same as VS230-F3(F4/FA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses; also includes RD54 disk drive	29,325	318	379	278	318
VS235-F3(F4/FA)	Same as VS230-F3(F4/FA) except includes RD54 disk drive and TK50 95M-byte tape drive	37,225	475	565	376	475
VS235-G3(G4/GA)	Same as VS230-F3(F4/FA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal; also includes RD54 disk drive and TK50 tape drive	37,225	475	565	376	475
VAXSTATION II/GPX PACKAGED SYSTEMS						
SU-LV55R-EK	Two-user, eight-plane color system; includes BA123 enclosure, 5M bytes of main memory (1M bytes with CPU and one MS630-BB 4M-byte memory board), RD53 71M-byte fixed disk, TK50 95M-byte cartridge tape, DEQNA Ethernet controller, two eight-plane graphics co-processors, keyboard, mouse, monochrome monitor, and ULTRIX-32 and UWS licenses	48,700	487	580	406	487
SU-LV59D-EK	Includes BA123 enclosure; 5M bytes of main memory (1M bytes with CPU and one MS630-BB 4M-byte memory board); BA123 enclosure; RD54 159M-byte fixed disk; TK50 95M-byte cartridge tape; DEQNA Ethernet controller; eight-plane graphics co-processor; keyboard; mouse; color monitor; and ULTRIX-32 and UWS binary licenses	65,795	538	640	439	538
SV-LV55W-EK	Gray-scale system; includes BA23 enclosure, 5M bytes of main memory (1M bytes on CPU board and one 4M-byte MS630-BB memory board), RD53 71M-byte fixed disk, TK50 95M-byte tape, DEQNA Ethernet controller, four-plane graphics co-processor, keyboard, mouse, monochrome monitor, and VMS and VWS licenses	25,745	250	298	208	250
SV-LV55Y-EK	Color system; same as SV-LV55W-EK, but with color monitor	26,745	260	310	217	260
SV-LV59D-EK	Color system; includes BA123 enclosure, 8M bytes of main memory (MS630-CA 8M-byte memory board), two RD54 159M-byte fixed disks, TK50 95M-byte tape, DEQNA Ethernet controller, eight-plane graphics co-processor, keyboard, mouse, color monitor, VMS, VWS, and Lisp licenses	65,795	538	640	439	538

NA—Not applicable.
 NC—No charge.

