Xerox Sigma Series

MANAGEMENT SUMMARY

Since the advent of the Sigma series with announcement of the Sigma 7 processor in March 1966, the product line has grown through the subsequent addition of models 2, 3, 5, 6, 8, and 9. The small-scale Sigma 2, announced in August 1966, has been obsoleted by the Sigma 3, and the Sigma 7 has largely been superseded by the Sigma 6. The 7 remains available for sale, although it is no longer actively marketed.

Market reception of the Sigma series has been good among sophisticated scientific users, but has been slow in the commercial marketplace. Historically, Xerox (then Scientific Data Systems) introduced the Sigma series as a direct competitor to the IBM System/360, with the promise of "at least two times more computations per dollar than any other machine in the industry." This claim was overly ambitious, but the Sigma 7 did offer about 50 percent more processing power than the System 360/50 at its introduction, and the ratio has increased in Xerox's favor since then with the availability of faster memory. Many of the advanced features of the current Sigma computers are based upon the experience which Scientific Data Systems gained by developing and marketing its very successful 900 and 9000 Series scientific computers between 1961 (when SDS was founded) and 1966.

There are a number of strengths in the Sigma Series, based for the most part upon excellent hardware ▷

The Sigma family includes some of the industry's most impressive medium-to-large-scale computer hardware. The traditional market emphasis of the series has been heavily directed toward real-time and scientific applications, but sophisticated commercial users with strong in-house systems development capabilities can also take advantage of the Sigma computers.

CHARACTERISTICS

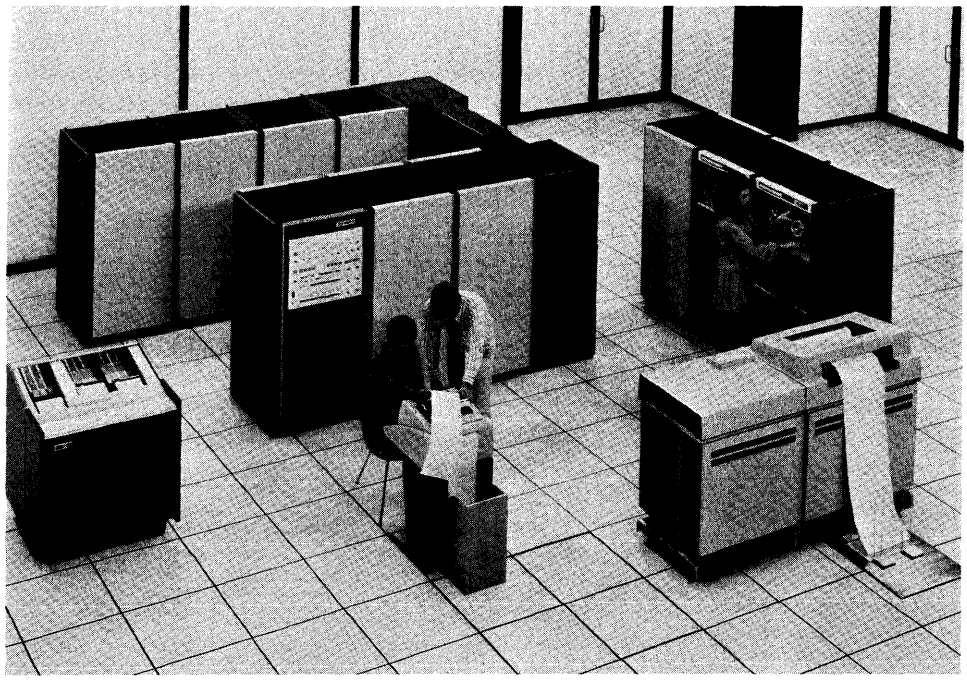
MANUFACTURER: Xerox Corporation, 701 South Aviation Boulevard, El Segundo, California 90245.

MODELS: Sigma 3, 5, 6, 7, 8, and 9.

DATA FORMATS

BASIC UNIT: Although the same 34-bit/word core memory is used in all Sigma processors, the Sigma 3 operates with a 16-bit word (two 8-bit bytes) plus a parity bit, and all the larger models use a 32-bit (four 8-bit bytes) word plus parity bit.

FIXED-POINT OPERANDS: The Sigma 3 uses a 16-bit word, with optional double-precision (32-bit doubleword) arithmetic operations. The larger models all use 32-bit words, with operations performed upon 8-bit bytes, 16-bit halfwords, 64-bit doublewords, and/or immediate operands contained in the instruction words. ▶



The Sigma 8 computer system is oriented toward real-time and scientific applications. It was developed for use in process control, manufacturing, education, health care, research, and other high-technology environments.

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designs. Although many of the hardware features were designed for SDS's traditional real-time, time-sharing, and scientific computer markets, a substantial number are also intended for general-purpose and commercial users.

For real-time use, Xerox provides a flexible interrupt system ranging from 112 interrupts on the Sigma 3 to 237 or more on the larger Sigma processors. Watchdog timers are built-in to assure that special real-time sensors or asynchronous devices which do not respond within a reasonable period cannot hang the entire system up, and up to four real-time clocks provide timing information and signals for critical time-dependent processes in real-time environments.

Time-sharing users can benefit from rapid context switching and storing by using multiple register blocks and push-down stack instructions to load entire blocks of registers with a single command. Master and slave modes of operation provide lock-and-key protection to certain memory locations and restricted access to privileged instructions. A memory mapping capability allows programs to be swapped into fragmented memory areas, thus reducing the swapping overhead time otherwise required to clear large, contiguous memory areas. A wide variety of fixed-head Rapid Access Data (RAD) storage devices is available for temporary storage of swapped programs.

Scientific users in general benefit from many of the above features, plus the symbiont I/O processors (IOP's) which handle I/O along independent memory access paths to permit heavy number-crunching to continue in the CPU without I/O interference. Floating-point single and extended precision hardware is also available for scientific users.

Commercial users can take advantage of decimal instructions and comprehensive data manipulation and conversion capabilities, and they can also benefit from many of the above scientific and real-time features.

All of these fine hardware capabilities, however, must be driven by the Xerox operating systems, and these systems have historically been at the root of many of Xerox's computer problems.

Among the early pitfalls encountered in developing the Sigma series were considerable delays in delivering several complex operating systems, notably the Universal Time-Sharing System. UTS was announced in 1966 as a multipurpose system that would, in effect, be all things to all people. Initially, Xerox (then Scientific Data Systems) contracted for extensive out-of-house software development work, which failed to produce the necessary results.

FLOATING-POINT OPERANDS: The Sigma 5 and larger models use either a short form, consisting of one word with a 24-bit-plus-sign fraction and 7-bit exponent; or a long form, consisting of two words with a 56-bit-plus-sign fraction and 7-bit exponent. Floating-point hardware is optional on the Sigma 5, 6, and 7, and standard on the 8 and 9. Floating-point hardware is not available for the Sigma 3.

INSTRUCTIONS: The Sigma 3 uses one 16-bit word consisting of a 4-bit Operation Code, 4 bits for Register Designators, and an 8-bit Address Field. The Sigma 5 and larger models use one 32-bit word consisting of a 1-bit code for immediate or indirect addressing, a 7-bit Operation Code, a 4-bit General Register Address Field, and either a 20-bit Value Field Integer (for immediate instructions) or a 3-bit Index Register Address and a 17-bit Reference Address (for indirect address instructions).

INTERNAL CODE: Either 8-bit EBCDIC or 7-bit ASCII is used for internal data representation, with no two printable EBCDIC codes having their seven low-order bits common with one another.

MAIN STORAGE

STORAGE TYPE: Magnetic core for main memory, plus optional high-speed integrated-circuit (IC) memories for storage of a set of memory access and/or write-protection codes or locks for the Sigma 5 and larger models.

CAPACITY: See table.

CYCLE TIME: See table.

CHECKING: Parity bit with each 16-bit word in the Sigma 3 or each 32-bit word in the larger Sigmas is generated during writing and checked during reading.

STORAGE PROTECTION: The Sigma 3 provides 16 optional 1-word registers, each bit of which specifies write protection only for memory blocks or pages of 256 addresses. Each 1-word register, therefore, can protect up to 4,096 16-bit words (8K bytes). The full bank of 16 protection registers can thus protect the full 64K-word Sigma 3 maximum memory size.

The Sigma 5 and all larger models use 256 2-bit write-protect locks to protect 512-word pages of main memory from unauthorized writing only. The keys to these locks can be set up only in the privileged or "master" mode of operation. The Sigma 6, 7, and 9, equipped with the memory map, also provide write-only access or complete denial of access to 512-word pages from programs operating in the "slave" mode, in addition to the read-only access provided by the basic lock-and-key protection feature.

CENTRAL PROCESSORS

CONFIGURATION RULES: The Sigma 5 and larger models are designed to permit the attachment of multiple CPU's and independently functioning I/O processors up to the number of ports available on the memory banks. (Standard Xerox software, however, supports only one CPU). The basic memory bank on the Sigma 5 has one memory port which can be expanded to six. The Sigma 6 through 9 each have two standard ports, which can be expanded to eight on the Sigma 6 or 7 and up to twelve on

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CHARACTERISTICS OF THE SIGMA SERIES SYSTEMS

	Sigma 3	Sigma 5	Sigma 6	Sigma 7	Sigma 8	Sigma 9
SYSTEM CONFIGURATION						
Max.no. of I/O Processors (excluding CPU) supported by standard software	2	8	8	8	8	8
Max. no. of interactive terminals	None	64	128	128	64	128
Orientation of system	Process control, communications, scientific	Real-time, time-sharing, communications, general-purpose	General-purpose	Time-sharing, real-time, general-purpose	Scientific, real-time	Business, general-purpose
Typical system rental (including maintenance)	$3,500	$12,000	$18,000	$20,000	$20,000	$30,000
Date of first delivery	1969	1967	1970	1966	1971	1971
MAIN STORAGE						
Word length, bits	16	32	32	32	32	32
Cycle time, microseconds	0.975	0.950	0.950	0.950	0.900	0.900
Words accessed per cycle	1	1	1	1	1	1
Minimum capacity, words	8,192	8,192	32,768	8,192	16,384	65,536
Maximum capacity, words	65,536**	131,072	131,072	131,072	131,072	524,288
Increment size, words	8,192	8,192	16,384	8,192	16,384	16,384
Storage interleaving	None	2 or 4-way	2 or 4-way	2 or 4-way	2 or 4-way	2 or 4-way
Memory mapping	No	No	Standard	Optional	No	Standard
CENTRAL PROCESSOR						
No. of hardware instructions	37	90	106	108	101	112
Instruction look-ahead	No	No	1 instruction	1 instruction	2 instructions	2 instructions
Index registers	8	1x16 to 16x16	2x16 to 32x16	1x16 to 32x16	1x16 to 4x16	2x16 to 4x16
Double-precision floating-point	No	Optional	Optional	Optional	Standard	Standard
Decimal instructions	No	No	Standard	Optional	No	Standard
Interrupt service time, microseconds	7 (min.)	6 (min.)	6 (min.)	6 (min.)	6 (min.)	6 (min.)
Max. no. of interrupts—external/internal	96/16	224/13	224/13	224/13	224/14	224/14
Watchdog timer	Optional	Standard	Standard	Standard	Standard	Standard
INSTRUCTION TIMES						
Fixed-point binary microseconds:						
Add/subtract (32 bits)	3.2	2.0	2.0	2.0	0.7	0.7
Multiply (32 bits)	7.8*	7.2	5.0	5.0	3.3	3.3
Divide (32 bits)	8.1*	15.8	12.6	12.6	9.5	9.5
Load/store (32 bits)	4.2	2.0/2.5	1.8/2.6	1.8/2.6	0.7	0.7
Compare (32 bits)	4.2	2.1	2.0	2.0	0.8	0.8
Floating-point, microseconds:						
Add/subtract (single-precision)	Not avail.	4.8	3.3	3.3	2.1	2.1
Multiply (single-precision)	Not avail.	10.0	6.0	6.0	3.3	3.3
Divide (single-precision)	Not avail.	14.0	12.4	12.4	7.7	7.7
Add/subtract (double-precision)	Not avail.	9.0	4.1	4.1	2.9	2.9
Multiply (double-precision)	Not avail.	16.0	9.1	9.1	6.3	6.3
Divide (double-precision)	Not avail.	25.3	25.4	25.4	17.5	17.5
I/O CONTROL						
SIOP transfer rate, bytes/sec	Not used	4,000,000	4,000,000	4,000,000	Not used	Not used
MIOP/EIOP transfer rate, bytes/sec:						
Standard	500,000	450,000	450,000	450,000	500,000	500,000
With 4-byte option	850,000†	900,000	900,000	900,000	1,000,000	1,000,000
HSRIOP transfer rate, bytes/sec***	Not used	Not used	Not used	Not used	3,200,000	3,200,000
IIOP transfer rate, bytes/sec	450,000	Not used	Not used	Not used	Not used	Not used

*For 16-bit operands.
**The equivalent of 256K 16-bit words can be added through a Sigma 5/7 Memory Adapter.
***HSRIOP includes controller for 7212 RAD.
†Two-byte data transfer path on Sigma 3.

