DEC VAX 6000 Systems

MANAGEMENT SUMMARY

UPDATE: *Since our last update, Digital Equipment Corporation has introduced eight new VAX 6000 systems that significantly strengthen its competitiveness in the midrange and workstation marketplace. At the entry level, the VAX 6000 Model 210 starts at $129,000, followed by Models 310/410/420/430/440/450. At the top of the line is the VAX 6000 Model 460, priced at $752,000.*

The company continues as a sponsor of the Open Software Foundation and also maintains an alliance with Apple Computer to strengthen its presence in the PC market.

Analysis

In another overhaul of its entire product line, Digital introduced a raft of computers that significantly strengthen its competitiveness in the midrange and workstation marketplace. Now, new VAX 6000 systems meet users' growing application and performance needs. The machines range from the entry level VAX 6000 Model 210 to the top-of-the-line VAX 6000 Model 460, with up to 36 times the performance of the VAX-11/780.

The VAX 6000 systems redefine VAX system potential with a quantum leap in price/performance and expansion capability, as well as a unique, integrated vector processing option. The capability to support either one or two vector processors will be available within the next 12 months. This option—with full VAX compatibility—brings compute-intensive processing capabilities to a flexible, general purpose system.

Along with the new lineup of VAX systems, a new numbering scheme reflects the upgradability of the whole 6000 Series platform. Existing 6000 systems models have been renumbered as well. The VAX 6200 and 6300 series are now called VAX 6000-200 and VAX 6000-300 systems, respectively.

Compatibility is key with the VAX 6000 series. This family of VAX systems supports the same I/O devices, systems options, and software, and the platform strategy provides an extra measure of investment protection.

All members of VAX 6000 Model 400 systems use a new central processor based on CMOS II semiconductor technology. Each system has 11 slots to support up to six processors, 256M bytes of memory, and 6 VAXBI channels.

DECISION POINTS

The following systems and upgrades comprise Digital's latest product line announcements: ▷

The VAX Systems run varied applications, from office automation in departmental environments to complex engineering and scientific applications in research centers. The family now includes multiprocessor models—distinguished by symmetric multiprocessor systems (SMPs)—that permit multistream computing and parallel execution of Fortran applications. Digital's VAX Systems are frequently configured in multinode VAXcluster configurations with high-performance I/O controllers.

MODELS: VAX 6000-210/310/410/420/430/440/450/460.
MAIN MEMORY: 32M bytes to 192M bytes.
DISK CAPACITY: 2.2G bytes to over 800G bytes.
WORKSTATIONS: Up to 656 (practical limit).
PRICE: $129,000 to $752,000 (base configuration prices with paid-up licenses).
GSA SCHEDULE: Yes.

CHARACTERISTICS

MANUFACTURER: 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 FORMATS

BASIC UNIT: 32-bit word.

FIXED-POINT OPERANDS: Integers can be 8-bit bytes, 16-bit words, 32-bit longwords, 64-bit quadwords, and 128-bit octawords. Integer data is stored in a binary format that can be signed or unsigned. As unsigned quantities, integers increment from zero. As signed quantities, the integers are represented in two's complement form.

FLOATING-POINT OPERANDS: The VAX instruction set supports floating-point data in longwords, quadwords, and octawords. Four types of floating-point data are available. Two types—D and G—are 8 bytes long; the third type—F—is 4 bytes long; the last type—H—is 16 bytes long. Data type F is single precision; type D is double precision. Type H is emulated by software in the VAX 6000 Systems.

A Floating-Point Accelerator (FPA) is standard on VAX 6000 systems. The FPA executes in parallel with the base CPU, taking advantage of the CPU's instruction buffer to prefetch instructions and of the memory cache to access main memory. Once the CPU has the required data, the FPA overrides the normal execution flow of the standard ▶

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TABLE 1. SYSTEM COMPARISON

6000 Systems: Model	210	310	410	420
SYSTEM CHARACTERISTICS				
Date of introduction	July 1989	July 1989	July 1989	July 1989
Date of first delivery	July 1989	July 1989	July 1989	July 1989
Performance (VAX-11/780)	2.8	3.8	7.0	Up to 13.0
ALL-IN-1 subscribers	120	152	216	368
Debit/credit TPS	6.0	8.4	12.0	21.3
Processors	1	1	1	2
Cache per processor (on chip/on board)	1KB/256KB	1KB/256KB	2KB/128KB	2KB/128KB
Cycle time	80 ns.	60 ns.	28 ns.	28 ns.
Vector processors	0	0	1	1 or 2
In-cabinet expansion	To models 310-460	To models 410-460	To models 420-460	To models 430-460
MEMORY and I/O				
Memory VMS	32-256MB	32-256MB	32-256MB	64-256MB
Memory ULTRIX	32-256MB	32-256MB	32-256MB	32-256MB
Max. I/O bandwidth (secs.)	60MB	60MB	60MB	60MB
VAXBI channels	1 to 6	2 to 6	2 to 6	2 to 6
Max. Disk in-cabinet	2.2GB	2.2GB	2.2GB	2.2GB
Max. Disk local	58.2GB	58.2GB	58.2GB	58.2GB
Max. Disk HSC	Over 800GB	Over 800GB	Over 800GB	Over 800GB
Ethernet controllers	1-4	1-4	1-4	1-4
VAXcluster adapters	1	1	1	1
SYSTEM PRICING*				
VMS	$129,000	$184,100	$239,000	$399,000
ULTRIX	$101,600	$155,200	$204,700	$376,000

*All prices are U.S. list prices with standard warranty for base systems with paid-up licenses.

- The new VAX 6000 Model 400 systems provide a major enhancement to the VAX 6000 line. They deliver up to 85 percent more performance than VAX 6300 systems with significant price/performance improvements. The Model 410 provides 85 percent more performance at only a 30 percent higher price than the VAX 6310. At the top of the line, the Model 460 provides 60 percent more performance than the 6360 at no additional cost. The VAX 6000 Model 460 is the most powerful VAX system available to date—with up to 36 times the performance of the VAX-11/780. The VAX 6000 Model 400 kernel prices start at $239,000 and system prices start at $257,000.

- The VAX 6000 Model 210, a new, lower-priced entry model in the VAX 6000 family, provides performance of 2.8 times the VAX-11/780 system. Priced 30 percent lower than the previous entry-level VAX 6310 system, its performance can expand by 13 times within the same cabinet, to equal the VAX 6000 Model 460. Kernel prices start at $129,000 while system prices start at $147,000.

- The VAX 6000 platform strategy provides upgrades from existing VAX 6000 systems to the new Model 400 systems. This technique eliminates obsolescence by allowing customers to add new processor technology for increased performance as it becomes available. These upgrades can be completed within minutes and all within the same cabinet.

- Within the next 12 months, Digital plans to extend the VAX architecture by adding vector processing to VAX 6000 Model 400 systems.

- Version 5.2 of the VMS operating system supports the new systems with new features that include an increase in the number of computers in a VAXcluster system from

floating-point microcode and forces the use of its own code. Then, while the FPA is executing, the CPU performs other operations in parallel.

INSTRUCTIONS: The native VAX instruction set consists of 304 basic operations, most of which can be applied to any one of several types of data, which can in turn be addressed in any one of nine ways. The native instruction set provides 32-bit addressing, 32-bit I/O operations, and 32-bit arithmetic.

