

# NAS AS/66X0, AS/80X3, and AS/9XX0

## MANAGEMENT SUMMARY

**UPDATE:** During the past year, National Advanced Systems has introduced a plethora of hardware and software enhancements that affect its entire line of plug-compatible mainframe processors. For the product lines discussed in this report, the most recent additions include three engineering/scientific enhancements for the AS/66X0 Series; increased main memory capacity and expanded VM support for the AS/80X3 Series; and more microcode assists, more main memory, and a greater number of input/output channels on the AS/9XX0.

The National Advanced Systems (NAS) AS/6600, AS/80X3, and AS/9XX0 Series are three IBM plug-compatible product lines that compete primarily with IBM's 4381 and 3080 Series. NAS is a subsidiary of National Semiconductor Corporation, but it no longer manufactures any of the product lines it is now selling. The current systems are altered versions of the Hitachi M Series families in Japan, which have their own MVS-like operating system and are somewhat incompatible with IBM. The degree of incompatibility between M Series machines and IBM-compatible machines is small enough to make it worthwhile for Hitachi to design for both markets, and sometimes even to announce comparable new models simultaneously in both countries. NAS is the marketing, sales, and service organization in many countries outside North America as well as in the United States and Canada.

The four AS/6600 Series models, like the IBM 4341 and 4361, use VSE operating systems in their native ECPS:VSE operating mode as well as the usual 370 environments, but the NAS systems are altogether more powerful than the native IBM VSE systems. They span 4381-11 to 4381-12 performance levels, an estimated throughput range of 1.6 to ➤

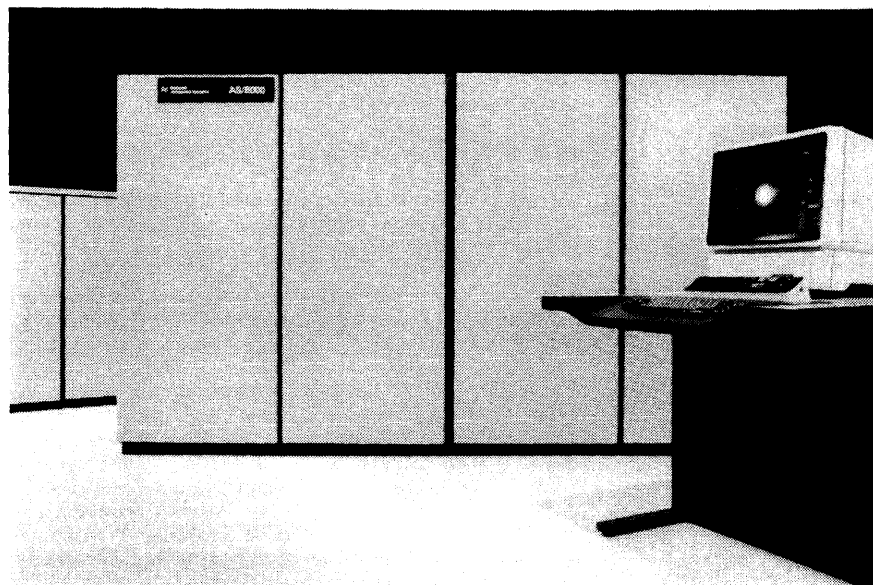
The National Advanced Systems (NAS) AS/6600, AS/80X3, and AS/9XX0 Series consist of 19 models that are not only plug compatible with their corresponding IBM mainframe lines, but also allow a wider range of compatibility for older operating system versions than IBM does. Their upward growth path is currently one of the best in the industry, since the compatible AS/XL and AS/XL V Series now tops out at considerably above either IBM or Amdahl. NAS also provides IBM-compatible software, firmware, and peripheral equipment.

**MODELS:** AS/6620, AS/6630, AS/6650, AS/6660, AS/8023, AS/8043, AS/8053, AS/8063, AS/8083, AS/9040, AS/9050, AS/9060, AS/9070, AS/9080, AS/9140, AS/9150, AS/9160, AS/9170, and AS/9180.

**CONFIGURATION:** One or 2 CPUs with 8 to 128 megabytes of main memory, 16K to 256K bytes of buffer storage per processor, and 5 to 48 I/O channels, depending on the model. A vector processor is integrated into AS/91X0 models.