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At least part of the reason for the company's overconfidence that UTS could be developed readily was the huge success enjoyed by the earlier SDS 940 system—a "9" series time-sharing machine that ranks as one of the best time-sharing systems ever developed and is still in wide use. (Xerox maintains a special sales unit today to sell the "9" series as used equipment in response to a continuing market demand.) Unfortunately, the time-sharing operating system for the "9" series was developed at the University of California at Berkeley, and the true extent of its complexities and the difficulty of developing such a system for the then-fledgling Sigma series was not fully appreciated.

When UTS did not materialize, Xerox went on to develop several interim operating systems, such as the Real-Time Batch Monitor (RBM) and the Batch Time-Sharing Monitor (BTM). At least one of these, BTM, also encountered initial difficulties, resulting in an intensive Xerox program to make the promised operating systems work effectively.

Today, many of the problems in the earlier operating systems have been resolved, and a version of UTS brought out late in 1970 (which bears only slight resemblance to the UTS originally announced with the Sigma 7) is running on the Sigma 6. XOS, a major operating system designed by CII of France for systems in the IRIS series (manufactured under license agreement with Xerox), is now also available for the Sigma 6 and Sigma 9. Thus, Xerox currently places emphasis upon three main operating systems: RBM (for real-time users, available for the Sigma 3 through 9); XOS (for multiprogramming batch users); and UTS (for time-sharing).

The Xerox computers have had a heritage of scientific system usage. For that marketplace, Xerox has developed one of the industry's most extensive product offerings of system interface units to tie analog and sensor-based special-purpose devices into the computer mainframes. An experienced group of systems engineers has been organized specifically to respond to special user interface requirements for real-time, scientific, and university users.

Until 1969, the company placed only a secondary emphasis upon commercial data processing. At that time (coincident with the acquisition of the former Scientific Data Systems by Xerox Corporation), a business plan was established to focus heavier attention upon commercial activities. Recent additions to the Sigma product line (apart from the Sigma 6, 8, and 9 processors and on-going releases of operating system software) have aimed at increasing the number of standard Xerox peripheral devices available, such as magnetic tape units, printers, etc. The announcements

the Sigma 8 or 9. Bus-sharing MIOP's on the Sigma 5 through 9 allow two I/O processors to be attached to a given memory port.

The Sigma 3 is basically a stand-alone processor. An interface to Sigma 5 or 7 core memory is provided, however, to permit up to 8 banks with 4K to 16K 32-bit words each to be added to the Sigma 3. Thus, the Sigma 3 can effectively have up to 256K 16-bit words of Sigma 5 or 7 memory in addition to the maximum Sigma 3 memory.

REGISTERS: The Sigma 5 and larger models have 32-bit general-purpose registers grouped into blocks of 16 registers each. These fast integrated-circuit registers are activated in 16-register blocks by a 4-bit (on Sigma 5, 8, or 9) or 5-bit (on Sigma 6 and 7) control field in the Program Status Doubleword (PSD) known as the Register Block Pointer. The PSD is kept in the arithmetic and control unit, and is alterable only in the "master" mode. This prevents the register Block Pointer from being altered by any user program, and allows the Operating System Control programs to switch contexts from one user job to another with a different set of index registers assigned to each. Any of the registers in a block can be used as fixed- or floating-point accumulators, temporary storage, or for counters, etc. Registers 1 through 7 in each block can also be used as index registers, and registers 12 through 15 in each block are also used as accumulators for decimal arithmetic (optional on the Sigma 5, 6, and 7; standard on Sigma 8 and 9).

The Sigma 3 has one block of 32 16-bit high-speed integrated-circuit registers which is divided into 3 different groups: 8 General-Purpose Registers, 8 I/O Channel Registers, and 16 optional Protection System Registers. The I/O Channel Registers hold control information for the integrated I/O processor (IIOP). The Protection System Registers are explained under the "Storage Protection" heading above.

INDEXING: In the Sigma 5 and larger models, operand addresses can be modified by the 32-bit contents of any one of registers 1 through 7 in the current register block. The resulting effective address following an indexing operation is automatically adjusted (scaled) for operands of 1-byte, halfword, fullword, or doubleword length.

In the Sigma 3, the first two general-purpose registers are also used as index registers.

INDIRECT ADDRESSING: In the Sigma 3, one level of indirect addressing is allowed, and this may be indexed.

Larger Sigma systems permit indirect addressing for all instructions except those using immediate addressing, to one level only. Indirect addressing may be combined with indexing, but indirect addressing takes place before indexing. That is, the index displacement modifies the direct reference address obtained from the location pointed to by the indirect reference address, rather than modifying the indirect reference address itself. The 17 low-order bits of the referenced address effectively replace the 17-bit reference address field of the current instruction.

INSTRUCTION REPERTOIRE: In the Sigma 3, a basic complement of 37 hardware instructions, each one word in length, permits direct addressing of up to 1024 memory locations. Neither floating-point hardware nor decimal instructions are available.

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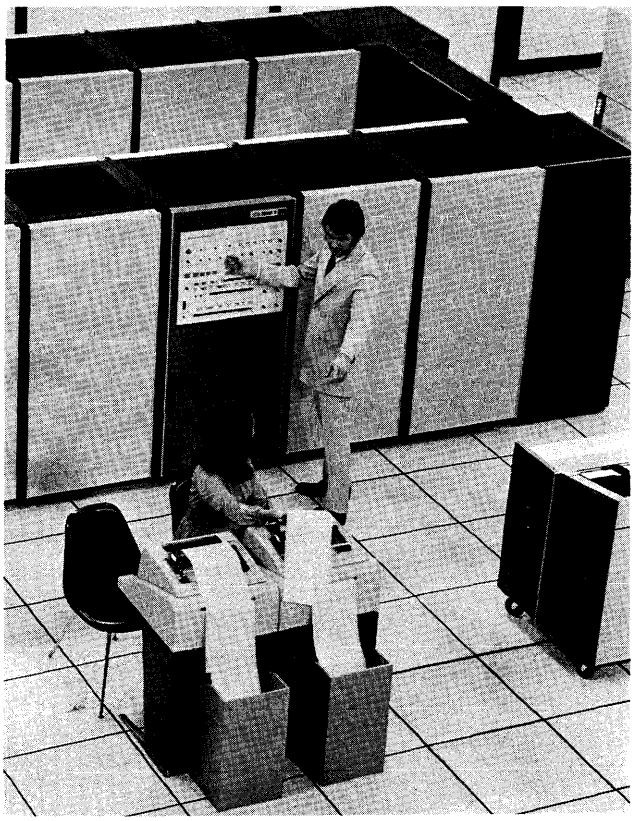
of the 120KB 7323 Magnetic Tape Unit, the 1500-1pm 7446 Printer, the 1500-cpm 7140 Card Reader, etc., have done their share to fill out the peripheral product line. Significant gaps still exist in the magnetic tape area (no 1600-bpi drives), in the disk area (no really high-performance disk in the class of the IBM 3330 for very large data bases), and in lower-speed peripherals such as card readers (200, 400, or 1500 cpm only). Missing from the Xerox product line are more specialized devices such as MICR and OCR input units. However, it is reported that Xerox plans to correct these deficiencies in the near future. Until that time, customer requirements for peripherals that are not part of the standard product line must be satisfied with hardware (and software) interfaces to non-Xerox devices by the Data Systems Group.

Currently, although excellent commercial data manipulation capabilities (decimal arithmetic, conversion instructions, etc.) are available in the Xerox hardware, fully supported applications software is provided only for a small group of scientific programs. For scientific users, however, these programs are among the best of their types available and are in wide use.

Xerox has a modest communications product line with a number of well-designed and reliable communications system building blocks, including local and remote batch terminal controllers. Missing from the standard product line, however, are numerous commonplace components of commercial communications systems such as a full line of CRT display devices, data collection stations, etc. This product-line gap is also a heritage of the Xerox scientific computer background, where most user communications requirements are for unique special-purpose subsystems that cannot be satisfied by any standard communications product line. Xerox does, however, have all the interfaces necessary to tie in nearly any communications terminals desired by the user.

Thus, although Xerox has recently demonstrated a strong emphasis upon commercial data processing, the historic Sigma Series weaknesses in operating systems, peripheral product line, and off-the-shelf communications products are being cleared up only slowly. The Sigma series presents a very strong alternative to IBM for scientific, real-time, and time-sharing users. But for business data processing users, the Sigma Series—mainly because of a dearth of fully supported commercial software applications packages—remains a practical alternative only for sophisticated users who can provide extensive in-house software development, or whose applications are already developed in COBOL for relatively straightforward conversion to the Xerox ANS



The top-of-the-line Sigma 9 system, designed for general-purpose business and scientific applications, offers up to 2 million bytes (524K 32-bit words) of core storage with a 900-nanosecond cycle time.

Larger Sigma processors have more extensive instruction sets (see table) to provide a full range of computational and data manipulation capabilities. Decimal instructions are available for the Sigma 6, 7, and 9 only to provide improved commercial processing facilities. Floating-point single and double precision hardware is standard in the Sigma 8 and 9, and optional in the Sigma 5, 6, and 7. Extensive facilities are also included for testing, searching, logical, and byte-manipulation operations.

INSTRUCTION TIMES: The table on page 70C-930-01c lists representative minimum instruction execution times for each Sigma processor. All times are in microseconds and are for direct addressing without indexing (i.e., with no effective address calculation).

PROCESSOR MODES: The Sigma 5 through 8 processors operate in either a master mode or a slave mode, and the Sigma 9 operates in master, slave, or master-protected mode. The mode is determined by three control bits in the Program Status Doubleword (PSD). Master mode allows the execution of all instructions in any part of memory except certain protected areas. Under master mode operation, an operating system (in master mode) controls and supports the operation of other programs which may be in master, slave, or master-protected modes (Sigma 9 only). Most user application or "problem solving" programs run in slave mode, in which certain privileged operations such as I/O control and alteration of the Program Status Doubleword

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COBOL. Assistance in such conversion is provided through a Commercial Systems Integration Group, formed early in 1971.

Major market targets for the Xerox Sigma Series currently are large-scale university, medical, manufacturing, and governmental institutions where multiple-use environments consisting of on-line plus batch operations are found with extensive, sophisticated in-house programming talent.

Compatibility within the Sigma line is very good, with almost complete transferability of most programs across the entire series, especially at the source-language level. Xerox's ANS COBOL (announced in 1971) offers source-language compatibility with numerous COBOL processors supported by a variety of other vendors. FORTRAN is Xerox's strong suit, and the Sigma compilers exhibit a high degree of compatibility with the FORTRAN languages of nearly every popular third-generation computer system. Numerous real-time extensions to the Xerox FORTRAN compilers place them among the most powerful FORTRAN systems in the industry.

Excluding the small-scale Sigma 3 computer, a modest range of processing capability is available across the Sigma product line, with the larger models possessing only a little more than four times the internal performance of the smaller systems. The Sigma 6 and 7 processors are nearly identical in performance; each provides approximately 20% more throughput in a scientific environment than the Sigma 5, while the commercial processing capabilities of the Sigma 6 or 7 are at least twice those of the Sigma 5. The difference in commercial processing capabilities is due primarily to the lack of decimal hardware and byte-string manipulation instructions in the lower-priced Sigma 5. The top-of-the-line Sigma 8 and 9 processors also differ from one another primarily in the provision of various features as standard or optional equipment. The Sigma 8 is oriented toward scientific and real-time applications, while the Sigma 9 is intended for business and general-purpose use.

