

Amdahl 470 Systems

MANAGEMENT SUMMARY

First delivered in 1978, the Amdahl 470 systems continue to be enhanced. Amdahl is adding support for MVS/SP Version 2 and the associated data management facilities. This support will be available second quarter 1984. The Amdahl 470 systems are plug-compatible with the IBM 303X and 308X series and use semiconductor technology.

There are five models in the 470 product line: the 470V/7C, 470V/7B, 470V/7A, and 470V/7, and the top-in-the-series 470V/8. The Amdahl 470 configurations consist of a central processor unit with 8, 12, 16, 24, 28, or 32 integrated input/output channels, a minicomputer-based system console with CRT display, from 8 to 32 million bytes of main memory, and a power distribution unit. Central processor functions are performed by four independent functional units: a Storage Unit that controls accesses to main memory and includes both virtual address translation hardware and a cache memory; an Instruction Unit for controlling instruction interpretation and execution; an Execution Unit that performs the arithmetic, logic, and data manipulation functions of instruction execution; and a Channel Unit that interprets and executes input/output instructions and interfaces with the standard control unit interface that can communicate with any System/360 or System/370 compatible peripheral equipment. Operation of all the functional units can be overlapped, and 8- or 16-way interleaving can be performed on accesses to main memory. The degree of interleaving is partially dependent on the processor model.

PROCESSORS AND MAIN MEMORY

The Amdahl 470 design is based on the System/370 functional architecture. It achieves its higher level of performance. ▶

The Amdahl 470 Systems comprise a family of mainframes which are plug-compatible with the large-scale IBM 303X and 308X mainframes. All 470 systems are air-cooled and field upgradeable, and can execute any IBM 370 software.

MODELS: 470V/7C, 470V/7B, 470V/7A, 470V/7, and 470V/8.

CONFIGURATION: All systems are uni-processors, and have from 8 to 32 megabytes of main memory and 8 to 32 I/O channels.

COMPETITION: IBM 303X and 308X Series, NAS AS/7000 and AS/9000 Series.

PRICE: Purchase prices range from \$1,150,000 (470V/7C) to \$4,000,000 (470V/8).

CHARACTERISTICS

MANUFACTURER: Amdahl Corporation, 1250 East Arques Avenue, Sunnyvale, California 94086. Telephone (408) 746-6000. In Canada: One First Canadian Place, Suite 3940, P.O. Box 123, Toronto, Ontario, Canada M5X1B4.

CURRENT MODELS: Amdahl 470V/7C, 470V/7B, 470V/7A, 470V/7, and 470V/8.

PRIOR MODELS: Amdahl 470V/5, 470V/5-II, 470V/6, and 470V/6-II.

DATE ANNOUNCED: See characteristics chart.

DATE OF FIRST DELIVERY: See characteristics chart.



The highest performing member of the 470 line is the 470V/8 System. Shown here, this system has a cycle time of 26 nanoseconds with a performance rate estimated at between 6.5 to 7.0 MIPS (million instructions per second). All 470 systems can execute any IBM System/370 software as well as utilize System/370-compatible peripheral devices.

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CHARACTERISTICS OF THE AMDAHL 470 SYSTEMS

	470V/7C	470V/7B
SYSTEM CHARACTERISTICS		
Relative performance	1.1	0.9 to 1.0
To	IBM 3033S	IBM 3083E
Date announced	11/80	11/79
Date of first delivery	3rd Quarter 1981	3/80
Production status	Not in new production	Not in new production
Number of processors	1	1
Multiprocessor configurations	No	No
Principal operating systems	OS/V/S1, SVS, MVT, MVS, MVS/SP, MVS/XA, VM/370, VM/SP, ACP	OS/V/S1, SVS, MVT, MVS, MVS/SP, MVS/XA, VM/370, VM/SP, ACP
Upgradeable to:	470V/7B	470V/7A
MAIN STORAGE		
Type	Dynamic NMOS	Dynamic NMOS
Cycle time, nanoseconds	320	320
Bytes fetched per cycle	4	4
Interleaving	16-way	16-way
Minimum capacity, megabytes	8	8
Maximum capacity, megabytes	16	32
Increment size (field upgrade)	4MB	4MB
Error detection and correction	8 bits/8 bytes	8 bits/8 bytes
PROCESSOR		
Cycle time, nanoseconds	29	29
Translation lookaside buffer	512 entries	512 entries
Segment table origin stack	128 entries	128 entries
Instruction lookahead	4 levels	4 levels
High speed buffer (Bipolar RAM)		
Cycle time, nanoseconds	58 for 4 bytes	58 for 4 bytes
Capacity, bytes	32K	32K
I/O Channels		
Number standard	8	8
Number optional	8	24
Subchannels per channel	256	256
Total subchannels	2,048	2,048; opt. 4,096
Channel to channel adapter	Yes	Yes
Block multiplexer, bytes per second	2.0M	2.0M
With two-byte interface	4.0M	4.0M
With data streaming	3.0M	3.0M
Selector, bytes per second	2.0M	2.0M
With two-byte interface	4.0M	4.0M
Byte multiplexer, bytes per second	110K	110K
Burst mode	2.0M	2.0M
Aggregate data rate, bytes per second	18M	18M

➤ mance through the use of super-fast integrated circuit technology and, to a lesser extent, from central processor architectural optimization that provides for more efficient operation of the high-speed memory and the virtual storage address translation hardware, and permits extensive overlapping of input/output operations and instruction execution in the central processor.

Large-scale integrated (LSI) semiconductor circuits are used extensively throughout the system, resulting in increased processing speeds, higher reliability, and reduced space and cooling requirements. The central processor uses an LSI version of bipolar emitter-coupled logic (ECL) with chip speeds in the area of 600 picoseconds (trillionths of a second), and has a CPU cycle time of 29 nanoseconds for the 470V/7 systems, while the 470V/8 boasts a cycle time of 26 nanoseconds.

NUMBER INSTALLED TO DATE: Over 700 worldwide.

DATA FORMATS

All data formats, instruction formats, and other architectural features completely follow IBM System/370 functional architecture.

BASIC UNIT: 8-bit bytes. Each byte can represent 1 alphanumeric character, 2 BCD digits, or 8 binary bits. Two consecutive bytes form a "halfword" of 16 bits, while 4 consecutive bytes form a 32-bit "word."

FIXED-POINT OPERANDS: Can range from 1 to 16 bytes (1 to 31 digits plus sign) in decimal mode; 1 halfword (16 bits) or 1 word (32 bits) in binary mode.

FLOATING-POINT OPERANDS: 1 word, consisting of 24-bit fraction and 7-bit hexadecimal exponent, in "short" format; 2 words, consisting of 56-bit fraction and 7-bit

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	470V/7A	470V/7	470V/8
SYSTEM CHARACTERISTICS			
Relative performance	1.0 to 1.1	1.0 to 1.1	0.9
To	IBM 3033N	IBM 3083B	IBM 3083J
Date announced	8/79	3/77	10/78
Date of first delivery	9/79	8/78	9/79
Production status	Not in new production	Not in new production	Not in new production
Number of processors	1	1	1
Multiprocessor configurations	No	No	No
Principal operating systems	OS/V/S1, SVS, MVT, MVS/SP, MVS/XA, MVS, VM/370, VM/SP, ACP	OS/V/S1, SVS, MVT, MVS/SP, MVS/XA, MVS, VM/370, VM/SP, ACP	OS/V/S1, SVS, MVT, MVS/SP, MVS/XA, MVS, VM/370, VM/SP, ACP
Upgradeable to:	470V/7	470V/8	—
MAIN STORAGE			
Type	Dynamic NMOS	Dynamic NMOS	Dynamic NMOS
Cycle time, nanoseconds	320	320	320
Bytes fetched per cycle	4	4	4
Interleaving	16-way	16-way	16-way
Minimum capacity, megabytes	8	8	8
Maximum capacity, megabytes	32	32	32
Increment size (field upgrade)	4MB	4MB	4MB
Error detection and correction	8 bits/8 bytes	8 bits/8 bytes	8 bits/8 bytes
PROCESSOR			
Cycle time, nanoseconds	29	29	26
Translation lookaside buffer	512 entries	512 entries	512 entries
Segment table origin stack	128 entries	128 entries	128 entries
Instruction lookahead	4 levels	4 levels	4 levels
High speed buffer			
Type	Bipolar RAM	Bipolar RAM	Bipolar RAM
Cycle time, nanoseconds	58 for 4 bytes	58 for 4 bytes	52 for 4 bytes
Capacity, bytes	32K	32K	64K
I/O Channels			
Number standard	8	8	8
Number optional	24	24	24
Subchannels per channel	256	256	256
Total subchannels	2,048; opt. 4,096	2,048; opt. 4,096	2,048; opt. 4,096
Channel to channel adapter	Yes	Yes	Yes
Block multiplexer, bytes per second	2.0M	2.0M	2.0M
With two-byte interface	4.0M	4.0M	4.0M
With data streaming	3.0M	3.0M	3.0M
Selector, bytes per second	2.0M	2.0M	2.0M
With two-byte interface	4.0M	4.0M	4.0M
Byte multiplexer, bytes per second	110K	110K	110K
Burst mode	2.0M	2.0M	2.0M
Aggregate data rate, bytes per second	18M	18M	20M

➤ Instruction execution is performed in a "pipeline" structure which allows the execution of various phases of up to six instructions to occur concurrently within the pipeline. This results in a maximum execution rate of one instruction per two processor cycles. In addition, although the Amdahl Dynamic Address Translation (DAT) feature provides virtual-storage operations comparable to those of the

➤ hexadecimal exponent, in "long" format; or 4 words in "extended precision" format.

