



Cover Letter for VMS Version 4.7

AV-EF56F-TE

Kit Contents

Enclosed is the VMS Version 4.7 Kit. Depending on the type of kit you ordered, your kit contains either documentation only, or media and documentation.

VMS Version 4.7 is an update to VMS Version 4.6. VMS Version 4.6 *must* be installed on your system before the VMS Version 4.7 update can be applied. Before proceeding with the update, please read the *VMS Release Notes, Version 4.7*, especially Chapter 1, "Installing the Version 4.7 Update Kit."

The VMS source listings on microfiche are no longer included with the media and documentation kits. VMS Version 4.7 source listings on microfiche may be ordered separately, according to DIGITAL policy. Please contact your local Software Product Services representative for specific ordering information or questions.

Order of Software Installation

First install the VMS Version 4.7 update, then reinstall the following layered products:

- VMS Workstation Software (VWS)
- VAX Volume Shadowing Version 1.x License Key
- Local Area VAXcluster Version 1.x License Key

These are the only layered products that must be reinstalled after VMS Version 4.7 is installed.

If you are currently running the Local Area VAXcluster software, use the VMS Version 4.7 software kit to update your system; do *not* use the MicroVMS Version 4.7 software kit.

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SOFTWARE
BILL OF MATERIALS

Option Number Option Title Date Page #
QD001-WM4.7 VAX/VMS V4.7 BIN 16MT9 19-Dec-87 1 of 1

QTY	PICK	LOCATION	PART NUMBER	PART DESCRIPTION
1	*****	NS (UR)	QD001-0M4.7	ASSEMBLY, MANUFACTURING
1	*FS*		36-28231-07	THERMAL BARCODE LABEL
2	*FS*		99-07809-01	CRONEL Notes: Can also use 98-08007-00
1	*FS*		AV-R447B-TK	SOFTWARE UPDATE SURVEY CARD
1	_____	(UR)	BB-KY59A-BE	VAX/VMS V4.7 BIN 16MT9
1	*FS*		EN-01044-07	SFTWR PERFORMANCE REPORT FORM
1	*****	NS (UR)	QL001-WZ4.7	VAX/VMS V4.7 DOC UPDATE KIT
2	*FS*		99-07809-01	CRONEL Notes: Can also use 98-08007-00
1	_____	(UR)	AA-KX21A-TE	VMS SUPPLEMENTAL INFORMATION
1	_____	(UR)	AA-KX22A-TE	LAT/VMS USER'S GUIDE
1	_____	(UR)	AA-KX23A-TE	VAX/VMS V4.7 RELEASE NOTES
1	_____		AE-HD44A-TK	SOFTWARE WARRANTY ADDENDUM
1	_____	(UR)	AE-HQ86D-TE	VAX/VMS V4.7 SPD 25.01.29
1	_____	(UR)	AV-EF56F-TE	VAX/VMS V4.7 COVER LETTER

EXPORT CONTENTS SUMMARY:

5 PACKAGING 2 FORMS 1 MAGTAPE
3 SOFTWARE MANUALS 3 SPD / LETTER 2 COMPLETE KITS

Software Product Description

PRODUCT NAME: VAX/VMS Operating System, Version 4.7

SPD 25.01.29

DESCRIPTION

System Overview

The VAX/VMS Operating System supports all VAX series computers, working reliably and efficiently in both time-sharing and production environments. Time-sharing users can work interactively with the system and can submit batch jobs. Jobs of all types, including processor intensive, I/O intensive, large memory, and real-time, in any mix, perform well on VAX/VMS. The system permits an absolute limit of 8192 concurrent processes. However, the actual amount of work supported at one time with good performance depends on the types of processing performed as well as on the physical memory and secondary storage available.

System Configuration

The user receives with VAX/VMS a standard system configuration file and a site-independent start-up procedure. The system manager can modify the site-independent start-up procedure or create a site-specific start-up procedure.

To start the system, the system manager performs a bootstrap operation. Optionally, the parameter values of the selected file can be modified at bootstrap time. The system configures itself by executing the start-up procedures. After system start-up, the system manager can reset system parameter values on-line for the next bootstrap operation and can dynamically change a subset of the parameter values, i.e., change the configuration of the running system.

To aid the system manager in setting up system parameters, a procedure is provided that analyzes the system configuration and generates a file containing parameter settings. This file can be modified by the system manager and a system parameter file generated. In addition, the system incorporates self-tuning mechanisms. For example, the system monitors job performance and increases the amount of physical memory for jobs that need it and decreases the amount for jobs that do not. However, the system manager is always free to modify system parameters to suit special situations or to fine-tune. For example, the system manager has the

ability to govern the real memory limits for each job. Services are provided for monitoring system performance and for adjusting system parameters.

The system manager starts the system from a console and a storage device that contains the bootstrap routine. After the system starts, the system manager can operate the system from any terminal. An automated procedure for shutting down the system in an orderly manner (telling interactive users to log off, spinning down disks, etc.) is provided with the system.

General Access

User access to VAX/VMS is by means of a command language. The DIGITAL Command Language (DCL), the standard command language for VAX/VMS, is supplied with the system. DCL commands take the form of a command name followed by parameters and qualifiers. The commands can be typed on the terminal, included in command procedures, and submitted as batch jobs (either from the terminal or the card reader). The commands provide basic system services, initiate system utility programs, and initiate user programs.

Many qualifiers exist to provide detailed levels of control where needed. However, most qualifiers have default values so that the typical command consists only of the command name and a few qualifiers. In addition, command names and keywords can be abbreviated. Another facility that saves keystrokes is the ability to substitute symbolic names for commands. For example, the user might equate a lengthy command to a short symbolic name. Thereafter, only the short name need be typed to execute the command.

On erroneous input, the user receives a message. The user can obtain on-line documentation by typing HELP followed by the name of a command and (optionally) a qualifier. The help facility can be used in an interactive mode and also is available within many of the interactive utility programs.

In addition to the usual services of an operating system in support of program development and operations, VAX/VMS provides the following services that enable nonprogrammers to process data:

- Text processing - The general user requires a few days to learn how to use one of the text editors supplied with the system.

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AE-HQ86D-TE

- **Mail facility** - A personal mail facility permits a user to send messages to any other user by typing the recipient's name, the subject of the message, and the text of the message. If the recipient is logged in, a notification that new mail has arrived appears on the recipient's terminal. Otherwise, the recipient is notified of the new mail at log-in time. Mail recipients can reply to messages and forward them to other users. Messages can be examined, printed, filed, and edited at the terminal. A directory and search capability is incorporated to permit rapid scanning of mail files. Multi-node operation is available if DECnet-VAX is installed.
- **Phone facility** - An interactive communication utility with networking capability (optional DECnet-VAX license is required for multi-node operation).
- **Disk I/O** - The general user can create and process sequential character files with a few simple DCL commands. Processing includes editing, expanding, copying, sorting, merging, and deleting files.
- **Command-level programming** - The general user can create special files called command procedures, that contain a series of DCL commands. When a user invokes a command procedure, the system processes all the commands. Command procedures save many keystrokes by permitting the user to catalog series of often-entered commands. In addition, the user can take advantage of special DCL commands to perform programming-type functions such as assigning symbolic names, evaluating numerical and logical expressions, accepting parameters, communicating with the interactive user invoking the command procedure, performing conditional (IF) and branching (GOTO) logic, and error handling conditions.

VAX/VMS provides a number of line-mode editors, a line-mode/character-mode editor (EDT), and a character-mode editor (TPU).

In character mode (also known as keypad mode), EDT permits the user to quickly insert and delete any amount of text within the existing text. Some of the capabilities are as follows:

- **Position** - The user can move a cursor up, down, right, left, to the next word, to the preceding word, or to the end of the line to be in position for an editing operation.
- **Insertions** - To insert text, the user simply types the characters.
- **Deletions** - The user can delete the current character or word, the preceding character or word, or blocks of text.
- **Cut and paste** - The user can move blocks of text from one position to another.
- **Searches** - The user can search for the next or preceding occurrence of a particular string of characters.

EDT logs changes and replays them on demand should a failure occur during an editing session.

Finally, the general user has access to any facilities that the applications programming user makes available through application systems built on top of VAX/VMS. Programming users, for example, might construct an inventory system that permits general users to query and update indexed files that hold the inventory data.

Program Development

VAX/VMS provides a comprehensive set of tools for developing programs including editors (such as EDT for producing and editing source programs), a file differences utility, programming languages, a linker, a librarian, a symbolic debugger, and a patch utility. The assembly-level VAX MACRO language is supplied with all systems. Optional high-level languages are listed in the VAX/VMS System Software Order Table (SPD 28.98.xx).

The file differences utility contrasts two files by automatically aligning matching text and optionally ignoring comments, empty records, trailing blanks, and multiple blanks. Output can consist of a side-by-side display of differences, a file-by-file list of differences, an interleaved list of differences, a list with change bars, or an input file for the batch editor.

The linker binds programs written in the various languages into executable and shareable images. Shareable programs permit the storage of code and data used by many executable images as a single disk file and permit this code and data to be shared in physical memory at image run-time. The linker encourages the modular development of application systems by permitting images to be written as small modules and then bound into a large image, and by binding programs written in different languages. (Programs written in all native-mode languages can call one another.) The large per-process address space provided by the system removes any requirement for program overlays.

The VAX Common Run-Time Procedure Library provides general string manipulation, I/O and I/O conversion, terminal independent screen handling, date/time, mathematics, G_ and H_floating point emulation, resource allocation, signaling and condition handling, syntax analysis routines and cross reference procedures that can be called from programs written in VAX MACRO or any optional, native-mode high-level languages.

The common run-time procedure library provides run-time support for the VAX native-mode, high-level languages Ada®, BASIC, C, COBOL, FORTRAN, PASCAL, PL/I, RPG, and SCAN. All routines in the common run-time library follow standard call and condition handling conventions and most are contained within a shareable image.

At a lower level, programs can call the system directly for event flag, asynchronous system trap, logical name, record and file I/O, process control, timer, conversion, condition handling, lock management, and memory management services. Again, the system uses standard call and condition handling conventions.

Programmers using native mode, high-level languages need not worry about the mechanics of calling the common run-time procedures or the base system services. The necessary functions are built into the VAX languages. However, the various levels of detail are available for those with special requirements, for example, programmers constructing real-time applications. In addition, the user can add procedures to the common run-time procedure library and can write new system services.

A system utility, *sort/merge*, creates sorted files from unsorted binary or character input and merges several sorted files into one, in ascending or descending sequence based on one or more keys.

The *sort/merge* routines can be invoked as a utility through DCL commands or can be called as subroutines by user programs. In addition to the usual record sort, the *sort/merge* routines provide tag, address, and index sorts.