In summary, it remains to be seen whether the current emphasis by Xerox product development groups upon commercial processing will succeed in harnessing the outstanding hardware of the Sigma Series into a viable alternative for medium-scale business data processing users—or whether the historically strong scientific emphasis of the Sigma Series will continue to dominate the Xerox computer product line. Xerox certainly appears to have made a real commitment to the computer business by integrating XDS into the corporation at a high level in March 1972, and the

are prohibited. The master-protected mode of operation is used in Sigma 9 processors with the memory map to protect virtual memory.

INTERRUPT STRUCTURE: All of the Sigma Series processors have extensive prioritized interrupt structures, well suited to on-line and real-time environments. Each Sigma processor has internal and external interrupts. The internal interrupts are divided into 3 main groups: the counter group, the override group, and the I/O group. The counter group interrupts are each associated with override interrupts, and are triggered when the result of a modify and test instruction in the interrupt counter location produces a zero result. Counter interrupts may be inhibited, if desired, by programs operating in the master mode. Override interrupts have the highest priority in a Sigma processor and are used for memory parity errors, power on and off, clock pulse signals, etc. Override interrupt signals cannot be shut off. The Internal I/O interrupt group handles standard I/O device interrupt signals and operator control panel interrupts, and may be inhibited by the Program Status Double Word, which is alterable in the master control mode.

Sigma Series external interrupts are configured into groups of 16 interrupts or levels per group. The priority of each level within a group is fixed, but the priority of each group may be established by the user. The Sigma 5 through 9 processors have 14 groups of external interrupts each, for a total of 224; and the Sigma 3 has 6 groups of interrupts, for a total of 96. External interrupts may be in four basic states—disarmed, armed, waiting, or active—in response to interrupt signals. The processor can stimulate any given external interrupt level, thus permitting the simulation of special device attachments for testing and debugging real-time or on-line configurations.

A trap system is also available on the Sigma 5 and larger models. Traps automatically cause a branch to a predesignated location when a trap condition is encountered. Unimplemented Instruction traps (or Unidentified Operator Handlers) are provided to cause program control to be transferred to user-written or XDS-supplied routines for execution of certain instructions to aid in software simulation. On the Sigma 5, decimal instructions (available in hardware on the Sigma 6 and larger models) are trapped as unimplemented instructions for execution by software routines.

VIRTUAL MEMORY: The Memory Map feature (standard on the Sigma 6 and 9, and optional on the Sigma 7) permits user programs up to 128K words in length to occupy up to 256 pages of 512 words each that are distributed throughout the main memory. The entire user program being executed must fit into main memory at one time, but it need not occupy one large contiguous area. The memory map permits referencing of addresses in virtual memories of up to 4 million words (8192 pages) by translating (or mapping) the 8 most significant bits of the 17-bit effective virtual address (the page identifier portion) into a 13-bit page address. This 13-bit page address is concatenated with the low-order 9 bits of the effective virtual address to produce a 22-bit memory address (for up to 4 million words).

WATCHDOG TIMER: All Sigma processors have a watchdog timer (optional on the Sigma 3 and standard on the larger models) to ensure that real-time operations will not be hung up because of an improperly functioning

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future may yet see the long-promised marriage between imaging equipment and computer systems emerge from Xerox Corporation. □

sensor or other attached device. The watchdog timer issues a trap instruction at user-specified maximum time intervals, and if the currently executing program has not had a normal level of activity by the time this interval has expired, it is aborted and the next user job is activated.

INPUT/OUTPUT CONTROL

I/O CHANNELS: The Sigma Series uses symbiont I/O processors (IOP's) to perform selector and multiplexer data transfer between main memory and peripheral I/O devices. On the Sigma 3, selector operations are done by the Integral I/O Processor (IIOP), and multiplexer operations are handled by the External I/O Processor (EIOP). The basic IIOP shares the CPU memory bus and provides four I/O channels. The IIOP can be expanded to 12 channels. The maximum transfer rate of the IIOP is approximately 450,000 8-bit bytes/second on a 1-byte wide data path. The EIOP, conversely, has its own registers and memory bus for independent memory bank access. The basic EIOP contains 8 I/O channels and can be expanded to 16 channels. The EIOP transfers data on a 1-byte-wide path at approximately 500,000 bytes/second. With the optional 2-byte interface, maximum data transfer rate is approximately 850,000 bytes/sec. Any combination of two IIOP's or EIOP's can be connected to a Sigma 3.

The Sigma 5, 6, and 7 processors can each have a combined total of eight multiplexer and/or selector I/O processors with independent paths to main memory. From 8 to 24 device controllers can be attached to each MIOP, and up to 32 high-speed devices to each SIOP. The MIOP transfers data between main memory and the attached device controllers at approximately 450,000 bytes/sec. Both the MIOP and SIOP have 1-byte-wide data paths that can be expanded to 4 bytes with an optional interface feature. The Sigma 5 can have an integral IOP as well as fully independent MIOP's, while the Sigma 6 includes one 8-controller MIOP as a standard feature. Bus-sharing MIOP's are available on the Sigma 5 through 9 to permit the attachment of two MIOPS to a single memory port.

The Sigma 8 and 9 have I/O channel characteristics that are identical with one another, including a dual-channel capability for connection of up to 24 device controllers on Channel A and 8 devices on Channel B. Other characteristics are similar to those of the Sigma 5, 6, and 7 MIOP. The high-speed RAD I/O Processor (HSRIOP) differs from the lower Sigma series SIOP only in the standard inclusion of a 7211 RAD controller equivalent in the HSRIOP; 7212 RAD storage devices can be attached directly to the HSRIOP without a controller. Up to 11 IOP's in any combination of MIOP's and HSRIOP's can be connected to a Sigma 8 or 9 each with its own memory path. Additional IOP's can be configured through bus-sharing. One MIOP with 8 channels is standard in either the Sigma 8 or 9.

Direct Device I/O (DIO) of a full word (16 bits for Sigma 3, 32 bits for other Sigmas) without use of a channel is possible on all processors to transfer data directly to a general-purpose register from a seldom-activated or low-speed sensor or asychronous device. High-speed real-time I/O is normally handled through an MIOP, SIOP, or Direct Memory Access through a separate port.

On the Sigma 5 through 9, up to 32,000 output control signals and input test signals can be handled through the DIO channel.

SIMULTANEOUS OPERATIONS: Each controller is capable of transferring data to or from only one of the devices connected to it at a time. The 7240 Disk subsystem, however, can have two-way access, enabling two controllers on different IOP's or different channels on the same IOP to access a 7242 or 7246 Disk Storage Unit simultaneously. The IOP's on the Sigma series operate independently of one another through individual memory ports (two bus-sharing IOP's occupy the same path to memory), with simultaneous computing. Sigma 8 and 9 MIOP's permit 32 simultaneous operations, while other Sigma MIOP's permit only 24 concurrent operations.

Two-way or four-way memory interleaving is possible on the Sigma 5 and larger models; consecutive addresses are stored in alternate physical memory banks, permitting overlapped memory accesses. The Sigma 3 has 2-way memory interleaving only. Instruction look-ahead, on the Sigma 6 and larger models, causes the next instruction to be fetched and decoded during execution of any given instruction. The Sigma 6 and 7 have 1-instruction look-ahead, while the Sigma 8 and 9 have 2-instruction look-ahead.

MASS STORAGE

7201/7202/7203/7204 RAPID ACCESS DATA (RAD) STORAGE SYSTEM: Consists of a 7201 RAD Controller and from one to eight head-per-track 7202, 7203, or 7204 RAD Storage Units in any combination. Each 7202 has a capacity of 737, 280 bytes (128 tracks); the 7203 stores up to 1,474,560 bytes (256 tracks); and the 7204 stores up to 2,949,120 bytes (512 tracks). Each single-spindle RAD Storage unit organizes data into tracks of 16 sectors each, with 360 8-bit bytes per sector. Average access time for the 7202, 7203, or 7204 is 17 milliseconds, and data transfer rate for each unit is 187,500 bytes/second when accessing a single sector, or an overage of 170,500 bytes/second for multiple-sector accesses. The 7201 RAD System connects to an SIOP or MIOP channel.

7211/7212 HIGH-SPEED RAPID ACCESS DATA (RAD) STORAGE SYSTEM: Consists of a 7211 RAD Controller and from one to four head-per-track 7212 RAD Storage Units. Each 7212 has a capacity of 5,373,952 8-bit bytes, for a maximum 7211 system capacity of 21,495,808 bytes. Data is organized into sectors of 1024 bytes each, with 82 sectors per band and 64 bands per 7212 unit. Average access time is 17 milliseconds, and data transfer rate is 3 million bytes/second when accessing a single sector or 2.47 million bytes/second when accessing one or more full bands (82 sectors). The 7211 Controller connects only to a Selector I/O Processor (SIOP) on the Sigma 5 or 7. On the Sigma 8 or 9, the 7212 RAD connects directly to the High-Speed RAD I/O Processor (HSRIOP) without the 7211 Controller.

7231/7232 EXTENDED-PERFORMANCE RAPID ACCESS DATA (RAD) SYSTEM: Consists of a 7231 RAD Controller and from one to four head-per-track 7232 RAD Storage Units. Each 7232 has a capacity of 6,291,456 bytes, for a maximum 7231 system capacity of 25,165,824

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bytes. Data is organized into sectors of 1024 bytes each, with 12 sectors per track and 512 tracks per 7232 unit. Average access time is 17 milliseconds, and data transfer rate is 384,000 bytes/second when accessing a single sector or 365,000 bytes/second for multiple-sector accesses. The 7235 Extended Width Interface feature provides a 4-byte data path for increased effective data transfer rates over the standard 1-byte-wide data path. The 7231/7232 RAD system connects to an SIOP or MIOP channel.

7240/7242/7246 REMOVABLE DISK STORAGE SYSTEM: Consists of a 7240 Disk Storage Controller and from one to eight spindles of single-spindle 7246 drives and/or dual-spindle 7242 drives. Both the 7242 and the 7246 use the 7244 Disk Pack for 24,576,000 bytes of on-line storage per spindle. The 7244 is an industry-standard 11-disk pack with 20 recording surfaces, and is physically interchangeable, but not format-compatible, with the IBM 2316 Disk Pack. Data is organized into sectors of 1024 bytes, with 6 sectors per track and 200 tracks per surface. In both the 7242 and 7246, average head movement time is 62.5 milliseconds, average rotational delay is 12.5 milliseconds, and data transfer rate is 312,500 bytes/second for single sectors, or 250,800 bytes/second for multiple sectors. The 7244 pack uses a special indexing ring to provide reference points for the six-sector recording format. Attachment of the 7241 Extended Width feature to the 7240 Controller permits full 32-bit-word data transfers, effectively increasing the transfer rate by 100% over the standard 1-byte-wide data path. A Device Pooling feature can be added to each 7242 or 7246 drive to permit dual access by two 7240 Controllers for simultaneous reading and/or writing.

INPUT/OUTPUT UNITS

7315/7316 MAGNETIC TAPE SYSTEM: Consists of a 7315 Controller combined with one tape drive and one optional 7316 Add-on Tape Drive. This 9-track NRZI system has a tape speed of 75 inches/second and a recording density of 800 bpi for a maximum data transfer rate of 60,000 bytes/second. The tape is 1/2 inch wide and is compatible with the IBM 2400 and 3400 Series Magnetic Tape Units.

7320/7322/7323 MAGNETIC TAPE SYSTEM: Consists of a 7320 Controller and from one to eight 7322 and/or 7323 tape drives that can read either forward or backward. The 7322 9-track NRZI tape drives have a tape speed of 75 inches/second and an 800-bpi recording density for a maximum data transfer rate of 60,000 bytes/second. The 7323 9-track NRZI tape drives have a tape speed of 150 inches/second and a recording density of 800 bpi for a maximum data transfer rate of 120,000 bytes/second. Both cyclic and longitudinal redundancy checks are generated by the 7320. The tape is 1/2 inch wide and is compatible with the IBM 2400 and 3400 Series Magnetic Tape Units. Patented Push-On-Pull-Off (POPO) tape hubs simplify mounting and removing tape reels.

7261/7362 MAGNETIC TAPE SYSTEM: Consists of a 7361 Controller and one or two 7362 7-track NRZI Magnetic Tape Drives. The drives have a tape speed of 37.5 inches/second and a recording density of 556 bpi for a maximum data transfer rate of 20,850 characters/second. A program-selectable, binary packing mode of operation permits 8-bit bytes to be recorded on the 7362; this BCD option for the controller allows the 7362 to be used as a low-speed 9-track tape substitute. The tape is 1/2 inch wide and is compatible with IBM 7-track recording formats. Patented Push-On-Pull-Off (POPO) tape hubs simplify mounting and removing tape reels. The 7362 reads in the forward direction only.