INSTRUCTIONS: 2, 4, or 6 bytes in length, which usually specify 0, 1, or 2 memory addresses, respectively.

INTERNAL CODE: EBCDIC (Extended Binary-Coded Decimal Interchange Code).

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➤ System/370, Amdahl has extended its design for more efficient operation. The Amdahl DAT feature maintains a segment table origin (STO) stack that allows up to 128 different virtual storage environments to maintain translation information in the Translation Lookaside Buffer, reducing the amount of updating activity in the buffer.

When the capacity of the STO stack is exceeded, the oldest entry in the stack and its associated translation lookaside buffer entries are purged during spare machine cycles. In the 470V/7 series and 470V/8, the translation lookaside buffer portion of the address translation hardware has also been expanded to 512 entries, compared to the System/370's 128.

Main memory in the 470 processors is metal oxide semiconductor (MOS) LSI circuits with a cycle time of 320 nanoseconds (depending on processor model). Ultra-high-speed components are used in the cache-like buffer memory with a 52 (470V/8) or 58 (470V/7 series) nanosecond cycle time per 8-byte access. Buffer loading from main memory is performed in 32-byte blocks. Memory interleaving can be either 8-way or 16-way.

INPUT/OUTPUT CONTROL

The Amdahl 470 systems are equipped initially with 8 high-speed channels. All 470 models can be expanded to 32 channels (except the 470V/7C). Each I/O channel can be configured as a byte multiplexer, a block multiplexer, or a selector channel. Byte multiplexer channels have a maximum data transfer rate of 110,000 bytes per second. Block multiplexers and selectors can transfer data at 2 million bytes per second, or at 4 million bytes per second using the optional two-byte interface. The 3 million bytes-per-second data streaming feature is available for any two channels within a four-channel group. A 470 system can have from 2 to 8 data streaming channels, depending on the processor model. The aggregate data rate, however, is the limiting factor in each system, and this, in turn, is governed by the channel-to-processor interface circuitry of each four-channel group. The exact aggregate data rate is heavily dependent on the system configuration, but a rule-of-thumb value is available. The aggregate data rate is approximately 18 million bytes per second on 470V/7 series and 20 million bytes per second on 470V/8 systems.

A dynamic priority allocation scheme based on the availability of space in each channel buffer is used to allocate cycles between central processor operations and input/output data transfers. Normally, the central processor has the highest priority in the system, but channels performing high-speed data transfers are allowed to take precedence over the central processor by the Amdahl internal priority scheme. This allows high speed devices to be attached to any channel without performance degradation and provides additional flexibility in the configuration of peripheral subsystems.

➤ MAIN STORAGE

STORAGE TYPE: Dynamic NMOS.

CYCLE TIME: See characteristics chart.

CAPACITY: See characteristics chart. Memory units are equipped with their own power supply. Expanded main memories up to 32 megabytes will be available in the third quarter of 1982.

CHECKING: Error checking and correction (ECC) circuitry in main memory performs automatic correction of all single-bit errors and detection of all double-bit and most other multiple-bit memory errors. See table for number of bits per byte group added for ECC.

A Configuration Control Register, associated with each two-million-byte storage unit, maintains a map of the assignment of main storage address space for that storage unit. In the event of an unrecoverable memory error, the memory module can be removed from operation and the remaining memory reconfigured for continuous system operation. This process typically involves memory increments of two megabytes.

In addition, a parity check is performed on all data transferred between main memory and the High-Speed Buffer. A separate parity check is also made on storage keys, which are used to implement storage protection and to record references and modifications to main storage.

STORAGE PROTECTION: Storage protection facilities are comparable to those implemented in the IBM System/370.

RESERVED STORAGE: The 470 processors reserve an area in lower memory for such purposes as interrupt handling routines, CPU ID, channel ID, and machine check logouts.

STORAGE CONTROL UNIT (S-UNIT): The Storage Control Unit, or S-Unit, handles all requests for data from main storage made by the CPU and the channels. An internal priority structure is used to resolve conflicts resulting from multiple concurrent requests for access to main memory. The internal priority structure of the S-Unit has the following five priority levels, in descending order: Internal High (including ECC handling), Channel Unit High, Central Processing Unit, Channel Unit Low, and Internal Unit Low (such as instruction prefetch). Normally, the central processor unit is given higher priority than a channel except when a channel issues a high-priority request. The Storage Control Unit locates the requested data either in the High-Speed Buffer or in main memory and includes a dynamic address translation facility for translating program-specified virtual addresses into real-memory addresses.

All Amdahl processors include a High-Speed Buffer (HSB) that is organized as a set associative memory composed of eight partitions. Each partition is organized into 32-byte lines that can be addressed on a single-word or double-word basis.

The 470V/7, 470V/7A, 470V/7B, and 470V/7C all have eight equal partitions with each partition having 128 32-byte lines. The 470V/8 is partitioned four ways where each partition has 512 32-byte lines. Partitioning allows the system to bypass buffer errors by reconfiguring out a buffer section. The 470V/8 HSB incorporates a special prefetching

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COMMUNICATIONS CONTROL

➤ Amdahl's Communications Processors consist of the 4705 and the 4705E, both compatible with IBM's 3705-II. The 4705 can handle memory up to a million bytes in 256K-byte increments. Both the 4705 and 4705E systems support up to 352 communications lines with transmission speeds from 50 bps to 64,000 bps. As many as four CPUs can be connected to a 4705/4705E through a standard channel adapter. Host channels can be either byte, block, or selector channel types. The 4705 and 4705E feature on-line and standalone diagnostics, instruction lookahead, instruction retry, and automatic fault isolation. The 4705 can be field upgraded to a 4705E. Two new features include support for asynchronous traffic up to 9600 bps, a low-cost approach to backup, and an integrated line switch. Deliveries of the 4705 began in November 1980; deliveries of the higher performance 4705E began in May 1983. The 4705 and 4705E take a unique approach to 3705 compatibility. The systems use standard IBM ACF/NCP/EP code from IBM since the 4705 and 4705E are compatible from a hardware (principles of operations) standpoint. This means compatibility with IBM's SNA networking architecture and the ability to coexist with 3705s or 3725s in a network. This also means compatibility with the most current versions of 3705 NCP, access methods (VTAM, BTAM, TCAM, QTAM), and protocols (BSC, SDLC, start/stop, and X.25). Communications lines can have the following characteristics: half or full duplex, EIA RS-232-C, and CCITT V.24 and V.35.

To further enhance its communications capabilities, Amdahl added the 4400 Series of network management systems. The 4400 Series includes the 4410 Network Processor, the 4440, 4450, and 4460 Network Concentrators, and the 4404 Network Administrator. Designed to support interactive applications, the various concentrators can support 3270 bisynchronous, asynchronous, and X.25 packet switching facilities. The 4404 handles all essential network management functions.

SOFTWARE AND SUPPORT

Amdahl maintains a Software Systems Support group in Sunnyvale, California that supports the various IBM operating systems running on the 470 Series. At the end of second quarter 1983, supported operating system software included the following: OS/MVT, OS/VS1, MVS3.8, MVS/SP Version 1, VM/370, VM/SP and the associated HPO Extensions, and ACP. Support for MVS/SP Version 2 and the associated data management facilities are scheduled to be available second quarter 1984.

IBM subsystems, such as TSO, TCAM, JES2, JES3, VTAM, RSCS, CMS, and IPCS are also supported. Amdahl developed software includes: MVS/ECS and VM/ECS which provides software support for 32 channels on any processor; MVS/SPA which provides the performance of MVS/SP Version 1 Release 3 when run on a CPU without extended hardware and microcode facilities; VM/PE which improves MVS performance levels to near-native state when running under VM/SP; UTS (Universal Timesharing) ➤

➤ technique which predicts the next most logical consecutive data to be called into the buffer from main storage and then moves the data into the buffer.

For systems control programs using 2K pages, the HSB operates in 16K mode, causing each buffer partition to contain 64 32-byte lines.

Data is transferred between the buffer and the central processing unit in groups of 4 bytes per cycle and is brought into the buffer from main memory in lines of 32 bytes, each requiring 4 buffer cycles. In contrast to the System/370, Amdahl I/O channels as well as the CPU access the High-Speed Buffer. A tag field associated with each 32-byte line in the buffer includes a block identifier containing the high-order real address bits of the buffer data, plus parity and check fields, modification indicators, and reference bits to specify whether a central processor or channel access brought the data into the buffer and whether the CPU was in the supervisor or problem state of operation.