A librarian utility permits the programmer to efficiently store object modules, macros, help text, or any general record-oriented information in central, easily accessible files. Object modules are automatically incorporated in images by the linker as they are referenced by calling programs. Macros are automatically included in the source code of VAX MACRO programs as the programs are assembled. Programs can call librarian routines to access help text or general information stored in a library file.

A symbolic debugger permits programmers to trace program execution and to display and modify program contents using the same symbols that are in the source code. Working interactively with DCL-like commands, the programmer can:

- Set breakpoints - Specify locations in the program where execution will temporarily halt
- Set tracepoints - Specify locations or operation codes which, if used, will cause a message to be displayed during program execution
- Set watchpoints - Specify locations, that, if modified, will cause a message to be displayed during program execution
- Step through the program - Execute the program on a line-by-line basis
- Examine locations - Display the contents of a location
- Modify locations - Change data and instructions at a location
- Call routines - Call routines in the program from the interactive command level
- Log the debugger session - Place a record of the debugger session in a log file
- Run from a command procedure - Invoke a command procedure that contains debugger commands (created from a log file and/or an editing session) to rerun a

previous session, to continue a previous session, or to check a series of items in the program

Expressions and data formats are generally similar to those of the language in which the program being debugged is written.

A patch utility permits the modification of programs without recompilation and linking. Fixes are applied directly to the executable image files. Locations in programs, however, can be addressed using the same symbols that are in the source code (i.e., the programmer does not have to interpolate from listings and maps). In addition, the utility automatically relocates patches that are larger than the program content being replaced.

The definition, creation, loading, and maintenance of efficient VAX RMS Indexed Sequential (ISAM) files is facilitated by a set of utilities that are integrated by a common File Definition Language (FDL). Analysis of the current state of any RMS file provides information on the file's internal efficiency and validity. The space efficiency of an RMS ISAM file can be improved with a reclamation utility. The most appropriate set of RMS file parameters can be found with an RMS file tuning tool. The utilities that create, efficiently load and reclaim space in RMS files can all be called by user programs as well as invoked from the DCL command language. They reside in shareable images.

Operations

The basic unit of execution in VAX/VMS is the process, which consists of context and executable images. The context identifies the process and describes its current state. The executable images consist of system and/or user programs that have been compiled and linked.

Processes receive processor time for the execution of their images on an event-driven, pre-emptive priority basis. Each time an event such as an I/O interrupt occurs, the system services the event, then passes control to the highest priority process ready to execute (even if the process that had control before the event could continue to execute). Processes can be assigned base priorities in the range of 0 to 31, with 4 (as a typical default) the norm for time-sharing users and applications that are not time critical. The system automatically adjusts priorities whose bases are in the range of 0 to 15 to favor I/O-bound processes. Interactive users do not have to wait long periods while computation bound processes tie up the processor. Real-time processes can be assigned higher priorities to ensure that they receive processor time whenever they are ready to execute.

The system does not adjust priorities whose bases are in the range of 16 to 31, nor does it raise above 15, priorities whose bases are in the range of 0 to 15.

Processes can be started in the following ways:

- User log-in - When an interactive user logs in, the system creates a process for the user. The process provides an environment in which the user can communicate with the system to name images to be executed and to perform other activities.

- **Explicit creation** - A user can specify the creation of a new process. In creating a process, the user names an image that will be executed when the process starts.
- **Batch job** - A user can name images to be executed and other activities to be performed and can submit this information to the system as a batch job either from a terminal or a card reader.

The system queues batch jobs for execution. The user can regulate the number of queues and the number of streams per queue (that is, the number of batch jobs in the queue that can execute concurrently). Time-sharing users can enhance performance by restricting interactive use of the system to work that requires immediate responses (such as editing), by submitting as batch jobs, work that requires lengthy execution times, and by limiting batch streams to a number that is reasonable for the system configuration.

Different batch job queues may have different attributes such as the maximum CPU time permitted, working set size, and priority. Facilities are provided for starting and stopping queues, as well as the jobs in a queue. Jobs in a given queue may be removed or held until a particular time.

Peripheral devices can be controlled by the system or allocated by individual processes. At least one disk must be a system disk. Users can designate other disks as system or group disks for the general use of all users logging into the system or for a subset of users known as a "group". Interactive terminals are controlled by the system, and the system normally controls one or more printers.

Print queues, both generic and specific (with forms recognition) together with queue management facilities give the user versatile print capabilities.

The system manager or operator designates system-controlled printers as spooled devices associated with output queues. Processes submit printed output as jobs to these output queues. Within each queue, print jobs are processed serially by priority; jobs with the same priority are processed serially by priority; print jobs with the same priority can be processed either on a first-in/first-out basis or by print job size (smallest job first). A generic output queue can be associated with one or more print queue and, therefore, with one or more printers. In this scenario, the next job entered in the generic queue is submitted to the first available print queue. Special forms and printer characteristics can be specified. Print jobs can be stopped, held, requeued, positioned (forward or backward), and aborted.

Processes can allocate devices that are not for general use. For example, an interactive user might allocate a tape drive on which to back up some disk files. An application system might allocate 12 terminals, two disk drives, and a printer to be used exclusively for certain production work.

Each process is permitted an address space as large as four gigabytes (one of which is reserved) with an upper

limit of one gigabyte on program size. In practice, processes use more modest address spaces; but even so, many processes, some requiring extensive space, can be running concurrently. VAX/VMS uses the following two mechanisms to provide sufficient physical memory for the many processes using the system:

- **Paging** - The system allots physical memory to a process as needed up to a user-specified limit (typically in the ranges of 100 to 200 kilobytes for interactive users and 200 to 300 kilobytes for batch jobs). If memory in excess of the limit is needed, the system allows the physical memory requirements to expand to a quota and then releases some of the process code and data already in memory (taking care to preserve modifications) to make room for the new code and data. The released code and data are initially cached in memory in case they are needed again, but later they may be removed from physical memory (modifications being written to disk) depending on process directives and total system operations.
- **Swapping** - If too many processes exist to fit in physical memory, the system stores some of the processes on disk. The system monitors process status changes and ensures that the highest priority processes ready to execute are in physical memory. In addition, the system will attempt not to swap an executable process out of memory, until the process has accomplished work for a minimum (configuration-specified) period of time.

Paging and swapping should not be high overhead activities as long as concurrent processes do not exceed a reasonable number for physical memory, secondary storage, and the types of processing being performed. The in-memory cache for released code and data, the technique of paging each process against itself, and the assurance that ready-to-execute processes are in memory combine to minimize overhead.

If desired, processes can exercise control over memory management. A real-time process, for example, could inhibit the paging and/or swapping of critical code and data.

The system maintains structures in physical memory for sharing code and data among processes, for synchronizing image execution among processes, and for communicating (sending messages) among processes. User processes create and control the structures by requesting appropriate services of the system. Nonshared structures and shared structures can be protected against access by other processes.

The system minimizes operating system overhead by taking advantage of the following VAX hardware features:

- **Context switching and queue instructions** - To schedule processes quickly and efficiently
- **Software interrupt delivery mechanism** - To minimize the processor time required to return from performing a service

- Asynchronous system trap delivery mechanism and queue instructions - To minimize the processor time required for I/O processing
- Interrupt priority levels - To improve I/O response time

Reliability

The system handles errors as transparently as possible while maintaining data integrity and providing sufficient information to diagnose the errors. The system limits the effects of an error by first attempting to recover from the error, then if recovery fails, by reporting the error to the current process for action, and finally (if the error cannot be clearly bounded), by shutting down and restarting the system. VAX/VMS will shut itself down rather than continue operating with a condition that could propagate undetected bad data. The types of errors possible are as follows:

- Processor errors (machine checks) - The system retries the instruction on which the processor failed, as long as no internal state has been modified. If no retry is possible or the retry fails, the system reports the error to the current process as an exception. However, if the executive is currently executing, the system shuts down and performs a cold restart by bootstrapping a fresh copy of VAX/VMS from the system disk.
- Operating system errors (system errors or undetected hardware failures) - The system checks its internal data structures for consistency to provide early detection of a system error. If the error affects only a single process, the system reports the error to the process. If the error affects more than one process, the system shuts down and performs a cold restart by bootstrapping a fresh copy of VAX/VMS from the system disk.
- User errors (user bugs) - The system uses hardware and software protection mechanisms to prevent processes from damaging one another and from damaging the system. As with a system error, the system detects a user error through internal consistency checks and reports the error to the single affected process.
- Memory errors - The system examines memory at start-up time and does not use any pages found to be bad. During system operation, the hardware transparently corrects all single-bit memory errors. An unrecoverable error causes the memory page on which the error occurred to be added to the bad page list; if the page has not been modified, system operation continues with a new copy of the page. (Unrecoverable memory errors that occur during a read by an I/O device are reported to the device so that the I/O operation can be reported as failed.)
- I/O errors - The system automatically retries failed I/O operations to recover from transient errors and marginal media conditions. Disk I/O errors are retried using the hardware recovery mechanisms. Optionally, the system validates disk I/O transfers with read-check and write-check functions. If an I/O

request cannot be completed, all data that was correctly transferred is returned to the initiator.

The system logs all processor errors, all operating system errors detected through internal consistency checks, all double-bit memory errors (and a summary of corrected single-bit errors), and all I/O errors. The log can be printed or examined interactively to locate failed and troublesome components.

If the effects of an unrecoverable error cannot be limited to a process, the system shuts down and restarts without operator intervention by bootstrapping a fresh copy of VAX/VMS from the system disk (although the user can inhibit the automatic restart feature). Whenever the system fails, a dump of physical memory is taken; the dump includes the contents of the processor registers. Additionally, an entry is made in the error log indicating the hardware and software states of the machine at failure. A utility that can access system data structures symbolically is provided for analyzing dumps.

On a power failure, the system shuts down automatically. On power restoration, the system restarts automatically and resumes processing at the point of interruption if the system has a time-of-day clock and a memory battery back-up unit, and if the contents of memory are still valid. The system restarts devices and communications lines. All I/O operations in progress, including magnetic tape, are restarted. On request, programs can be notified of power restoration. An optional battery operated hardware clock resets the date and time of day when the system restarts. If the system does not have a battery backup unit, or if the memory contents are not valid on power restoration, the system will perform a cold start (reboot).

If for any reason the system disk does not come back on line after a power failure within a specific time after the CPU gains power the system shuts down.

Diagnostics can be run on individual devices during normal system operation.

Certain critical components can operate in degraded mode. For example, the memory cache can be disabled. The system places a component in degraded mode when errors pass a threshold.