DEC VAXstations

		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)	Basic Node Service (Monthly) (\$)	Basic System Service (Monthly) (\$)
VAXSTATION 3200						
Each VAXstation 3200 includes a MicroVAX 3500/3600 CMOS CPU and FPU. The VAXstation 3200 is housed in the BA23 enclosure.						
VS300-A3(AA)	Gray-scale system; includes 8M bytes of memory; four-plane graphics co-processor; 19-in. monochrome monitor; DELQA Ethernet interface; documentation; one-year hardware/software warranty; and VMS, VWS, LAVC, and DECnet end node licenses	20,725	219	261	171	219
VS300-B3(BA)	Same as VS300-A3(AA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses	20,725	219	261	171	219
VS305-A3(A4/AA)	Color system; includes 8M bytes of main memory; eight-plane graphics co-processor; 19-in. color monitor; DELQA Ethernet interface; documentation; one-year hardware/software warranty; and VMS, VWS, LAVC, and DECnet end node licenses	28,725	259	308	202	259
VS305-B3(B4/BA)	Same as VS305-A3(A4/AA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses	28,725	259	308	202	259
VS310-A3(AA)	Same as VS300-A3(AA) but also includes an RD54 159M-byte disk drive	27,775	298	355	250	298
VS310-B3(BA)	Same as VS300-A3(AA) except with ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses; also includes RD54 disk drive	27,775	298	355	250	298
VS315-A3(A4/AA)	Same as VS305-A3(A4/AA) but also includes an RD54 disk drive	35,775	338	402	281	338
VS315-B3(B4/BA)	Same as VS305-A3(A4/AA) except with ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal; also includes an RD54 disk drive	35,775	338	402	281	338
VAXSTATION 3500						
Each VAXstation 3500 includes a MicroVAX 3500/3600 CMOS CPU and FPU. The VAXstation 3500 is housed in the BA213 enclosure.						
VS350-A3(AA)	Gray-scale system; includes 16M bytes of main memory; four-plane graphics co-processor; 19-in. monochrome monitor; DELQA Ethernet interface; RA70 280M-byte disk drive; TK70 296M-byte tape drive; documentation; one-year hardware/software license; and VMS, VWS, LAVC, and DECnet end node licenses	52,405	484	576	386	495
VS350-B3(BA)	Same as VS350-A3(AA) but with ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses	52,405	484	576	386	495
VS355-A3(A4/AA)	Color system; includes 16M bytes of main memory; eight-plane graphics co-processor; 19-in. color monitor; DELQA Ethernet interface; RA70 disk drive; TK70 tape drive; documentation; one-year hardware/software warranty; and VMS, VWS, LAVC, and DECnet end node licenses	60,405	524	624	417	535
VS355-B3(B4/BA)	Same as VS355-A3(A4/AA) except includes ULTRIX-32, UWS, NFS, Fortran, VAX-C, and Pascal licenses	60,405	524	624	417	535
VAXSTATION 8000						
VS710-A2	VAXstation 8000 3-D graphics subsystem; 16M bytes of memory; 58-plane; 19-in. color monitor; DELQA Ethernet interface; RD54 159M-byte disk; TK50 tape unit; and VMS; high-performance workstation software (HPWS); and DECnet licenses	89,900	—	—	—	—
VAXSERVERS						
DV-350S1-AA	VAXserver 3500; 16M bytes of memory; KDA50 disk controller; RA70E 280M-byte disk; TK70 tape unit; and VMS license	52,300	429	511	373	429
DU-350S1-AA	Same as DV-350S1-AA, but with ULTRIX license	52,300	429	511	373	429
DV-360S1-AA	VAXserver 3600; 16M bytes of memory; KDA50 disk controller; RA82 622M-byte disk; TK70 tape; and VMS license	69,300	443	527	387	443
DU-360S1-AA	Same as DV-360S1-AA, but with ULTRIX license	69,300	443	527	387	443
DV-360S2-AA	VAXserver 3602; dual CPU server system; 16M bytes of memory per CPU; two KDA50 disk controller; one RA82 622M-byte disk; TK70 tape; and VMS license	110,300	787	937	675	787
DU-360S2-AA	Same as DV-360S2-AA, but with ULTRIX license	110,300	787	937	675	787

NA—Not applicable.
 NC—No charge.