In conjunction with a software executive running in native mode, the VAX processors can concurrently execute a compatibility-mode instruction set, which is a subset of the Digital PDP-11 instruction set. The execution is not achieved by emulation or simulation; both instruction sets are built into the microcode and logic of the processor. The compatibility-mode instruction set contains all the PDP-11 instructions except those which perform execution of floating-point instructions and execution of privileged functions.

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

MAIN STORAGE

TYPE: The VAX Systems employ both 1M-bit and 256K-bit error correcting and checking (ECC) MOS RAM chips.

CYCLE TIME and CAPACITY: See Table 1.

STORAGE PROTECTION: The system's memory management logic divides memory into 512-byte pages. A protection code specifies the access modes that have read or write access to each page. In addition, fault detection hardware causes a memory error-correcting code to detect all double-bit errors and correct all single-bit errors. Each VAX System features a 7-bit error-correcting code per 32-bit longword.

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TABLE 1. SYSTEM COMPARISON (Continued)

6000 Systems: Model	430	440	450	460
SYSTEM CHARACTERISTICS				
Date of introduction	July 1989	July 1989	July 1989	July 1989
Date of first delivery	July 1989	July 1989	July 1989	July 1989
Performance (VAX-11/780)	Up to 19.0	Up to 25.0	Up to 31.0	Up to 36.0
ALL-IN-1 subscribers	—	600	600	656
Debit/credit TPS	—	38.5	—	44.0
Processors	3	4	5	6
Cache per processor (on chip/on board)	2KB/128KB	2KB/128KB	2KB/128KB	2KB/128KB
Cycle time	28 ns.	28 ns.	28 ns.	28 ns.
Vector processors	1	1	0	0
In-cabinet expansion	To models 440-460	To models 440-460	To model 460	NA
MEMORY and I/O				
Memory VMS	64-256MB	128-256MB	128-192MB	128-192MB
Memory ULTRIX	NA	NA	NA	NA
Max. I/O bandwidth (secs.)	60MB	60MB	40MB	40MB
VAXBI channels	2 to 6	2 to 6	2 to 4	2 to 4
Max. Disk in-cabinet	2.2GB	2.2GB	2.2GB	2.2GB
Max. Disk local	58.2GB	58.2GB	38.8GB	38.8GB
Max. Disk HSC	Over 800GB	Over 800GB	Over 800GB	Over 800GB
Ethernet controllers	1-4	1-4	1-4	1-4
VAXcluster adapters	1	1	1	1
SYSTEM PRICING*				
VMS	$489,000	$627,000	$700,000	$752,000
ULTRIX	NA	NA	NA	NA

*All prices are U.S. list prices with standard warranty for base systems with paid-up licenses.
NA—Not applicable.

42 to 96; VAXcluster support for the license management facility (LMF); backup and security enhancements; and increased centralized system management capabilities. The new VMS version is available with no increase in price.

With the new VAX 6000 systems, Digital now provides a single-image multiprocessor, where all processors use a single copy of the operating system running in shared memory.

Symmetrical Multiprocessor (SMP) architecture and Version 5.2 of the VMS operating system permits each CPU to initiate instructions independently and run multiple applications simultaneously. Each processor can initiate I/O calls without relying on a master processor. The new systems can execute Fortran programs in parallel through a facility in the new Fortran compiler for VMS Version 5.1; that is, a program can be split up and worked on simultaneously by several processors.

DIGITAL AND UNIX

ULTRIX-32 is Digital's implementation of UNIX. It currently runs only on the VAX 6000 models 210, 310, 410, and 420. Digital is a sponsor of OSF, an alliance of computer vendors dedicated to developing a single, nonproprietary version of UNIX. OSF has endorsed the IEEE POSIX, a standard for communication between an operating system and application programs. Datapro believes that Digital is developing a POSIX-compliant ULTRIX-32 (which may be renamed to support SMP in the UNIX environment).

An 8-bit ECC code with its own controller protects each VAX 6000 main memory module. A battery option protects memory during power fluctuations.

RESERVED STORAGE: Information unavailable from the vendor.

CACHE MEMORY: All VAX Systems include cache memory. Refer to Table 1 for cache sizes on specific machines.

CENTRAL PROCESSOR

GENERAL: All VAX CPUs feature virtual memory management facilities, bootstrap loader, cache memory, programmable realtime clock, time-of-year clock with battery backup, control store, and console subsystem. All VAX 6000 Models employ CMOS technology.

REGISTERS: The VAX systems provide sixteen 32-bit general registers that can be used for temporary storage, as accumulators, as index registers, and as base registers. Four registers have special significance: the Program Counter contains the address of the next instruction to be executed; the Stack Pointer contains the address of the base (or top) of a stack maintained for subroutine and procedure calls; the Frame Pointer contains the address of the base of a software data structure stored on the stack and called the stack frame, which is maintained for procedure calls; and the Argument Pointer contains the address of the base of a software data structure called the argument list, which is maintained for procedure calls.

ADDRESSING: The processor's addressing modes allow almost any operand to be in a register or in memory, or used as an immediate constant. There are nine basic addressing modes that use the general registers to identify the operand location: Register, Register Deferred, Autodecrement, Autoincrement, Immediate, Autoincrement Deferred, Absolute, Displacement, and Displacement Deferred. The processor also provides Literal Mode addressing.

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TABLE 2. MASS STORAGE

MODEL	RA60	RA90	RA82	SA482	SA600
Type	Removable	Winchester	Winchester	Storage Array	Storage Array
Controller model	UDA50, KDA50, KDB50, HSC5X-BA (on HSC70 or HSC50)	UDA50, KDA50, KDB50, HSC5X-BA (on HSC70 or HSC50)	UDA50, KDA50, KDB50, HSC5X-BA (on HSC70 or HSC50)	UDA50, KDA50, KDB50, HSC5X-BA (on HSC70 or HSC50)	UDA50, KDA50, KDB50, HSC5X-BA (on HSC70 or HSC50)
Drives per subsystem/controller	4	6	4	1 to 8	1 to 8
Formatted capacity per drive, megabytes	205	1.2GB	622	1.244-2.488GB	9.7GB
Number of usable surfaces	6	7	7	32	13
Bytes per sector or track	512/sector	512/sector	512/sector	512/sector	512
Average seek time	41.7 ms.	18.5 ms.	24 ms.	24 ms./spindle	18.5 ms.
Average rotational/relay time	8.3 ms.	8.3 ms.	8.3 ms.	8.3 ms./spindle	8.3 ms./spindle
Average access time	50 ms.	32.3 ms.	32.3 ms.	32.3 ms./spindle	32.3 ms.
Data transfer rate	1.98MB/sec.	2.8MB/sec.	2.4MB/sec.	2.4MB/sec./spindle	2.4MB/sec./spindle
Supported by system models	All	All	All	All	All
Purchase price	$20,747	$27,500-$145,000	$17,340-$52,020	$34,680-$67,320	$27,500-$189,000
Comments	Comprises 1 to 8 RA90s			Comprises 2 to 4 RA82s	Not supported as system disk; data transfer device only

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

POSIX may also provide the means to remove the proprietary label from the VMS operating system. If VMS were made POSIX compliant, an enormous library of UNIX-based applications programs would be available to VAX users.