7371/7372 MAGNETIC TAPE SYSTEM: Consists of a 7371 Controller and from one to eight 7372 7-track NRZI Magnetic Tape Drives. The drives have a tape speed of 75 inches/second and recording densities of 200, 556, or 800 bpi for maximum data transfer rates of 15,000, 41,700, and 60,000 characters/second, respectively. A program-selectable, binary packing mode of operation permits 8-bit bytes to be recorded on the 7372; this BCD option for the controller allows the 7372 to be used as a low-speed 9-track tape substitute. The code conversion operation is performed in the controller. The tape is 1/2 inch wide and is compatible with IBM 7-track recording formats. Patented Push-On-Pull-Off (POPO) tape hubs simplify mounting and removing tape reels.

7121/7122 CARD READERS: Read 80-column cards serially by column at the rate of 200 or 400 cards per/minute for the 7121 or 7122, respectively. Both tabletop readers accept EBCDIC on binary code. Input hopper capacity for either reader is 1400 cards, and output stacker capacity is 1000 cards. The 7121 or 7122 includes a controller and connects directly to the Multiplexer I/O Processor.

7140 HIGH-SPEED CARD READER: Reads 80-column cards serially by column at the rate of 1500 cards/minute in either EBCDIC or binary code. The input stacker holds 2500 cards, and two output stackers hold a combined total of 2000 cards. The stackers are program-selectable to facilitate the separation of exception or error cords. The 7140 includes a controller and connects directly to the Multiplexer I/O Processor.

7160 CARD PUNCH: Punches 80-column cards in row-by-row fashion at 300 cards/minute in either EBCDIC or binary code. Read-after-punch verification is provided. The input hopper holds 1000 cards, and two program-selectable output stackers hold 1000 cards each. The 7160 includes a controller and connects directly to the Multiplexer I/O Processor.

7165 LOW-SPEED CARD PUNCH: Punches 80-column cards in column-by-column fashion in either EBCDIC or binary code. With 80 columns punched, the speed is 100 cards/minute; maximum punch speed is 300 cards/minute with up to 20 columns punched. The input hopper and the output stacker each have a capacity of 1000 cards. Cards in the output stacker can be offset under program control to segregate error cards, etc. The 7165 includes a controller and connects directly to the Multiplexer I/O Processor.

7060 PAPER-TAPE INPUT/OUTPUT SYSTEM: Includes a 7061 Controller and Cabinet, a 7062 Paper-Tape Reader, a 7063 Paper-Tape Punch, and a 7064 Spooler. The 7062 reads paper tape at a speed of 300 characters/second, and is mounted with the 7064 Spooler and the 7061 Controller in a separate cabinet. The 7063 Punch operates at a rate of 120 characters/second. The punched tape may be 5-, 6-, 7-, or 8-level format, and is passed through the 7060 system at a rewind or fast forward rate of 200 inches/second.

7440 LINE PRINTER: Provides full-line buffering of 132 positions for print speeds of 628 to 795 lines/minute, depending upon the number of different characters printed

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per line. The 7440 uses a 56-character print drum and has an 8-channel vertical format control tape and a print spacing of 6 lines/inch. Among the 8 operator controls are an indicator for low paper supply. The 7440 includes a controller and connects directly to the Multiplexer I/O Processor:

7441 LINE PRINTER: Provides full-line buffering of 132 positions for print speeds of 550 to 1100 lines/minute for the full 96-character drum or a subset consisting of the first 42 characters, respectively. The drum may be ordered with full or partial ASCII or EBCDIC character sets, and prints under operator control at either 6 or 8 lines/inch. A 64-character drum is also available. Forms control is handled by an 8-channel control tape. The 7441 includes a controller and connects directly to the Multiplexer I/O Processor.

7446 LINE PRINTER: Provides full-line buffering of 132 positions for print speeds of 1200 to 1500 lines/minute for the full 64-character drum or a subset consisting of the first 47 characters, respectively. The drum may be ordered with either a 64-character ASCII or EBCDIC set. The 7446 prints 6 or 8 lines/inch under operator control, and uses an 8-channel carriage control tape to handle forms control. The single-line forms feed rate is 16 inches/second, and the multiple-line feed rate for 6 lines or more is 90 inches/second. A motor-operated accoustical cover is used to reduce the noise level. This printer provides operator facilities similar to those of the widely used IBM 1403 Printers. The 7446 includes a controller and connects directly to the Multiplexer I/O Processor.

7450 LINE PRINTER: Offers low-cost, low-speed printing of 128-position lines at 225 to 450 lines/minute, depending upon the number of different characters printed per line. The print drum has 63 EBCDIC characters plus a blank, consisting of the numerals, upper-case letters, and 27 punch marks and symbols. Half-line buffering is provided, and basic forms control is handled by a 2-channel control tape which senses bottom-of-page and skips to top-of-page. Vertical spacing is 6 lines per inch. Automatic forms advance is provided under processor control, and inhibition of automatic advance as well as skipping of up to 7 lines per command is provided under program control. The 7450 includes a controller and connects directly to an MIOP channel.

7012/7014 KEYBOARD/PRINTERS: Provide the required operator console interface through an I/O channel. The 7012 is a modified Model 35 KSR Teletypewriter and controller which sends or receives EBCDIC code a rate of 10 characters/second. Print line width is 86 characters at a horizontal spacing of 12 characters/inch. Vertical spacing is 6 lines/inch. The 7014 is a spare print mechanism.

7015/7016/7017 AND 7025/7026/7027 REMOTE COMMUNICATION TELETYPEWRITERS: These units are modified Teletype Model 35's and are ASCII-compatible. Each teletypewriter can operate in a simplex (one-way only), half-duplex (two-way alternate), or full-duplex (two-way simultaneous) mode using Bell System 103 modems. Input/output printing speed is 10 characters/second, with horizontal spacing of 12 characters/inch and vertical spacing of 6 lines/inch. The 7015 (KSR-35), 7017 (ASR-35), 7025 (KSR-35), and 7027 (ASR-35) are keyboard/printers; and the 7016 (RO-35) and 7026 (RO-35) are printers only.

7018 REMOTE KEYBOARD PRINTER: This unit is a modified Teletype Model 37 and is ASCII-compatible.

7020/7021 KEYBOARD–PRINTERS: The 7020 is a modified Teletype Model 35 ASR with a paper tape reader/punch and controller which provides the required operator console interface to a Sigma operating system through an I/O channel. The 7021 is a replacement print mechanism. Standard EBCDIC code can be sent or received via the keyboard, printer, and/or punch at 10 characters/second, and via the paper tape reader at 19 characters/second on-line and 10 characters/second off-line. Horizontal spacing of the 86-character line is 12 characters/inch, and vertical spacing is 6 lines/inch.

7530/7531 GRAPH PLOTTERS AND 7534 CONTROLLER: These modified Calcomp drum-type plotters produce X-Y plots under computer control on rolls of paper either 11 inches (7530) or 29.5 inches (7531) in width. Maximum plotting speeds are as follows:

Increment Size	7530 (Modified Calcomp 565)	7531 (Modified Calcomp 563)
0.010 in.	3 in./sec.	2 in./sec.
0.005 in.	1.5 in./sec.	1.5 in./sec.
0.100 mm.	30 mm./sec.	30 mm./sec.

7580 GRAPHIC DISPLAY: Provides a CRT with a light gun, keyboard, 16 programmable function keys, four interrupt-generating keys and controller. Buffering is done in the Sigma memory, and the 7580 is interfaced directly to a memory port by the 7580 Controller, included with the display. Among the features of the 7580 are two levels of display intensity and automatic blinking of any displayed item. The 7580 has both long (10 inches) and short (1/4-inch) vector generators; these vectors are drawn in 41 and 6 microseconds, respectively. In addition to the two vector generators, the 7580 also has a 3-size character generator (5/32, 5/16, and 5/8 inch high), a dot generator (0.02-inch diameter), and a raster generator. The raster generator provides a 1024 x 1024 matrix on the 10-inch by 10-inch screen with a raster interval of 0.01 inches. The 7.580 uses two external interrupt levels to transfer command signals to the processor. Software support for the 7580 includes the Graphic Display Library (GDL) under RBM and BPM.

COMMUNICATION CONTROLS

7601 DATA SET CONTROLLER: Enables half-duplex or full-duplex connection (optional feature 7602) of a Bell System 100, 200, or 300 Series modem for communication over common-carrier private lines or switched message networks. Message transmission is provided at rates of 45 to 230,400 bits/second in a variety of standard speeds and formats. Operating synchronously or asynchronously, the 7601 is code-independent. An Automatic Dialing Feature (7603) provides control for the Bell System 800 Series Automatic Calling Unit or its equivalent to perform automatic dialing on a common-carrier switched network under computer control. The 7601 connects to a Sigma MIOP channel. Full-duplex operations use two MIOP channels.

7604 LOCAL BATCH TERMINAL CONTROLLER: Provides full-duplex tie-in for either a local batch terminal or a 7670 Remote Batch Terminal. Operating speed is 2400 bits/second.

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7611 CHARACTER-ORIENTED COMMUNICATION (COC) SUBSYSTEM: Provides low-to-medium-speed asynchronous communications control for up to 64 remote terminals operating simultaneously at speeds up to 1800 bits/second each. Independent simplex, half-duplex, or full-duplex operation is provided for each line handled. Up to 16 COC Subsystems can be connected to any Sigma Series computer, each through an MIOP channel. Up to five 7612 Timing Modules can be added to each COC Subsystem to control line interfaces. For each group of 8 lines tied to the COC subsystem, a 7613 Line Interface Unit (LIU) is required. A variety of other interface features are available for special-purpose requirements, including commercial modems, DC interfaces, military device interfaces, etc.

7630/7631 COMMUNICATION SUBSYSTEM: Consists of a 7611 COC Subsystem packaged to handle 8 lines.

7650 CHANNEL INTERFACE UNIT: Enables transfer of data and control information between two Sigma Series computers. Transmission is in half-duplex mode at a rate of 900,000 8-bit bytes/second (at 1000-foot distances or less) or over 450,000 8-bit bytes/second (at distances up to 2000 feet) using private-wire communications systems. The 7650 connects to any multiplexer or selector I/O processor in the Sigma Series. With the Sigma 7, interconnection cables are provided at no extra charge; these cables are separately priced for other Sigma processors.

7670 REMOTE BATCH TERMINAL: Consists of a control unit, an operator's console, a 250-line/minute, 128-position bar printer, and an 80-column card reader/punch that reads 200 cards/minute and punches 75 to 200 cards/minute, depending upon the number of columns punched. Three noteworthy standard features are provided: Unattended Call Answering, Off-line Listing capability, and a Transmit/Receive Monitor. The Transmit/Receive Monitor permits data transmission to/from the card punch or reader to be simultaneously printed. The 7670 operates over voice-grade lines to a 7601 Data Set Controller or a 7604 Local Batch Terminal Controller. Transmission in half- or full-duplex mode is at 2400 or 2000 bits/second over private lines or switched networks, respectively. The 7670 includes two 128-character buffers.

COMMUNICATIONS I/O PROCESSOR: The CIOP is available from Xerox as a special programmable subsystem on an RPQ basis. This subsystem is capable of handling up to 512 voice-grade lines with line speeds of 75 to 9600 bits/second, or multiple wide-band lines with line speeds ranging from 20,000 to 230,400 bits/second, for an aggregate line capacity of more than 500,000 characters per second. The CIOP has a sustained message-switching capacity greater than 50,000 fifty-character messages (or 25,000,000 characters) per hour. The CIOP can operate in three modes–message switching, transaction mode, or a combination of both–to provide most of the communications interface functions in a Sigma communications network, thereby minimizing the communications demand on the central processor.

SWITCHING EQUIPMENT AND SPECIAL INTERFACE UNITS: Xerox offers a number of programmable switches to transfer up to ten peripheral controllers from one channel or I/O processor to another on the same or different Sigma system(s). A wide variety of special System Interface Units is also available to accommodate analog devices, display drivers, counters, frequency sources, etc.