When a request is made for data by the central processor Instruction Unit or by the Channel Unit, the Storage Control Unit forms a pointer into the buffer and reads a 32-byte line of data from each partition of the buffer. The SUnit then uses the real line address calculated by the address translation hardware to select one of the lines, and a tag comparison on the real address bits is used to select the data from the proper partition of the buffer. Location of the data in the buffer can be performed in two machine cycles, although overlapped buffer operations allow it to accept a request for data during each cycle. If the data is not in the buffer, a main storage request is generated and the request data is made available to the program and is also placed in the High-Speed Buffer.

Operation of the High-Speed Buffer is based on a non-storethrough technique, in which data that is modified in the buffer is not written to main storage until the line is removed from the buffer to make room for new data. As a result, frequently referenced data can be accessed and modified in the buffer without incurring a large number of main memory accesses. An instruction prefetch function can be enabled for accesses to the buffer from input/output channels, the operand stream, or the instruction stream. A combination of three bits in the Storage Unit controls the order of prefetch operations, although that order can be modified through the use of an additional register bit provided for that purpose. Six operating state register bits are used to control the operation of the buffer replacement algorithm. Four additional bits of the S-Unit operating state register can be set through the System Console, and can be used to partition the buffer to configure out a portion of the buffer with a hardware failure.

DYNAMIC ADDRESS TRANSLATION: The dynamic address translation facility is located in the S-Unit. It controls the translation of program-specified virtual addresses into real-memory addresses when the 470 is operating in extended control (EC) mode. Virtual memory implementation in the 470Vs is similar to that of the IBM System/370. Virtual storage is divided logically into segments of 64K bytes or 1024K bytes, which are in turn divided into pages of either 2048 or 4096 bytes. Segment and page tables are maintained in main storage to perform address mapping. A high-speed Translation Lookaside Buffer (TLB) is used to store the most recently referenced addresses, and a Segment Table Origin (STO) stack stores information on the size and main memory location of the segment table associated with TLB entries. ➤

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▷ System) which provides UNIX under VM for use on System 370 architecture processors; and CMS Accelerator (CMS/XL) which improves CMS performance on a VM system.

COMPETITIVE POSITION

Amdahl competes in the marketplace against NAS AS/7000 and AS/9000 Series in addition to targeting its 470 models against its major competitor, specific IBM 303X and 308X processors. Amdahl's pricing activities usually mirror those of IBM, in addition to matching IBM's products stride-for-stride.

The entry-level 470V/7C is about 8 percent more powerful than the 3033S, and costs about 12 percent less. The 470V/7B and 470V/7A are comparable in performance to IBM's 3083E and 3033U, respectively. The 470V/7 has slightly more power than the 3083B, and the 470V/8 has about 10 percent less power than the 3083J, according to Amdahl. The 470V/7C is field-upgradeable to the 470V/8.

Amdahl's 470 product line does not include attached processor or multiprocessor configurations, and its 470V/8 price/performance is competitive with IBM's newest generation. For example, a 470V/8 with 16 megabytes of memory and 16 channels costs \$2,525,000. A 3083J with 16 megabytes of memory and 16 channels costs \$2,968,102. In performance the Amdahl 470V/8 is estimated at about 6.5 MIPS (million instructions per second), and its IBM counterpart clocks in with about 7.3 MIPS. Amdahl's price per MIPS, however, is about \$388,000, compared to \$408,000 for the 3083J. Those organizations requiring greater processing power than the 470V/8 should consider Amdahl's 580 Series (Report 70C-044-03).

ADVANTAGES AND RESTRICTIONS

The Amdahl Corporation has the advantage of being the first company to develop and produce an IBM-compatible mainframe computer. The company was formed in 1971 by Dr. Gene Amdahl, principal designer of the IBM System/360 and subsequently a director of IBM's advanced systems laboratory and an IBM Fellow, the company's highest scientific position.

Reliability of equipment and effectiveness of maintenance service appears to be two key advantages of the Amdahl 470 systems.

Amdahl announced support for IBM's MVS/SP Version 2 and related data management facilities, also known as the System/370 Extended Architecture, for MVS/XA on its 470 Series. In particular, the company said it would support 31-bit addressing, bimodal operation, and dynamic channel subsystem facilities as part of the new extended architecture mode. Amdahl has developed a hardware/software product specifically for the 470, called 470/Extended Architecture (470/XA), to support MVS/XA. Amdahl also supports the 3880 Storage Control models 11 and 13.

▶ The STO stack contains 128 locations, and is addressed by the current segment table origin. The TLB is divided into primary and alternate halves, each containing 256 address pairs.

Translation of virtual to real addresses for data located in the TLB is overlapped with the High-Speed Buffer search, and data for both real and virtual operation can be accessed in two S-Unit cycles. If the data is not located in the TLB, an address translation is performed and two additional storage references are required to locate the data either in High-Speed Buffer or in main memory. The new translated address is translated in the TLB according to an algorithm similar to that used by the High-Speed Buffer.

The STO stack contains virtual-storage identification fields associated with the TLB entries. The identification fields correspond with address translation information such as segment table size and location, contained in Control Register 0 and Control Register 1. When the contents of these registers are modified, subsequent TLB entries are assigned a new STO ID by the S-Unit, but earlier TLB entries are not invalidated provided they do not exceed the capacity of the stack. If Control Registers 0 and 1 are restored to a previous value, any previous TLB entries remaining are thus still available. The S-Unit controls selective purging (when an STO entry is automatically removed from the stack and its associated TLB entries invalidated) of the TLB and STO stack during spare cycles.

CENTRAL PROCESSOR

Central processor functions such as instruction fetching and decoding and instruction execution are performed by two separate units, the Instruction Unit (I-Unit) and Execution Unit (E-Unit).

The I-Unit controls instruction execution through a pipeline structure and can have up to six instructions concurrently in some phase of execution. The instruction execution process is divided into the fetch phase plus six additional decoding and execution phases. The instruction fetching operation requires three cycles, while Phases A, B, and C, which perform instruction decoding, operand address generation, and operand retrieval, each require a minimum of two central processor cycles. Phases D, E, and F each require a minimum of one cycle, and perform execution plus checking and writing of the results of the instruction execution. The overlapped instruction execution in the pipeline can result in the completion of an instruction execution every two machine cycles, except in the case of long instructions requiring additional cycles for execution.

Extensive parity checking is performed throughout the IUnit. All incoming instructions are checked for parity, and the results are checked again after the completion of execution. All control registers and the program status word are checked each time they are used. In addition, parity is checked for the timer and the address generation function, and parity is also maintained for all program-referable data.

The Execution Unit (E-Unit) executes arithmetic and logical instructions received from the I-Unit; it consists of a logical unit and checker (LUCK), a group of functional units (multiplier, adder, shifter, and byte mover), a table lookup unit to generate an inverse in the I-register (for divide operations), registers for storage of intermediate results, and a result register for output of the result of instruction execution to the I-Unit. Instruction operation codes plus control information are sent from the I-Unit to the E-Unit, and instruction operands are received either from the I-Unit or directly from main storage. The LUCK checks the valid-

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- This system, though well-supported by Amdahl is no longer in new production.

USER REACTION

Responses from 46 users of 83 Amdahl 470 systems were received in reply to Datapro's 1983 Computer System User Survey. Most users had single systems, while 24 percent had two or more 470 systems installed. More than half of these 470 users had purchased their systems, while the balance rented or leased their systems from the manufacturer or leased from a third party. Almost all systems replaced an older IBM System 360 or 370 product. Several upgraded within the 470 line, while one user converted from a CDC Omega.

Users of the Amdahl 470 and respondents to this survey were engaged primarily in Finance, Chemical and Petroleum, and Construction followed by Government, Insurance, and Public Utilities. The applications most frequently mentioned by these companies included accounting and billing, payroll and personnel, order processing and inventory control, engineering and scientific, and mathematics and statistics. Every respondent developed some or all applications in-house, while approximately 61 percent of these respondents also secured applications from contract programming arrangements or from the purchase of proprietary software packages. Approximately 61 percent of the respondents also used programs from the manufacturer.

The bulk of the Amdahl systems were installed at a central processing installation. All respondents reported using both local and remote workstations or terminals, and the majority of users said they had over 60 terminals. Approximately 83 percent of the Amdahl respondents are using a data base management system, while about 12 percent use a communications monitor. As might be anticipated from the respondents' applications, the most widely used program language is Cobol and to a lesser degree PL1 and BAL.

In terms of future acquisitions, most respondents were planning to add software, and to expand their present hardware and data communications facilities. One third said they were planning to use business graphics in 1983.

As part of the survey, users were asked to rate their Amdahl equipment from excellent to poor. A weighted average was then calculated based on the total responses. A summary of these Amdahl user ratings are included in the following table.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	20	19	4	0	3.37
Reliability of mainframe	26	20	0	0	3.57
Reliability of peripherals	10	29	3	0	3.17
Maintenance service:					
Responsiveness	24	17	5	0	3.33
Effectiveness	23	19	4	0	3.41
Technical support:					
Trouble-shooting	20	20	3	0	3.40
Education	8	23	8	1	2.98
Documentation	7	23	10	0	2.83

- **ity of incoming operands, performs logical operations and comparisons on incoming operands, validates decimal digit formats, sets conditions codes, and counts leading zeroes for use in shifting and normalization. LUCK operations require one CPU cycle. Additional arithmetic functions are performed by the multiplier, adder, shifter, and byte mover units, each of which also completes its functions in one machine cycle.**

When instructions require processing by multiple E-Unit functions, the I-Unit synchronizes the operation of its pipeline by delaying the progress of other instructions in the pipeline until the final cycle of the instruction that is currently in the E-Unit. The E-Unit performs parity checks on all incoming data and on logical and shift operations, and uses a check summation technique to verify the results of addition and multiply functions. The E-Unit also generates parity for final instruction execution results, and the parity is checked by the I-Unit before storing the final results.