DIGITAL AND THE PC

To bolster its image in the PC market, Digital forged an agreement with Apple Computer, wherein both vendors will develop products that link Macintoshes in AppleTalk networks to DECnet-based VAX systems. Digital's MS-DOS-compatible VAXmate PC never lived up to expectations. Datapro suspects that Digital may actually begin selling Macintoshes to its VAX users.

COMPETITIVE POSITION

Digital's announcements of products and strategic alliances over the last six months have occurred at a dizzying pace. Such speed is necessary; Digital's growth is slowing for the first time in several years. This slowdown doubtless stems from general market saturation and slowed capital expenditures for computers in the wake of the financial markets' downturn of October 1987. If Digital is to maintain its footing in this turbulent economic climate, it must continually enhance the flagship VAX line and demonstrate its utility in a wide variety of functions and in diverse operating environments. To coin a phrase, as the VAX goes, so goes Digital.

The VAXes certainly continue to do very well in price/performance comparisons, particularly against competing IBM offerings. Even at the lower end of the line, Digital's departmental machines have demonstrated a marked cost advantage over comparable IBM offerings.

However, the across-the-board increase in system prices necessitated by the industry-wide shortage of DRAM memory chips could not have come at a less opportune time. As it tries to get the SMP systems off the ground and simulta-

INTERRUPTS: Each VAX processor recognizes 32 priority interrupt levels—16 for hardware, 15 for software, and one for normal user software, which runs at the process level (interrupt priority level zero).

The interrupt service routine executes at the interrupt priority level of the interrupt request. When the processor receives an interrupt request at a level higher than that of the currently executing software, the processor honors the request and services the new interrupt at its priority level. When the interrupt service routine issues the Return from Exception or Interrupt (REI) instruction, the processor returns control to the previous level.

INPUT/OUTPUT CONTROL

The input/output information provided is for systems running under VMS; ULTRIX-32 systems use the same I/O control devices, but are more restricted as to the number that can be configured.

The VAX systems employ the VAXBI (detailed below) as the primary I/O bus. However, all support Digital's older UNIBUS I/O architecture.

The *VAX Bus Interconnect (VAXBI)*, a 32-bit synchronous bus, serves only as the I/O bus; all systems employ a high-speed memory interconnect as the system bus.

In the VAXBI bus, all arbitration, address, and data transmissions are time multiplexed over 32 data lines.

The VAXBI provides connections for up to 16 VAXBI nodes, each of which is an interface occupying a logical position on a VAXBI bus; the node can be a mix of processors, memories, and adapters. The VAX 6000 Series computers deliver aggregate throughput of up to 60M bytes per second.

All VAX Systems support the *UNIBUS*, an asynchronous, bidirectional bus, which controls all Digital- and user-developed realtime peripherals other than high-speed disk drives and magnetic tape transports. The UNIBUS is connected to the system or I/O bus through the UNIBUS adapter, which handles priority arbitration among devices on the UNIBUS.

The UNIBUS adapter provides access from the VAX processors to the UNIBUS peripheral device registers by translating UNIBUS addresses, data transfer requests, and

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TABLE 3. WORKSTATIONS

MODEL	VT320	VT330	VT340
DISPLAY PARAMETERS			
Max. chars./screen	3,168	3,168	3,168
Buffer capacity	—	19K characters	19K characters
Screen size (lines x chars.)	24 x 80 or 132	24 x 80 or 132	24 x 80 or 132
Tilt/swivel screen	Optional	Standard	Standard
Symbol formation	7 or 12 x 7 dot matrix	8 or 9 x 11 (80 col.); 4 or 5 x 9 (132 col.)	8 or 9 x 11 (80 col.); 4 or 5 x 9 (132 col.)
Character phosphor	White, green, or amber	White, green, or amber	White, green, or amber
Total colors/no. simult. displayed	Not applicable	4 shades of gray	4,096/16
KEYBOARD PARAMETERS			
Style	Typewriter	Typewriter	Typewriter
Character/code set	ASCII, NRCS, ISO Latin 1, Digital Special Graphics and Supplemental	ASCII, NRCS, ISO Latin 1	ASCII, NRCS, ISO Latin 1
Detachable	Yes	Yes	Yes
Program function keys	15	15	15
TERMINAL INTERFACE	DEC-423, RS-232-C	DEC-423, RS-232-C	DEC-423, RS-232-C
PURCHACE PRICE	$525	$1,795	$2,595
COMMENTS	1200-by-300 pixel resolution	800-by-500 pixel graphics array; supports split-screen viewing, ReGIS, Sixels, Tektronix 4010/4014	800-by-500 pixel graphics array; supports split-screen viewing, ReGIS, Sixels, Tektronix 4010/4014

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

neously confronts a low-end challenge from IBM, Digital needs every economic advantage it can get. The price increase is surely a detriment to the price/performance curve. We cannot help wondering whether Digital will lower VAX prices once the crisis ends.

The IBM AS/400 represents a threat to digital low-end uniprocessors. If IBM either reduces AS/400 prices, or adds processing power, Digital may be forced to lower prices.

ADVANTAGES AND RESTRICTIONS

VAXclustering has proven popular with users. In fact, Digital pushes clustering harder with each announcement. Certainly, the scheme provides an innovative mechanism for upgrading systems.

Of course, in-group migration options exist within the VAX line. The 6000 model 210, for example, can be upgraded to any other 6000. Through clustering, though, a system can gain additional computing power and throughput. VAXclustering also delivers enhanced load balancing and gives users access to far more disk storage than is available through local system connections.

Additionally, VAXclustering can also provide fault tolerance through processor switchover and automatic dualported disk switchover in case of failure, through the Hierarchical Storage Controllers (HSCs) it employs. In addition, the VMS operating system supports Volume Shadowing software, writes data to two disks simultaneously, preserving data if one disk fails.

VAXclusters linked by Ethernet LANs can now access large clusters of VAX superminis, providing the greater computing and storage resources of the bigger clusters.

interrupt requests to their memory interconnect equivalents, and vice versa. The UNIBUS adapter includes an address translation map.

The *Hierarchical Storage Controller (HSC)* family is a series of intelligent servers for high-speed disks and tapes, primarily in VAXclusters. (For details on VAXclusters, see the CONFIGURATION RULES section of this report.)

The HSC connects to the host system through Digital's Computer Interconnect (CI), a serial bus with a bandwidth of 70M bytes per second; the CI features a dual-path interface to hosts in a cluster. The port onto the CI bus can support a sustained 4.2M bytes per second transfer rate.

Based on PDP-11 microprocessors, the HSC servers use the Standard Disk Interconnect (SDI) and the Standard Tape Interconnect (STI) to attach disk drives and tape formatters. The SDI and STI buses both support burst transfer rates up to 3.1M bytes per second.

The HSC70 allows up to eight data channels, providing direct support for up to 32 SDI disk drives (32 RA-series or eight SA482 storage arrays) or a combination of SDI disk drives and up to 24 TA-Series tape drives. Through six data channels, the HSC50 can directly support up to 24 SDI disk drives (including six SA482 Storage Arrays) or 16 SDI drives and eight TA Series tape drives.