SOFTWARE

OPERATING SYSTEMS: Software support for the Sigma Series is provided at six major levels. Their designations, in order of increasing power and complexity, are: Basic Control Monitor (BCM), Real-Time Batch Monitor (RBM), Batch Processing Monitor (BPM), Batch Time-Sharing Monitor (BTM), Xerox Operating System (XOS), and Universal Time-Sharing System (UTS). The facilities provided at each of these support levels are summarized in the following paragraphs. Although multiple CPU connections are possible in hardware configurations, the standard Xerox software provides support for single-CPU configurations only.

BASIC CONTROL MONITOR: BCM is designed for minimal Sigma systems, such as those which do not contain RAD storage devices. BCM runs on the Sigma 3, 5, and 7 processors and provides real-time foreground processing concurrently with general-purpose background batch processing. Availability of operator communication support to the background batch job streams and automatic I/O handling are two of the key features of BCM.

REAL-TIME BATCH MONITOR: RBM was developed to fully utilize the advanced real-time hardware features present on the Sigma 3, 5, 7, and 8 processors to run real-time processing in the foreground concurrently with batch processing in the background. The following capabilities have been designed into RBM: priority scheduling using Sigma's extensive hardware interrupt capabilities; program re-entrancy using both the push/pull stack feature and high speed "context" switching between register blocks; and memory protection. RBM uses RAD or disk files for swapping of non-resident user programs and segments of RBM itself. Toward this end, RBM is extensively segmented, permitting resident operating system memory requirements to be much smaller than the overall RBM size.

Up to 100 real-time tasks can be processed concurrently by RBM, with re-entrant monitor services, use of the public library, and selected dedicated peripheral devices available to the real-time users. Background batch users can take advantage of a job accounting facility that records system utilization by name and account, and can also use a variety of language processors, including a macro assembly language, several versions of FORTRAN, etc. Foreground programs which require more memory than has been reserved for foreground use can temporarily seize all of the Sigma system resources by using a checkpoint capability to dump the background on direct-access storage for subsequent restoration to memory. To complement this variable partitioning capability, the operator can reduce the size of the foreground area from his console if desired, thus making more memory available for background use. Other features of RBM include symbolic I/O device references, allowing specific hardware assignment to be deferred until execution time under program control, and a Real-Time Debug package to assist in debugging foreground or background programs.

BATCH PROCESSING MONITOR: BPM has been designed for general-purpose batch processing on the Sigma 5, 6, 7, 8, and 9; it includes a "symbiont" feature to handle I/O simultaneously with processing. BPM can operate in three modes: local batch, remote batch, and real-time. In local batch processing, input jobs are queued

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on an RAD or disk unit for subsequent processing according to individual job priority. The operator may suspend or delete a job and may change individual job priorities. Symbiont file processing and language processors are supported in the local batch mode. Symbionts perform a spooling function to permit peripheral operations to occur simultaneously with processing. BPM remote batch processing supports the 7670 Remote Batch Terminal and provides the same services as the local batch mode. For real-time processing, both resident and non-resident tasks can be assigned to the foreground at SYSGEN time. These tasks can be invoked by the operator and are driven by Sigma hardware interrupts concurrently with local or remote batch processing. The facilities for real-time processing under BPM are very similar to those provided in RBM, including use of checkpoint service for the real-time foreground to preempt all system resources temporarily, etc.

BPM supports consecutive (sequential), keyed (indexed sequential), and random file structures for ANS COBOL, 3 versions of FORTRAN including FORTRAN Load And Go (FLAG), Xerox Meta Assembler, and BASIC. A number of standard XDS program products are also supported, including DMS, MANAGE, SL-1, GPDS, FMPS, CIRC, etc. Other features of BPM include overlay service, a character-oriented communications (COC) system (for support of the 7611 Communications Controller), accounting statistics, debug aids, automatic or manual recovery procedures, and an error log for I/O or parity errors, etc.

BATCH TIME-SHARING MONITOR: BTM supports local, remote, and/or terminal-initiated batch processing simultaneously with real-time operations and up to 64 on-line time-sharing users on Sigma 5, 6, 8 and 9 systems. Swapping of on-line users' programs or segments is overlapped with batch operations, which are located in a dedicated Sigma memory partition. BTM is an extended version of BPM with a time-sharing Terminal Executive program added. Symbiont routines that buffer I/O to high-speed RAD's or disks are provided. On-line users may use Symbol (the Xerox assembler), BASIC, or FORTRAN IV-H with complete compatibility at the source and object language level to the batch processors. Language processors supported under BTM include COBOL, FORTRAN, interactive FORTRAN Debugger (FDP), BASIC, on-line Edit, etc. The structures for data files created on-line are common to those of batch users. A user can develop a program and/or data base interactively, then initiate remote or local batch processing to execute his job.

The BTM scheduling algorithm, as well as other basic parameters used by the time-sharing executive program, can be dynamically modified by the operator during execution to adjust for varying work-load requirements. Basically, a two-level round-robin scheduler (the higher level for conversational users and the lower level for compute-bound users) controls interactive access to the system resources under BTM. An upper limit on total interactive resource use can be set. A Performance Monitor which provides on-going profiles of system and user activity can give the operator on-line feedback as to the system's performance. Although the maximum number of interactive users under BTM is 64, the practical limit depends upon the type of work done by each user and the availability of swapping devices.

The greater the number of time-sharing users, the greater the reduction in potential batch throughput under BTM. Within a basic user-specified parameter guaranteeing a certain percentage of system resources to batch operations, batch throughput and concurrent interactive user response will vary widely with workload fluctuations. Individual time-sharing users can be allocated set percentages of the overall time provided for all time-sharing operations.

BTM also includes the following on-line subsystems: EDIT–a tool to create and modify data files; FDP and DELTA–interactive debugging packages; FERRET–a program to provide a list of user files and/or reassign their storage locations; and Terminal Oriented MANAGE (TOM)–to permit on-line access to MANAGE files.

XEROX OPERATING SYSTEM: XOS is the top-of-the-line general-purpose XDS operating system, for use with Sigma 6, 7, and 9 computers. The main functions of XOS are divided into multiprogramming, communications, and file and data management services. The multiprogramming system takes advantage of the memory map, a hardware feature that can increase the number of jobs residing in available main memory at one time by utilizing non-contiguous 512-word pages of memory. Any number of repetitive, single-step parallel jobs (such as tape-to-disk utilities, etc.) can be run concurrently with up to six job streams of multi-step production jobs, provided that enough system resources are available. Relative run priorities are assigned for each job at SYSGEN time, and hardware interrupts are associated with each program. These interrupts permit subsequent run-time scheduling to be done by the processor using hardware rather than software, thereby reducing system overhead. Extensive memory protection capability, restart facilities, and security provisions are also designed into XOS for multiprogramming operations.

Included in XOS is a Communications Management System (CMS) that provides teleprocessing communications with remote terminals. The CMS is normally used to support transaction processing, although the user can avail himself of a generalized Telecommunications Access Method (TAM) to design remote file inquiry systems, source data entry applications, etc. XOS also provides file management support for sequential, indexed sequential, partitioned, and direct file organization structures, as well as "basic" or "assisted" file data access methods. With assistance, data access is automatically blocked, buffered, etc., whereas basic access requires that the user do his own file housekeeping. Together with DMS, the XOS file structure support provides comprehensive data management capabilities. All of the Sigma language processors are available under XOS.

Although XOS will run on a 48K-word Sigma 6 or 7 (64K words on Sigma 9), the recommended minimum memory size is 64K words. XOS itself occupies 15K words of memory, or 19K words with communications management, and approximately 20K additional words should be allowed for each concurrent compilation and/or assembly. Of the basic XOS resident memory requirement, 1K is reserved for non-resident portions of the operating system.

UNIVERSAL TIME-SHARING SYSTEM: UTS is the major time-sharing operating system for Sigma 6, 7, and

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9. Up to 128 on-line time-sharing users can be handled concurrently with local or remote batch processing and real-time operations. Batch operations permit up to 16 separate multiprogramming "partitions." Since UTS utilizes hardware relocation registers to address each 512-word block of memory, "partition" describes job streams, rather than physical core areas. On-line access is provided through the character-oriented communications (COC) system. UTS provides more than 15 language and utility processors for on-line users, all of which are re-entrant to reduce swapping overheads and take full advantage of available memory. Several additional processors are available only to batch users. In addition to detailed system accounting by user and job, UTS permits dynamic adjustment of the basic time-sharing parameters to tune the system for changing user work-loads. To assist the operator in adjusting the UTS parameters, a control program displays current utilization of the system and the balance of the workload.

UTS is designed to use RAD storage and provides the following facilities: error detection and system protection features including the watchdog timer, etc; segmentation of user programs into pages using the memory map; and multiple memory-band access by the CPU and I/O processors, using the multiple memory-port structure. Generally, UTS requires from 24K to 27K words of resident memory as well as a Selector I/O Processor and 2 Multiplexer I/O Processors. Xerox states that up to 64 users can be supported with fast response on Sigma processors with 80K to 96K words; larger systems are required to give adequate support for more on-line users. File structures supported by UTS are consecutive (sequential), keyed (indexed sequential), and random. MANAGE and Terminal-Oriented MANAGE (TOM) are provided with DMS for file and data management capability.

COBOL: Xerox offers an ANS COBOL compiler which is segmented for use on Sigma equipment with memory mapping. Extended COBOL language features include implementation of the Table Handling module, sort/merge linkages, common data storage for independently compiled programs, etc. ANS COBOL is available for the Sigma 5, 6, 8, and 9 systems.

FORTRAN: Xerox offers FORTRAN in a number of different versions. For the Sigma 3, Basic FORTRAN, FORTRAN IV, and ANS FORTRAN IV are available, all of which are upward-compatible with their FORTRAN counterparts on the larger Sigma series processors.

A FORTRAN Load and Go (FLAG) compiler is available for the Sigma 5, 6, 7, 8, and 9. FLAG is designed for one-pass operation to compile and execute a small-to-medium-size program without leaving main memory.

Extended FORTRAN IV-H is another one-pass compiler for operation under BCM, BTM, BPM or RBM on the Sigma 5, 6, 7, 8, and 9. This compiler produces re-entrant programs with a number of extensions beyond ANS FORTRAN. Among these are IMPLICIT statements, END and ERROR options on READ statements, an in-line assembly-language option, run-time path-of-flow tracing for debugging, etc. Extended FORTRAN IV-H is intended for use on smaller-configuration systems, and provides a high degree of compatibility with the FORTRAN compilers of numerous other computer vendors.

Extended FORTRAN IV is another superset of ANS FORTRAN for the Sigma 5 through 9. This 3-pass compiler requires more memory for compilation than Extended FORTRAN IV-H, but produces more efficient code along with extensive diagnostics to reduce debug time. Extended FORTRAN IV runs under RBM, BPM, BTM, XOS, or UTS. In addition to producing re-entrant object code, this compiler offers mixed-mode expressions, punctuation flexibility, automatic double precision, generalized DO loops and subscripts, bit manipulation, etc.

ASSEMBLERS: Four assemblers are offered for the Sigma Series: are Symbol, Extended Symbol, Macro Symbol, and Meta Symbol.

Symbol is the basic assembler under BCM, RBM, BPM, or BTM for the Sigma 3 through 8. It provides essential literal and external referencing capabilities, common area definitions, absolute or relocatable program segments, and conditional assembly.

Extended Symbol, available for the Sigma 3 only, is a 3-pass assembler under RBM that is upward-compatible with basic Symbol on the larger Sigmas. A concordance (cross-reference table that lists the data and/or statement names) and a macro capability are the primary enhancements over basic Symbol. Many of the features of Extended Symbol are found in either Meta Symbol or Macro Symbol on higher-numbered versions of the Sigma Series.

Macro Symbol is available under RBM for the Sigma 5, 6, 7, and 8 as a multi-pass superset of Symbol with an expanded directive syntax and the full flexibility of macro statements. Macro Symbol is intended to be run in the background concurrently with foreground and real-time operations.

Meta Symbol is the full-scale XDS assembler used under BPM, XOS, and UTS. It includes provisions for procedure-oriented statements, symbolic references, etc. This 2-pass assembler allows parameter testing during assembly that can vary the generated code. Other features of Meta Symbol include self-defining constants, full use of lists and subscripted elements, automatic alignment of instructions on word boundaries, etc. Meta Symbol runs on all Sigma processors except the Sigma 3.