Failure to complete the execution of an instruction because of a hardware malfunction results in a machine check condition. Most instructions in the Amdahl 470 repertoire can be automatically retried by the E-Unit. The instruction retry feature attempts to re-execute the failed instruction (in contrast to returning the machine state to a hardware checkpoint). Instructions that cannot be retried or recovered result in a hard machine check, which is handled according to standard System/370 procedures.

The Amdahl 470 family uses a "fourth-generation" LSI packaging technique that was developed to reduce both physical system size and power consumption. The basic logic unit of the 470 system is a "chip" that contains 75 to 100 emitter-coupled logic (ECL) circuits and requires significantly less power. Each chip has its own air cooling fins. The chips are mounted in multiple chip carriers (MCCs) that can contain up to 42 of the LSI circuits. The MCCs are, in turn, connected to a computer backplane with the chip cooling fins protruding into an air stream. The 470V/7s and the 470V/8 contain 59 MCCs. The use of air cooling in the 470 systems is a distinct advantage over their IBM counterparts, the System/370-168 and the 3033.

PROCESSOR FEATURES: The standard timing features of the System/370 architecture are included in all Amdahl central processors. These include a CPU timer and a Clock Comparator; the latter provides a means for causing an interrupt when the standard Time-of-Day Clock reaches a program-specified value. Additional instructions are provided to set and store the Time-of-Day Clock, Clock Comparator, and CPU Timer.

Other features of the System/370 found in Amdahl processors include control registers, direct addressing, double word buffer, interval timer, machine check handling, multiple bus architecture, time-of-day clock, channel command retry, channel indirect addressing, byte-oriented operand feature, console audible alarm, remote console, remote data link, console file, extended control mode, and program event recording. Control registers are used for operating system control of relocation, priority interruption, program event recording, error recovery, and masking operations. A double-word buffer consists of a 64-bit area temporarily reserved for data used in performing an I/O operation. Each channel attached to the CPU has a fixed amount of channel control buffer dedicated to its use.

The interval timer is a 32-bit decremental counter that is reduced by one several hundred times per second. The timer generates an interrupt when the contained value is decremented from a positive to a negative number. Machine check handling analyzes errors and attempts recovery by retrying

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	Excellent	Good	Fair	Poor	WA*
Manufacturers software:					
Operating system	10	19	6	0	3.11
Compiler & assemblers	7	22	3	0	3.03
Application programs	5	16	9	0	2.87
Ease of programming	9	18	9	0	3.00
Ease of conversion	8	21	5	0	3.09
Overall satisfaction	15	29	1	0	3.31

*Weighted Average on a scale of 4.0 for Excellent.

For additional qualification, Datapro telephoned several Amdahl 470 users for their comments. The first organization reached was an insurance company in the Midwest. The Director of Operations and Research noted that his organization had recently upgraded from an Amdahl 470/V7 to a V/8 system, and felt it would satisfy his requirements for the next two to three years. He stated that his Amdahl equipment was very reliable, and that service was fast and dependable. During Datapro's telephone conversation with the Director, he stated that he felt there was really nothing negative that could be said. The Director also mentioned having an Amdahl 6280 disk which he felt was an outstanding piece of equipment.

Our second call went to an energy organization in the West. This organization also appears very satisfied with the performance of its Amdahl 470 equipment. Their system is used for an energy data base including regulatory, sales and production types of information. The Manager of Computer Operations stated he was particularly pleased with Amdahl's response to maintenance calls. He pointed out that following a hurricane which struck their facility, Amdahl was on site as soon as the company opened its doors. Another plus factor was that the equipment cost less than comparable IBM equipment. It was also noted that the Amdahl equipment takes up less floor space than similar equipment. The Manager of Computer Operations plans to recommend an upgrade in the Amdahl product line, probably to a 580 system.

Our third call was to a service organization in the Midwest. The management of this organization installed an Amdahl 470/V7 approximately two years ago, and is very satisfied with its performance. The Director of this organization said he feels Amdahl service is "fantastic". He said he can "grow" the equipment, if he requires expansion capability. Currently, his equipment has an accelerator capability for peak periods, but he is required at this time only to pay for actual usage. For other potential users of this equipment, he advises the importance of being comfortable with the compatibility issue if they are an IBM shop. He suggests that users will find there is an advantage in being a mixed vendor shop.

Datapro reached a new data facility in the South which was a facilities management organization for the U.S. Army. This data center was built around the equipment, so the floor plan was designed for it. This facility is a mirror image of other regional centers around the country as part of their disaster recovery plan. We spoke to the Manager of Executive Operating Systems who indicated his organization is

the failed instruction if possible. If retry is unsuccessful, it attempts to correct the malfunction or to isolate the affected task. Multiple bus architecture implies that the various segments of the processor, namely memory, arithmetic and logic, central control, etc, are tied together by more than one central bus. The time-of-day clock is incremented once every microsecond and provides a consistent measure of elapsed time suitable for the indication of date and time. Some channels have the capability to perform channel command retry, a channel and control-unit procedure that causes a command to be retried without requiring an I/O interrupt. Channel Indirect Addressing (CIA) is a companion feature to dynamic address translation, providing data addresses for I/O operations. CIA permits a single channel command word to control the transmission of data that crosses noncontiguous pages in real main storage. If CIA is not indicated, then channel onelevel (direct) addressing is employed.

The byte-oriented operand feature permits storage operands of most non-privileged operations to appear on any byte boundary. Instructions must appear on even byte addresses. The console audible alarm is a device activated when predetermined events occur that require operator attention or intervention for system operation. A remote console is a console attached to a system through a data link. The remote console is configured in addition to the standard console. The remote data link allows establishment of communications with a technical data center to remotely diagnose system malfunctions. The console file is the basic microprogram loading device for the system, containing a read-only file device. The media read by this device contains all the microcode for field engineering device diagnostics, basis system features, and any optional system features. The extended control mode (EC) is a mode in which all features of the System/370 computing system, including dynamic address translation, are operational. Program event recording is a hardware feature used to assist in debugging programs by detecting and recording program events.

The Direct Control Feature, as on the System/370, provides six external interrupt lines which operate independently of the normal data channels, plus the Read Direct and Write Direct Instructions which provide for single-byte data transfers between an external device and main storage.

The optional Channel-to-Channel Adapter permits direct communication between an Amdahl processor and a System/370, 303X, or 308X via a standard I/O channel. It can be attached to either a selector channel or a block multiplexer channel and uses one control unit position on either channel. In a loosely-coupled configuration consisting of an Amdahl 470 and a System/370, 303X, or 308X, either system can be equipped with the Channel-to-Channel Adapter, and it is required on only one of the interconnected channels.

The Two-Byte Interface, available as an option for all selector and multiplexer channels, doubles the bandwidth of the data path between the channel and the control units which support this option.

The Data Streaming feature permits data transfer rates of 3 megabytes per second. In any given four-channel group, up to two channels can be designated as high-speed. Within the 470V/7 and 470V/8 product lines the number of data streaming channels ranges from two to eight.

The maximum number of channels in the 470V/7 and 470V/8 systems (except the 470V/7C) is 32. Once the initial 16 channels are in place, expansion to 32 progresses through one 8-channel and two 4-channel increments. The maximum number of subchannels is 4,096.

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➤ very satisfied with the excellent service they have received from Amdahl. The primary work on their Amdahl equipment is for accounting and general administration applications. This Manager stated that the Amdahl product is good and has done everything it was advertised to do. He said he also feels the accelerator feature is a good one. Currently, the organization is looking at the next family of Amdahl computers, the 580 Series.□

➤ **OPERATIONAL MODES:** Like the System/370, the Amdahl 470 CPUs can operate in either the Basic Control (BC) or Extended Control (EC) mode. The BC mode maintains general upward compatibility with the System/360 architecture and programming. In the EC mode, the Program Status Word (PSW) and the layout of the permanently assigned lower main storage area are altered to support Dynamic Address Translation and other new system control functions; therefore, the virtual-storage-oriented operating systems must be used.

The 470 can also operate in the Extended Architecture (XA) mode. This capability supports 31-bit addressing, with real and virtual address sizes of two billion bytes. Normal EC mode supports 24-bit addressing with a maximum of 16 million bytes of real and virtual address space per user program. The 470 will support bimodal operation, in which user programs with 24- and 31-bit addresses can execute concurrently, and a dynamic channel subsystem. Amdahl has developed the 470/Extended Architecture (470/XA) hardware/software facility to accommodate MVS/XA. The new hardware includes a modification to existing 31-bit addressing and the software utilizes certain functions of Amdahl's MVS/SEA program products. Since 470/XA software performs what Amdahl terms "interpretive emulation," some performance degradation is anticipated. Implementation of this capability will not be available until some time after IBM has its XA feature working.