VAX/VMS includes a User Environment Test Package, which verifies that the major hardware components of the system are complete, properly installed, and ready for use. This package can be executed as part of system installation, or it can be run in stand-alone mode at any time. One binary version of the operating system is created and distributed for each major release of VAX/VMS. Patches are applied through an automatic, machine-readable, maintenance update procedure. Each patch checks for the proper version number and revision level, and updates these figures as appropriate.

Security and Control

VAX/VMS provides privilege, protection, and quota mechanisms to limit user access to system-controlled structures in physical memory, system-structured files and volumes, and certain devices. Typically, one or a few users (system managers and/or operators) who maintain

the system on a day-to-day basis have unlimited access to the system, while the access rights of the remaining users are strictly limited.

User accounts maintained in a user authorization file constitute the basis for privilege and quota assignment. The system manager can modify this file through services provided by the system. Each user account identifies a user by name and password. To login and gain access to the system, the user must supply this name and password, passwords can never be displayed. (Even users submitting batch jobs from card readers must supply a name and password.) The password is encoded and does not appear on displays; once logged in, the users can change their passwords. In each user's account, the system manager assigns privileges and sets quotas on activities and structures that consume system resources, e.g., physical memory, CPU time, disk space, etc.

Login security includes breakin detection which allows terminals to be disabled when a breakin attempt is detected. The user is also informed at login as to the last time login was done for the account. Secure serving provides a means to prevent user programs from initiating the login process to obtain user-names and passwords.

The System Manager also has the ability to limit each user to specific time of day access, such as allowing a user to only have access to the system from 9 AM to 5 PM.

Access control lists exist and allow more flexible protection for files, and devices. These lists also allow for the logging of successful and unsuccessful attempts to access files.

Each user receives a user identification code (UIC), on which the protection mechanism is based. The UIC is associated with each structure, file, volume, and device that the user owns. For example, when the user creates a file, the system associates the user's UIC with the file. The system also attaches a user-specified protection mask that permits and/or prohibits categories of access to the protected entity. Typically, a protection mask might permit all users to read a data file, while permitting only the owner to modify or delete it. The protection mechanism also permits users to associate in groups, such that access can be permitted to all members of the group and denied to all others.

Scavenge protection is also provided in three forms. File high-water marking prevents users from reading beyond the end of a file mark. Erase on delete insures that information in a file is zeroed before being returned to general use. Erase on extend prevents a user from reading information that may have been previously allocated to another file.

Each of these scavenge protection mechanisms may be enabled or disabled individually, by a user with appropriate privileges. Security alarms are provided on both a file and a system-wide basis. A class of operations may be defined to receive security related messages.

Note, however, that DIGITAL does not warrant that the system is secure, although DIGITAL will fix any security problem that is brought to our attention in a future release of VMS.

Input/Output

I/O directives can be specified on the following levels:

- DCL commands - Commands such as EDIT, CREATE, APPEND, COPY, PRINT, TYPE, SORT, and DELETE provide the nonprogramming user with the ability to manipulate files.
- High-level programs - Programs written in COBOL, FORTRAN, BASIC, PASCAL, C, PL/I and other high-level languages can perform I/O using standard language elements. Application programmers will find this level the simplest and most efficient in most cases.
- VAX Record Management Services (RMS) - VAX RMS consists of a set of routines that MACRO and high-level language programs can call for device-independent I/O. VAX MACRO and VAX BLISS-32 programmers will find VAX RMS the most efficient level in most cases.
- Queue I/O (QIO) system services - The QIO system services are direct calls to the operating system. Programmers can use this level of I/O to perform special device dependent functions and to eliminate the system overhead involved in RMS; for example, to respond to interrupts from real-time devices as rapidly as possible.

A special program called a device driver executes I/O instructions to actually effect the data transfers. Each different type of I/O device requires its own driver. DIGITAL supplies drivers for all devices supported by VAX/VMS, and users with special needs or nonstandard devices can write their own drivers. (The VAX/VMS documentation set includes the "VAX/VMS Guide to Writing a Device Driver".) Additionally, the system provides services for programs to bypass the driver mechanism and handle device interrupts directly for certain UNIBUS devices.

DIGITAL supplies a set of programs called ancillary control processes (ACPs), which maintain standard structures associated with disk, tape, network, and remote terminal I/O. When a new file is created on a structured disk volume, for example, the disk ACP will update the volume's directory.

The I/O routines of the native mode, high-level languages and native-mode utilities are built on top of VAX RMS, which uses the QIO services; thus, all I/O within the system is standard, unless the user elects to bypass the DIGITAL-supplied mechanisms. Supported devices include disks, tapes, unit record equipment, terminals, networks, and mailboxes (virtual devices for interprocess communication). VAX RMS provides both record access to supported file organizations and an option to bypass record processing; thus, a program can address blocks within a file directly.

VAX RMS supports sequential, relative, stream, and multiple-key indexed disk files. Sequential, relative, and indexed files can be shared for reading, writing, updating, and deleting records. The system automatically locks and releases records as they are processed. In addition, the programmer can lock and release records explicitly. For shared files, the user can optionally request that RMS allocate I/O buffers in a shared global section. Depending on the application, this could reduce the total amount of physical memory used for I/O buffers and/or reduce the amount of disk I/O necessary for processing a file. For other record formats, the user must assume responsibility for an interlocking mechanism. (Compatibility mode programs can also use RMS, but cannot use record locking or file sharing.)

Disk and Tape Volumes

Disk volumes can be organized into volume sets. Files of any organization type can span any number of volumes within a volume set. They can be allocated to the set as a whole (the default) or to specific volumes within the set. Volume sets can contain a mix of disk device types and can be extended by adding volumes. Optionally, specified portions of indexed files can be allocated to specified areas of a single disk volume or to specified volumes in a volume set.

Quotas can be placed on the amount of space individual users can allocate. Quota assignment is by UIC and may be controlled individually for each volume set in the system (or volume if the volume is not part of a set).

Structure information can be cached in memory to reduce the I/O overhead required for file management services. Although not required to do so, users can preallocate space and control automatic allocation. For example, when a file is extended, it can be extended by a given number of blocks, contiguously or noncontiguously for optional file system performance in specific cases.

The system applies software validity checks and check-sums to critical disk structure information. The critical information is duplicated. If a volume is improperly dismounted because of user error or system failure, its structure information is automatically rebuilt the next time it is mounted. The system detects bad blocks dynamically and prevents their reuse once the files to which the blocks were allocated are deleted.

The system provides eight levels of named directories and subdirectories, whose contents are alphabetically ordered. Device and file specifications follow standard conventions. Logical names can be used to abbreviate the specifications and to make application programs device and file-name independent. A logical name can be assigned to an entire specification, to a portion of a specification, or to another logical name.

VAX/VMS supports multi-volume magnetic tape files with transparent volume switching. Access positioning is either by filename or by relative file position.

System utilities that aid in file maintenance include:

- File transfer - Transfers files from one volume to another; files can be in any of several formats.
- Backup/restore - Provides comprehensive, on-line and standalone full volume, and incremental file backup for file structured mounted volumes and volume sets. Files can be backed up to magnetic tape or another disk. Individual files, selected directory structures, or all files on a volume set can be backed up and restored using standard file naming conventions with selection by date. Backup/restore takes place onto previously initialized and mounted volumes or on uninitialized media. The N + 1 redundant recording technique permits recovery of backed up data even if one of the N blocks has been corrupted. In the case of incremental backups, detection that a file has not been modified since the last backup eliminates the unnecessary movement of data. It is also possible to completely restore a volume or volume set from a series of (for example) daily incremental backups. Backup and restoration of disk files can be selectively performed on-line or on a per-volume basis off line. Per-volume operations require exclusive access to the volume.
- Bad block locator - Locates and records bad blocks on a disk.
- Analyze disk structure - Validates structure information on a disk volume against the actual contents, prints structure information, and permits changes to structure information.

Intersystem Facilities

DECnet-VAX interfaces and the associated documentation are integral parts of VAX/VMS.

The VAX/VMS kit includes that portion of DECnet-VAX code for use on a stand-alone local node, not physically connected to any other system. This capability allows users to design applications using distributed techniques with considerations for expansion to a network in the future. A DECnet-VAX software license and distribution kit are required for each VAX/VMS system physically connected to a DECnet network. (For more details on the DECnet-VAX product refer to the DECnet-VAX Software Product Description, SPD 25.03.xx.)

Examples of network participation for VAX to VAX communication include:

- Network Command Terminal Facility (requires optional DECnet-VAX on each node) - Allows an authorized user to connect and log onto a remote VAX/VMS system. Once logged onto the remote system, the user can connect and log onto yet another VAX system, or proceed to use DCL commands as if on the local VAX system.
- Mail messages to remote systems (requires optional DECnet-VAX on each node) - Can be sent to other VAX systems using the personal VAX/VMS MAIL utility.

Local Area Networks

In addition to the DECnet-VAX ability to use Ethernet for communication with other DECnet nodes, VAX/VMS provides device drivers for all DIGITAL Ethernet adapters. Application programmers may use the QIO system service to communicate with other systems connected via the Ethernet using either Ethernet or IEEE 802.3 packet format. Simultaneous use of DIGITAL Ethernet and IEEE 802.3 protocols are supported on any DIGITAL Ethernet adapter. Refer to the DECnet-VAX Software Product Description (SPD 25.03.xx) for further information on supported communications devices.

DIGITAL's terminal server products can be used for terminal access to VMS. An application running under VMS can also establish a connection to other devices attached to such terminal servers.

Shared Memory

The optional MA780 multi-port memory controller provides a means for processes on different systems to communicate at the speed of accessing memory. Up to four VAX-11/780 processors can be physically connected to one multi-port memory controller of 256 to 2048 kilobytes, and up to two multi-port memory controllers can be physically connected to one processor. Through a utility, the VAX/VMS user can set up a multi-port memory controller to contain the standard interprocess structures for sharing code and data, for synchronizing image execution, and for sending messages. In this way, a process on one system can create a message in multi-port memory and a process on another system can read that message out of the same memory location. Users can also place their own data structures in multi-port memory.

The VAX-11/782 uses MA780 shared multi-port memory in a way that is mutually exclusive with that described above.

Attached Processor Support

VAX/VMS support of the attached processor found on the VAX-11/782, VAX 8300, and VAX 8800 is transparent to the VAX/VMS user. The scheduling of the two CPUs, with VAX/VMS running in shared memory, is handled deep in the kernel of VAX/VMS and thus is hidden from software layers above. The user of VAX/VMS in this environment enjoys all the capabilities of VAX/VMS while transparently reaping the benefits of the power of a multi-processor system. This form of multi-processing is most effective with compute intensive applications.