**COMPETITION:** IBM 4341-2, 4341-12, 4361-5 (some configurations) and the IPL 4400 Series for the AS/6600; 4381 Series, 3080 Series (except 3084), low-end 3090 Series; and Amdahl 580 Series for the AS/80X3 and AS/9XX0 Series.

**PRICING:** Purchase prices range from \$255,000 to \$4,478,000. ➤



The AS Series family is composed of three product lines. The AS/80X3 Series, shown here, is a family of XA-oriented systems available in single- and dual-processor models that compete directly with IBM's 4381 and 3080 Series. The AS/80X3 has 8 to 32 megabytes of memory and 8 to 32 channels, just reaching the 3081KX performance level.

## NAS AS/66X0, AS/80X3, and AS/9XX0

TABLE 1. SYSTEM COMPARISON

MODEL	AS/6620	AS/6630	AS/6650	AS/6660	AS/8023
<b>SYSTEM CHARACTERISTICS</b>					
Date announced	Jan. 1983	Oct. 1982	Oct. 1982	Sept. 1984	April 1984
Date first delivered	July 1983	Oct. 1982	Nov. 1982	Dec. 1984	July 1984
Field upgradable to	AS/6630	AS/6650	AS/6660	—	AS/8043
Relative performance	—	—	—	—	1.0
Number of processors	1	1	1	1	1
Cycle time, nanoseconds	60	60	50	43	35
Word size, bits	32	32	32	32	32
Operating systems	DOS/V5, DOS/V5E, MVS, MVS/SE, MVS/SP V1, OS/V51, VM/370, VM/SP	DOS/V5, DOS/V5E, MVS, MVS/SE, MVS/SP V1, OS/V51, VM/370, VM/SP	DOS/V5, DOS/V5E, MVS, MVS/SE, MVS/SP V1, OS/V51, VM/370, VM/SP	DOS/V5, DOS/V5E, MVS, MVS/SE, MVS/SP V1, OS/V51, VM/370, VM/SP	ACP, DOS/V5, DOS/V5E, MVS, MVS/SE, MVS/SP V1, OS/V51, VM/370, VM/SP
<b>MAIN MEMORY</b>					
Type	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS
Minimum capacity, bytes	8M	8M	8M	8M	16M
Maximum capacity, bytes	16M	16M	16M	16M	64M
Increment size	4MB & 8MB	4MB & 8MB	4MB & 8MB	4MB & 8MB	8MB & 16MB
Cycle time, nanoseconds	420	420	350	301	360
<b>BUFFER STORAGE</b>					
Minimum capacity, bytes	—	—	—	—	—
Maximum capacity, bytes	64K	64K	64K	64K	32K
Increment size	—	—	—	—	—
<b>INPUT/OUTPUT CONTROL</b>					
Number of channels:					
Byte multiplexer	1 or 2	1 or 2	1 or 2	1 or 2	0 to 6
Block multiplexer	4 or 6	4 or 6	4, 6, 8, or 10	4, 6, 8, or 10	6 to 24
Word	—	—	—	—	—
Other	—	—	—	—	—

➤ 2.7 millions of instructions per second (MIPS), but the 4381 models are 370 XA-oriented processors that do not run ECPS:VSE microcode. Their compatibility lies only in their common alternative System/370 personality.

The five AS/80X3 and ten AS/9XX0 models use XA operating systems in their native mode, like the IBM 4381 and 3080, but overlap the IBM system performance levels, and each other's, in a more complicated fashion. If the IBM 4381 and 3080 Series performance is rated as ranging from 1.6 MIPS to 7.2 MIPS for the 4381-11 single processor through the 4381-14 dual processor, and from 3.0 MIPS to 28.0 MIPS for the 3083-CX single processor through the 3084-QX quad processor, then we would estimate the comparable performance ranges would be about 3.0 MIPS to 14.0 MIPS for the AS/80X3 and about 7.2 to 20.0 MIPS for the AS/9XX0. The NAS AS/XL Series, covered in a separate report, provides performance levels that compete with and exceed the 3084-QX and the 3090 Series.