RPG: For the Sigma 3 only, a Report Program Generator is available as a background batch job under RBM. The generator accepts RPG input that has been coded for IBM 1800, 1130, or 360/20 computers. Other features of Sigma 3 RPG include the selective execution of RPG subroutines, printing of multiple lines per input record by dynamically altering the normal RPG logic flow, full user control over spacing, specialized edit codes, etc. RPG will operate on a minimum Sigma 3 with 8K words of memory.

BASIC: A compiler for the BASIC language is usable in either the batch or on-line mode of operation on Sigma 5, 6, 8, and 9 systems under BTM or BPM. An extended version is also available for use under UTS.

MANAGE: This generalized file management system can be used for developing and updating files as well as for the production of reports based upon data selection criteria specified by the programmer. MANAGE is available for use on 32K-word Sigma 5, 6, 8, and 9 systems under BPM. MANAGE consists of four separate processors: file creation (DICTNARY), file maintenance

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(FILEUP), data retrieval (RETRIEVE), and report generation (REPORT). The system processes sequential files of fixed or variable-length records, and may produce up to 99 separate reports in a single pass of RETRIEVE. Up to 9 levels of control breaks are provided. MANAGE requires 15K words of main memory and 28K words of RAD storage, plus additional peripheral storage for data bases and communication files. Basic security provisions are included, and audit trails of data base updates can be maintained. Retrieval requests use AND/OR logic, with up to 20 consecutive AND's permitted in a single data-qualifying statement. The normal range of relational operators and arithmetic associations is provided. A number of basic defaults are included in the REPORT phase, most of which can be overridden by the user. TOM, a terminal-oriented version of MANAGE, is also available. MANAGE is a separately priced program product.

DATA MANAGEMENT SYSTEM: DMS has many similarities to Honeywell's time-proven Integrated Data Store (IDS). As a generalized data management system, DMS uses the random file facilities of BPM, BTM, or UTS File Management for batch or on-line operation on the Sigma 5 and larger models. Closed chains or rings of pointers are used to maintain data element relationships, with optional secondary indices for specified fields. This secondary indexing is a form of partial file inversion to greatly speed data retrievals using frequently keyed-upon fields. Extensive security provisions are for various types of data base access make use of passwords. DMS consists of three basic programs: file definition processor (FDP), data base manager (DBM), and data base utility routines (DUR). The features of DMS include multi-level, hierarchical (tree structure) data organization using repeating groups, with audit trails, direct (random) storage and retrieval of data, etc. DMS is a separately priced program product.

APL: Full APL is available under UTS for initial delivery during the third quarter of 1972, and does not require that the system be dedicated to APL exclusively.

TEXT: Xerox offers a TEXT publication processor under UTS that is functionally identical with IBM's ATS/360.

UTILITY ROUTINES: Sort/merge programs are offered at all six levels of software support for the Sigma Series. All are generalized programs which are controlled by user-supplied parameters, and all can accommodate either fixed or variable-length records. Each software level also includes an appropriate number of data transcription, diagnostic, mathematical, and other utility routines. IBM 1400 simulation routines are available for the Sigma 5 and larger models.

APPLICATION PROGRAMS: A number of applications programs are available from Xerox on an unbundled (separately priced) basis.

General Purpose Discrete Simulator (GPDS) is a version of IBM's GPSS that runs on a Sigma 5, 6, 7, or 9 under BPM, BTM, or UTS.

Functional Mathematical Programming System (FMPS) is a linear programming system developed jointly with Bonner and Moore Associates. FMPS operates on a Sigma 5, 6, 7, or 9. GAMMA III is an adjunct to FMPS that formulates linear programming problems into specialized matrix notation to simplify FMPS input.

CIRC is a sophisticated circuit design and analysis tool for electrical engineers that runs under BPM, BTM, or UTS on the Sigma 5 and larger models. Three versions are available: CIRC-DC (direct current), CIRC-AC (alternating current), and CIRC-TR (transient analysis).

Simulation Language (SL-1) provides digital or hybrid simulation through a superset of IBM's Continuous System Simulation Language (CSSL) under RBM, BPM, or BTM on a Sigma 5, 7, or 9. A version called CSS/3 is available for the Sigma 3.

In addition to the applications supported by Xerox, more than 1,000 programs are listed in the Xerox Users' Group Catalog of Programs.

USERS' GROUP: Xerox has a users' group composed of over 1200 active members. Semiannual meetings are held to coincide with the Joint Computer Conferences, and a newsletter, *User News,* is published monthly. A number of Special Interest Groups have been formed, covering topics such as commercial Sigma applications, real-time operation, educational applications, etc. A comprehensive catalog of the Xerox Users' Group porgrams is available from XDS. For further information, contact: Secretary, Xerox Users' Group, Xerox Corporation, 701 South Aviation Blvd., El Segundo, California 90245.

PRICING

EQUIPMENT: All necessary control units, I/O processors, and adapters are included in the indicated prices for the following typical configurations, and the quoted one-year rental prices include equipment maintenance. Note that numerous special interface units and communications controllers for real-time and on-line use have not been included.

SIGMA 3 DISK (EXPANDED RBM) SYSTEM: Consists of a 16K-word (32K-byte) Central Processor, 7203 RAD Storage System (1.5 MB), 8195 Magnetic Tape System, 7122 Card Reader (400 cpm), 7121 Card Punch (200 cpm), 7440 Line Printer (628-795 lpm) and 8192 Printer-Keyboard. Monthly rental and purchase prices are approximately $4,456 and $165,875, respectively, and monthly maintenance (for purchased systems) is $1,125.

SIGMA 5 DISK (EXPANDED RBM) SYSTEM: Consists of a 24K-word (96K-byte) Central Processor, 7246 Disk Storage Drive (24.58 MB), 7203 RAD Storage System (1.5 MB), 7122 Card Reader (400 cpm), 7160 Card Punch (300 cpm), 7440 Line Printer (628-795 lpm), and 7012 Printer-Keyboard. Monthly rental and purchase prices are approximately $8,055 and $319,200, respectively, and monthly maintenance (for purchased systems) is $1,830.

SIGMA 6 TAPE/DISK (XOS) SYSTEM: Consists of a 48K-word (192K-byte) Central Processor, three spindles of 7242 Disk Storage (73.74 MB), two 7322 Magnetic Tape Units (60KB), 7122 Card Reader (400 cpm), 7160 Card Punch (300 cpm), 7446 Line Printer (1500 lpm), and 7012 Printer-Keyboard. Monthly rental and purchase prices are approximately $15,910 and $634,400, respectively, and monthly maintenance (for purchased systems) is $3,305.

SIGMA 7 TAPE/DISK/RAD (BTM) SYSTEM: Consists of a 48K-word (192K-byte) Central Processor, 7242 Disk Storage Unit (49.16 MB), 7204 RAD Storage Unit (1.5 MB), 2 7322 Magnetic Tape Units (60KB), 7122 Card

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Reader (400 cpm), 7160 Card Punch (300 cpm), 7441 Line Printer (1100 lpm), and 8495 System Supervisory Console. Monthly rental and purchase prices are approximately $18,635 and $742,200, respectively, and monthly maintenance (for purchased systems) is $3,520.

SIGMA 8 TAPE/DISK/RAD (BPM) SYSTEM: Consists of a 64K-word (256K-byte) Central Processor, one 7242 Disk Storage Unit (49.16 MB), two 7212 RAD Storage Units (11.75 MB), two 7322 Magnetic Tape Units (60KB), 7122 Card Reader (400 cpm), 7160 Card Punch (300 cpm), 7441 Line Printer (1100 lpm), and 7020 Printer-Keyboard. Monthly rental and purchase prices are approximately $22,600 and $865,800, respectively, and monthly maintenance (for purchased systems) is $4,490.

SIGMA 9 TAPE/DISK/RAD (UTS) SYSTEM: Consists of a 256K-word (1024K-byte) Central Processor, four 7242 Disk Storage Units (196.64 MB), four 7212 RAD Storage Units (23.50 MB), four 7323 Magnetic Tape Units (120KB), two 7122 Card Readers (400 cpm), one 7140 Card Reader (1500 cpm), two 7160 Card Punches (300 cpm), two 7446 Line Printers (1500 lpm), and two 7020 Printer-Keyboards. Monthly rental and purchase prices are approximately $58,800 and $1,970,000, respectively, and monthly maintenance (for purchased systems) is $10,400.

SOFTWARE: Xerox was among the first mainframe vendors to price applications software separately. This policy applies to the major applications systems developed by Xerox or by outside sources under contract to Xerox. Such software is currently limited to a handful of scientifically oriented packages. Operating systems, utilities, and language processors are bundled at no additional cost to Sigma users. A number of the separately priced applications packages are provided at no charge to qualified educational institutions.

SUPPORT: Xerox has formed a Commercial Systems Integration Group to provide systems engineering and field support to customers. "Emergency" operating system software support is available from Field Engineers at $25/hour on weekdays and $28/hour on Sundays and holidays. On-site custom software assistance is provided by Systems Engineers at $25/hour for small Sigma 3 systems and $30/hour for more complex systems.

EDUCATION: Xerox maintains an Education Center in Los Angeles at which standard and special courses are taught. These courses cover all aspects of Sigma usage and range in length from 2 to 10 days, at costs ranging from $100 to $300. A training program consisting of a number of courses may be desired, depending upon customer requirements. On-site training can be arranged at negotiated charges.

CONTRACT TERMS: Xerox offers a purchase agreement for Sigma computer systems, and 1, 4, or 6-year lease terms. A 9-hour weekday principal period of maintenance is included at no additional charge for leased Sigma systems. Additional maintenance support is available: Saturday or Sunday coverage is offered at a premium of 20% of the separate maintenance charge; 16-hour maintenance is available for 5, 6, or 7 days per week at premiums of 40%, 70%, or 90%, respectively, of the separate maintenance charge; and 24-hour maintenance is available for 5, 6, or 7 days per week at premiums of 110%, 125%, or 140%, respectively, of the separate maintenance charge. ■

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
SIGMA 3 PROCESSOR AND MAIN STORAGE						
8101**	Sigma 3 CPU including IIOP w/4 Channels, 1 Port, and 8K 16-bit words of Memory	29,700	200	804	689	612
8102**	Sigma 3 CPU including EIOP w/8 Channels, 2 Ports, 8K 16-bit words of Memory, and DIO Interface	37,800	230	1,023	877	779
8105	Integral I/O Processor (IIOP) with 4 I/O Channels	6,480	30	175	150	134
8111	Two Real-Time Clocks	540	5	15	12	11
8113	Power Fail-Safe Interrupt	1,080	5	29	25	23
8114	Fault Interrupt & Protect Feature—includes Interface Time & Memory Parity	2,700	15	73	64	56
8119	Extended Arithmetic Unit	2,700	15	73	64	56
8121	Interrupt Control Chassis	2,375	10	65	54	49
8122	Priority Interrupt, 2 Levels (for 8121)	380	0	11	9	8
8123	Two Integral Priority Interrupt Levels (for 8101 or 8102)	865	5	24	21	17
8150	Sigma 5/7 Memory Adapter	8,100	40	219	188	167
8151	Basic Memory Module, 8K 16-bit Words (first and odd-numbered subsequent memory increments)	18,360	85	496	424	378
8152	Memory Increment, 8K 16-bit Words (second and even-numbered subsequent memory increments)	12,960	60	350	300	267
8155	Additional Memory Port	1,620	10	44	38	33
8170	External Interface Feature	1,080	5	29	25	23
8171	External I/O Processor (EIOP) With 8 I/O Channels (requires 8155 and 8170)	12,960	60	350	300	267
8172	Additional 8 I/O Channels (for CPU, IIOP, or EIOP)	4,320	20	117	100	89
8175	Two-Byte Interface (for 8102 or EIOP)	1,620	10	44	38	33
8191	First Keyboard Printer—KSR-35 (Console for Sigma 3 only)	4,320	35	117	100	89
8192	First Keyboard Printer—ASR-35 w/Paper Tape Reader & Punch (Console for Sigma 3 only)	6,480	50	176	150	134