VAXcluster Support

A VAXcluster configuration is a system that combines two or more VAX processors, and mass storage servers (if desired) in a loosely coupled manner. Clustering via a highspeed bus called the Computer Interconnect (CI) is possible with the following processors:

VAX-11/750	VAX 8500
VAX-11/780	VAX 8530
VAX-11/782	VAX 8550

VAX-11/785	VAX 8600
VAX 8200	VAX 8650
VAX 8250	VAX 8700
VAX 8300	VAX 8800
VAX 8350	

The mass storage server in the CI environment is a free-standing, high-speed, intelligent service designed to the specifications of the DIGITAL Storage Architecture and known as the Hierarchical Storage Controller, either the HSC50 or the HSC70. Each VAX processor or HSC-series controller in a CI-based VAXcluster is called a node. Up to 16 nodes may be connected in such a CI-based VAXcluster.

VAXcluster system disks can be configured in several different ways:

- One common system disk for all nodes in the cluster
- Individual system disks for each node in the cluster
- Any combination of common or individual system disks

Note: Each VAX must have only one system disk. Common system disks must be served by an HSC-series controller.

Note: All nodes in a VAXcluster must be running the same version of VMS. Mixed versions may be supported temporarily during a rolling upgrade procedure.

Clustering is also possible over a 10 Megabit/Second Ethernet link. Such clusters, known as Local Area VAXclusters, are identical in software features to CI-based VAXclusters. For more information on Local Area VAXclusters, see the Local Area VAXcluster Software Product Description (SPD 27.65.xx).

VAXcluster software features include the following:

- System Communications Services - System Communication Services (SCS) is the protocol used over the CI by VMS. This high-performance protocol utilizes the CI hardware for efficient data transfer between cluster nodes.
- Network Interconnect System Communications Services - The Local Area VAXcluster Software provides the Network Interconnect Systems Communications Services protocol (NISCS) to utilize the Ethernet for data transfer between cluster nodes.
- Connection Manager - The Connection Manager uses the System Communication Services to provide an acknowledged message delivery service for higher VMS software layers. The Connection Manager also tracks cluster state changes, i.e., nodes, joining or leaving the cluster.
- Distributed Lock Manager - The Distributed Lock Manager synchronizes access to resources within the VAXcluster. The lock database is distributed throughout the cluster; consequently, access to shared resources from cooperating processes on different VAX processor nodes may be synchronized. Deadlock

detection has been expanded to be cluster-wide and should a VAX processor fail, all locks held by the failed VAX processor are released. This allows processing to continue on the remaining VAX processors.

- **Distributed File System** - The Distributed File System allows all VAX processors to share disk mass storage, whether the disk is connected to an HSC-series controller or to a VAX processor. All cluster available disks appear as if they are local to every VAX processor.
- **Record Management Services** - Record Management Services (RMS) has been enhanced to take advantage of the Distributed File System and the Distributed Lock Manager. RMS files may be shared cluster-wide to the record level.
- **Distributed Job Controller** - The Distributed Job Controller allows the job controller database to be placed on a shared disk, making it available from any VAX processor in a VAXcluster. This allows cluster-wide batch and print queues to be implemented. Cluster-wide batch queues allow batch jobs submitted from any VAX processor to be placed on a cluster-wide queue. Cluster-wide print queues are also a feature of the Distributed Job Controller. Printing jobs submitted from any VAX processor may be printed on the least loaded printer in the VAXcluster. Alternatively, printing may be placed on a specific device queue anywhere in the VAXcluster. This gives the VAXcluster a basic form of load balancing capability, since the batch job distribution algorithm numerically balances the batch jobs over the VAX processors.
- **The Mass Storage Control Protocol Server** - The MSCP Server provides a VAX-to-VAX version of the MSCP disk I/O services, allowing disks connected to other VAX processors, (e.g. MASSBUS disks or DSA disks connected to a UDA50) to be shared throughout the VAXcluster.
- **Show Cluster Utility** - This dynamic display utility shows the status of the VAXcluster, giving the status of each node, cables, connections, SCS traffic, VAXcluster membership and Connection Manager traffic.
- **DECnet and the Cluster** - All VAX processor nodes in a VAXcluster must be licensed for either end-node or full-function DECnet-VAX. Some VAXcluster features, e.g., cluster node name, require at least one node licensed for full-function DECnet-VAX and configured as a routing node. Refer to the DECnet-VAX Software Product Description (SPD 25.03.xx) for further information about the DECnet-VAX product.

DECnet-VAX supports the ability to access some or all nodes in a VAXcluster using a separate alias node address, while retaining the ability to address each node in the cluster individually. Not all network objects may be accessed using this mechanism.

Also, DECnet is needed if process-to-process communication is desired between processes on different VAXcluster nodes under program control. The MONITOR utility requires multi-node DECnet-VAX for some MONITOR activities.

Installation

VAX/VMS systems are distributed as binary kits on tape or disk. Procedures for setting up the system disk from a kit and for readying the system for day-to-day operations are simple and straightforward. The binary kit includes the following facilities:

- System installation package
- System configuration procedures
- User Environment Test Package
- Operating system kernel, including virtual memory manager, swapper, system services, and drivers for VAX/VMS supported I/O devices
- System generation utility (for tailoring system parameter files)
- User authorization control program
- Interactive and batch job controller and symbiont manager
- Card reader input symbiont
- Line printer output symbiont
- Bootstrap utility
- Start-up procedure
- Shut-down procedure
- Accounting manager
- Accounting report utility
- Operator communication process
- Message utility
- MAIL utility (requires optional DECnet-VAX on each node for remote mail to another VAX/VMS system)
- Error logging and print utility
- Help facility
- DCL command interpreter
- DCL command definition utility
- Monitor utility (for displaying system activity)
- Various interactive and batch editors
- Text formatter (DIGITAL Standard Runoff)
- Log-in facility
- Network command terminal facility (allows remote log-in to another VAX system if the optional DECnet-VAX software license and kit is installed on each node)

- Phone facility - An interactive communications utility with networking capability (requires the optional DECnet-VAX software license and on each node for remote communication)
- VAX MACRO assembler with cross-reference capability
- Linker with cross-reference capability
- Install utility
- Librarian utility with cross-reference capability
- Common run-time procedure library
- Symbolic debugger (for MACRO and most optional native-mode languages)
- VAX Record Management Services
- RMS file analysis and validation utility
- RMS file conversion and loading utility
- RMS Indexed Sequential file space reclamation utility
- RMS file design and tuning utility
- Files-11 ancillary control process
- Disk quota utility
- Back-up and restore facilities
- Disk structure analysis
- Magnetic tape ancillary control process
- Sort/merge utility
- File management facilities
- File differences utility
- File search utility (for searching the content of files)
- Dump utility
- Patch utility
- System dump analyzer
- Bad block locator utility
- Software maintenance update procedure

Tailoring Facility

Tailoring is supported on processors with small disk configuration (RK07, RC25). Tailoring allows users to enjoy the full functionality of VAX/VMS, while providing a compact version of the operating system tailored to the users' needs on the system disk. VMS upgrade procedures are not supported in tailored environments.

Due to space constraints, there is no guarantee that products can be installed if user code and data reside on the system disk. The execution environment supports all application programs as long as layered products or optional software are NOT DEPENDENT on optional software run-time components which are not supported in the tailored environment. (Refer to the product's SPD and VAX/VMS System Software Order Table (SPD

28.98.xx) for the optional products supported in the tailored environment).

VAX/VMS Distribution

The software installation guides contain a complete list of the modules included in the binary kit, as well as instructions for their installation.

A source kit is available for users who wish to retrieve and modify selected source modules. (Source modules are useful as templates for user-written device drivers.) This kit contains most modules in source form, but does not contain the sources for all modules which are used to create the VMS binary kit. Object files are included for those modules which are not on the kit in source code form.

Retrieval of selected source modules can occur once the source kit is copied to disk. The source kit can be used for a complete rebuilding of the system, except as noted below. The kit includes the tools (including source patches) that DIGITAL used to build the binary kit; however, any patches released after building the binary kit are not reflected in the source kit.

Although every attempt is made to include accurate source modules, corresponding compiler-version modules, and supporting command procedures, DIGITAL does not warrant the ability to build a complete binary kit of the system. DIGITAL will neither warrant nor supply updates and support services for the compiler-version binary modules. No supporting documentation is provided, and source modules for intermediate updates of VAX/VMS are not available. Source kits are available only on major releases, (i.e., Versions 3.0, 4.0, 4.2, 4.4 etc.) and are not updated with any maintenance updates. Depending on how much of the source kit is needed, up to three RA60 disk drives or equivalent disk space can be required for processing the source modules after copying them from tape.

In addition, DIGITAL does not warrant the results of using the source kit to change selected portions of the system.

Sources listings on microfiche for the system software components are available on an "AS IS" basis without DIGITAL warranty express or implied. The microfiche listings contain most, although not all, of the modules which appear in the VMS binary kit.

Standards

VAX/VMS is based on the following American National Standards Institute (ANSI), U.S. Federal Information Processing (FIPS), and International Standards Organization (ISO) standards:

- X3.4-1977 American Standard Code for Information Interchange
- X3.6-1973 Perforated Tape Code for Information Exchange
- X3.18-1974 One-inch Perforated Paper Tape for Information Exchange

- X3.41-1974 Code Extension Techniques for Use with 7-bit ASCII
- X3.42-1975 Representation of Numeric Values in Character Strings
- X3.27-1978 Magnetic Tape Labels and File Structure, Level 1 and Level 2. (Level 3 without user file labels and buffer offset)
- FIPS PUB 79
- X3.39-1973 Recorded Magnetic Tape (1600 BPI, PE)
- X3.22-1973 Recorded Magnetic Tape (800 BPI, NRZI)
- X3.54-1976 Recorded Magnetic Tape (6250 BPI, GCR)
- X3.26-1970 Hollerith Punched Card Code
- FIPS PUB 1, 2, 3-1, 7, 13, 14, 15, 16, 22, 25, 26, 35, and 37, but not FIPS PUB 17-1 or 46; other FIPS PUBs are not applicable
- ISO 646-1973 7-bit Coded Character Set for Information Exchange
- ISO 1001-1979 Magtape Labelling and File Structure, Level 3
- ISO 2022-1973 Code Extension Techniques for Use with ISO 646
- ISO 3307-1975 Representations of Time of the Day

SOURCE CODE INFORMATION

Machine-readable source code as coding examples is provided to allow users to more easily access system services. In addition, source listings are provided on microfiche to enhance serviceability.

This source code is provided on an "AS IS" basis without any warranty of any kind, either express or implied.

MINIMUM HARDWARE REQUIRED

The minimum hardware requirements are listed below for each VAX CPU. Also see "Minimum Cluster" for additional requirements for those VAX systems which participate in VAXclusters.