DEC VAXstations

OPTIONS PRICES

		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)
VAXSTATION OPTIONS				
VS40X-MA	Four-plane video accelerator for VAXstation 2000	2,000	NA	NA
MEMORY				
MS400-BA	4M-byte memory increment for the VAXstation 2000	3,500	NC	NC
MS630-BA	2M-byte memory increment for MicroVAX II/GPX	1,575	NC	NC
MS630-BB	4M-byte memory increment for MicroVAX II/GPX	1,968	NC	NC
MS630-CA	8M-byte memory increment for MicroVAX II/GPX	3,583	NC	NC
MS650-AA	8M-byte ECC memory increment for VAXstation 3200	6,000	NC	NC
MS650-AF	8M-byte ECC memory increment for VAXstation 3500	6,000	NC	NC
MS820-BA/KL	4M-byte memory for VAXstation 8000	4,000	—	—
MS820-CA/KL	16M-byte memory for VAXstation 8000	8,000	—	—
GRAPHICS MONITORS				
VR150-AA(A3)	VR150 high-resolution, 15-in. monochrome/gray-scale monitor; 240 V	1,200	NA	NA
VR260-AA/A3	VR260 high-resolution, 19-in. monochrome/gray-scale monitor; 120 V/240 V	2,300	NA	NA
VR160-DA/D3	VR160 high-resolution, 15-in. color monitor; 120 V/240 V	2,000	NA	NA
VR290-DA	VR290 high-resolution, 19-in. color monitor; 120 V	6,300	NA	NA
GRAPHICS INPUT DEVICES				
VSXXX-AA	Mouse	195	NC	NC
VSXXX-AB	Tablet with stylus and puck	1,095	8	10
LK201-LA/MA	Keyboard	210	NA	NA
MASS STORAGE				
KDA50-QA	DSA Controller for BA23	6,825	50	60
RQDX3-AA/BA	RQDX3 controller for RD53 disk; for BA23(AA) or BA123(BA) enclosure; cables and distribution panel (for Model BA) included	2,142	16	19
RQDX3-M	Q-bus controller without cables; for use when replacing existing RQDX2 controllers (cables can be reused)	2,090	16	19
RQDXE-AA	Dual-height disk drive bus extender for use with RQDX2 or RQDX3 control- ler in a BA23 enclosure and for external disk	263	NA	NA
RQDXE-FA	Dual-height disk drive bus extender for use with RQDX2 or RQDX3 control- ler and disk in BA23-CC expander enclosure	263	NA	NA
RX33-A	1.2M-byte diskette drive	388	8	10
RX50A-AA/BA	RX50 800KB dual diskette drive with cables for BA23(AA) or BA123(BA) enclosure	1,050	8	10
RX50-AA	RX50 800KB dual diskette drive	1,050	8	10
RX50-D	RX50 800KB dual diskette drive mounted in desktop enclosure with I/O cable	1,890	20	24
RX50-R	RX50 800KB dual diskette drive for mounting in 19-in. standard equipment rack	1,890	20	24
RD32-A	42M-byte Winchester disk drive	1,615	20	24
RD53-A	RD53 71M-byte, 5¼-in. Winchester disk drive	4,190	38	45
RD53A-AA/BA	RD53 71M-byte drive with cables for BA23(AA) or BA123(BA) enclosure	4,190	38	45
RD53-DA/DB	RD53 71M-byte drive mounted in desktop enclosure with I/O cables	4,850	38	45
RD53-EA	71M-byte Winchester disk drive for VAXstation 2000	4,190	38	45
RD53-FA/F3	71M-byte Winchester disk drive in expansion box for VAXstation 2000	5,570	38	45
RD53-RA/RB	RD53 71M-byte drive in 19-in. standard equipment rack; requires H9302 enclosure	4,850	38	45
RD54-DA/DB/RA/RB	RD54 159M-byte Winchester disk drive	5,500	63	75
RD54-A(AA/BA)	RD54 159M-byte Winchester disk drive for BA23	4,500	63	75
RD54-EA	RD54 159M-byte disk for addition to diskless MicroVAX 2000s	4,500	63	75
RD54-FA(F3)	RD54 159M-byte Winchester disk drive in expansion box for VAXstation 2000	5,500	63	75
RA70E-SA/SF	RA70 280M-byte disk drive	9,000	45	54
RA60-CA	205M-byte removable disk drive with cabinet	23,000	105	125
RA60-AA	Same as RA60-CA, but without cabinet	20,340	105	125
RA81-CA	456M-byte fixed disk drive with cabinet	20,400	95	113
RA81-AA	Same as RA81-CA, but without cabinet	17,640	95	113
RA82-CA	622M-byte fixed disk drive with cabinet	17,000	50	70
RA82-AA	Same as RA82-CA, but without cabinet	17,000	59	70
RA82-DA	Two 622M-byte fixed disk drives in cabinet	34,000	118	140
RA82-EA	Three 622M-byte fixed disk drives in cabinet	51,000	177	211
RRD50-QA	600M-byte CD-ROM disk drive and controller	1,325	28	33

NA—Not applicable.
 NC—No charge.