REGISTERS: Sixteen 32-bit general registers are used for indexing, base addressing, and as accumulators. Other program-visible registers are the same as in the System/370. Machine-dependent registers contained in the 470 processors are not visible to the user and may differ from the System/370.

ADDRESSING: The same techniques as employed in the System/370, 303X, and 308X are found in the 470 processors.

INSTRUCTION REPERTOIRE: The Amdahl 470 instruction set consists of the complete System/370 Universal Instruction Set, including the five System/370 instructions for Dynamic Address Translation. Two exceptions are the Store CPU ID (STIDI) and Store Channel ID (STIDC) instructions, which differ in their operations because of architectural differences between the System/370 and the Amdahl processors. In the Amdahl units, a machine check extended logout (MCEL) is performed by the Console Processor in its own memory, whereas in the System/370 the address in main memory and size of the machine check extended logout are dependent on the central processor model and control register information. Since the MCEL on the 470 is made to the Console Processor, the MCEL length field stored by the STIDP instruction is all zeroes. The model number is 0470. The STIDC instruction stores zeroes for a channel model number because all Amdahl channel types are implicit in CPU type. According to Amdahl, no system or application program is likely to be affected by these model dependencies.

INSTRUCTION TIMING: The following instruction execution times, in nanoseconds, have been estimated by scaling performance information supplied by Amdahl for the Model 470V/6 in the absence of specific timing data for the newer models. Timings are presented for the 470V/6-II, 470V/7, and 470V/8 as representative systems.

Chart 1

	470V/6-II	470V/7	470V/8
Add (32-bit binary):	65	40	32
Multiply (32-bit binary):	228	140	112
Divide (32-bit binary):	1625	1015	812
Load (32-bit binary):	65	40	32
Store (32-bit binary):	65	40	32
Add (5-digit packed decimal):	423	265	212
Compare (5-digit packed decimal):	488	305	244
Add (short floating-point):	195	120	96
Multiply (short floating-point):	260	165	132
Divide (short floating-point):	878	550	440
Add (long floating-point):	260	165	132
Multiply (long floating-point):	650	405	324
Divide (long floating-point):	2080	1300	1040

Chart 2

	Operating
Temperature Range	60° to 90° F
Optimum Temperature	75° F
Relative Humidity Range (noncondensing)	35% to 55%
Optimum Relative Humidity (noncondensing)	50%
Maximum Wet Bulb Temperature	78°F
Maximum Altitude (feet equivalent pressure)	+7,000

PHYSICAL SPECIFICATIONS: Environmental conditions for 470 processors is given in the following table.

Amdahl 470 processors are air-cooled and require a minimum of 12.5 tons of air conditioning and 4890 cubic feet of air per minute. Minimum BTU output for a 470 processor is 79,000 BTUs per hour. Figures are generally higher depending on the processor model and amount of memory installed. Power must be available to the Amdahl 470 power distribution unit from two sources, 415 and 60 Hz. Both sources must be four-wire and three-phase at 208 volts.

The processors in the upper end of the 470 line, including the 470V/7, are 72 inches long, 64.5 inches high, 30 inches wide, and weigh 6,800 pounds in a 12-megabyte, 12-channel configuration.

A typical configuration layout requires a 200 by 154 or 220 by 30 inch area depending on the layout (exclusive of the console). The console requires a 173 by 113 inch area. ➤

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► CONSOLE INPUT/OUTPUT

The system console includes a minicomputer that acts as a console processor, an operator control panel, and a 3200-character CRT display and keyboard. The console processor is also equipped with a magnetic disk cartridge that is used by the console operating system and for logout and other functions, a floppy disk unit for loading diagnostic programs, and a modem to provide for remote diagnostic services.

The console has a direct interface to the central processing unit to allow access to the status of approximately 17,000 system key logic points and setting of control and data registers. The computer-to-console interface allows diagnostic tests to be performed on the central processor modules under control of the Console Processor without regard to the operating condition of the central processor, the I/O channels, or other components of the main system. The system console is also equipped with a channel interface to a selector or multiplexer channel for operation as a standard console device.

The system console operates in three modes: the maintenance mode, the hardware command mode, and the device support mode. In the device support mode, the console emulates either an IBM 3066 system console or an IBM 3215 console printer-keyboard (using the CRT display for output in place of the 3210 matrix printers), and can be connected to either a selector or block multiplexer channel. Functions that can be performed in the hardware command mode include IPL, reset operations, display and modification of the contents of registers and main storage locations, and setting of operating conditions for the system.

INPUT/OUTPUT CONTROL

Each 470 central processor includes standard input/output channels, each of which can be configured as a byte multiplexer, block multiplexer, or selector channel. Data rates are given in the table on pages 01b and 01c.

The aggregate I/O data transfer rate for each system is less than the total of the maximum rates of all the attached channels. Each group of four channels shares certain hardware elements, causing contentions at the interface to the CPU.

Each selector-type channel can address up to 256 input/output devices and contains a single implicit channel for addressing one device at a time at burst-mode speeds. In the 470V/7C through 470V/7, 2,048 subchannels are available for assignment to either byte or block multiplexer channels. Channels with either 64 or 128 assigned subchannels can be configured for shared-channel operation. In channels with 64 subchannels, 4 can be shared, while those with 128 subchannels can have 8 shared subchannels. For the 470V/7 Series and 470V/8, subchannels are allocated in groups of 32, providing a total of 2,048 subchannels. The maximum number of subchannels available on all current models (except the 470V/7C) is 4,096.

In all 470 processors, input/output operations are performed under control of the Channel Unit (C-Unit), which operates independently of central processor operations. The C-Unit consists of three major functional units called the Central Interface Control Logic (CICL), the Direct Access Control Logic (DACL), and the Operation Control Logic (OCL), plus buffers and communications areas and the Remote Interface Logic which interfaces to control units for any System/360 or System/370-compatible peripheral devices.

The CICL controls the transfer and buffering of data between the Channel Buffer Store and the peripheral devices. It polls the channels every eight cycles for data transfer requests, and transfers data from the Channel Buffer Store to the Remote Interface Logic one or two bytes at a time.

The DACL controls the movement of data between the Storage Unit and the Channel Buffer Store and has a data transfer rate of one word every eight cycles. The DACL is organized as a pipeline to allow overlapping of the functions. It polls each channel every 16 cycles for service requests, concurrently transfers data in both directions between the Storage Unit and the Channel Buffer Store, and reads or stores the results of each transfer operation.

The OCL translates channel commands and coordinates channel program execution for the C-Unit.

A dynamic priority scheme controls the allocation of service to I/O channels. Channels can issue high-priority and low-priority requests for service. Each channel is assigned a 32-byte buffer area in the Channel Buffer Store. Channels with less than half a buffer area remaining are assigned high priority, while those with more than half a buffer space available are assigned low priority. The S-Unit resolves conflicts for access to the High-Speed Buffer according to its own internal priority structure, permitting high-priority channel requests to take precedence over central processor requests for access to the High-Speed Buffer. An I/O operation is always executed at a higher priority than buffer prefetch operations.

The C-Unit performs parity checks on all input and output data transfers and on data transfers to the Storage Unit. Other functions include channel indirect addressing comparable to that implemented on the System/370 and 303X, and extended channel logout.

SIMULTANEOUS OPERATIONS: The Channel Unit operates independently of central processor operations. Both can access the HSB simultaneously and independently. Also, instruction lookahead is on four levels with a maximum of six instructions in the pipeline running concurrently with instruction execution, checking, and storage of results.

HARDWARE MONITOR INTERFACE: HMI is designed for customers who wish to monitor their 470V/7C, 470V/7B, 470V/7A, 470V/7, and 470V/8 processors, allowing users to record up to 30 categories of signals. The HMI does not record the signals, but makes them available so that they can be utilized by hardware monitors. The types of signals processed include quantity of instructions executed, processor time in active state, processor time in problem state, number of interrupts, and channel busy time.

AMDAHL DIAGNOSTIC ASSISTANCE CENTER (AMDAC): Located at Sunnyvale, CA, Columbia, MD, Toronto, and London, AMDAC is maintained 24 hours per day and 7 days a week by technical support specialists to solve difficult problems that cannot be resolved by field engineering on site. Via the modem in the user's 470 console, an on-line telephone hookup can be established between AMDAC and the customer system. AMDAC maintains a variety of system consoles, any of which can perform standard diagnostic tests on the user's system.

470/ACCELERATOR: Available in the 470V/7C, 470V/7B, and 470V/7A, the 470/Accelerator is a hardware product initiated by a software command. The feature is implemented in LSI circuitry within the 470 mainframe, and requires no additional cabinets or frames. The 470/Accelerator is designed for users who want increased processing ►

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power on an as-needed basis, without having expensive idle capacity over the long term. By invoking the 470/Accelerator, a 470V/7C user can have the power of a 470V/7B; a 470V/7B user the power of the 470V/7A; and the 470V/7A user the power of the 470V/7. Activation of the 470/Accelerator is by a single console command, ACCL. The feature is deactivated by the DECL command. 470/Accelerator billing is on a metered-hour basis.