For VAX-11/725 and VAX-11/730 Systems

- Two megabytes of memory
- At least one of the following:
 - One RC25 drive (VAX-11/725 only)
 - One RL02 disk drive and one R80 disk drive
 - One UDA (at least at microcode level Rev. 3) with an RA60/80/81/82 disk drive and either an RA60 disk drive or a TU80/TU81/TU81-PLUS tape drive

For VAX-11/750 Systems

- Two megabytes of memory

- Any VAX-11/750 system at ECO Rev. 4 with at least one of the following:

- Two RK07 disk drives
- One RM03/RM05/RM80 disk drive and one TE16/TS11/TU77/TU80/TU81/ TU81-PLUS magnetic tape
- One CI750, one HSC-series controller (see "Optional VAXcluster Hardware" for correct HSC Software version), with an RA60/80/81/82, and an RA60 or RK07 or a TA78/TA81/TE16/TU45/TU77 /TU78/TU80/TU81/ TU81-PLUS magtape.

The CI750 requires the VAX-11/750 system to be at least ECO Rev. 5.

- One UDA (at least at microcode level Rev. 3) with an RA60/80/81/82 disk drive and either an RL02 or RA60 disk drive, or a TU77/78/80/81 tape drive

Note: Combinations of UDA50s and CI750s on the same VAX-11/750 are supported if the VAX-11/750 is at ECO Rev. 7 or later.

Note: The console TU58 is not available as a user storage device.

For VAX-11/780 and VAX-11/785 Systems

- Two megabytes of memory
- Any VAX-11/780 system at ECO Rev. 4 and WCS123 with at least one of the following:
 - Two RK07 disk drives
 - One RM03/RM05/RM80/RP05/RP06/RP07 disk drive and one TE16/TU45/TU77/TU78/TU80/TU81 /TU81-PLUS magnetic tape
 - One UDA (at least at microcode level Rev. 3) with an RA60/80/81/82 disk drive and an RA60 or a TU78/80/81/81-PLUS tape drive
 - One CI780, one HSC-series controller (see "Optional VAXcluster Hardware" for correct HSC Software version), with an RA60/80/81/82, and an RA60 or an RK07 or a TA78/TA81/TE16/TU45/TU77 /TU78/TU80/TU81/TU81-PLUS

Note: Combinations of CI780s and VAX-11/780s are supported if the VAX-11/780 is at ECO Rev. 7 or later.

For VAX-11/782 Systems

The same requirements as for the VAX-11/780 apply except that the minimum amount of shared memory (MA780) in this environment is one and one half megabytes, and the minimum local memory required for diagnostic purposes is one megabyte.

The two CPUs of the VAX-11/782 system must be at the same ECO level Rev. 7 minimum. Both CPUs must have the same CPU options, (i.e., if one CPU has an FP780, both must have an FP780).

The primary CPU has all the input and output adapters and interfaces connected to it. The SECONDARY (or the ATTACHED) is a bare CPU with 256 kilobytes of local memory for diagnostic purposes. Any input and output devices on the SECONDARY are ignored.

For VAX 8200/8250 and VAX 8300/8350 Systems

- Two megabytes of memory
- At least one of the following:
 - One KDB50 with an RA60/80/81/82 disk drive and, in addition, either an RA60 disk drive or a TU80/81/81-PLUS Tape Drive
 - One CIBCI or one CIBCA (VAXcluster Port), one HSC-series controller (see "Optional VAXcluster Hardware" for correct HSC Software version), with an RA60/80/81/82, and an RA60 or a TA78/TA81 /TU80/TU81/ TU81-PLUS magtape

For VAX 8600 and VAX 8650 Systems

- Four megabytes of memory
- At least one of the following:
 - One CI780, one HSC-series controller (see "Optional VAXcluster Hardware" for correct HSC Software version), with an RA60/80/81/82 and a TA78/81
 - One Integrated Disk and Tape Controller (IDTC) with an RA60/80/81/82 and a TU81/TU81-PLUS

For VAX 8500, VAX 8530, VAX 8550, VAX 8700 and VAX 8800 Systems

- Four megabytes of memory
- At least one of the following:
 - One KDB50 with an RA60/80/81/82 disk drive and a TU80/TU81/TU81-PLUS tape drive
 - One CIBCI or one CIBCA (VAXcluster Port), one HSC-series controller (see "Optional VAXcluster Hardware" for correct HSC Software version), with an RA60/80/81/82, and a TA78 For VAX 8300/8350 Systems

MINIMUM CLUSTER

For CI-based VAXcluster Systems

Each VAX processor or HSC-series controller in a VAXcluster is called a node. Up to 16 nodes may be connected in a VAXcluster via a high-speed bus known as the Computer Interconnect, or CI. No other device is supported on the CI. The VAX processors which are supported in a CI-based VAXcluster are:

VAX-11/750	VAX 8500
VAX-11/780	VAX 8530
VAX-11/782	VAX 8550
VAX-11/785	VAX 8600
VAX 8200	VAX 8650
VAX 8250	VAX 8700
VAX 8300	VAX 8800
VAX 8350	

A VAXcluster may consist of any combination of two or more supported VAX processors, up to a total of 16 VAX Processors.

A VAXcluster may also consist of any combination of two or more supported VAX processors and at least one HSC-series controller with at least one RA-series disk, and a minimum of either one local tape drive or a TA-series tape drive connected to an HSC-series controller. The maximum number of nodes is 16.

The CI interface in any VAX/VMS system which participates in a VAXcluster must be at Microcode Level 7 or later. The supported CI interfaces are the CIBCI, the CIBCA, the CI780, and the CI750.

Each VAX/VMS system in a CI-based VAXcluster must have at least four megabytes of memory. The minimum memory requirement for a particular VAX CPU may be higher than four megabytes. See individual CPU requirements above.

For Local Area VAXcluster Systems

VMS provides support for the MicroVAX family of processors which are operating in a Local Area VAXcluster environment. VMS for MicroVAX series processors running in Local Area VAXcluster systems may be ordered using the Q*ZDL-Hx order number (* denotes processor type; x denotes media type for the kit). Refer to the Local Area VAXcluster SPD (27.65.xx) for further information on supported configurations and key ordering.

VAX/VMS Disk Block Requirements

Block Space Requirements (Block Cluster Size = 2):

Disk block size for VAX/VMS, Version 4.7 after installation is approximately 42,000 blocks. This figure includes a 4,600 block page-file. Most systems will require a larger page-file, and a swap-file. This figure also includes library files which were in data-reduced format. Most installations will choose to data-expand these files. This would require approximately 3,000 additional blocks.

This block size will be approximately the same for tailored, normal, and syscommon configurations. For tailored systems, the blocks are distributed on two disks. Approximately 6,525 blocks will be placed on the system disk, while the remaining blocks will be placed on the library disk.

These sizes are approximations; actual sizes may vary depending on the user's system environment, configuration and options selected.

GROWTH CONSIDERATIONS

The minimum hardware requirements for any future version or update of VAX/VMS may be different from the minimum hardware requirements for the current version.

OPTIONAL HARDWARE

Additional memory may be required if additional devices are included in the configuration. Additional memory and/or secondary storage may be required if multiple optional software products are being used concurrently.

NOTE(1): Combinations of hardware options are subject to limitations such as bandwidth, physical configuration restraints and electrical loads/power.

NOTE(2): Combinations of UDA50s and CI750s on the same VAX-11/750 processor are supported if the VAX-11/750 is at ECO Rev. 7 or later.

VAX configuration details are described in the VAX Systems and Options Summary.

For VAX 8800 Systems

- CPU Options
 - Additional memory up to 128 MB
 - Additional VAXBI channels up to a maximum of four
 - One DWBUA UNIBUS adaptor per VAXBI channel up to two per system
 - Up to two KDB50 disk controllers per VAXBI channel and up to eight KDB50s per system. Each KDB50 allows any combination of RA60/80/81/82 disk drives up to a total of four per KDB50
 - Up to two TU81-Plus tape drives per VAXBI, up to a maximum of four TU81-PLUS tape drives per system
 - One CIBCI or CIBCA, VAXcluster Port
 - Two DMB32 per VAXBI or eight per system, 8 line asynchronous, one synchronous and one line-printer interface)

Note: The synchronous port is NOT supported by VMS. Support is provided by a layered product, (DMB32 Synchronous Device Driver. Refer to SPD 27.35.xx for details)

- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- Real-Time Devices
 - One DR11-W General Purpose High Speed DMA interface

For VAX 8700 Systems

- CPU Options
 - Additional memory up to 128 MB
 - One additional processor
 - Additional VAXBI channels up to a maximum of four
 - One DWBUA UNIBUS adaptor per VAXBI channel up to two per system
 - Up to two KDB50 disk controllers per VAXBI channel and up to eight KDB50s per system. Each KDB50 allows any combination of RA60/80/81/82 disk drives up to a total of four per KDB50

- Up to two TU81-Plus tape drives per VAXBI for a maximum of four TU81-PLUS tape drives per system
- One CIBCI or one CIBCA, VAXcluster Port
- Two DMB32 per VAXBI or 8 per system, (8 line asynchronous, one synchronous and one line-printer interface)

Note: The synchronous port is NOT supported by VMS. Support is provided by a layered product, (DMB32 Synchronous Device Driver. Refer to SPD 27.35.xx for details)

- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- Real-Time Devices
 - One DR11-W General Purpose High Speed DMA interface

For VAX 8600 and VAX 8650 Systems

- CPU Options
 - Additional memory up to a system total of 260 megabytes
 - Up to two SBIs
 - Up to four UNIBUS adaptors per SBI (to a system maximum of seven)
 - Up to four MASSBUS adaptors per SBI (to a system maximum of six)
 - One IDTC (Integrated Disk and Tape Controller)
 - FP86-AA Floating Point Accelerator
 - Up to four DR780s (on the second SBI only)
 - One CI780
- UNIBUS Disk Systems
 - Up to two UDAs per UNIBUS (at least at microcode level Rev. 3) and any combination of RA60/80/81/82 disk drives, up to four drives per UDA
 - Up to four RL02 disk drives per system (not supported as a system disk)
 - Up to two RX02 disk drives per system (not supported as a system disk)
 - One RC25
 - One RUX50
 - One TUK50
- MASSBUS Disk Systems
 - Up to four MASSBUS adapters can be connected to a VAX-11/780.

MASSBUS adapters are available in MASSBUS ADAPTER/DISK SUBSYSTEM combinations, (REM03, REM05, REM80, REP05, REP06, REP07) that include a MASSBUS adapter and disk drive,

(RM05, RP07) respectively. Up to seven additional disk drives can be added to a subsystem. Different disk drive types can be attached to the same disk subsystem; this gives a total of 32 disk drives per VAX-11/780 system.