DEC VAXstations

		Purchase Price (\$)	Basic Service (Monthly) (\$)	DECserv. (Monthly) (\$)
MAGNETIC TAPE				
TQK50-AA	TK50 controller with cables for BA23 enclosure	1,213	8	10
TQK50-AB	Q22 controller for TK50-D/R in BA23 enclosure	1,213	8	10
TQK50-BA	TK50 controller with cables for BA123 enclosure	1,213	8	10
TQK50-BB	Q22 controller for TK50-D/R in BA123 enclosure	1,213	8	10
TK50-AA	TK50 95M-byte cartridge streaming tape drive	3,087	22	26
TK50-DA/DB	TK50 desktop tape drive	3,749	22	26
TK50-RA/RB	TK50 rackmount tape drive	3,749	22	26
TK50Z-FA/F3	TK50 in expansion box for VAXstation 2000	4,956	30	36
TQK70-AA	Controller for TK70 tape unit	1,785	10	12
TK70-AA	296M-byte TK70 cartridge tape drive for BA23/BA123 boxes	5,880	30	36
BA40A-AA	Expansion adapter for VAXstation 2000	1,200	NA	NA
TSV05-SE/SF	9-track, 1600 bpi TSV05 magnetic tape subsystem with cabinet and Q-bus controller	12,800	89	106
TSV05-SK/SL	9-track, 1600 bpi TSV05 magnetic tape subsystem for 3600 cabinet	11,200	89	106
TU81E-SA	TU81-Plus magnetic tape subsystem with Q-bus controller	29,665	140	167
PRINTERS				
LA75-CA	LA75 32/42/125/250 cps dot matrix printer	835	8	10
LA210-AA	LA210 40/80/240 cps dot matrix printer	1,760	28	33
LA21X-BT	Bidirectional tractor for LA210	257	NA	NA
LA21X-SF	Single-tray sheet feeder for LA210	105	NA	NA
LN03-AA	LN03 8-ppm laser printer; includes two toner cartridges, organic photo receptor cartridge, AC power cord, toner collection bottle, 250 sheets of letter-size paper, and documentation	2,895	49	58
LN03S-AA	LN03 Plus 8-ppm desktop graphics laser printer; includes 1M bytes of RAM, Modern Gothic typeface, two toner cartridges, organic photoreceptor cartridge, AC power cord, toner collection bottle, 250 sheets of letter-size paper, and documentation	3,995	56	67
LN03S-UA	Graphics board to upgrade LN03 to LN03 Plus	1,095	7	8
LNO3R	LNO3R 8-ppm PostScript laser printer	5,495	56	67
LPS40-AA	Print Server 40, 40-ppm Ethernet printer with power cord	49,900	475	565
LCGO1-AA	Two PE ppm ink jet color printing system	17,490	125	149
LJ250-CA	LJ250 color printer; serial version	1,695	11	13
LJ252-CA	Same as LJ250-CA, but parallel version	1,695	11	13
COMMUNICATIONS/NETWORKING				
DPV11-M	DPV11 single-line synchronous interface; requires cable	826	14	17
DPV11-SA	DPV11 single-line synchronous interface for BA213	969	14	17
DMV11-M	DMV11 single-line synchronous interface; requires cable	2,550	41	49
DMV11-N	Integral modem interface	2,160	41	49
H4000	Ethernet/IEEE 802.3 transceiver	315	4	5
DESTA-AA	ThinWire Ethernet station adapter	289	4	5
DSRVB-AA	Eight-line DECserver 200	3,806	37	44
DEQNA-SA/SF	DEQNA Ethernet-to-Q-bus synchronous communications controller for BA213	2,756	15	18
DEQNA-M	DEQNA Ethernet-to-Q-bus synchronous communications controller; requires cable	2,625	15	18
DELQA-M	Ethernet/802.3 Adapter	2,500	15	18
DELQA-SA/SF	DELQA for BA213	2,500	15	18
DEMPR-AA	ThinWire Ethernet multiport repeater	3,255	36	43

NA—Not applicable.
NC—No charge.

SOFTWARE PRICES

		License Fee (\$)*
OPERATING SYSTEM		
Q4001-CZ	VMS two-user license for VAXstation II/GPX	1,050
Q8001-CZ	VMS two-user license for VAXstation 2000	1,050
Q1ZEK-UZ	ULTRIX-32 two-user license for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	2,500
Q8A96-UZ	VMS Workstation Software for VAXstation 2000	263
COMMUNICATIONS		
Q1D04-UZ	DECnet end node license for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	500
Q8D04-UZ	DECnet end node license for VAXstation 2000	525

*Note: Prices listed are for VMS Version 4.7.