470/EXTENDED PERFORMANCE ACCELERATOR: Similar to the 470/Accelerator, and also charged on an hourly basis, this feature is available only on the 470V/7B system and increases performance by 50 percent, equivalent to that of the 470V/7. Both features can be installed on a 470V/7B, and are mutually exclusive.

PERIPHERAL EQUIPMENT

The Amdahl 470 systems can utilize all IBM System/360 and System/370 input/output and mass storage devices, as well as their plug-compatible counterparts from independent vendors. This also includes Amdahl 6000 Series of DASD equipment. Detailed coverage of many of these peripherals can be found in Volume 2 of DATAPRO 70.

COMMUNICATIONS EQUIPMENT

COMMUNICATIONS PROCESSORS: The 4705 and 4705E Communications Processors are program-compatible with IBM's 3705-II front-end processor. The 4705 is claimed to have 1.8 times and the 4705E to have 2.5 times the throughput of a comparable 3705-II. The controller has 64K bytes of memory, and is expandable to 512K in 64K-byte increments. Up to 352 communications lines can be connected to the 4705 and 4705E, with transmission speeds up to 64,000 bps possible. As many as four CPUs can be connected to a 4705 and 4705E through a standard channel adapter. Host channels can be either byte multiplexer, block multiplexer, or selector-type.

Communications features include support for the following access methods—BTAM, QTAM, TCAM, VTAM, ACF, and MSNF. The 4705 and 4705E is compatible with IBM's SNA network architecture and handles the following protocols: BSC, SDLC, and start/stop. Communications lines can have the following characteristics: half- or full-duplex, EIA RS-232-C and CCITT V.24 and V.35.

The 4705 and 4705E also features on-line and standalone diagnostics, instruction lookahead, instruction retry, and automatic fault isolation.

4400 SERIES NETWORK SYSTEMS: Amdahl developed a family of network products designed for support of interactive applications plus the capability to access X.25 packet switching networks. The 4400 Series includes four Network Concentrators, each of which supports different communications protocols, and a Network Administrator, which centralizes network management functions, handles billing, and conducts diagnostics. Included in the Network Concentrators are the 4410, which supports X.25; the 4440, for asynchronous devices; the 4450, for 3270-type bisynchronous terminals; and the 4460, which supports a mix of asynchronous and bisynchronous devices. The 4404 Network Administrator includes a console, disk storage, and one or more printers. The 4440 Series products will be available by the end of 1982.

SOFTWARE

Amdahl offers complete functional compatibility with IBM 360/370/303X/308X software. Operating systems support-

ed include OS/VS1, OS/MVT, SVS, MVS, MVS/SP, MVS/XA, VM/370, VM/SP, SVS with HPO Extensions, and ACP. Support is included for such major IBM subsystems as HASP, ASP, TSO, TCAM, JES2, JES3, VTAM, RSCS, CMS, and IPCS.

VM/EXTENDED CHANNEL SUPPORT (VM/ECS): Used in conjunction with Amdahl's 470/Extended Channels hardware, this program product provides support for up to 32 channels operating in a VM environment. The software also supports Amdahl's MVS/ECS program product.

VM/EXTENDED CHANNEL SUPPORT (MVS/ECS): Similar to VM/ECS, MVS/ECS can support up to 32 channels on a 470 system. MVS/ECS does not, however, extend the maximum number of controllers, devices, or optional channel paths that can be configured under MVS.

Amdahl also offers several other software products for use on 470 and compatible processors. These software products are briefly described below. For further details, please see the Datapro Directory of Software.

VM/PERFORMANCE ENHANCEMENT (VM/PE): This product improves the performance to near native state levels and availability of an MVS system when running under VM/SP.

VM/SOFTWARE ASSIST (VM/SA): This product improves virtual machine performance under VM/SP by reducing privileged instruction simulation.

MVS/SP ASSIST (MVS/SPA): MVS/SPA is designed to improve the performance of an MVS/SP Version 1 Release 3 system when run on a CPU without the IBM System 370 extended facilities.

MVS/SE ASSIST (MVS/SEA): This software package allows the execution of MVS/SE and MVS/SP systems on uniprocessors without the IBM System/370 Extended Facility (EF) feature.

MVS/SE SUPPORT (MVS/SES): This product allows the execution of MVS/SE and MVS/SP systems on attached processors and multiprocessors without the IBM System/370 Extended Facility (EF) feature.

UNIVERSAL TIMESHARING SYSTEM (UTS): UTS provides a UNIX V.7-based time sharing system for use on System/370 architecture processors.

CMS ACCELERATOR (CMS/XL): This product is designed to improve performance in a CMS-intensive environment by reducing system overhead and system disk contention.

SERVICE AND SUPPORT

AMDAHL DIAGNOSTIC ASSISTANCE CENTER (AMDAC): Located at Amdahl headquarters in Sunnyvale, and in Columbia, MD, Toronto, and London, AMDAC is maintained 24 hours per day and 7 days a week by technical support specialists to solve difficult problems that cannot be resolved by field engineering on site. An on-line telephone hookup can be established between AMDAC and the customer system to isolate system problems. AMDAC maintains a variety of system consoles, any of which can perform standard diagnostic tests on the user's system. Program Temporary Fixes (PTFs) can also be implemented on a 470.

Field Support Centers (FSC), located worldwide, help insure a smooth transition at installation time. FSCs are also

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► chartered to analyze and correct problems in supported operating systems.

PRICING

The Amdahl 470 systems are offered for purchase or for lease under two- or four-year operating lease plans. Leases can be renewed for 12-month periods. Lease payments must be made monthly in advance. Lease payments include the lease charge, property taxes, and insurance, but not maintenance charges. The minimum lease term for a system up-

grade is 12 months. Leases can be terminated after two years upon payment of 30 percent of the total remaining rental payments. A 90-day written notice is required for cancellation. For users wishing to purchase leased equipment, purchase credits of 25 percent of each monthly payment are allowed to a maximum aggregate credit of 50 percent of the purchase price. The purchase credit applies either to the original price or the current price.

Maintenance is provided for 24 hours per day and 7 days per week.

EQUIPMENT PRICES

PROCESSORS AND MAIN MEMORY

470V/7C CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below

With 8,388,608 bytes of main memory and:

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
8 channels	\$1,150,000	\$9,550	\$67,425	\$52,150
12 channels	1,300,000	9,850	74,550	57,900
16 channels	1,450,000	10,150	81,675	63,450

With 12,582,912 bytes of main memory and:

8 channels	1,300,000	10,150	79,825	61,800
12 channels	1,450,000	10,450	86,950	67,450
16 channels	1,600,000	10,750	94,075	73,100

With 16,777,216 bytes of main memory and:

8 channels	1,450,000	10,750	92,225	71,450
12 channels	1,600,000	11,050	99,350	77,100
16 channels	1,750,000	11,350	106,475	82,750

470V/7B CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:

With 8,388,608 bytes of main memory and:

8 channels	1,225,000	11,140	69,875	54,285
12 channels	1,375,000	11,440	77,000	59,935
16 channels	1,525,000	11,740	84,125	65,585
24 channels	1,950,000	13,600	104,740	81,625
28 channels	2,100,000	13,900	111,865	87,275
32 channels	2,250,000	14,200	118,990	92,925

With 12,582,912 bytes of main memory and:

8 channels	1,375,000	11,740	82,275	63,935
12 channels	1,525,000	12,040	89,400	69,585
16 channels	1,675,000	12,340	96,525	75,235
24 channels	2,100,000	14,200	117,140	91,275
28 channels	2,250,000	14,500	124,265	96,925
32 channels	2,400,000	14,800	131,390	102,575

*Includes 24-hour 7-day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

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EQUIPMENT PRICES

		<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY**					
470V/7C	CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
	With 8,388,608 bytes of main memory and:				
	8 channels	\$1,150,000	\$ 9,550	\$ 67,425	\$52,150
	12 channels	1,300,000	10,050	74,550	57,800
	16 channels	1,450,000	10,550	81,675	63,450
	With 12,582,912 bytes of main memory and:				
	8 channels	1,300,000	11,450	79,825	61,800
	12 channels	1,450,000	11,950	86,950	67,450
	16 channels	1,600,000	12,450	94,075	73,100
	With 16,777,216 bytes of main memory and:				
	8 channels	1,450,000	13,350	92,225	71,450
	12 channels	1,600,000	13,850	99,350	77,100
	16 channels	1,750,000	14,350	106,475	82,750
470V/7B	CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
	With 8,388,608 bytes of main memory and:				
	8 channels	1,225,000	11,140	69,875	54,285
	12 channels	1,375,000	11,640	77,000	59,935
	16 channels	1,525,000	12,140	84,125	65,585
	With 12,582,912 bytes of main memory and:				
	8 channels	1,375,000	13,040	82,175	63,935
	12 channels	1,525,000	13,540	89,300	69,585
	16 channels	1,675,000	14,040	96,425	75,235
	With 16,777,216 bytes of main memory and:				
	8 channels	1,525,000	14,940	94,475	73,585
	12 channels	1,675,000	15,440	101,600	79,235
	16 channels	1,825,000	15,940	108,725	84,885
470V/7A	CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
	With 8,388,608 bytes of main memory and:				
	8 channels	1,375,000	11,440	77,340	60,245
	12 channels	1,525,000	11,940	84,465	65,895
	16 channels	1,675,000	12,440	91,590	71,545
	With 12,582,912 bytes of main memory and:				
	8 channels	1,525,000	13,340	89,740	69,895
	12 channels	1,675,000	13,840	96,865	75,545
	16 channels	1,825,000	14,340	103,990	81,195
	With 16,777,216 bytes of main memory and:				
	8 channels	1,675,000	15,240	102,140	79,545
	12 channels	1,825,000	15,740	109,265	85,195
	16 channels	1,975,000	16,240	116,390	90,845
470V/7	CPU Complex; includes 32K-byte buffer-storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
	With 8,388,608 bytes of main memory and:				
	12 channels	1,850,000	12,170	90,805	70,960
	16 channels	2,000,000	12,670	97,930	76,610
	With 12,582,912 bytes of main memory and:				
	12 channels	2,000,000	14,070	103,205	80,610
	16 channels	2,150,000	14,570	110,330	86,260
	With 16,777,216 bytes of main memory and:				
	12 channels	2,150,000	15,970	115,605	90,260
	16 channels	2,300,000	16,470	122,730	95,910