In addition to a "native mode" VSE or XA personality, all three NAS AS product lines have in common an alternative System/370 operating mode that provides a compatibility thread linking all NAS product lines together. In this fundamental design, NAS mirrors IBM faithfully. In all its currently marketed mainframes, IBM provides one "native" operating mode (either VSE or XA) that fully exploits the performance of the machine, plus a System/370 mode that is characterized by its wide compatibility. The 4321, 4331, 4341, and 4361 are VSE dual personality systems; the 4381, 3080, and 3090 are XA dual personality systems, with the second personality in all seven cases being a 370 operating mode. The older 3030 (and of course the 370 itself) only had a single, 370 personality. The native mode and the 370 mode are mutually exclusive, but can be easily ➤

### ► CHARACTERISTICS

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**MODELS:** AS/6620, AS/6630, AS/6650, AS/6660, AS/8023, AS/8043, AS/8053, AS/8063, AS/8083, AS/9040, AS/9050, AS/9060, AS/9070, AS/9080, AS/9140, AS/9150, AS/9160, AS/9170, and AS/9180.

### DATA FORMATS

All data formats, instruction formats, and other architectural features of the National Advanced Systems (NAS) processors have evolved from the IBM System/370 architecture, although the implementation may be different in ways that are transparent to the software. The most important element in defining the predominant personality of a series—and the range of operating systems it can support—is the processor mode microcode loaded at Initial Microprogram Load (IML, or IMPL) time. The AS/6600 Series can support VSE or 370 modes. The AS/80X3 and AS/9XX0 support 370 or 370 XA modes. All three modes differ in the instruction set they support (see Instructions), in their address translation algorithms and associated virtual memory paging logic and capacity (see Main Memory), and in their channel loading and channel addressing methods (see I/O Channels). The 370 mode, furthermore, can operate in either the Basic Control (BC) mode or Extended Control (EC) mode. The BC mode maintains general upward compatibility with the System/360 architecture and programming. In the EC mode, the Program Status Word (PSW) and the layout of the permanently assigned main storage area are altered to support Dynamic Address Translation and other system control functions; therefore, the virtual-storage-oriented operating systems must be used. ➤

## NAS AS/66X0, AS/80X3, and AS/9XX0

TABLE 1. SYSTEM COMPARISON (Continued)

MODEL	AS/8043	AS/8053	AS/8063	AS/8083	AS/9040/9140*
<b>SYSTEM CHARACTERISTICS</b>					
Date announced	May 1983	May 1983	May 1983	April 1984	Sept. 1982 (9040) July 1982 (9140)
Date first delivered	May 1983	June 1983	Dec. 1983	Mar. 1985	Nov. 1982 (9040) July 1982 (9140)
Field upgradable to	AS/8053	AS/8063	AS/8083	Not applicable	9050 or 9140
Relative performance	1.5	2.2	2.5	4.6	1.0
Number of processors	1	1	1	2	1
Cycle time, nanoseconds	35	35	33	35	35
Word size, bits	32	32	32	32	32
Operating systems	ACP, DOS/VS, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, OS/VS1, VM/SP, VM/370	ACP, DOS/VS, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, OS/VS1, VM/SP, VM/370	ACP, DOS/VS, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, OS/VS1, VM/SP, VM/370	ACP, DOS/VS, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, OS/VS1, VM/SP, VM/370	ACP, DOS/VS, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, TPF2, OS/VS1, VM/SP, VM/SP, VM/370, VM/XA
<b>MAIN MEMORY</b>					
Type	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	64K-bit & 256K-bit NMOS	256K-bit NMOS
Minimum capacity, bytes	16M	16M	16M	32M	8M
Maximum capacity, bytes	64M	64M	64M	128M	64M
Increment size	8MB & 16MB	8MB & 16MB	8MB & 16MB	16MB & 32MB	8MB
Cycle time, nanoseconds	360	360	315	315	315
<b>BUFFER STORAGE</b>					
Minimum capacity, bytes	—	—	—	—	—
Maximum capacity, bytes	32K	64K	64K	64K/CPU	64K
Increment size	—	—	—	—	—
<b>INPUT/OUTPUT CONTROL</b>					
Number of channels:					
Byte multiplexer	0 to 6	0 to 6	0 to 6	0 to 8	1 to 6
Block multiplexer	6 to 24	6 to 24	6 to 24	12 to 32	6 to 23
Word	—	—	—	—	—
Other	—	—	—	—	—

\*91X0 models have an integrated vector processor.