DEC VAXstations

COMMUNICATIONS (Continued)

		License Fee (\$)*
Q4D04-UZ	DECnet end node license for VAXstation II/GPX	714
Q1D05-UZ	DECnet full license for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,029
Q8D05-UZ	DECnet full license for VAXstation 2000	1,029
Q4D05-UZ	DECnet full license for VAXstation II/GPX	1,796
Q1D09-UZ	DECnet end node to full license upgrade for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	746
Q8D09-UZ	DECnet end node to full license upgrade for VAXstation 2000	746
Q4D09-UZ	DECnet end node to full license upgrade for VAXstation II/GPX	1,302
Q1363-UZ	DECnet/SNA 3270 for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	515
Q8363-UZ	DECnet/SNA 3270 for VAXstation 2000	515
Q4363-UZ	DECnet/SNA 3270 for VAXstation II/GPX	515
Q1455-UZ	DECnet/SNA Application Programming Interface (API) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	410
Q8455-UZ	DECnet/SNA Application Programming Interface (API) for VAXstation 2000	410
Q4455-UZ	DECnet/SNA Application Programming Interface (API) for VAXstation II/GPX	410
Q1022-UZ	DECnet/SNA Advanced Program-to-Program Communications (APPC) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	473
Q8022-UZ	DECnet/SNA Advanced Program-to-Program Communications (APPC) for VAXstation 2000	473
Q4022-UZ	DECnet/SNA Advanced Program-to-Program Communications (APPC) for VAXstation II/GPX	473
Q1454-UZ	DECnet/SNA Terminal Emulator (TE) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	221
Q8454-UZ	DECnet/SNA Terminal Emulator (TE) for VAXstation 2000	221
Q4454-UZ	DECnet/SNA Terminal Emulator (TE) for VAXstation II/GPX	221
Q1453-UZ	DECnet/SNA RJE for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	221
Q8453-UZ	DECnet/SNA RJE for VAXstation 2000	221
Q4453-UZ	DECnet/SNA RJE for VAXstation II/GPX	221
Q1452-UZ	DECnet/SNA Gateway Management for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	75
Q8452-UZ	DECnet/SNA Gateway Management for VAXstation 2000	79
Q4452-UZ	DECnet/SNA Gateway Management for VAXstation II/GPX	236
Q1042-UZ	DECnet/SNA DISOSS Document Exchange Facility (DDXF) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	336
Q8042-UZ	DECnet/SNA DISOSS Document Exchange Facility (DDXF) for VAXstation 2000	336
Q4042-UZ	DECnet/SNA DISOSS Document Exchange Facility (DDXF) for VAXstation II/GPX	336
Q1044-UZ	DECnet/SNA Printer Emulator (PrE) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	221
Q8044-UZ	DECnet/SNA Printer Emulator (PrE) for VAXstation 2000	221
Q4044-UZ	DECnet/SNA Printer Emulator (PrE) for VAXstation II/GPX	221
Q4111-UZ	DECnet/SNA 2780/3780 Protocol Emulator for VAXstation II/GPX	956
Q4112-UZ	DECnet/SNA 3271 Protocol Emulator for VAXstation II/GPX	1,292
Q1B12-UZ	VAX VIDA for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	2,625
Q8B12-UZ	VAX VIDA for VAXstation 2000	2,756
Q4B12-UZ	VAX VIDA for VAXstation II/GPX	2,756
Q8ZCE-UZ	Local Area VAXcluster for VAXstation 2000	525
Q4ZCE-UZ	Local Area VAXcluster for VAXstation II/GPX	1,859

DATABASE MANAGEMENT

Q1898-UZ	Datatrieve for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,230
Q8898-UZ	Datatrieve for VAXstation 2000	1,292
Q4898-UZ	Datatrieve for VAXstation II/GPX	1,292
Q1897-UZ	Common Data Dictionary (CDD) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	340
Q8897-UZ	Common Data Dictionary (CDD) for VAXstation 2000	357
Q4897-UZ	Common Data Dictionary (CDD) for VAXstation II/GPX	357
Q1800-UZ	Forms Management Systems (FMS) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	620
Q8800-UZ	Forms Management Systems (FMS) for VAXstation 2000	651
Q4800-UZ	Forms Management System (FMS) for VAXstation II/GPX	651
Q1D07-UZ	Rdb/ELN Development license for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,125
Q1354-UZ	Rdb/Micro VMS for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,770
Q8354-UZ	Rdb/Micro VMS for VAXstation 2000	1,859
Q4354-UZ	Rdb/MicroVMS for VAXstation II/GPX	1,859
Q1357-UZ	Rdb/MicroVMS Remote for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	205
Q8357-UZ	Rdb/MicroVMS Remote for VAXstation 2000	215
Q4357-UZ	Rdb/MicroVMS Remote for VAXstation II/GPX	215
Q1358-UZ	Rdb/MicroVMS Run Time Option (RTO) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	683
Q8358-UZ	Rdb/MicroVMS Run Time Option (RTO) for VAXstation 2000	717
Q4358-UZ	Rdb/MicroVMS Run Time Option (RTO) for VAXstation II/GPX	717