Both HSC controllers support volume shadowing through specialized VMS software. That feature, which provides a measure of fault tolerance, allows all data written to a disk to be duplicated on compatible disk volumes.

CONFIGURATION RULES

VAX Systems are available in basic systems, preconfigured systems, and VAXcluster configurations. All systems include VMS or ULTRIX-32 operating system and DECnet networking software licenses.

A *VAXcluster* is a multiprocessing system comprising one or more VMS-based VAX processors and/or Hierarchical Storage Controllers (HSCs) linked by a high-speed Computer Interconnect (CI) bus. Each processor or HSC in the

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TABLE 4. PRINTERS

MODEL	LPS20	LP37	LP27	LP29	LG01/LG02
Type	Laser	Band	Band	Band	Matrix
Speed	20 ppm	1,200 lpm	1,200/800 lpm	1,500/2,000 lpm	600 lpm
Bidirectional printing	Not applicable	Not applicable	Not applicable	Not applicable	—
Paper size	7.5 to 11 in. wide; 10.5 to 17 in. long	Up to 18.75 inches	Up to 18.75 inches	—	4-16 in. wide, 3-20 in. long
Character formation	Electrophotographic	Full	Full	Full	Dot matrix
Horizontal character spacing (char./inch)	Variable	10	10	Variable	Variable
Vertical line spacing (char./inch)	Variable	6 or 8	6 or 8	—	—
Character set	29 resident type-faces	64/96	64/96	96 ASCII or 64 upper case	64 (data proc. mode)
Controller/Interface	—	LP11, DMF32, DMB32	Integrated, DMF32, DMB32	LP11, DMB32, DMF32	RS-232-C, Datapro-ducts parallel
Printer dimensions, in. (h x w x d)	—	—	49 x 35 x 38	—	38 x 33.5 x 22.3
Graphics capability	No	No	No	Not applicable	LGO2 only
Purchase price	$22,900	$22,500	$29,900	$34,900	$10,990 (LGO1); $12,990 (LGO2)
Comments	Ethernet-based print server				LGO1 text printer up-gradable to LGO2 text/graphics printer

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

Digital's VMS operating system is one of the VAX line's greatest strengths. VMS provides a uniform operating environment from the desktop to the data center. Users can thus migrate applications upward without conversion and share applications across networks.

VAX networking products are excellent. Connectivity is provided to OSI and SNA. Communications software employs IBM's LU6.2 protocol.

SMP technology is most effective in technical applications rather than I/O intensive commercial applications, where Digital claims that 46 percent of the VAX systems are installed. Parallelism is restricted to Fortran programs.

USER REACTION

Responses to Datapro's 1989 Computer Users Survey included returns from 15 users of the VAX 6000 systems. Of the users surveyed, 73 percent purchased their systems from Digital, while the remaining 27 percent were equally divided between leasing from Digital and leasing from a third party. As of March, 1989, the average length of installation for the systems was approximately five months. Despite Digital's reputation as a engineering/scientific-oriented system vendor, most of the users were running business and administrative computing applications. Of the VAX 6000 system customers surveyed, 60 percent have accounting/billing applications; 46 percent have order processing/billing applications; 40 percent have payroll and personnel applications; 33 percent have purchasing system applications; and 33 percent have educational administration applications. In contrast, only 26 percent have engineering/scientific and mathematical and statistical applications.

For applications, most programming is performed by in-house personnel (93 percent). Other methods of obtaining applications software are independent suppliers (80 percent), purchasing packaged programs from Digital (26 percent), and contract programming (7 percent).

configuration is considered a node. The smallest VAXcluster configuration can be two VAX processors connected by a CI and a Star Coupler. An HSC is not required for a cluster; VMS allows locally connected disks to be shared by VAXcluster users. Up to 16 CI-connected nodes can be configured in a VAXcluster.

VAXclusters differ from SMP systems in that the former is a set of cooperating but independent processors, while the latter is a single-image system composed of multiple processors. Each system in a VAXcluster has its own memory-resident copy of VMS; an SMP system has a single memory-resident copy of VMS shared by all processors. SMP systems can participate in VAXclusters.

A VAXcluster Console System, linked to nodes in the cluster through fiber optic facilities, is available for VAXclusters. The Console System, based on Digital's MicroVAX II, allows system management operations to be performed from any terminal, local or remote, attached to it.

GENERAL: The configuration rules provided here are for SBBs under VMS. Systems operating under ULTRIX-32 use the same components, but configurability is more limited.

6000 systems, the number of processors (up to six), VAXBI channels (up to six), and memory boards (up to eight) can total up to 14. Memory can be expanded to 256M bytes in 64M-byte increments comprising two 32M-byte memory boards. Device support on the 6000 systems is as follows:

- Up to six VAXBI channels (occupying five slots each).

- Up to eight KDB50 disk controllers. Two can be configured per VAXBI channel, with each taking up two VAXBI slots.

- Up to four TU81-Plus tape drives. Two can be configured per VAXBI channel, with each occupying one VAXBI slot.

- Up to four DEBNA Ethernet controllers; two can be configured per VAXBI channel.

- Up to two DMB32 eight-line or DNB32 16-line communications controllers can be configured per internal VAXBI channel; up to four can be configured per external VAXBI channel. Each device occupies one VAXBI slot.

Refer to Table 1 for additional information.

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TABLE 4. PRINTERS (Continued)

MODEL	LG31	LN03	LN03 Plus	ScriptPrinter (LN03R)	PrintServer 40 (LPS40)
Type	Dot matrix	Laser	Laser	Laser	Laser
Speed	300 lpm	8 ppm	8 ppm	8 ppm	40 ppm
Bidirectional printing	—	Not applicable	Not applicable	Not applicable	Not applicable
Paper size	Up to 15 in. wide	Up to 8.3 x 11.7 in.	Up to 8.3 x 11.7 in.	Up to 8.3 x 11.7 in.	7.5 to 11 in. wide; 10.5 to 17 in. long
Character formation	Dot matrix	300 x 300 dots/in.	300 x 300 dots/in.	300 x 300 dots/in.	Electrophotographic
Horizontal character spacing (char./inch)	5 to 16.7	Variable	Variable	Variable	Variable
Vertical line spacing (char./inch)	—	Variable	Variable	Variable	Variable
Character set	7- or 8-bit, ANSI/ISO-compatible	ASCII; 16 resident Courier/Elite fonts	ASCII; technical; 17 resident fonts	29 resident fonts	29 resident typefaces
Controller/Interface	RS-232-C interface	RS-232-C interface	RS-232-C interface	RS-232-C interface	—
Printer dimensions, in. (h x w x d)	—	15 x 21 x 23.5	15 x 21 x 23.5	15 x 21 x 23.5	40.4 x 60 x 28.4
Graphics capability	Not applicable	150 dpi (average)	300 x 300 dpi	300 x 300 dpi	300 x 300 dpi
Purchase price	$7,990	$2,895	$3,995	$5,233	$49,900
Comments	Prints Code 39 and Interleaved 2 of 5 bar codes		Includes PLOTLN software and 2 EPROMs	Supports PostScript page description language	Ethernet-based print server suitable for local area networks

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

▷ The following table shows how the 15 respondents rated their VAX 6000 systems:

Ease of operation	8.7
Reliability of system	9.1
Reliability of peripherals	8.1
Maintenance service:	
Responsiveness	8.7
Effectiveness	8.3
Technical support:	
Troubleshooting	8.4
Education	7.2
Documentation	7.8
Vendor's software:	
Operating system	8.7
Compilers & assemblers	8.2
Application programs	7.9
Ease of programming	8.4
Ease of conversion	8.1
Overall satisfaction	8.6

*Average based on a scale from 1 (Poor) to 10 (Excellent).