➤ changed by the user at Initial Microprogram Load (IMPL) time. NAS systems, in addition to their compatible dual personalities, also provide identical interface characteristics with IBM peripherals and the all-important software. IBM users can swap to NAS processors—and back to IBM, if desired—without difficulty of any kind, other than the usual problems of getting the equipment to fit through the doors and then cabling it all together.

NAS, like all plug-compatible vendors, wins its customers from IBM primarily by providing a machine with better performance than a comparably priced IBM machine or by offering lower prices for a machine of comparable performance; at times a more compact design, lower power or cooling requirements, and/or a high reliability track record will affect the buyer's decision. In addition, one of the more intriguing selling characteristics of NAS machines is that they can be more compatible with IBM than IBM is. How can this be?

The NAS compatibility advantage comes from IBM's penchant for indirectly making a particular operating system environment obsolete by not implementing an instruction, a feature, or some basic logic elements that that environment needs. For instance, the XA mode always uses 4K protect keys and 4K-byte paging, whereas the 370 mode uses either the older 2K keys (on all VSE systems) or the 4K keys (on most XA systems). Only on the 4381 systems are both the 2K and 4K keys implemented in 370 mode, allowing the user to run older operating system versions as well as newer ones. NAS, on the other hand, supports both ➤

➤ **BASIC UNIT:** 8-bit byte, due to byte-oriented instructions. However, the basic word orientation of the instruction set means there is a performance degradation if a byte is not on a word boundary. Each byte can represent 1 alphanumeric character, 2 BCD digits, or 8 binary bits. Two consecutive bytes form a halfword of 16 bits, while four consecutive bytes form a 32-bit word.

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

**FLOATING-POINT OPERANDS:** 1 word consisting of 24-bit fraction and 7-bit hexadecimal exponent, in "short" format; 2 words, consisting of 56-bit fraction and 7-bit hexadecimal exponent, in "long" format; or 4 words in "extended precision" format.

**INSTRUCTIONS:** 2, 4, or 6 bytes in length, which usually specify 0, 1, or 2 memory addresses, respectively. The basic System/370 mode in the AS/6600 implements the 183 instructions of the System/370 Universal Instruction Set, and adds instructions for handling extended precision (28 hexadecimal digits) floating-point operands on the AS/80X3 and AS/9XX0 Series. The instruction sets for the other two processor modes are somewhat modified forms of this core instruction set. ECPS:VSE mode implements 187 instructions which include the 12 instructions required to support VSE in native mode, and excludes others in the 370 set that are unnecessary for native-mode VSE operations. The 370 XA mode includes additional XA instructions, which substitute for and augment certain 370 instructions, and which are primarily needed to fully exploit the redesigned I/O subsystem. Some of the standard and optional microcode assists in 370 mode, such as S/370 Extended Facility and ECPS:VM, also add microcoded instructions to the base set, but these just build on the personality that is established by the processor-mode microcode. ➤

## NAS AS/66X0, AS/80X3, and AS/9XX0

TABLE 1. SYSTEM COMPARISON (Continued)