*Rental prices include monthly maintenance charges.
**Minimum monthly rental for a Sigma 3 system is $1200.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
SIGMA 3 PROCESSOR AND MAIN STORAGE (continued)						
8195	Magnetic Tape Controller plus one Tape Drive (For Sigma 3 only)	15,000	200	562	528	500
8196	Add-On Tape Drive (For 8195)	8,000	150	337	317	300
SIGMA 5 PROCESSOR AND MAIN STORAGE						
8201	Sigma 5 CPU including Integral I/O Processor, two Real-Time Clocks, Control Panel, & Power Supplies	70,000	450	1,750	1,645	1,558
8202	Sigma 5 CPU without Integral I/O Processor	65,000	425	1,625	1,528	1,360
8203	Integral I/O Processor (IIOP)	7,500	25	188	177	168
8211	Two Additional Real-Time Clocks	1,000	5	25	24	23
8213	Power Fail-Safe	1,000	5	25	24	23
8214	Memory Protect	4,000	15	100	94	89
8216	Additional Register Block	2,500	10	63	60	56
8218	Floating-Point Arithmetic	10,000	100	250	235	223
8221	Interrupt Control Chassis (Required for 8270)	2,200	30	55	52	49
8222	Priority Interrupt, 2 Levels (Requires 8270)	350	0	9	9	8
8261	Memory Bank, 8K 32-bit Words (first and odd-numbered subsequent memory modules)	42,000	120	1,050	987	935
8262	Memory Increment, 8K 32-bit Words (second and even-numbered subsequent memory modules)	31,000	110	775	729	690
8264	Each Port Expansion (Required for each pair of 8261's in same memory cabinet)	4,000	20	100	94	89
8270	External Interface Feature (Requires 8221)	2,000	10	50	47	45
8273	Multiplexer Input/Output Processor (MIOP); includes eight Multiplexer Channels	20,000	80	500	470	445
8375	4-Byte Interface Feature for MIOP	2,500	15	63	60	56
8276	Additional Eight Multiplexer Channels for MIOP	4,000	15	100	94	89
8277	Bus-Sharing MIOP	15,000	80	375	353	334
8285	Selector Input/Output Processor (SIOP)	30,000	100	750	705	668
SIGMA 6 PROCESSOR AND MAIN STORAGE						
8310A	Sigma 6 CPU including Multiplexer I/O Processor (MIOP) w/8 channels & 4-byte Interface Feature, Decimal Arithmetic, Memory Map w/Access Protection, Memory Write Protection, Two Register Blocks, Two Real-Time Clocks, Power Fail-Safe, External Interface, Dual Access (2-port), and 32K 32-bit words of memory	306,800	1,250	7,670	7,210	6,827
8310B	Same as above, with 48K 32-bit words	374,400	1,495	9,360	8,798	8,331
8310C	Same as above, with 64K 32-bit words	425,800	1,740	10,645	10,007	9,474
8310D	Same as above, with 80K 32-bit words	493,400	1,985	12,335	11,595	10,979
8310E	Same as above, with 96K 32-bit words	519,600	2,230	12,990	12,211	11,562
8310F	Same as above, with 112K 32-bit words	561,400	2,475	14,035	13,193	12,492
8310G	Same as above, with 128K 32-bit words	587,600	2,720	14,690	13,809	13,075
8311	Two Additional Real-Time Clocks	1,000	5	25	24	23
8316	Additional Register Block	2,500	10	63	60	56
8318	Floating-Point Arithmetic Unit	25,000	100	625	588	557
8321	Interrupt Control Chassis (Required for 8322)	2,200	30	55	52	49
8322	Priority Interrupt, 2 Levels (Requires 8321)	350	0	9	9	8
8364A	Each Port Expansion for 8310A	4,000	20	100	94	89
8364B,C	Each Port Expansion for 8310B, C	8,000	40	200	188	178
8364D,E	Each Port Expansion for 8310D, E	12,000	60	300	282	267
8364F,G	Each Port Expansion for 8310F, G	16,000	80	400	376	356
8370	Additional MIOP w/8 Channels and 4-Byte Interface Feature	22,500	95	563	530	502
8375	I/O Processor (IOP) Expansion Feature; 8 Channels, 4-Byte Interface Feature (For MIOP)	17,500	95	438	412	390
8376	Additional 8 Multiplexer Channels (For MIOP)	4,000	15	100	94	89
8385	Selector I/O Processor (SIOP)	30,000	100	750	705	668
SIGMA 7 PROCESSOR AND MAIN STORAGE						
8401	Sigma 7 CPU including two Real-Time Clocks, Control Panel, and Power Supplies	203,000	650	5,075	4,771	4,517
8411	Two Additional Real-Time Clocks	1,000	5	25	24	23
8413	Power Fail-Safe	1,000	5	25	24	23
8414	Memory Protect	5,000	20	125	118	112
8415	Memory Map	32,500	80	813	765	724
8416	Additional Register Block	2,500	10	63	60	56
8418	Floating-Point Arithmetic	25,000	100	625	588	557
8419	Decimal Arithmetic	30,000	120	750	705	668
8421	Interrupt Control Chassis (Required for 8422)	2,200	30	55	52	49
8422	Priority Interrupt, 2 Levels (Requires 8421)	350	0	9	9	8
8461	Memory Bank, 8K 32-bit Words (first and odd-numbered subsequent memory modules)	35,850	135	897	843	798

*Rental prices include monthly maintenance charges.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
SIGMA 7 PROCESSOR AND MAIN STORAGE (continued)						
8462	Memory Increment, 8K 32-bit Words (second and even-numbered subsequent memory modules)	23,650	110	592	556	527
8464	Each Port Expansion (Required for each pair of 8461's in same memory cabinet)	4,000	20	100	94	89
8473	Multiplexer Input/Output Processor (MIOP), including eight Multiplexer Channels	20,000	80	500	470	445
8475	4-Byte Interface Feature for MIOP	2,500	15	63	60	56
8476	Additional Eight Multiplexer Channels for MIOP	4,000	15	100	94	89
8477	Bus-Sharing MIOP	15,000	80	375	353	334
8485	Selector Input/Output Processor (SIOP)	30,000	100	750	705	668
8495	System Supervisory Console (For Sigma 7 only)	25,000	100	625	588	557
SIGMA 8 PROCESSOR AND MAIN STORAGE						
8510A	Sigma 8 CPU including Multiplexer I/O Processor (Channel A), 16 General-Purpose Registers, Floating-Point Arithmetic, Memory Write Protect, two Real-Time Clocks, Power Fail-Safe, External Interface, and 16K 32-bit words of memory	295,000	1,295	9,500	8,930	8,455
8510B	Same as above, with 32K 32-bit words	340,000	1,550	10,150	9,541	9,034
8510C	Same as above, with 48K 32-bit words	395,000	1,820	11,200	10,528	9,968
8510D	Same as above, with 64K 32-bit words	440,000	2,075	11,850	11,139	10,547
8510E	Same as above, with 80K 32-bit words	495,000	2,345	12,900	12,126	11,481
8510F	Same as above, with 96K 32-bit words	540,000	2,600	13,550	12,737	12,060
8510G	Same as above, with 112K 32-bit words	595,000	2,870	14,600	13,724	12,994
8510H	Same as above, with 128K 32-bit words	640,000	3,125	15,250	14,335	13,573
8511	Two Additional Real-Time Clocks	1,000	5	25	24	23
8516	Additional Register Block	2,500	10	63	60	57
8517	Alternate CPU Bus	3,000	10	75	71	67
8521	Interrupt Control Chassis (Required for 8522)	2,200	30	55	52	49
8522	2 Levels of Priority Interrupt (Requires 8521)	350	0	9	9	8
8560	Memory Reconfiguration Control Unit	4,000	10	100	94	89
8564A,B	Each Port Expansion for 8510A, B	4,800	25	120	113	107
8564C,D	Each Port Expansion for 8510C, D	9,600	50	240	226	214
8564E,F	Each Port Expansion for 8510E, F	14,400	75	360	339	321
8564G,H	Each Port Expansion for 8510G, H	19,200	100	480	452	428
8570	Additional MIOP—Channel A	20,000	155	500	470	445
8571	4-Byte Interface (For MIOP)	3,000	15	75	71	67
8572	8 Additional Subchannels (For MIOP)	4,000	15	100	94	89
8573	Memory-to-Memory Move (For MIOP)	2,800	15	70	66	63
8574	Alternate MIOP Bus (For MIOP—Channel A)	3,000	10	75	71	67
8575	MIOP—Channel B	15,000	155	375	353	334
8580	High Speed RAD IOP (HSRIOP); includes control for 7212 RAD	45,000	200	1,125	1,058	1,002
8584	Alternate HSRIOP Bus (For HSRIOP)	3,000	10	75	71	67
SIGMA 9 PROCESSOR AND MAIN STORAGE						
8610A	Sigma 9 CPU including Decimal Arithmetic Unit, Floating-Point Arithmetic Unit, Memory Map w/Access Protection, Memory Write Protection, two Register Blocks, two Real-Time Clocks, Power Fail-Safe, External Interface, Interrupt Control Chassis, Eight Interrupt Levels, Multiplexer I/O Processor (Channel A w/8 subchannels), Motor Generator Set, and 64K 32-bit wrods of memory	644,800	2,240	16,120	15,171	14,347
8610B	Same as above, with 80K 32-bit words	698,120	2,510	17,453	16,426	15,534
8610C	Same as above, with 96K 32-bit words	731,840	2,780	18,296	17,219	16,284
8610D	Same as above, with 112K 32-bit words	785,200	3,050	19,630	18,474	17,471
8610E	Same as above, with 128K 32-bit words	818,920	3,140	20,473	19,268	18,221
8610F	Same as above, with 160K 32-bit words	890,680	3,680	22,267	20,956	19,818
8610G	Same as above, with 192K 32-bit words	950,320	4,040	23,758	22,360	21,145
8610H	Same as above, with 224K 32-bit words	1,014,040	4,580	25,351	23,859	22,562
8610I	Same as above, with 256K 32-bit words	1,061,800	4,940	26,545	24,982	23,625
8610J	Same as above, with 320K 32-bit words	1,201,200	5,840	30,030	28,263	26,727
8610K	Same as above, with 384K 32-bit words	1,324,680	6,740	33,117	31,168	29,474
8610L	Same as above, with 448K 32-bit words	1,464,480	7,640	36,602	34,448	32,576
8610M	Same as above, with 512K 32-bit words	1,587,560	8,540	39,689	37,353	35,323
8611	Two Additional Real-Time Clocks	1,000	5	23	21	20
8616	Additional Register Block	3,200	10	72	67	64
8617	Alternate CPU Bus	3,000	10	67	63	60
8621	Additional Interrupt Controller	2,700	30	60	57	53
8622	Priority Interrupt, 2 Levels	450	0	10	10	9
8664A	Each Port Expansion for 8610A	9,600	50	214	201	190
8664B,C	Each Port Expansion for 8610B, C	14,400	75	320	302	285
8664D,E	Each Port Expansion for 8610D, E	19,200	100	427	402	380
8664F	Each Port Expansion for 8610F	24,000	125	534	502	475

*Rental prices include monthly maintenance charges.