VAX 6000 users were very satisfied with their systems. In fact, all users surveyed said that their computers performed as expected and would recommend the system to another user. Users' plans for acquisition and implementation included expansions to present hardware (47 percent), expansions to data communications facilities (67 percent), proprietary software from other suppliers (60 percent), and additional software from the manufacturer (47 percent). □

▶ **WORKSTATIONS:** Digital contends that the number of users supported by any system depends on the type of application and the associated demands on the processor and bus. Moreover, company spokespersons almost invariably contend that the maximum number of locally connectable terminals is a false limit, because frequently VAX systems employ Ethernet terminal servers; theoretically, each system can be connected to over 1,000 servers. Generally, Digital provides either the number of asynchronous local lines supported, or, in some cases, the range of users typically supported on a given system across a spectrum of applications. Refer to Table 1 for the quoted workstation support figures for each system.

Digital also provides ranges of support for users of the ALL-IN-1 integrated office system, which many VAX users employ as the primary application umbrella for their organizations.

DISK STORAGE: The KDB50 disk controller supports up to four RA60 (205M-byte fixed/removable), RA81 (456M-byte Winchester), and RA82 (622M-byte Winchester) drives in any combination.

MAGNETIC TAPE: The principal locally connectable tape device for the VAX Systems is Digital's TU81-Plus. See the "General" portion of this section for information on the number of those drives locally configurable on each VAX System.

The HSC70 and HSC50 I/O controllers, which attach to all VAX Systems through the Computer Interconnect, also support tape devices. Refer to the INPUT/OUTPUT CONTROL section of this report for information on HSC family tape support.

PRINTERS: Each VAX System can support up to 16 line printers. Each printer must connect to an asynchronous line or to a DMF32 or DMB32 port. Each system can use a maximum of two DMF32 or DMB32 printer ports.

MASS STORAGE

For information on available mass storage devices for VAX systems, refer to Table 2, Mass Storage.

INPUT/OUTPUT UNITS

Refer to Table 3 for terminals, Table 4 for printers, and Table 5 for magnetic tape equipment.

OTHER PERIPHERALS: VAX systems also support an optical storage system, printing terminals, and a voice synthesis module.

The RV20 laser drive is a Write Once, Read Many (WORM) optical storage device. Average seek time is 150 milliseconds; the continuous data transfer rate is approximately 250K bytes per second for both read and write operations. The RV20 master drive can be daisychained to three slave drives to provide up to 4G bytes of storage. Digital guarantees data readability for 30 years.

The LA100 is a microprocessor-controlled hard copy terminal and printer; it can print up to 240 cps in draft mode, 30 cps in letter-quality mode, and 80 cps in memo mode. The ▶

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TABLE 5. MAGNETIC TAPE EQUIPMENT

MODEL	TA79	TU79	TA81	TU80	TU81-Plus	TK50
TYPE	Reel to reel	Reel to reel	Streaming	Streaming	Streaming	Cartridge
FORMAT						
Number of tracks	9	9	9	9	9	22
Recording density, bits per inch	1600/6250	1600/6250	1600/6250	1600	1600/6250	6667
Recording mode	PE/GCR	PE/GCR	PE/GCR	PE	PE/GCR	Serial (serpentine)
CHARACTERISTICS						
Controller model	HSC5X-CA (on HSC70 or HSC50)	TA79 master (on HSC5X-CA)	HSC5X-CA (on HSC70 or HSC50)	UNIBUS adapter	UNIBUS or VAXBI adapter	UNIBUS interface
Drives per controller	4 per HSC5X-CA	3 per TA79	4 per HSC5X-CA	1	1	1
Storage capacity, bytes	40M PE, 145M GCR	40M PE, 145M GCR	40M PE, 145M GCR	40M	40M PE, 145M GCR	95M
Tape speed, inches per second	125	125	75 and 25 (streaming)	25 and 100 (streaming)	75 ips	75
Data transfer rate, units per second	200KB PE; 781KB GCR	200KB PE; 781KB GCR	468KB	160KB	468KB	45KB
Streaming technology	No	No	Yes	Yes	Yes	Yes
Start/stop mode; speed	Not applicable	Not applicable	Yes; 25 ips	Yes; 25 ips	Yes; 25 ips	—
Switch selectable	Yes	Yes	—	No	Not applicable	Not applicable
PURCHASE PRICE	$65,450	$32,350	$35,318	$14,294	$33,100 (UNIBUS); $33,850 (VAXBI)	$3,824

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

LA120 is a 180 cps printing terminal. Those two printing terminals can be used as consoles for VAX Systems.

DECtalk, a speech synthesis unit, converts standard ASCII text into speech output. The unit features 10 voices (9 pre-defined and 1 user defined). Available in single- and eight-line versions, DECtalk uses an RS-232-C interconnection for each line. DECtalk accepts input from a Touch-tone telephone keypad and provides voice output through a built-in speaker, headphones, audio jack, or telephone. The eight-line version is upward compatible with the single-line version.

COMMUNICATIONS CONTROL

The variety of communications interfaces supported by the VMS operating system allows VAX systems to be connected to other VAX systems, to other Digital systems, and to other manufacturers' computer systems. Synchronous, point-to-point, and multipoint connections are supported for inter-processor communications. For terminal-to-host communications, asynchronous connections are supported.

SOFTWARE

OPERATING SYSTEMS: Operating systems for the VAX systems are the general-purpose VMS and ULTRIX-32, Digital's version of Berkeley UNIX.

VMS (also known as VAX/VMS) is a general-purpose operating system that provides the environment for the concurrent execution of multiuser timesharing, batch, and time-critical applications. It also contains special features for VAXcluster support and provides programming tools, scheduling services, and protection mechanisms for multiuser program development.

The most recent release, Version 5.2, provides symmetric multiprocessing (SMP) support for all VAX 6000 systems. In SMP, a form of tightly coupled multiprocessing, all processors perform operations simultaneously in all VAX access modes (including user, supervisor, executive, and kernel). For example, processors in an SMP system can simultaneously execute user mode programs, execute system services, and initiate I/O. Actual parallel computing (in which all processors work simultaneously on parts of the same application) is supported only through the VAX Fortran compiler.

VMS Version 5.2 has specialized facilities—including Sysman—that centralize the management of VAXcluster systems (see below for a discussion of VAXcluster support), and the License Management Facility (LMF), a tool that enables a system manager to register, manage, and track software licenses.

VMS also features user and operator interfaces. The former allows special prompts and command recall and editing, while the latter permits management of batch and print queues.

VMS incorporates VAXcluster support features that allow the creation of homogenous environments providing transparent cross-cluster data access and resource sharing.