MODEL	AS/9050/9150*	AS/9060/9160*	AS/9070/9170*	AS/9080/9180*
<b>SYSTEM CHARACTERISTICS</b>				
Date announced	Sept. 1982 (9050) July 1982 (9150)	May 1982 (9060) July 1982 (9160)	Jan. 1982 (9070) July 1982 (9170)	May 1982 (9080) July 1982 (9180)
Date first delivered	Sept. 1982 (9050) July 1982 (9150)	Aug. 1982 (9060) July 1982 (9160)	Sept. 1982 (9070) July 1982 (9170)	Dec. 1982 (9080) July 1982 (9180)
Field upgradable to	9060, 9070, or 9150	9080 or 9160	9080 or 9170	9180
Relative performance	1.25	1.55	2.25	2.8
Number of processors	1	1	2	2
Cycle time, nanoseconds	35	30	35	30
Word size, bits	32	32	32	32
Operating systems	ACP, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, TPF2, OS/VSE1, VM/SP, VM/370, VM/XA	ACP, DOS/VSE, MVS, MVS/SE, MVS/XA, MVS/SP V1, TPF2, OS/VSE1, VM/SP, VM/370, VM/XA	MVS/SE, MVS/SP V1, MVS/XA, TPF2, VM/SP, VM/XA	MVS/SE, MVS/SP V1, MVS/XA, TPF2, VM/SP, VM/XA
<b>MAIN MEMORY</b>				
Type	256K-bit NMOS	256K-bit NMOS	256K-bit NMOS	256K-bit NMOS
Minimum capacity, bytes	8M	16M	16M	16M
Maximum capacity, bytes	64M	64M	64M	64M
Increment size	8MB	8MB	16MB	16MB
Cycle time, nanoseconds	315	270	315	270
<b>BUFFER STORAGE</b>				
Minimum capacity, bytes	—	—	—	—
Maximum capacity, bytes	64K	256K	64K/CPU	256K/CPU
Increment size	—	—	—	—
<b>INPUT/OUTPUT CONTROL</b>				
Number of channels:				
Byte multiplexer	1 to 6	1 to 6	2 to 12	2 to 12
Block multiplexer	6 to 23	12 to 23	12 to 46	12 to 46
Word	—	—	—	—
Other	—	—	—	—

\*91X0 models have an integrated vector processor.

➤ 2K and 4K keys on all models of the AS/80X3 and AS/9XX0, which are much more powerful. IBM's more recent operating system versions can run with both key types, and hence are more portable, but an NAS user with an older version of an operating system and impediments to immediate upgrade would be able to run the older environment standalone on more powerful processors than could be obtained from IBM. The IBM solution would require either an upgrade or the addition of VM, or both.

The AS processors also include firmware enhancements comparable to IBM's. The firmware enhancements implement several frequently used operating system functions in microcode for increased operational efficiency. Firmware assist features supported by the AS processors include System/370 Extended Facility, Virtual Machine Assist, VM Extended Control Program Support, OS/VSE1 Extended Control Program Support, MVS/SP Assists, and Preferred Machine Assists. The System/370 Extended Facility enables NAS users to execute the MVS/SE or MVS/SP enhancement program product that permits the MVS operating system to utilize the firmware enhancements.

The VSE-oriented, entry-level AS/66X0 Series systems all have uniprocessors with a main memory of 8 megabytes, expandable to 16 megabytes, and have 64K bytes of buffer storage. There are up to 8 I/O channels on the AS/6620 and 6630 and 10 I/O channels on the AS/6650 and 6660. In addition to the DOS/VSE and VSE/AF operating system

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

### MAIN MEMORY

Main memory modules are interleaved 2, 4, 8, or 16 ways (depending on model and configuration) to reduce intersystem contention in highly interactive environments. The entry-level AS/66X0 processors use a two-way interleaving technique that significantly reduces main storage contention and increases the aggregate data rate.

For the mid-range AS/80X3 uniprocessor models, each 8-megabyte main storage extension comprises four banks, each bank having a 2-megabyte capacity using an 8-byte data path. On the multiprocessor model, each processor's 16-megabyte main storage extension comprises four banks, each bank with a 4-megabyte capacity using an 8-byte data path. Main storage is interleaved (4-way on uniprocessor models and 8-way on multiprocessor model), four-bank, real storage using monolithic integrated circuit memory elements. The four banks may be accessed independently.

In the AS/9XX0 Series, uniprocessor models implement 8-way, double-word interleaving, while the dual-processor models use 16-way, double-word interleaving. Each logical storage element of main storage is able to support a memory access independent of other logical storage element activity.

**STORAGE TYPE:** See Table 1.

**CAPACITY:** See Table 1.

**CYCLE TIME:** See Table 1.

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➤ supported in the machines' native mode, the AS/6600 Series can support DOS/VS, DOS/VSE, OS/VS1/BPE, VM/370, and VM/SP in System/370 mode. Recent enhancements to the AS/66X0 Series include the Engineering/Scientific Assist, High-Accuracy Arithmetic Facility, and the Remote Operator Control Facility. The Engineering/Scientific Assist is designed for work loads that must manipulate vector data structures; the High-Accuracy Arithmetic Facility provides a higher degree of accuracy for work involving scientific and engineering applications. A High-Speed Arithmetic feature also increases execution times. The Remote Operator Control Facility allows an operator at the central site to control the operation of a processor at a remote site.