- RP07s are supported at 2.2 MB/sec if the RH780 is at REV B1 or greater.
- Refer to MASSBUS Magnetic Tape Systems for information on disks and tapes configured on the same MASSBUS.
- **MASSBUS Magnetic Tape Systems**
 - MASSBUS adapters are also available in MASSBUS ADAPTER/TAPE SUBSYSTEM combinations, (TEU77, TEE16, TEU45, TEU78) that include a MASSBUS adapter and a specific tape formatter and transport (TU77, TE16, TU45, TU78), respectively. Up to three additional TU77 or TU78 magnetic tape transports can be added to each TEU77 or TEU78 subsystem respectively. Up to seven additional TE16 or TU45 magnetic tape transports can be added to each TEE16 or TEU45 subsystem, respectively. Different magnetic tape transports can not be mixed on the same TExxx subsystem. A TU78 Master (which includes TM78 formatter and a TU78 transport) can be attached to any MASSBUS tape subsystem.
 - With disks and magnetic tape transports mixed on the same MASSBUS, the following rules apply:
 - Disks can be added to a magnetic tape subsystem, with up to seven add-on disks per TExxx subsystem.
 - Tape transports cannot be added to a disk subsystem.
 - A TU78 Master (which includes a TM78 formatter and a TU78 transport) can be attached to a disk subsystem.
 - The combination of disks and tape formatters must not exceed eight on a single MASSBUS.
- **UNIBUS Magnetic Tape Systems**
 - TU80 or TU81/TU81-PLUS magnetic tape subsystems, up to a total of four per UNIBUS
- **Card Readers**
 - Up to a system total of two CR11 card readers
- **Line Printers**
 - Up to system total of 16 LA11, LP11, LP11-A, LP11-B, LP11-C, LP11-D, LP11-E, LP11-G, LP11-R, LP11-S, LP11-V, LP11-W, LP11-Y, LP11-Z, LP27 line printers, the LN03 Laser Printer, and the LN01 Laser Printer (at ECO DEC007)
- **Communications Devices**
 - Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- **Real-Time Devices**
 - One DR11-W General Purpose High Speed DMA interface

For VAX 8550, VAX 8530 and VAX 8500 Systems
- **CPU Options**
 - Additional memory up to 80 MB
 - Additional VAXBI channels up to a maximum of two
 - One DWBUA UNIBUS adaptor per system
 - Up to two KDB50 disk controllers per VAXBI channel and up to four KDB50s per system. Each KDB50 allows any combination of RA60/80/81/82 disk drives up to a total of four per KDB50
 - Up to two TU81-Plus tape drives per VAXBI, up to a maximum of four TU81-PLUS tape drives per system
 - One CIBCI or CIBCA VAXcluster Port
 - Two DMB32 per VAXBI up to a total of 4 per system, (8 line asynchronous, one synchronous and one lineprinter interface)

Note: The synchronous port is NOT supported by VMS. Support is provided by a layered product, (DMB32 Synchronous Device Driver. Refer to SPD 27.35.xx for details)
- **Communications Devices**
 - Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- **Real-Time Devices**
 - One DR11-W General Purpose High Speed DMA interface

For VAX 8350, VAX 8300, VAX 8250, VAX 8200 Configuration 2 Systems
- **CPU Options**
 - One addition processor for the VAX 8200 and the VAX 8250
 - Additional memory up to a system total of 32 megabytes
 - One DWBUA UNIBUS adaptor per system
 - Up to four KDB50 disk controller and any combination of RA60/80/81/82 disk drives up to a total of four disk drives per KDB50
 - Up to three TU80/TU81-PLUS tape drives per system
 - One CIBCI or one CIBCA, VAXcluster Port
 - One TUK50 tape controller for one TK50 Tape Cartridge Drive
 - Up to six DMB32 (8 line asynchronous, one synchronous and one lineprinter interface)

Note: The synchronous port is NOT supported by VMS. Support is provided by a layered product, (DMB32 Synchronous Device Driver. Refer to SPD 27.35.xx for details)

- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.

- Real-Time Devices

- One DR11-W General Purpose High Speed DMA interface

For VAX 8350, VAX 8300, VAX 8250, VAX 8200 Configuration 1 Systems

- CPU Options

- One additional processor for the VAX 8200 and VAX 8250
- Additional memory up to a system total of 24 megabytes
- Up to four KDB50 disk controller and any combination of RA60/80/81/82 disk drives up to a total of four disk drives per KDB50
- One DWBUA UNIBUS adaptor per system
- Up to two KDB50 disk controller and any combination of RA60/80/81/82 disk drives up to a total of four disks drives per KDB50
- One TU81-PLUS tape drive per system
- One CIBCI or CIBCA VAXcluster Port
- One TUK50 tape controller for one TK50 Tape Cartridge Drive
- Two DMB32 (8 line asynchronous, one synchronous and one lineprinter interface)

Note: The synchronous port is NOT supported by VMS. Support is provided by a layered product, (DMB32 Synchronous Device Driver. Refer to SPD 27.35.xx for details)

- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.

- Real-Time Devices

- One DR11-W General Purpose High Speed DMA interface

For VAX-11/782 Systems

All of the VAX-11/780 optional hardware applies to the VAX-11/782 except for the following CPU options:

- KU780 (User Writable Control Store)
- VAX/VMS runs (or resides) in the MA780 shared memory on a VAX-11/782 attached processor configuration. The maximum amount of shared memory (MA780 memory) that can be on the system is eight megabytes (four MA780s with two megabytes on each).

For VAX-11/780 and VAX-11/785 Systems

- CPU Options

- Additional memory up to a system total of 64 megabytes
- DR780 high-performance, general purpose interface
- Up to two MA780 multi-port memory controllers per system with up to 2048 kilobytes per MA780 controller
- H7112 memory battery back-up (required for power-fail/recovery)
- FP780 floating-point accelerator
- DW780 UNIBUS adapter, up to a system total of four
- KE780 G_and_H floating point microcode
- KU780 User Writable Control Store
- One CI780

- UNIBUS Disk Systems

- Up to four UNIBUS adaptors
- Up to eight disk drives per UNIBUS (RK06 and/or RK07)

Note: RK06 is not supported as a system device.

- Up to two UDAs per UNIBUS (at least at microcode level Rev. 3) and any combination of RA60/80/81/82 disk drives, up to four drives per UDA
- Up to four RL02 disk drives per system (not supported as a system disk)
- Up to two RX02 disk drives per system (not supported as a system disk)
- One RC25
- One RUX50
- One TUK50

- MASSBUS Disk Systems

- Up to four MASSBUS adapters can be connected to a VAX-11/780. MASSBUS adapters are available in MASSBUS ADAPTER/DISK SUBSYSTEM combinations, (REM03, REM05, REM80, REP05, REP06, REP07) that include a MASSBUS adapter and disk drive, (RM03, RM05, RM80, RP05, RP06, RP07) respectively. Up to seven additional disk drives can be added to a subsystem. Different disk drive types can be attached to the same disk subsystem; this gives a total of 32 disk drives per VAX-11/780 system.
- RP07 is supported at 2.2 MB/sec if the RH780 is at REV B1 or greater.
- Refer to MASSBUS Magnetic Tape Systems for information on disks and tapes configured on the same MASSBUS

- MASSBUS Magnetic Tape Systems

- MASSBUS adapters are also available in MASSBUS ADAPTER/TAPE SUBSYSTEM combinations, (TEU77, TEE16, TEU45, TEU78) that include a MASSBUS adapter and a specific tape formatter and transport (TU77, TE16, TU45, TU78), respectively. Up to three additional TU77 or TU78 magnetic tape transports can be added to each TEU77 or TEU78 subsystem respectively. Up to seven additional TE16 or TU45 magnetic tape transports can be added to each TEE16 or TEU45 subsystem, respectively. Different magnetic tape transports can not be mixed on the same TExxx subsystem. A TU78 Master (which includes TM78 formatter and a TU78 transport) can be attached to any MASSBUS tape subsystem.

With disks and magnetic tape transports mixed on the same MASSBUS, the following rules apply:

Disks can be added to a magnetic tape subsystem, with up to seven add-on disks per TExxx subsystem

Tape transports cannot be added to a disk subsystem

- A TU78 Master (which includes a TM78 formatter and a TU78 transport) can be attached to a disk subsystem.

The combination of disks and tape formatters must not exceed eight on a single MASSBUS.

- UNIBUS Magnetic Tape Systems

- TS11, TU80 or TU81/TU81-PLUS magnetic tape subsystems, up to a total of four per UNIBUS

- Card Readers

- Up to a system total of two CR11 card readers

- Line Printers

Up to system total of 16 LA11, LP11, LP11-A, LP11-B, LP11-C, LP11-D, LP11-E, LP11-G, LP11-R, LP11-S, LP11-V, LP11-W, LP11-Y, LP11-Z, LP27 line printers, the LN03 Laser Printer, and the LN01 Laser Printer (at ECO DEC007)

- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.

- Real-Time Devices

- Up to a total of two LPA11-K microprocessor controllers per UNIBUS for laboratory data acquisition I/O devices, with each LPA11-K able to accommodate up to two AD11-Ks, one AA11-K, one KW11-K, five DR11-Ks, and two AM11-Ks

- One DR11-W General Purpose High Speed DMA interface

For VAX-11/750 Systems

- CPU Options

- Additional memory up to a system total of fourteen megabytes

- H7112 memory battery back-up (required for power-fail/recovery)

- DW750 second UNIBUS adapter

- One DR750 high-performance, general purpose interface. The DR750 and the CI750 are not supported on the same system.

- KU750 User Writable Control Store

- FP750 floating point accelerator

- One CI750 (with 750 at Rev 5, if no UDA50 present or with 750 at Rev 7 if UDA50 present)

- UNIBUS Disk Systems (VAX-11/750 may have up to two UNIBUS adapters)

- Up to eight RK07 disk drives per system

- Up to four RL02 disk drives per system (not supported as a system device)

- Up to two RX02 dual-drive subsystems per system (not supported as a system device)

- One RC25

- One RUX50

- One TUK50

- Up to two UDAs (at least at microcode level Rev. 3 if no CI750 present, or at microcode level Rev 5, if CI750 present) per UNIBUS and any combination of RA60/80/81/82 disk drives, up to four drives per UDA

- MASSBUS Disk Systems

- Up to three MASSBUS adapters can be connected to a VAX-11/750. MASSBUS adapters are available in MASSBUS ADAPTER/DISK SUBSYSTEM combinations (RGM03, RGM05, RGM80, RGP06, RGP07) that include a MASSBUS adapter and disk drive, (RM03, RM05, RM80, RP06, RP07) respectively. Up to seven additional disk drives can be added to a subsystem. Different disk drive types can be attached to the same disk subsystem; this gives a total of 24 disk drives per VAX-11/750 system.