ULTRIX-32 is Digital's native-mode implementation of the UNIX operating system. It is based on the University of California at Berkeley's Fourth Berkeley Software Distribution (4BSD) and is compatible with AT&T's UNIX System V, Release 2.0. It does not comply fully with AT&T's System V Interface Definition (SVID). ULTRIX-32 cannot yet be used on VAX symmetric multiprocessor systems. Depending upon the application, ULTRIX-32 can support over 64 users.

DATABASE MANAGEMENT SYSTEM: The database management facilities available for the VAX 8000 systems are part of a larger scheme called VAX Information Architecture—a collection of database and data management tools arranged in layers above the operating system.

On the top layer, the VAX languages and VAX Forms Management System (FMS) provide a user interface for interactive and language-callable video forms.

On the next level, the VAX Common Data Dictionary (CDD) integrates the other components of the architecture. The CDD provides a facility for storing logical data definitions. Also on this level are the VAX Datatrieve high-level and distributed data management facilities, which allow access to data without the user specifying the means to access it, such as the file type and keys.

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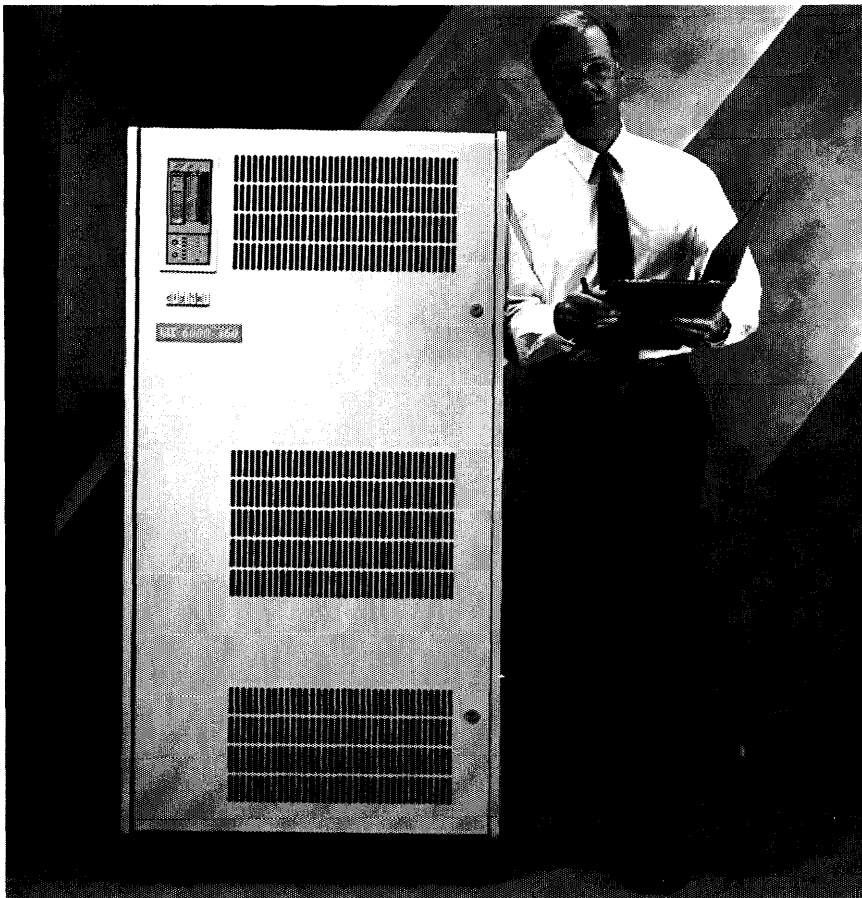
The VAX 6000 model 460, Digital's top-of-the-line VAX standalone system, employs a symmetric multiprocessor architecture that enables it to deliver up to 36 times the performance of the VAX-11/780 (long recognized as the standard of supermini performance). The 6000-460 and forthcoming vector processing systems represent Digital's best chance to challenge IBM's 3090 in the large-scale systems market.

► The lowest level consists of four online, multiuser data management facilities: VAX Rdb/VMS, VAX DataBase Management System (DBMS), VAX Application Control and Management System (ACMS), and VAX TDMS. The first two products, discussed below, are the actual database management systems for the VAX 6000 systems.

VAX Rdb/VMS is a relational database management system. Unlike VAX DBMS (detailed below), which is designed for highly structured databases, Rdb/VMS is designed for applications in which data items and relationships among records change frequently. Rdb/VMS conforms to the Digital Standard Relational Interface (DSRI) and is now Digital's premier DBMS product.

In Rdb/VMS, data is independent of application programs; users can change definitions without modifying or recompiling their programs. The product can retrieve and update information from both local and remote databases through DECnet. The VAX Rdb/VMS system also features a data definition language, an interactive query language, transaction management facilities, data validation functions, transaction recovery facilities, security constraints, and contention arbitration facilities that handle simultaneous attempts to access the same information. VAX Rdb/VMS can work with VAX Datatrieve to access the VAX Rdb/VMS database interactively; it can also work in conjunction with other VAX information management tools.

VAX Rdb/VMS can operate in a VAXcluster, providing shared database access, transparent failover, and automatic recovery.

VAX DBMS is a multiuser, general-purpose, Codasyl-compliant database management system based on the March 1981 Working Document of the ANSI Data Defini-

tion Committee. VAX DBMS administers databases ranging from simple hierarchies to complex, multisystem networks with multilevel relationships. The VAX Information Architecture allows DBMS data to be accessed directly from programming languages through VAX Datatrieve or DBMS utilities. VAX DBMS can operate in a VAXcluster environment and can access remote databases through DECnet networking software.

LANGUAGES: VMS provides a native programming environment consisting of language processors that produce native object code and program development tools that support native program development. VAX Fortran, RPG II, Cobol, Dibol, Basic, PL/1, Pascal, Coral 66, Bliss, APL, Digital Standard Mumps (DSM), C, Ada, Lisp, and OPS5 (for artificial intelligence programming) are native-mode language processors that produce native object code and take advantage of the native instruction set and 32-bit architecture of the VAX hardware. A VAX Macro assembler is available.

Two compilers are particularly noteworthy.

VAX Cobol Compiler Version 4.2, based on ANSI 1985 Cobol standard X3.23-1985, has been validated by the Software Standards Validation Group of the National Bureau of Standards for conformance to *FIPS Pub 21-2, Federal Standard Cobol* at the high level. Features enabling conformity to the government standard include NOT conditionals, the REPLACE statement, and the CLASS clause.

VAX Fortran Compiler Version 5.2, announced in April 1988, permits parallel processing on any VAX system running under VMS Version 5.1. (This compiler is also available for all other VMS-based processors, from the VAXstation up.) ►

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The Version 5.2 Fortran Compiler allows application programmers to perform directed decomposition, i.e., to write statements called directives that tell the Fortran compiler which sections of a program can be run in parallel on a multiprocessor CPU. The indicated sections are "decomposed" at run time and assigned to the various processors.

C, Fortran, and Lisp compilers are available for the ULTRIX-32 operating system.

COMMUNICATIONS: *Digital Network Architecture (DNA)* is a set of protocols governing the format, control, and sequencing of message exchange for all DECnet implementations. DNA controls all data that travels through a DECnet network and provides a modular design for DECnet. Digital announced DNA Phase V which, through 1990, will embrace even more of the standards established by the International Standards Organization (ISO) Open Systems Interconnect (OSI) networking model.