The XA-oriented AS/80X3 family is a five-model series that began replacing earlier AS/8040/8050/8060 models in 1983. The current models are available with single or dual processors, 16 to 128 megabytes of main memory, buffer storage of 32K or 64K bytes, and up to 24 I/O channels on the single processors and 32 I/O channels on the dual processor. Models AS/8023, 8043, 8053, and 8063 are all uniprocessors; Model AS/8083 is the only dual processor. In addition to the MVS/XA and VM/XA SF operating systems supported in the native XA mode, the AS/80X3 can run standalone DOS/VS, DOS/VSE, OS/VS1/BPE, VM/370, VM/SP, MVS/SE, MVS/SP Version 1, and ACP/TPF2 in System/370 mode. Recent enhancements to the AS/80X3 Series include increased main memory capacities, and four new microcode assist functions known collectively as the Extended Control Program Support for VM (ECPS:VM).

The XA-oriented AS/90X0 Series was first introduced in 1980 as the AS/9000, next augmented by the AS/9000N and the AS/9000DPC, and then replaced with the current model set, beginning in 1982. There are now three uniprocessors: Models 9040, 9050, and 9060; and two dual processors: Models 9070 and 9080. Cache buffer size is 64K or 256K bytes, depending on the model. In addition to the MVS/XA and VM/XA SF operating systems supported in the native XA mode, the AS/9XX0 can run standalone DOS/VS, DOS/VSE, OS/VS1/BPE, VM/370, VM/SP, MVS/SE, MVS/SP Version 1, and ACP/TPF2 in System/370 mode. More recently, NAS expanded maximum main memories on the AS/9040 and AS/9050 from 48 megabytes to 64 megabytes to match the 64M bytes per CPU found on the other models (i.e., 128M bytes on dual processors). In addition to memory expansions, NAS increased maximum channel capacity to 48 channels. Up to 24 channels can be installed on single-processor models and up to 48 on multiprocessors. When more than 16 channels are installed on a uniprocessor or more than 32 channels are installed on a multiprocessor, they can only be supported in IBM extended architecture (XA) mode. These upgrades can, according to NAS, yield an overall performance increase of 300 percent when migrating from the AS/9040 to the AS/9080.

An added feature of the AS/90X0 Series is the ability to migrate to the AS/91X0 Vector Processor Series. This offers the user entry-level supercomputing capability on the ➤

➤ **CHECKING:** Error checking and correction (ECC) circuitry in main memory performs automatic correction of all single-bit errors and detection of all double-bit and most other multiple-bit memory errors.

A reconfiguration capability is standard with all AS models. In the event of an unrecoverable error, or any other problem with a memory module, the operator can "dial out" the problem module (one-half million, one million, or two million bytes) and reconfigure the remaining memory for continuous operation.

The Store and Fetch Protection features, which guard against inadvertent overwriting and/or unauthorized reading of data, have an important role in circumscribing compatibility. Both XA and 370 modes implement key-oriented storage protection features. (Most IBM XA systems use 4K protect keys, while non-XA systems use 2K keys.) The NAS AS/80X3 and AS/9XX0 models support both key types, thus allowing for a greater range in the number of operating system versions that can run in standalone mode. In addition, the 370-Extended Facility feature provides protection for the first 512 bytes of storage for MVS/SE and MVS/SP Version 1 users. The PLPA segment protection feature protects portions of the MVS/SP Version 1 pageable length packed area, and CMS for VM/HPO users. In Extended Architecture mode, any 4K page can be protected to enhance availability.