- Refer to MASSBUS Magnetic Tape Systems for information on disks and tapes configured on the same MASSBUS.

- MASSBUS Magnetic Tape Systems

- MASSBUS adapters are also available in MASSBUS ADAPTER/TAPE SUBSYSTEM combinations. (TGU77, TGE16) that include a MASSBUS adapter, a tape formatter and a transport (TU77, TE16 respectively). Up to three additional TU77 magnetic tape transports can be added to a TGU77 subsystem. Up to seven TE16 magnetic tape transports can be added to each TGE16 subsystem. Different magnetic tape transports cannot be mixed on the same TGxxx subsystem.

- With disks and magnetic tape transports mixed on the same MASSBUS, the following rules apply:
Disks can be added to a magnetic tape subsystem, with up to seven add-on disks per TGU77 subsystem
Tapes cannot be added to a disk subsystem.
- UNIBUS Magnetic Tape Systems (VAX-11/750 may have up to two UNIBUSs)
 - TS11, TU80 or TU81/TU81-PLUS magnetic tape subsystems, up to a system total of two
- Card Readers
 - One CR11 card reader
- Line Printers
 - Up to a system total of four LA11, LP11-A, LP11-B, LP11-C, LP11-D, LP11-E, LP11-G, LP11-R, LP11-S, LP11-V, LP11-W, LP11-Y, LP11-Z, LP27 line printers, the LN03 Laser Printer, and the LN01 Laser Printer (at ECO DEC007)
- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- Real-Time Devices
 - Up to a system total of two (one per UNIBUS) LPA11-K microprocessor controllers for laboratory data acquisition I/O devices, each accommodating up to two AD11-Ks, one AA11-K, one KW11-K, five DR11-Ks, and two AM11-Ks
 - One DR11-W General Purpose High Speed DMA interface

For VAX-11/725 and VAX-11/730

Note: Combinations of hardware options are subject to limitations such as bandwidth, physical configuration restraints and electrical loads/power.

(VAX configuration details are described in the VAX Systems and Options Summary.)

- CPU Options
 - Additional memory up to a system total of five megabytes for VAX-11/730, R80/RL02 and RL02/RL02 systems. Up to 3 megabytes for VAX-11/725 and other VAX-11/730 systems.
 - FP730 floating point accelerator
 - Up to two RL02 disk drives can be added to the dual RL02 and the R80/RL02 Package Systems
- UNIBUS Disk Systems (11/730 has one UNIBUS)
 - Up to eight RK07 disk drives on one RK711 controller
 - Up to four RL02 disk drives on one RL211 controller*
 - One RX211 floppy disk subsystem (two RX02 drives) not supported as a system device*

- One RC25
- One RUX50
- One TUK50
- One UDA per UNIBUS (at least at microcode level Rev. 3) and any combination of RA60/80/81/82 disk drives, up to four drives per UDA

* Not available on VAX-11/725

- UNIBUS Magnetic Tape Systems
 - One TS11, TU80 or TU81/TU81-PLUS magnetic tape subsystem
- Card Reader
 - One CR11 card reader
- Line Printers
 - One LP32 line printer per system, connected to a DMF32
 - One LP11 line printer per system with built-in controller
- Communications Devices

Refer to the DECnet-VAX SPD (25.03.xx) for the supported configurations.
- Real-Time Devices
 - One DR11-W General Purpose High Speed DMA interface
 - Up to a system total of two (one per UNIBUS) LPA11-K microprocessor controllers for laboratory data acquisition I/O devices, each accommodating up to two AD11-Ks, one AA11-K, one KW11-K, five DR11-Ks, and two AM11-Ks.

Optional VAXcluster Hardware for CI-based VAXclusters

- The HSC-series Controller

Each HSC50 supports a maximum of six disk channels or six tape channels or any combination of up to six disk and tape channels. Each HSC70 supports a maximum of eight disk channels or eight tape channels or any combination of up to eight disk and tape channels. Each disk channel supports a maximum of four disk drives and each tape channel supports a maximum of four tape subsystems (with four tape drives each). VMS supports a maximum of 8 tape drives per HSC-series controller.

Static dual porting of TA-series tapes is supported. A dual-path HSC tape drive is a drive that connects to two HSCs, both of which have the same non-zero tape allocation class. For dual-pathed tape drives, VMS automatically selects a functional HSC when processing a MOUNT or initialize command. If the selected HSC becomes inoperative while a tape is mounted, the tape must be dismounted and re-mounted by the operator in order to cause the alternate HSC to be used. Note that this is not automatic failover, since operator intervention is required.

The HSC50 and the HSC70 must be running either HSC Software, Version 3.5. Static dual porting of TA-series tape drives is supported only if the HSC series controller is running HSC Software, Version 3.5.

Optional VAXcluster Hardware for Local Area VAXcluster Systems

MicroVAX systems, which are members of Local Area VAXclusters (SPD 27.65.xx) also support the following peripherals:

Optional Q-BUS Hardware

- DZV11 4-line serial terminal multiplexer
- DZQ11 4-line serial terminal multiplexer
- DHV11 8-line serial terminal multiplexer
- 8-line serial terminal multiplexer
- One DEQNA Q-BUS Ethernet interface
- Up to 2 RC25, each RC25 consists of a 26 MB fixed Winchester disk and a 26 MB removable disk
- One RRD50 600 MB read only optical disk
- One DMV11 point-to-point DECnet Synchronous interface
- Additional memory

MicroVAX II, VAXstation II, and VAXstation II/GPX Only:

- Up to 16 MB of memory
- Up to 3 additional fixed Winchester disks, depending upon configuration, in any mix. Supported Winchester disks are the RD51 10 MB (as a data disk only), RD52 31 MB, RD53 71 MB, and RD54 159 MB
- TK50 95 MB tape cartridge drive
- TK70 296 MB tape cartridge drive
- RL02 10 MB removable disk
- LPV11 parallel line printer interface

Note: The RQDX disk controller supports up to 4 disk units. The RX50 counts as two units. Those configurations that include an RX50 may only add one additional Winchester drive. The RQDX3 disk controller is required for the RD54 disk drive.

MicroVAX II Only:

- DRV11-WA General Purpose DMA Interface
- CXA16 16-line serial terminal multiplexer (no modem)
- CXB16 16-line serial terminal multiplexer (no modem) (RS422)
- CXY08 8-line serial terminal multiplexor (full modem)
- One KDA50 Q-BUS Disk Controller for any combination of RA60/80/81 disk drives, up to four drives per KDA50
- One TU81-Plus

MicroVAX 2000 and VAXstation 2000 Only:

- One additional RD53 71 MB fixed Winchester disk or one RD54 159 MB Winchester disk
- One TK50 95 MB tape cartridge drive

Terminals and Terminal Line Interfaces

To prevent buffer overruns on input the terminals use the ASCII control characters DC1 and DC3 for synchronization, as defined by DIGITAL's DEC STD 111, Revision A.

The list of terminals that are supported and can interact with VAX/VMS and its associated utilities are: VT52, VT100, VT101, VT102, VT105, VT125, VT131, VT132, VT180, VT200 series (VT220, VT240 and VT241), VT300 series (VT330 and VT340) and the Professional 300 series (Professional 325, 350, and 380), the Rainbow 100 and DECmate II are supported in VT100 mode. In addition, the LA12, LA34, LA50, LA36, LA38, LA100, LA120, LA210, and LQP02 are supported in hardcopy mode. There is only limited support for the VT52.

The VT131 and VT132, when operating in an applications environment, are supported in block mode. When interacting with VAX/VMS and its associated utilities they are only supported in VT100 (or interactive) mode, and not in block mode.

Per UNIBUS, VMS will recognize any mix of controllers such that the vector requirements are less than or equal to 80. The tables below list the vector requirements for each multiplexer. The maximum number of controllers recommended is a number which may be less than physically connectable, but which makes sense for this system in normal configuration. All limits are also subject to UNIBUS requirements (slots, power, UNIBUS loads, etc.) which may not be included here.

Table 1

VAX-11/780, VAX-11/782, VAX-11/785, VAX 8600, VAX 8650 Systems

Multiplexer	Lines	Vector Requirement	Maximum Per UNIBUS	Maximum Recommended
DZ11, DZ32	8	2	12 *1*	12
DZ11	16	4	6 *1*	6
DHU11	16	2	12 *1*	10
DMF32	8	8	12 *2*	10
DMZ32	24	7	12 *1*	8

Table 2

VAX-11/750 Systems

Multiplexer	Lines	Vector Requirement	Maximum Per UNIBUS	Maximum Recommended
DZ11, DZ32	8	2	12 *1*	8
DZ11	16	4	6 *1*	4
DHU11	16	2	12 *1*	8
DMF32	8	8	10 *2*	8
DMZ32	24	7	12 *1*	6

Table 3

VAX-11/730 Systems

Multiplexer	Lines	Vector Requirement	Maximum Per UNIBUS	Maximum Recommended
DZ11, DZ32	8	2	12 *1*	4
DZ11	16	4	6 *1*	2
DHU11	16	2	12 *1*	2
DMF32	8	8	12 *2*	3
DMZ32	24	7	12 *1*	2

Table 4

VAX 8200, VAX 8250, VAX 8300, VAX 8350, VAX 8500, VAX 8530, VAX 8550, VAX 8700, VAX 8800 Systems

Multiplexer	Lines	Vector Requirement	Maximum Per UNIBUS	Maximum Recommended
DHU11	16	2	12 *1*	4
DMF32	8	8	12 *2*	2
DMZ32*	24	9	12 *1*	2

* Remote device only

Table 5

VAX 8200, VAX 8250, VAX 8300, VAX 8350 Configuration 1

Multiplexer	Lines	Vector Requirement	Maximum Per BI	Maximum Recommended
DMB32	8	4	2	2 **

** up to 6 DMB32 for Configuration 2

Table 6
VAX 8500, VAX 8530, VAX 8550, VAX 8700, VAX 8800

Multiplexer	Lines	Vector Requirement	Maximum Per BI	Maximum Recommended
DMB32	8	4	2	4 (VAX 85xx) 8 (VAX 8700, 8800)

1 Limited by bus loading requirements of UNIBUS

2 Limited by vector requirements

PREREQUISITE SOFTWARE

None

OPTIONAL SOFTWARE

Refer to the VAX/VMS System Software Order Table (SPD 28.98.xx) for additional information concerning processor support and license availability for layered products.

SOFTWARE WARRANTY

Warranty for this software product is provided by DIGITAL with the purchase of a license for the product as defined in the Software Warranty Addendum of this SPD.

INSTALLATION

Only experienced customers should attempt installation of this product. DIGITAL recommends that all other customers purchase DIGITAL Installation Services which provide for the installation of the software product by an experienced DIGITAL Software Specialist.