Conforming to the ISO/OSI model, DNA consists of the following seven functional layers (corresponding OSI layers are provided in parentheses): User and Network Management (Application), Network Application (Presentation), Session Control (Session), End Communications (Transport), Routing (Network), Data Link (same as OSI), and Physical Link (Physical).

DNA specifies the interface by which DECnet software modules in the same system interact with one another. Within each node, a layer contains only those modules required to support modules in higher layers.

DECnet-VAX permits suitably configured VMS-based systems to participate as routing or end nodes in DECnet computer networks. The vendor introduced DECnet-VAX as a Phase IV network product warranted only for use with other Digital Phase III and Phase IV products. Now that DNA is in Phase V, DECnet will certainly be upgraded for use with Phase III, IV, and V products. It offers task-to-task communications, file management, downline system and task loading, network command terminals, and network resource-sharing capabilities through Digital Network Architecture (DNA) protocols. DECnet-VAX currently communicates with adjacent and nonadjacent Phase III and Phase IV nodes. Among its features, DECnet-VAX permits area routing for development of networks containing several thousand processors. DECnet-VAX interfaces are standard with VMS.

DECnet-ULTRIX is a Phase IV Ethernet-based end-node implementation of the Digital Network Architecture for the ULTRIX-32 operating system. It provides communications among Digital systems using DNA Phase III or IV protocols and communications, including electronic mail, with non-Digital systems using TCP/IP protocols. DECnet-ULTRIX will be upgraded to comply with DNA Phase V.

DECnet-ULTRIX allows users to transfer data and files between ULTRIX- and VMS-based systems and also permits DECnet and TCP/IP protocols to share system resources, such as Ethernet communications controllers.

For multivendor networking, Digital provides *Network Applications Support* products that allow common access to services on DECnet/OSI networks. Those products provide application access, business communications, and information/resource sharing services for Digital's VT Series terminals, based on VMS and UNIX VAX Systems, Apple Macintosh microcomputers, and MS-DOS- and OS/2-based PCs.

Digital's *Internet* family of products supports the interconnection of Digital computers and Digital networks to systems built by IBM and other manufacturers. The most important members of the Digital-to-IBM portion of the family are DECnet/SNA Gateway and VMS/SNA.

DECnet/SNA Gateway permits connection of a DECnet network and an IBM Systems Network Architecture (SNA) network. IBM operating systems and subsystems supported by DECnet/SNA Gateway include MVS, MVS/SP, MVS/XA, VM/SP, DOS/VSE/SP, CICS/VS, IMS/VS, ACF/VTAM, and ACF/NCP. One version of DECnet/SNA Gateway links Digital local area networks to SNA networks and another connects Digital wide area networks to SNA nets.

VMS/SNA allows VAX systems to directly participate in an IBM SNA network. A VAX running VMS/SNA appears to the SNA network as a remote Physical Unit Type 2 node, providing access to IBM applications programs or other system resources and allowing the VAX to act as a 3270 display station exchanging documents and electronic mail between the VMS operating system and IBM's DISOSS.

Both DECnet/SNA Gateway and VMS/SNA require installation of appropriate *DECnet/SNA Access Routines and Programming Interfaces* on host systems.

UTILITIES: Available for the VAX systems are a number of utility programs (or, as Digital categorizes them, program development tools), including text editors, a linker, a librarian, a common runtime procedure library, and a symbolic debugger. More specialized products include a code management system, a UNIX-like command line interpreter, a spreadsheet package, a ReGIS graphics library (RGL) package, and a graphical kernel system. These tools are available to the programmer through the VMS command language.

OFFICE AUTOMATION: *VAX ALL-IN-1 Integrated Office and Information System* is a menu-oriented software package that electronic mail; word and document processing; calendar, time, and desk management; electronic filing; communications; and forms development on VMS-based systems. The system also features voice messaging support, DECtalk mail access through Touch-tone telephones, and integrated computer-based instruction for all major functions. A flow-control facility allows a user at a VT100, VT200, or VT300 family terminal to select from an option menu, moving from one application to another. The ALL-IN-1 software requires a VMS-based system with at least 2M bytes of dedicated main memory.

APPLICATIONS: Digital offers both proprietary and third-party applications packages for VAX systems. The company's External Applications Software (EAS) Library service acquires software from third parties and sells it through the company's software distribution channels. Digital tests Software for operation, documentation, and ease of installation prior to being included in the EAS Library. Software products from the EAS Library are sold on an "as is" unsupported basis, although the author of the software may offer a separate maintenance agreement.

Digital is also involved in two types of cooperative marketing agreements with a range of software vendors. In a Cooperative Marketing Program (CMP), Digital and the independent software vendor combine forces in sales calls, trade shows, and technical demonstrations, recommending each other's products to prospective buyers. Digital has CMPs with vendors in a range of application areas, including petroleum/geotechnical, investment management, office automation (based on UNIX), and human resources management (payroll/personnel).

System Cooperative Marketing Programs (SCMPs) are agreements through which Digital works with OEMs to market, demonstrate, and sell turnkey systems incorporat- ➤

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ing Digital hardware and the vendors' products. Among the areas Digital's SCMP program encompasses are manufacturing resource planning (MRP), mechanical computer-aided design (MCAD), electronic computer-aided engineering (CAE), and health care/medical information management.

PRICING

POLICY: Digital provides the VAX Systems on a purchase basis, with separately priced maintenance agreements. 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. A license can either be purchased outright for 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 VAX System 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.

SUPPORT: All VAX systems come with a one-year on-site warranty on CPU components and peripherals. The warranty includes system installation; repair parts and labor; Field Change Orders installation; and optional coverage up to 7 days a week, 24 hours a day. The hardware warranty can be extended up to three years.

Digital's Field Service organization offers both on-site and off-site support services for VAX systems.

Per Call Service is available to customers without service agreements, or as a supplementary program for service agreement customers requiring remedial maintenance outside their normal hours of coverage. Per Call Service is available on a best-efforts basis 24 hours a day, 7 days a week. The vendor bills customers for time and materials; charges are portal-to-portal, with labor, parts, and travel expenses rated separately.

An optional adjunct to Digital's on-site field service, *Recover-all*, provides full product repair or replacement for equipment damage caused by accidents or incidents normally not covered under service agreements, such as fire and water damage, power failures, and natural disasters. The cost of Recover-all is a percentage of the total monthly service charge of each covered contract line item. Actual charges depend on system configuration and type of service coverage.

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.

The *Customer Returns Center*, in Woburn, Massachusetts, provides service for all products under return-to-factory warranties, as well as for products requiring postwarranty work. The Customer Returns Center services products returned under the DECmailer agreement, which guarantees users a replacement within five working days for any defective board shipped to the center; it also provides as-needed service for modules and subassemblies under Digital's Loose Piece Module Repair Service plan.

The worldwide *Product Repair Centers* fix and refurbish modules, subassemblies, options, and systems for customers who have some technical expertise but who require additional field service assistance.

Digital Servicenters provide carry-in service for terminal products on a contractual or per-call basis; they also permit over-the-counter module swaps for users preferring to maintain the system themselves.

Digital's *Software Services* organization provides software support; installation, training, telephone support, newsletter, and on-site support services are available.