*Includes 24-hour 7-day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

Amdahl 470

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY** (Continued)				
470V/8 CPU Complex; includes 64K-byte buffer storage console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
With 8,388,608 bytes of main memory and:				
12 channels	2,075,000	12,650	97,335	76,100
16 channels	2,225,000	13,150	104,460	81,750
With 12,582,912 bytes of main memory and:				
12 channels	2,225,000	14,550	109,735	85,750
16 channels	2,375,000	15,050	116,860	91,400
With 16,777,216 bytes of main memory and:				
12 channels	2,375,000	16,450	122,135	95,400
16 channels	2,525,000	16,950	129,260	101,050
MEMORY AND PROCESSOR OPTIONS				
4-Megabyte Memory Increment for 470V/7 Series and 470V/8	150,000	1,900	15,500	12,065
Extended Memory, availability to be announced 1st quarter 1982	150,000	—	6,250	5,000
Additional 470 Series Channels; requires minimum 16 channels with CPU complex:				
24 channels	425,000	2,260	20,615	16,040
28 channels	575,000	2,760	27,740	21,690
32 channels	725,000	3,260	34,865	27,340
Four-Channel Group	150,000	500	8,910	7,065
Eight-Channel Group, above 16 channels	425,000	2,260	25,775	22,050
4,096 Subchannels (per Channel Unit)	50,000	—	3,125	2,500
High-Speed Channel Feature (provides two Data Streaming channels per four-channel group)	40,000	30	1,420	1,135
Channel to Channel Adapter	32,500	—	1,000	900
Two-Byte Interface	1,400	—	50	40
Hardware Measurement Interface for 470V/7C through 470V/8	40,000	150	1,865	1,400
Field Upgrade 470V/7C to 470V/7B	125,000	1,590	8,165	6,425
470V/7B to 470V/7A	200,000	300	9,330	7,450
470V/7A to 470V/7***	375,000	230	7,925	6,340
470V/7 to 470V/8	275,000	480	8,165	6,425

*Includes 24-hour/7-day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

***Minimum of 12 channels required for upgrade.

SOFTWARE PRICES

	<u>Field Installation Charge</u>	<u>Factory Installation Charge</u>	<u>Comments</u>
470/Accelerator Hardware for 470V/7C, 470V/7B, 470V/7A	\$1,500	\$1,000	No charge for first month plus \$90 for each additional metered hour thereafter
470/Extended Performance Accelerator Hardware for 470V/7B only	3,000	2,500	No charge for first month plus \$300 for each additional metered hour thereafter

Amdahl 470 Systems

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY** (Continued)				
With 16,777,216 bytes of main memory and:				
8 channels	1,525,000	12,340	94,675	73,585
12 channels	1,675,000	12,640	101,800	79,235
16 channels	1,825,000	12,940	108,925	84,885
24 channels	2,250,000	14,800	129,540	100,925
28 channels	2,400,000	15,100	136,665	106,575
32 channels	2,550,000	15,400	143,790	112,225
With 20,971,520 bytes of main memory and:				
8 channels	1,825,000	12,940	112,075	87,235
12 channels	1,975,000	13,240	119,200	92,885
16 channels	2,125,000	13,540	126,325	98,535
24 channels	2,550,000	15,400	146,940	114,575
28 channels	2,700,000	15,700	154,065	120,225
32 channels	2,850,000	16,000	161,190	125,875
With 25,165,824 bytes of main memory and:				
8 channels	1,975,000	13,540	124,475	96,885
12 channels	2,125,000	13,840	131,600	102,535
16 channels	2,275,000	14,140	138,725	108,185
24 channels	2,700,000	16,000	159,340	124,225
28 channels	2,850,000	16,300	166,465	129,875
32 channels	3,000,000	16,600	173,590	135,525
With 28,688,128 bytes of main memory and:				
8 channels	2,125,000	14,140	136,875	106,535
12 channels	2,275,000	14,440	144,000	112,186
16 channels	2,425,000	14,740	151,125	117,835
24 channels	2,850,000	16,600	171,740	133,875
28 channels	3,000,000	16,900	178,865	139,525
32 channels	3,150,000	17,200	185,990	145,175
With 33,554,432 bytes of main memory and:				
8 channels	2,275,000	14,740	149,275	116,185
12 channels	2,425,000	15,040	156,400	121,835
16 channels	2,575,000	15,340	163,525	127,485
24 channels	3,000,000	17,200	184,140	143,525
28 channels	3,150,000	17,500	191,265	149,175
32 channels	3,300,000	17,800	198,390	154,825
470V/7A	CPU Complex; includes 32K-byte buffer storage, console with maintenance processor and power distribution unit; main memory and channels as indicated below:			
With 8,388,608 bytes of main memory and:				
8 channels	1,375,000	11,440	77,340	60,245
12 channels	1,525,000	11,740	84,465	65,895
16 channels	1,675,000	12,040	91,590	71,545
24 channels	2,105,000	13,900	112,205	87,585
28 channels	2,250,000	14,200	119,330	93,235
32 channels	2,400,000	14,500	126,455	98,885

*Includes 24-hour 7-day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

Amdahl 470 Systems

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY** (Continued)				
With 12,582,912 bytes of main memory and:				
8 channels	1,525,000	12,040	89,740	69,895
12 channels	1,675,000	12,340	96,865	75,545
16 channels	1,825,000	12,640	103,990	81,195
24 channels	2,250,000	14,500	124,605	97,235
28 channels	2,400,000	14,800	131,730	102,885
32 channels	2,550,000	15,100	138,855	108,535
With 16,772,216 bytes of main memory and:				
8 channels	1,675,000	12,640	102,140	79,545
12 channels	1,825,000	12,940	109,265	85,195
16 channels	1,975,000	13,240	116,390	90,845
24 channels	2,400,000	15,100	137,005	106,885
28 channels	2,550,000	15,400	144,130	112,535
32 channels	2,700,000	15,700	151,255	118,185
With 20,971,520 bytes of main memory and:				
8 channels	1,975,000	13,240	119,540	93,195
12 channels	2,125,000	13,540	126,665	98,845
16 channels	2,275,000	13,840	133,790	104,495
24 channels	2,700,000	15,700	154,405	120,535
28 channels	2,850,000	16,000	161,530	126,185
32 channels	3,000,000	16,300	168,655	131,835
With 25,165,824 bytes of main memory and:				
8 channels	2,125,000	13,840	131,940	102,845
12 channels	2,275,000	14,140	139,065	108,495
16 channels	2,425,000	14,440	146,190	114,145
24 channels	2,850,000	16,300	166,805	130,185
28 channels	3,000,000	16,600	173,930	135,835
32 channels	3,150,000	16,900	181,055	141,485
With 28,688,128 bytes of main memory and:				
8 channels	2,275,000	14,440	144,340	112,495
12 channels	2,425,000	14,740	151,465	118,145
16 channels	2,575,000	15,040	158,590	123,795
24 channels	3,000,000	16,900	179,205	139,835
28 channels	3,150,000	17,200	186,330	145,485
32 channels	3,300,000	17,500	193,455	151,135
With 33,554,432 bytes of main memory and:				
8 channels	2,425,000	15,040	156,740	122,145
12 channels	2,575,000	15,340	163,865	127,795
16 channels	2,725,000	15,640	170,990	133,445
24 channels	3,150,000	17,500	191,605	149,485
28 channels	3,300,000	17,800	198,730	155,135
32 channels	3,450,000	18,100	205,855	160,785

*Includes 24-hour/7-day service; applies to both purchase and leased systems.