ORDERING INFORMATION

Single-Use licensed software is furnished under the licensing provisions of DIGITAL's Standard Terms and Conditions of Sale, which provide, in part, that the software and any part thereof may be used on only the single CPU on which the software is first installed, and may be copied, in whole or in part (with the proper inclusion of DIGITAL's copyright notice and any proprietary notices on the software) for use on that same CPU.

You will need a separate license for each CPU on which you will be using the software product (except as otherwise specified by DIGITAL). Then, Materials and Service Options are selected to utilize the product effectively. **THE LICENSE OPTIONS ARE DESCRIBED BELOW. IF YOU ARE NOT FAMILIAR WITH THE SERVICE OPTIONS, YOU MAY OBTAIN THE APPROPRIATE SOFTWARE PRODUCT SERVICE DESCRIPTION(S) FROM YOUR LOCAL DIGITAL OFFICE.** If you are already familiar with these options, you may obtain the ordering information directly from the Software Options Charts.

LICENSE OPTIONS

Single-Use License Option

The Single-Use License is your right to use the software product on a single CPU.

For your first installation of this software product you must purchase as a minimum:

- Single-Use License Option, and
- Distribution and Documentation Option

The license gives you the right to use the software on a single CPU and the Distribution and Documentation Option provides the machine-readable software and related documentation.

To use this software product on additional CPUs, you must purchase for each CPU as a minimum:

- Single-Use License Option

In addition to the right to use, the license gives you the one-time right to copy the software from your original CPU installation to the additional CPU. Therefore, the Distribution and Documentation Option is not required, but optional.

Note: The VMS license also licenses "execute only" images created with the System Building Utility in VAX LISP/VMS.

Distribution and Documentation Option

The Distribution and Documentation Option provides the machine-readable software and the basic documentation. You must have, or order, a Single-Use License to obtain this option. You will need this option to install the software for the first time. When revised versions of this software product become available, they may also be obtained by purchasing this option again.

Software Revision Right-To-Copy Option

The Right-To-Copy Option allows a customer with multiple CPUs to copy a revised version of a software product from one CPU to another. Each CPU must be licensed for that product. You first install the revised software on one CPU; then you can make copies for additional CPUs by purchasing the Right-To-Copy Option for each additional CPU.

Documentation-Only Option

The Documentation-Only Option provides one copy of the basic documentation.

Software Product Services

A variety of service options are available. For more information on these or other services, please contact your local DIGITAL office.

SOURCE MATERIALS OPTIONS

You can obtain optional source materials for this software product by signing DIGITAL's Software Program

Sources License Agreement and then purchasing the source option(s) you want. The agreement entitles you to use the source materials at one customer facility or location which is specified in the agreement.

Most users do not require source materials. They are used primarily to make modifications to the software product. Source kits provided by DIGITAL do not necessarily contain all source files used by DIGITAL to build binary kits.

Source License and Sources Distribution Option

This option provides you with the machine-readable source code for this software product. It gives you the right to use the source code on any CPU at the

facility/location specified in the agreement which has a Single-Use License for the object code.

Source License and Sources Listings Option

This option provides you with the Assembler/Compiler Output Listings on microfiche for this software product. It gives you the right to use the listings for any CPU at the facility/location specified in the agreement which has a Single-Use License for the object code.

Sources Update Distribution Option

This option provides you with the revised version of the machine-readable source code for this software product. You must have purchased the Source License and Source Distribution Option to obtain this option.

SOFTWARE OPTIONS CHARTS

The distribution Media Codes used in the Software Options Charts are described below. You specify the desired Media Code at the end of the Order Number, e.g., QC001-HH = binaries on RL02 disk cartridge.

- 4 = RC25 Disk Cartridge
- G = TU58 DECtape II Cartridge
- H = RL02 Disk Cartridge
- J = RA60 Disk Cartridge
- M = 9-track 1600 BPI Magtape (PE)

- R = Microfiche
- V = RK07 Disk Cartridge
- Y = RX01 Floppy Diskette
- Z = No hardware dependency

Chart I

Note: The availability of these software product options and services may vary by country. Customers should contact their local DIGITAL office for information on availability.

OPTIONS	ORDER NUMBER VAX-11/725 VAX-11/730	ORDER NUMBER VAX-11/750	ORDER NUMBER VAX-11/780 VAX-11/782* VAX-11/785
LICENSE OPTIONS: A LICENSE IS REQUIRED FOR EACH CPU.			
Single-Use License	QC001-UZ	QD001-UZ	QE001-UZ
MATERIALS AND SERVICE OPTIONS:			
Start-Up Service Package, Level III	QC001-B4 QC001-BH QC001-BJ QC001-BM	QD001-BH QD001-BM QD001-BJ QD001-BV	QE001-BM QE001-BJ QE001-BV
Start-Up Service Package, Level II	QC001-74 QC001-7H QC001-7J QC001-7M	QD001-7H QD001-7M QD001-7J QD001-7V	QE001-7M QE001-7J QE001-7V
Start-Up Service Package, Level I	QC001-54 QC001-5H QC001-5J QC001-5M	QD001-5H QD001-5M QD001-5J QD001-5V	QE001-5M QE001-5J QE001-5V

Chart I (cont.)

OPTIONS	ORDER NUMBER VAX-11/725 VAX-11/730	ORDER NUMBER VAX-11/750	ORDER NUMBER VAX-11/780 VAX-11/782* VAX-11/785
Distribution and Documentation Option	QC001-H4 QC001-HH QC001-HJ QC001-HM	QD001-HH QD001-HM QD001-HJ QD001-HV	QE001-HM QE001-HJ QE001-HV
Software Revision Right-To-Copy Option	QC001-HZ	QD001-HZ	QE001-HZ
Documentation-Only Option	QL001-GZ	QL001-GZ	QL001-GZ
Installation Service Option	QC001-I4 QC001-IH QC001-IJ QC001-IM	QD001-IH QD001-IM QD001-IJ QD001-IV	QE001-IM QE001-IJ QE001-IV
DECsupport Service	QC001-94 QC001-9H QC001-9J QC001-9M	QD001-9H QD001-9M QD001-9J QD001-9V	QE001-9M QE001-9J QE001-9V
Basic Service	QC001-84 QC001-8H QC001-8J QC001-8M	QD001-8H QD001-8M QD001-8J QD001-8V	QE001-8M QE001-8J QE001-8V
Self-Maintenance Service	QC001-34 QC001-3H QC001-3J QC001-3M	QD001-3H QD001-3M QD001-3J QD001-3V	QE001-3M QE001-3J QE001-3V
SOURCE MATERIALS OPTIONS:			
Source License and Source Distribution Option	QL001-EM	QL001-EM	QL001-EM
Source License and Source Listings Option	QL001-FR	QL001-FR	QL001-FR
Sources Distribution Option	QL001-NM	QL001-NM	QL001-NM

* For software licensing purposes, a VAX-11/782 is a multi-processor that is considered a single CPU.

Chart II

Note: The availability of these software product options and services may vary by country. Customers should contact their local DIGITAL office for information on availability.

OPTIONS	ORDER NUMBER VAX 8200	ORDER NUMBER VAX 8300	ORDER NUMBER VAX 8500
LICENSE OPTIONS: A LICENSE IS REQUIRED FOR EACH CPU.			
Single-Use License	Q5001-UZ	Q7001-UZ	Q9001-UZ
Periodic Payment License	Q5001-1P Q5001-JP	Q7001-1P Q7001-JP	Q9001-1P Q9001-JP
MATERIALS AND SERVICE OPTIONS:			
Start-Up Service Package, Level III	Q5001-BJ Q5001-BM	Q7001-BJ Q7001-BM	Q9001-BM
Start-Up Service Package, Level II	Q5001-7J Q5001-7M	Q7001-7J Q7001-7M	Q9001-7M
Start-Up Service Package, Level I	Q5001-5J Q5001-5M	Q7001-5J Q7001-5M	Q9001-5M
Distribution and Documentation Option	Q5001-HJ Q5001-HM	Q7001-HJ Q7001-HM	Q9001-HM
Software Revision Right-To-Copy Option	Q5001-HZ	Q7001-HZ	Q9001-HZ
Documentation-Only Option	QL001-GZ	QL001-GZ	QL001-GZ
Installation Service Option	Q5001-IJ Q5001-IM	Q7001-IJ Q7001-IM	Q9001-IM
DECsupport Service	Q5001-9J Q5001-9M	Q7001-9J Q7001-9M	Q9001-9M
Basic Service	Q5001-8J Q5001-8M	Q7001-8J Q7001-8M	Q9001-8M
Self-Maintenance Service	Q5001-3J Q5001-3M	Q7001-3J Q7001-3M	Q9001-3M
SOURCE MATERIALS OPTIONS:			
Source License and Source Distribution Option	QL001-EM	QL001-EM	QL001-EM
Source License and Source Listings Option	QL001-FR	QL001-FR	QL001-FR
Sources Distribution Option	QL001-NM	QL001-NM	QL001-NM

Chart III

Note: The availability of these software product options and services may vary by country. Customers should contact their local DIGITAL office for information on availability.

OPTIONS	ORDER NUMBER VAX 8600 VAX 8650	ORDER NUMBER VAX 8700 VAX 8550	ORDER NUMBER VAX 8800
LICENSE OPTIONS: A LICENSE IS REQUIRED FOR EACH CPU.			
Single-Use License	QK001-UZ	Q2001-UZ	QM001-UZ
Periodic Payment License	QK001-1P QK001-JP	Q2001-1P Q2001-JP	QM001-1P QM001-JP
MATERIALS AND SERVICE OPTIONS:			
Start-Up Service Package, Level III	QK001-BM	Q2001-BM	QM001-BM
Start-Up Service Package, Level II	QK001-7M	Q2001-7M	QM001-7M
Start-Up Service Package, Level I	QK001-5M	Q2001-5M	QM001-5M
Distribution and Documentation Option	QK001-HM	Q2001-HM	QM001-HM
Software Revision Right-To-Copy Option	QK001-HZ	Q2001-HZ	QM001-HZ
Documentation-Only Option	QL001-GZ	QL001-GZ	QL001-GZ
Installation Service Option	QK001-IM	Q2001-IM	QM001-IM
DECsupport Service	QK001-9M	Q2001-9M	QM001-9M
Basic Service	QK001-8M	Q2001-8M	QM001-8M
Self-Maintenance Service	QK001-3M	Q2001-3M	QM001-3M
SOURCE MATERIALS OPTIONS:			
Source License and Source Distribution Option	QL001-EM	QL001-EM	QL001-EM
Source License and Source Listings Option	QL001-FR	QL001-FR	QL001-FR
Sources Distribution Option	QL001-NM	QL001-NM	QL001-NM