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
SIGMA 9 PROCESSOR AND MAIN STORAGE (continued)						
8664G	Each Port Expansion for 8610G	28,800	150	640	603	570
8664H	Each Port Expansion for 8610H	33,600	175	747	703	665
8664I	Each Port Expansion for 8610I	38,400	200	854	804	760
8664J	Each Port Expansion for 8610J	48,000	250	1,067	1,004	950
8664K	Each Port Expansion for 8610K	57,600	300	1,280	1,205	1,140
8664L	Each Port Expansion for 8610L	67,200	350	1,494	1,406	1,330
8664M	Each Port Expansion for 8610M	76,800	400	1,707	1,607	1,519
8670	Additional MIOP — Channel A	20,000	155	445	419	396
8671	Four-Byte Interface (For MIOP)	3,000	15	67	63	60
8672	Additional Eight Subchannels (For MIOP)	4,000	15	89	84	79
8673	Memory-to-Memory Move (For MIOP)	2,800	15	63	59	56
8674	Alternate 8670 Bus (For MIOP)	3,000	10	67	63	60
8675	MIOP — Channel B	15,000	155	334	314	297
8680	High Speed RAD IOP (HSRIOP); includes control for 7212 RAD	45,000	200	1,000	942	890
8684	Alternate HSRIOP Bus (For HSRIOP)	3,000	10	67	63	60
CONSOLE INPUT/OUTPUT						
7012	Keyboard/Printer & Controller KSR-35); 10 cps	6,000	45	150	141	134
7014	Spare Mechanism for 7012 or 8091	3,600	0	90	85	81
7020	Keyboard/Printer (10 cps) w/Paper Tape Punch/Reader (10/19 cps) and Controller (ASR-35)	7,500	50	188	177	168
7021	Spare Mechanism for 7020 or 8092	5,000	0	125	118	112
MASS STORAGE						
7201	Rapid Access Data (RAD) Controller (for up to eight 7202, 7203, or 7204 RAD Storage Units in any combination)	8,000	35	200	188	178
7202	RAD Storage Unit; 0.75MB, 188,000 bytes/sec.	18,000	90	450	423	401
7203	RAD Storage Unit; 1.5MB, 188,000 bytes/sec.	24,000	120	600	564	534
7204	RAD Storage Unit; 3.0MB, 188,000 bytes/sec.	35,000	175	875	823	774
7211	Rapid Access Data (RAD) Controller (connected to Selector I/O Processor for up to four 7212 RAD Storage Units)	18,000	50	450	423	401
7212	RAD Storage Unit; 5.4MB (may be directly connected to Sigma 9 High-Speed RAD IOP)	60,000	250	1,500	1,410	1,335
7231	Extended Performance Rapid Access Data (RAD) Controller (for up to four 7232 RAD Storage Units)	14,000	70	350	329	312
7232	Extended Performance RAD Storage Unit; 6.3 MB	50,000	250	1,250	1,175	1,113
7235	Extended Width Interface Feature for 7231 (provides 4-byte data path through IOP channel)	2,500	15	63	60	56
7236	Extended Width Rapid Access Data (RAD) Controller (for up to four 7232 RAD Storage Units)	26,500	50	663	623	590
7240	Disk Controller (connected to any I/O Channel for up to 8 spindles in 7242 and/or 7246 Disk Storage Units)	20,000	100	500	470	445
7241	Extended Width Interface Feature for 7240 (provides 4-byte data path)	2,500	15	63	60	56
7242	Disk Storage Unit; Removable, Dual Spindle, 49.15 MB	25,000	265	800	752	712
7242B	Disk Storage Unit; Removable, Four Spindle, 98.30 MB	45,000	530	1,100	1,034	979
7243	Device Pooling Feature (for 7242 to provide dual access by two 7240's)	8,000	50	200	188	178
7244	Disk Pack for 7242 or 7246 Disk Storage Units; 24.58 MB	600	0	31	31	31
7246	Disk Storage Unit; Removable, Single Spindle, 24.58 MB	15,000	200	450	423	400
7247	Device Pooling Feature, Single Spindle (for 7246 to provide dual access by two 7240's)	5,000	40	125	118	111
MAGNETIC TAPE INPUT/OUTPUT						
7315	Magnetic Tape Controller plus one 7316 Drive, 9-track (one 7316 may be added)	28,000	270	950	900	850
7316	Add-On Tape Drive; 60KB, 9-track	12,000	170	450	422	400
7320	Magnetic Tape Control for up to eight 7322 and/or 7323 Magnetic tape units, 9-track	32,000	120	800	752	712
7322	Magnetic Tape Unit; 60KB, 9-track	22,000	165	500	470	445
7323	Magnetic Tape Unit; 120KB, 9-track	27,000	200	625	588	557
7361	Magnetic Tape Control, 7-track (for one or two 7362 Magnetic Tape Units)	6,000	40	150	141	134
7362	Magnetic Tape Unit; 20KC, 7-track	19,000	125	475	447	423
7365	BCD Option for 7361	2,000	0	50	47	46
7371	7-Channel Tape System Control; 200, 556, or 800 bpi (for up to eight 7372 Magnetic Tape Units)	22,000	100	550	517	490
7372	Magnetic Tape Unit 15/41.7/60 KC, 7-track	27,000	185	675	635	601
7374	Binary Packing Option for 7371	3,200	0	80	76	72

*Rental prices include monthly maintenance charges.

Xerox Sigma Series

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
OTHER INPUT/OUTPUT UNITS						
7121	Card Reader (including control); 200 cpm	8,800	45	220	207	196
7122	Card Reader (including control); 400 cpm	16,000	120	400	376	356
7140	Card Reader (including control); 1500 cpm	24,000	180	600	564	534
7160	Card Punch (including control); 300 cpm	32,000	250	800	752	712
7165	Card Punch (including control); 100 cpm	19,600	125	490	461	437
7440	Buffered Line (drum) Printer; 628 lpm, 132 positions	35,000	250	875	823	779
7441	Buffered Line (drum) Printer; 1100 lpm, 132 positions	46,000	275	1,150	1,081	1,024
7446	Buffered Line (drum) Printer; 1500 lpm, 132 positions	62,000	300	1,450	1,363	1,291
7450	Buffered Line (drum) Printer; 225 lpm, 128 positions	22,500	140	563	530	502
7060	Paper Tape Reader (7062), Punch (7063), Spooler (7064), w/Controller & Rack (7061)	12,000	85	300	282	267
7061	Paper Tape Equipment Cabinet & Controller	7,000	30	175	165	156
7062	Paper Tape Reader; 300 cps	2,000	15	50	47	46
7063	Paper Tape Punch; 120 cps	2,500	25	63	60	57
7064	Paper Tape Spooler	1,500	10	38	36	34
7530	Incremental Graph Plotter (11-inch	13,000	75	325	306	290
7531	Incremental Graph Plotter (30-inch)	22,000	100	550	517	490
7534	Graph Plotter Controller (For 7530 or 7531)	8,400	45	210	198	187
7580	Graphic Display Unit (including control)	45,000	300	1,124	1,058	1,002
COMMUNICATION CONTROLS						
7601	Data Set Controller	7,000	35	175	165	156
7602	Full Duplex Feature (for 7601)	800	0	20	19	18
7603	Automatic Dialing Feature (for 7601)	800	0	20	10	18
7604	Local Batch Terminal Controller	8,400	35	210	198	187
7611	Character-Oriented Communications Subsystem (for up to 64 simultaneous remote devices)	10,500	45	263	248	235
7612	Timing Module for 7615/7616 (a maximum of 5 may be connected to a 7611)	250	0	6	6	6
7613	Line Interface Unit (a maximum of 7 may be connected to a 7611 for up to 64 lines)	1,000	0	25	24	23
7615	Formatted Send Module (one per 7611 line)	250	2	6	6	6
7616	Formatted Receive Module (one per 7611 line)	250	2	6	6	6
7623	DC Power Supply (for 7611)	1,000	5	25	24	23
7618	Automatic Dialing Unit (controls 1 Bell System 800 Series Automatic Call Unit)	5,500	40	138	130	123
7619	Additional Dialing Position (up to 15 may be added to a 7618 for a total of 16 dialers)	500	0	13	13	12
7630	Communications Controller Plus 8 Lines	14,000	45	350	329	312
7631	8-Line Expansion Unit	5,800	30	145	137	130
7650	Channel Interface Unit for inter-processor data transmission	7,500	50	188	177	168
7670	Remote Batch Terminal; includes control unit, operator's console, 250-lpm bar printer, 200-cpm card reader, and 75-to-200-cpm card punch	36,000	180	900	846	801

*Rental prices include monthly maintenance charges.

SOFTWARE PRICES

Program Number	Program Product	Monthly Use Fee**	Prepaid Use Fee**
5008	Sigma 5/6/7/9 MANAGE	$117	$ 5,850
5014	Sigma 5/7/9 SL-1 (BPM/BTM)	200	10,000
5020	Sigma 5/6/7/9 FMPS	Not avail.	15,000
5022	Sigma 5/6/7/9 GAMMA III (requires 5020)	Not avail.	7,500
5028	Sigma 5/6/7/9 GPDS	72	3,600
5032	Sigma 5/6/7/9 DMS	425	21,250
5036	Sigma 5/7/9 SL-1 (RBM)	200	10,000
5040	Sigma 5/6/7/9 CIRC DC	78	3,900
5042	Sigma 5/6/7/9 CIRC AC (requires 5040)	24	1,200
5044	Sigma 5/6/7/8 CIRC-TR (requires 5040)	59	2,950

**Program products are available only on a Monthly Use Fee basis except to OEM's, who have a choice between Monthly Use Fee and Prepaid Use Fee. The exception is FMPS/GAMMA III, available to all customers only on a Prepaid Use Fee. All program products except FMPS/GAMMA III are available at no charge to qualified educational institutions.

Xeros Sigma Series

NEW PRODUCT ANNOUNCEMENT

SIGMA 6E SYSTEM: A specially packaged Sigma 6 configuration was added to the existing Xerox computer line in April 1972. Intended for use by small universities and other educational institutions, the Sigma 6E operates under BTM. The basic Sigma 6E system includes 32,000 32-bit words of core memory, a 7240/7242 dual-spindle Disk Storage Unit (49.15 million bytes), a 7630 Communications Controller plus 8 lines for time-sharing, and a teletypewriter operator console. Xerox's installment purchase prices (including maintenance) for typical Sigma 6E systems run about 40% less than the corresponding 6-year lease plus maintenance charges for standard Sigma 6 installations.

The 32K-word disk-oriented BTM is also available for other Xerox Sigma Series computers, including the 5 and larger. In all cases, the batch job must be swapped out with the time-sharing jobs, whereas on the 48K-word BTM, swapping of the batch job is optional.

7260/7261 AND 7265/7266 REMOVABLE DISK STORAGE SYSTEMS: With the announcements of these medium and high-capacity peripheral units on May 2, 1972, Xerox significantly extended the application range of the Sigma line into large commercial data base management environments. Although data management systems have been available from Xerox for some time, the former absence of large-capacity disk drives slowed the acceptance of the Sigma series in environments with large data base applications.

Both the 7260/7261 and the 7265/7266 use the same Model 7264 eleven-high, twenty-surface disk pack, and provide for data transfer at a peak rate of 512K bytes/second and an average (multiple-sector) rate of 450K bytes/second. Each system has an average positioning time of 30 milliseconds and an average rotational delay of 12.5 milliseconds. The 7260/7261 records 1024 bytes per sector, with 11 sectors per track, 200 data tracks per surface, and 20 recording surfaces for a data capacity of 45,056,000 bytes per spindle. The 7265/7266 has a similar recording format except that a higher recording density is used to provide 404 data tracks per surface for a data capacity of 91,012,120 bytes per spindle.

The Model 7260 consists of a controller and from two to fifteen 7261 drives for a subsystem capacity of from 90,112,000 to 675,840,000 bytes. The Model 7265 consists of a controller and from three to fifteen 7266 drives for a subsystem capacity of from 273,039,360 to 1,365,196,800 bytes. Optional dual access to each subsystem is available, as is independent seek for multiple-spindle access overlapping and hardware write protection on a full-spindle basis. Delivery of the Xerox-built disk systems is planned for the fourth quarter of 1972 and the first quarter of 1973 for the 7260 and 7265, respectively. □

EQUIPMENT PRICES

		Purchase Price	Monthly Maintenance	Rental (1-year lease)*	Rental (4-year lease)*	Rental (6-year lease)*
SIGMA 6E SYSTEM**						
6310A	Sigma 6E CPU with 32K 32-bit words of main memory and all standard Sigma 6 features except Memory Map, plus the following peripherals: 7012 Console, 7240/7242 Disk System, 7612 Timing Module, 7630 Communications Controller, 8321/8322 Interrupts and Control Chassis	217,780	1,655	–	–	–
6310B	Same as above, with 40K words of memory	258,580	1,795	–	–	–
6310C	Same as above, with 48K words of memory	299,380	1,900	–	–	–
6310D	Same as above, with 56K words of memory	340,180	2,040	–	–	–
6310E	Same as above, with 64K words of memory	380,980	2,245	–	–	–
6315	Memory Map Option	20,000	80	–	–	–
DISK STORAGE SYSTEMS						
7260	Disk Controller plus two 7261 Disk Drives (90MB)	91,600	450	2,290	2,153	2,038
7261	Disk Drive (45MB)	19,600	140	490	461	436
1032	Second Controller (for 7260 dual access)	40,000	170	1,000	940	890
1033	Dual Access (for 7261 Disk Drive)	5,000	25	125	117	111
7265	Disk Controller plus three 7266 Disk Drives (273MB)	145,000	625	3,625	3,408	3,226
7266	Disk Drive (91MB)	20,000	150	500	470	445
1034	Second Controller (for 7265 dual access)	45,000	175	1,125	1,058	1,001
1035	Dual Access (for 7266 Disk Drive)	5,000	25	125	117	111
7264	Disk Pack (for 7261 or 7266 Disk Drive)	600	N/A	31	31	31

*Rental prices include monthly maintenance charges.

**Available to qualified non-profit educational institutions on either a direct purchase basis or through a Xerox-financed installment purchase plan.