**Four megabytes of main memory no longer available.

Amdahl 470 Systems

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY** (Continued)				
470V/7	CPU Complex; includes 32K-byte buffer storage, console with maintenance processor, and power distribution unit; main memory and channels as indicated below:			
With 8,388,608 bytes of main memory and:				
8 channels	1,700,000	11,670	83,680	65,310
12 channels	1,850,000	11,970	90,805	70,960
16 channels	2,000,000	12,270	97,930	76,610
24 channels	2,425,000	14,130	118,545	92,650
28 channels	2,575,000	14,430	125,670	98,300
32 channels	2,725,000	14,730	132,795	103,950
With 12,582,912 bytes of main memory and:				
8 channels	1,850,000	12,270	96,080	74,960
12 channels	2,000,000	12,570	103,205	80,610
16 channels	2,150,000	12,870	110,330	86,260
24 channels	2,575,000	14,730	130,945	102,300
28 channels	2,725,000	15,030	138,070	107,950
32 channels	2,875,000	15,330	145,195	113,600
With 16,777,216 bytes of main memory and:				
8 channels	2,000,000	12,870	108,480	84,610
12 channels	2,150,000	13,170	115,605	90,260
16 channels	2,300,000	13,470	122,730	95,910
24 channels	2,725,000	15,330	143,345	111,950
28 channels	2,875,000	15,630	150,470	117,600
32 channels	3,025,000	15,930	157,595	123,250
With 20,971,520 bytes of main memory and:				
8 channels	2,300,000	13,470	125,880	98,260
12 channels	2,450,000	13,770	133,005	103,910
16 channels	2,600,000	14,070	140,130	109,560
24 channels	3,025,000	15,930	160,745	125,600
28 channels	3,175,000	16,230	167,870	131,250
32 channels	3,325,000	16,530	174,995	136,900
With 25,165,824 bytes of main memory and:				
8 channels	2,450,000	14,070	138,280	107,910
12 channels	2,600,000	14,370	145,405	113,560
16 channels	2,750,000	14,670	152,530	119,210
24 channels	3,175,000	16,530	173,145	135,250
28 channels	3,325,000	16,830	180,270	140,900
32 channels	3,475,000	17,130	187,395	146,550
With 28,688,128 bytes of main memory and:				
8 channels	2,600,000	14,670	150,680	117,560
12 channels	2,750,000	14,970	157,805	123,210
16 channels	2,900,000	15,270	164,930	128,860
24 channels	3,325,000	17,130	185,545	144,900
28 channels	3,475,000	17,430	192,670	150,550
32 channels	3,625,000	17,730	199,795	156,200

*Includes 24-hour/7 day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

Amdahl 470 Systems

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
PROCESSORS AND MAIN MEMORY** (Continued)				
With 33,554,432 bytes of main memory and:				
8 channels	2,750,000	15,270	163,080	127,210
12 channels	2,900,000	15,570	170,205	132,860
16 channels	3,050,000	15,870	177,330	138,510
24 channels	3,475,000	17,730	197,945	154,550
28 channels	3,625,000	18,030	205,070	160,200
32 channels	3,775,000	18,830	212,195	165,850
470V/8 CPU Complex; includes 64K-byte buffer storage console with maintenance processor, and power distribution unit; main memory and channels as indicated below:				
With 8,388,608 bytes of main memory and:				
8 channels	1,925,000	12,150	90,210	70,450
12 channels	2,075,000	12,450	97,335	76,100
16 channels	2,225,000	12,750	104,460	81,750
24 channels	2,650,000	14,610	125,075	97,790
28 channels	2,800,000	14,910	132,200	103,440
32 channels	2,950,000	15,210	139,325	109,090
With 12,582,912 bytes of main memory and:				
8 channels	2,075,000	12,750	102,610	80,100
12 channels	2,225,000	13,050	109,735	85,750
16 channels	2,375,000	13,350	116,860	91,400
24 channels	2,800,000	15,210	137,475	107,440
28 channels	2,950,000	15,510	144,600	113,090
32 channels	3,100,000	15,810	151,725	118,740
With 16,777,216 bytes of main memory and:				
8 channels	2,225,000	13,350	115,010	89,750
12 channels	2,375,000	13,650	122,135	95,400
16 channels	2,525,000	13,950	129,260	101,050
24 channels	2,950,000	15,810	149,875	117,090
28 channels	3,100,000	16,110	157,000	122,740
32 channels	3,250,000	16,410	164,125	128,390
With 20,971,520 bytes of main memory and:				
8 channels	2,525,000	13,950	132,410	103,400
12 channels	2,675,000	14,250	139,535	109,050
16 channels	2,825,000	14,550	146,660	114,700
24 channels	3,250,000	16,410	167,275	130,740
28 channels	3,400,000	16,710	174,400	136,390
32 channels	3,550,000	17,010	181,525	142,040
With 25,165,824 bytes of main memory and:				
8 channels	2,675,000	14,550	144,810	113,050
12 channels	2,825,000	14,850	151,935	118,700
16 channels	2,975,000	15,150	159,060	124,350
24 channels	3,400,000	17,010	179,675	140,390
28 channels	3,550,000	17,310	186,800	146,040
32 channels	3,700,000	17,610	193,925	151,690

*Includes 24-hour/7 day service; applies to both purchased and leased systems.

**Four megabytes of main memory no longer available.

Amdahl 470 Systems

EQUIPMENT PRICES

<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>
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PROCESSORS AND MAIN MEMORY** (Continued)

With 28,688,128 bytes of main memory and:

8 channels	2,825,000	15,150	157,210	122,700
12 channels	2,975,000	15,450	164,335	128,350
16 channels	3,125,000	15,750	171,460	134,000
24 channels	3,550,000	17,610	192,075	150,040
28 channels	3,700,000	17,910	199,200	155,690
32 channels	3,850,000	18,210	206,325	161,340

With 33,554,432 bytes of main memory and:

8 channels	2,975,000	15,750	169,610	132,350
12 channels	3,125,000	16,050	176,735	138,000
16 channels	3,275,000	16,350	183,860	143,650
24 channels	3,700,000	18,210	204,475	159,690
28 channels	3,850,000	18,510	211,600	165,340
32 channels	4,000,000	18,810	218,725	170,990

MEMORY AND PROCESSOR OPTIONS

4-Megabyte Memory Increment for 470V/7 Series and 470V/8	150,000	600	15,500	12,065
Extended Memory, availability to be announced 1st quarter 1982	150,000	—	6,250	5,000
Four-Channel Group	150,000	300	8,910	7,065
Eight-Channel Group, above 16 channels (not for 470V/7C) (includes 2nd Channel-Unit)	425,000	1,860	25,775	22,050
4,096 Subchannels (per Channel Unit)	50,000	—	3,125	2,500
High-Speed Channel Feature (provides two Data Streaming channels per four-channel group)	40,000	30	1,420	1,135
Channel to Channel Adapter	32,500	—	1,000	900
Two-Byte Interface	1,400	—	50	40
Hardware Measurement Interface for 470V/7C through 470V/8	40,000	150	1,865	1,400
Field Upgrade 470V/7C to 470V/7B	125,000	1,590	8,165	6,425
470V/7B to 470V/7A	200,000	300	9,330	7,450
470V/7A to 470V/7***	375,000	230	7,925	6,340
470V/7 to 470V/8	275,000	480	8,165	6,425

*Includes 24-hour/7-day service; applies to both purchased and leased systems.

Four megabytes of main memory no longer available. *Minimum of 12 channels required for update.

Amdahl 470 Systems

EQUIPMENT PRICES

	<u>Purchase Price</u>	<u>Monthly Maint.*</u>	<u>2-Year Lease</u>	<u>4-Year Lease</u>		
470/Extended Architecture Feature (470/XA), availability to be announced 2nd quarter 1984	250,000	250	15,625	12,500		
					<u>Field Installation Charge</u>	<u>Factory Installation Charge</u>
470/Accelerator Hardware for 470V/7C, 470V/7B, 470V/7A; no charge for first month plus \$90 for each additional metered hour thereafter					\$1,500	\$1,000
470/Extended Performance Accelerator Hardware for 470V/7B only; no charge for first month plus \$300 for each additional metered hour thereafter					3,000	2,500

SOFTWARE PRICES

	<u>Monthly License</u>
LEASE OR LICENSE ONLY PRODUCTS	
VM/Performance Enhancement Release 4.0/charge per processor	\$2,000
MVS/SE Support/charge per complex at Amdahl sites	
MVS/SE Assist/charge per processor	350
MVS/SP Assist/charge per processor	350
VM/Extended Channel Support/charge per processor	1,000
MVS/Extended Channel Support/charge per processor	500
VM/Software Assist	575
Universal Timesharing System (UTS)	1,500
CMS/XL	725

*Includes 24-hour/7 day service; applies to both purchased and leased systems.

Amdahl 470

SOFTWARE PRICES

LEASE OR LICENSE ONLY PRODUCTS

Monthly License

VM/Performance Enhancement Release 3.0	\$1,750 per processor
MVS/SE Support	1,750 per complex at Amdahl sites
MVS/SE Assist	250 per processor
VM/Extended Channel Support	1,000 per processor
MVS/Extended Channel Support	500 per processor
Universal Timesharing System (UTS)	3,000
Amdahl Internally Developed Software (AIDS)	
IMS/VS HDAM Optimizer	225* per processor
ACP/System Error Dump Analysis	500 per processor; for initially designated processor only; no charge for additional processors on site
VM/Software Assist	500 —

*24-month period only.