Digital also offers the *DECompatible Service* program, through which the company's Field Service organization provides maintenance for over 120 specific non-Digital hardware products linked to Digital systems. The company claims that the designated products receive the same response time and service coverage as Digital hardware under standard service agreements.

Under Digital's *software support* policy, all warranted VAX software products are covered under a policy guaranteeing that the product conforms to the Software Product Description (SPD) shipped with it. Most VAX software products include the warranty at no extra charge. Delivery of the warranty is provided through automated and manual problem reporting. Customers can purchase added-value services such as installation, training, telephone support, newsletters, and on-site support separately, or they can select a System Startup Service Package.

System Startup Service Packages provide customers with the system-level support and training required to start up and manage their systems. The packages provide training, documentation, and software service. The user selects from among three levels of support, based on a number of factors, including computer experience and system use. All three levels include dial-in telephone assistance, and support both the operating system and associated software products purchased with the system. The size and complexity of the system and the level of support required determine the prices.

Another software support service, the *Digital Software Information Network*, enables customers to access informational databases for help with software problems. The network provides messages that alert users to critical software problems and their solutions, a symptom/solution database to answer questions, and a means of submitting questions to Digital support personnel. The network is available at no extra charge to customers in the United States with systems currently under warranty or covered by a DEC-support or Basic Support service contract.

Because Digital designed its VAX Systems for use in networks, the company offers three special *Network Services*, including NETplan, for network planning and design; NETstart, for implementation and startup; and NETsupport, for ongoing operational support.

For general support, Digital also sponsors the *Digital Equipment Computer Users Society (DECUS)*, a voluntary, nonprofit user's group. DECUS provides an extensive program library, user's groups, special interest groups, and workshops/symposia. The society is responsible for maintaining the DECUS program library and publishing a library catalog, the proceedings of symposia, and a periodic newsletter.

TRAINING: Digital maintains training centers worldwide. Courses covering both Digital equipment-related and nonproduct-related topics are offered. Digital's Educational Services division publishes a digest listing available courses four times a year.

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EQUIPMENT PRICES

		Purchase Price ($)	Basic Service (monthly) ($)	DECserv. (monthly) ($)
VAX 6000-200 VMS BASE SYSTEMS				
62AMB-DE	VAX 6210 CPU; 32M bytes of memory; integral floating-point; one VAXBI channel; KDB50 disk controller; DEBNA Ethernet controller; TK70 console tape; one-year warranty; one-year VMS and DECnet end-node licenses	90,100	740	844
62AMB-AE	Same as 62AMB-DE, but with paid-up VMS and DECnet licenses	129,000	740	844
VAX 6000-200 VAXCLUSTER SYSTEMS				
62ACB-DP	VAX 6210 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point; two VAXBI channels; CIBCA VAXcluster port and CI cables; DEBNA Ethernet controller; TK50 tape drive; one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	106,600	825	940
62ACB-AP	Same as 62ACB-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	151,300	825	940
VAX 6000-300 VMS BASE SYSTEMS				
63AMB-DE	VAX 6310 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point; two VAXBI channels; KDB50 disk controller; DEBNA Ethernet controller; TK50 tape drive; one-year warrenty; one-year VMS and DECnet end-node licenses	143,200	772	880
63AMB-AE	Same as 63AMB-DE, but with paid-up VMS and DECnet end-node licenses	184,100	772	880
VAX 6000-300 VMS VAXCLUSTER SYSTEMS				
63ACB-DP	VAX 6310 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point two VAXBI channels; KDB50 disk controller; DEBNA Ethernet controller; TK50 tape drive; CIBCA CI Port and BNCIA-20; one-year warranty; one-year VMS and DECnet licenses	159,000	855	975
63ACB-AP	Same as 63ACB-DP, but with paid-up VMS and DECnet licenses	206,300	855	975
VAX 6000-400 VMS BASE SYSTEMS				
64AMA-DE	VAX 6410 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point DEBNI Ethernet controller; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	188,900	874	996
64AMA-AE	Same as 64AMA-DE, but with paid-up VMS, and DECnet licenses	239,000	874	996
64AMA-DE	VAX 6410 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point DEBNI Ethernet controller; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	188,900	874	996
64AMA-AE	Same as 64AMA-DE, but with paid-up VMS, and DECnet licenses	239,000	874	996
64AMA-DE	VAX 6410 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point DEBNI Ethernet controller; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	188,900	874	996
64AMA-AE	Same as 64AMA-DE, but with paid-up VMS, and DECnet licenses	239,000	874	996
64BMA-DE	VAX 6420 CPU; 64M bytes of 1M-chip ECC MOS memory; integral floating-point DEBNI Ethernet controller; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	330,200	1,032	1,176
64BMA-AE	Same as 64BMA-DE, but with paid-up VMS, and DECnet licenses	399,000	1,032	1,176
64CMA-DE	VAX 6430 CPU; 64M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	389,500	1,161	1,342
64CMA-AE	Same as 64CMA-DE, but with paid-up VMS, and DECnet licenses	489,000	1,161	1,342
64DMA-DE	VAX 6440 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point two DEBNI Ethernet controllers; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	523,500	1,291	1,472
64DMA-AE	Same as 64DMA-DE, but with paid-up VMS, and DECnet licenses	627,000	1,291	1,472
64EMA-DE	VAX 6450 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	596,500	1,379	1,572
64EMA-AE	Same as 64DMA-DE, but with paid-up VMS, and DECnet licenses	700,000	1,379	1,572
64FMA-DE	VAX 6460 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; KDB50 disk controller; TK70 tape drive; one-year warranty; one-year VMS and DECnet licenses	648,500	1,467	1,672
64FMA-AE	Same as 64FMA-DE, but with paid-up VMS, and DECnet licenses	752,000	1,467	1,672

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		Purchase Price ($)	Basic Service (monthly) ($)	DECserv. (monthly) ($)

VAX 6000-400 VMS VAXCLUSTER SYSTEMS

		Purchase Price ($)	Basic Service (monthly) ($)	DECserv. (monthly) ($)
64ACA-DP	VAX 6410 CPU; 32M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	207,000	958	1,092
64ACA-AP	Same as 64ACA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	264,200	958	1,092
64BCA-DP	VAX 6420 CPU; 64M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	348,100	1,116	1,272
64BCA-AP	Same as 64BCA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	431,000	1,116	1,272
64CCA-DP	VAX 6430 CPU; 64M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	408,400	1,246	1,420
64CCA-AP	Same as 64CCA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	524,100	1,246	1,420
64DCA-DP	VAX 6440 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	542,400	1,375	1,568
64DCA-AP	Same as 64ACA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	663,200	1,375	1,568
64ECA-DP	VAX 6450 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	615,400	1,463	1,668
64ECA-AP	Same as 64ECA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses	736,200	1,463	1,668
64FCA-DP	VAX 6460 CPU; 128M bytes of 1M-chip ECC MOS memory; integral floating-point; two DEBNI Ethernet controllers; CIBCA CI port and BNCIA-20; TK50 tape console one-year warranty; one-year VMS, VAXcluster, and DECnet licenses	667,400	1,551	1,768
64FCA-AP	Same as 64FCA-DP, but with paid-up VMS, VAXcluster, and DECnet licenses ■	788,200	1,551	1,768