LANGUAGES

Q1018-UZ	Dibol for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	623
Q8018-UZ	Dibol for VAXstation 2000	653
Q4018-UZ	Dibol for VAXstation II/GPX	651
Q1100-UZ	Fortran for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	780
Q8100-UZ	Fortran for VAXstation 2000	819
Q4100-UZ	Fortran for VAXstation II/GPX	819

*Note: Prices listed are for VMS Version 4.7.

DEC VAXstations



LANGUAGES (Continued)

		License Fee (\$)*
Q1917-UZ	Lisp for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	2,400
Q8917-UZ	Lisp for VAXstation 2000	2,520
Q4917-UZ	Lisp for VAXstation II/GPX	5,040
Q1126-UZ	Pascal for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	710
Q8126-UZ	Pascal for VAXstation 2000	745
Q4126-UZ	Pascal for VAXstation II/GPX	745
Q1056-UZ	Ada for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	3,735
Q8056-UZ	Ada for VAXstation 2000	3,922
Q4056-UZ	Ada for VAXstation II/GPX	3,922
Q1095-UZ	Basic for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	800
Q8095-UZ	Basic for VAXstation 2000	840
Q4095-UZ	Basic for VAXstation II/GPX	840
Q1015-UZ	C for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	710
Q8015-UZ	C for VAXstation 2000	745
Q4015-UZ	C for VAXstation II/GPX	745
Q1099-UZ	Cobol for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,200
Q8099-UZ	Cobol for VAXstation 2000	1,260
Q4099-UZ	Cobol for VAXstation II/GPX	1,260
Q1913-UZ	OPS5 for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,500
Q8913-UZ	OPS5 for VAXstation 2000	1,575
Q4913-UZ	OPS5 for VAXstation II/GPX	3,150

UTILITIES AND TOOLS

Q1425-UZ	Application Development Environment (ADE) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	405
Q8425-UZ	Application Development Environment (ADE) for VAXstation 2000	425
Q4425-UZ	Application Development Environment (ADE) for VAXstation II/GPX	425
Q1451-UZ	DECcor for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	900
Q8451-UZ	DECcor for VAXstation 2000	945
Q4451-UZ	DECcor for VAXstation II/GPX	945
Q1310-UZ	DECcalc for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	510
Q8310-UZ	DECcalc for VAXstation 2000	536
Q4310-UZ	DECcalc for VAXstation II/GPX	536
Q1038-UZ	DECtype for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	300
Q8038-UZ	DECtype for VAXstation 2000	315
Q4038-UZ	DECtype for VAXstation II/GPX	315
Q1007-UZ	DEC/CMS (Code Management System) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	1,301
Q8007-UZ	DEC/CMS (Code Management System) for VAXstation 2000	1,365
Q4007-UZ	DEC/CMS (Code Management System) for VAXstation II/GPX	1,365
Q1500-UZ	DEC/MMS (Module Management System) for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	320
Q8500-UZ	DEC/MMS (Module Management System) for VAXstation 2000	336
Q4500-UZ	DEC/MMS (Module Management System) for VAXstation II/GPX	336
Q1143-UZ	DECshell for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	710
Q8143-UZ	DECshell for VAXstation 2000	746
Q4143-UZ	DECshell for VAXstation II/GPX	746
Q1706-UZ	TDMS for VAXstation 3200/3500/8000, VAXserver 3500/3600/3602	620
Q8706-UZ	TDMS for VAXstation 2000	651
Q4706-UZ	TDMS for VAXstation II/GPX	651

*Note: Prices listed are for VMS Version 4.7. ■