**RESERVED STORAGE:** Not supplied by vendor.

### CENTRAL PROCESSORS

The basic implementation of all National Advanced Systems (NAS) Central Processing Units (CPUs) is fundamentally similar. Primary functional units are as follows: the Storage Control Unit (SCU), the Instruction Unit (IU), and the Execution Unit (EU). The SCU processes all fetch and store requests to main storage, and translates real addresses to absolute addresses prior to accessing main storage. Included in the SCU is a High-Speed Buffer that reduces the apparent fetch time of main storage. A Dynamic Address Translation Facility carries out all virtual-to-real address translations. The Storage Protection Facility uses 7-bit-long keys to protect against unauthorized access or alteration of data during store or fetch operations.

The IU fetches and prepares instructions and operands for execution by the EU. It also tests for address exceptions prior to execution, and buffers the current instruction stream and branch target stream. The IU is composed of two sets of instruction buffers, one instruction register, three instruction queuing registers, an adder, three operand address registers, and a length incrementer for computing the end of addresses.

The EU is divided into two independently operable subunits: the floating-point execution unit (FEU) for executing floating-point instructions, and the general execution unit (GEU) for executing instructions other than those mentioned above.

Aside from key differences in cycle times, data path widths, and cache buffer sizes, there are three CPU architectural features that point to significant differences in performance range. The first is the word length used in the Reloadable Control Storage, the second is the degree of pipelining implemented, and the third is the presence or absence of a vector processor. A longer RCS word length allows more complex operations to be performed in a single cycle than a shorter one would, and thus cuts back on the number of cycles needed to perform essential CPU tasks. The degree of pipelining affects how many instructions can be in various stages of execution at a given moment. The presence or absence of a vector processor can make a vast difference to ➤

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TABLE 2. MASS STORAGE

MODEL	7360-A4, B4	7380-A4, B4	7380-AD, BD	7380-AE, BE
Cabinets per subsystem	1 to 8	1 to 8	1 to 8	1 to 8
Disk packs/HDAs per cabinet	2 (4 logical)	2 (4 logical)	2 (4 logical)	2 (4 logical)
Capacity*	1.269GB	2.521GB	2.521GB	5.042GB
Tracks/segments per drive unit	16,650	13,275	13,275	26,650
Average seek time, msec.	20	16	9.3	9.3
Average access time, msec.	28.3	24.3	17.6	17.6
Average rotational delay, msec.	8.3	8.3	8.3	8.3
Data transfer rate	1.198MB/sec.	3.0MB/sec.	3.0MB/sec.	3.0MB/sec.
Controller model	7860-2	7880-3	7880-3, 7880-3C	7880-3, 7880-3C
Comments	Double-density 3350-type drive; A4 string master controls 1 more B4 add-on drive; 4 A4/B4 strings per subsystem; no field upgrade.	Single-density 3380-type drive; A4 string master controls 3 more B4 add-on drives; 2 A4/B4 strings per subsystem; no field upgrade.	Single-density 3380-type drive upgradable to E models; A4 string master controls 3 B4 add-on drives; 2 A4/B4 strings per subsystem.	Double-density 3380-type drive; A4 string master controls 3 B4 add-on drives; 2 AE/BE strings per subsystem.

\* Each cabinet has 4 logical drives because there are two actuators on each Head/Disk Assembly. All IBM-compatible subsystems can have no more than 32 logical drives.

▷ same machine that is used to run general computing applications such as payroll and accounts receivable. The AS/91X0 integrates a vector processor with an AS/90X0 Series scalar processor in the same enclosure. The vector processor is not an I/O device, as a channel-attached array processor is. The AS/91X0 Series models, and their IBM and Amdahl counterparts, are new types of entry-level supercomputers that combine IBM compatibility with efficient processing of arrays of data. This high-speed computing is intended for applications such as medical, scientific, aerospace and defense research; automotive manufacturing; and semiconductor design; in short, new market opportunities for NAS.

The AS/91X0 Vector Processor Series provides an upgrade path for those AS/90X0 users who have applications with significant segments of vectorizable code. The AS/91X0 is designed to perform at up to 50 MFLOPS (millions of floating-point operations per second). This is not in the same league as the supercomputer standard of 100 MFLOPS, nor is it a peak speed that is reached very often due to the wide extremes in the amount of vectorizable code in different programs, but it still looks attractive when compared to around 4 MFLOPS maximum for those mainframes who can only do scalar processing.

The AS/91X0 Series also features a Vector and Array Syntax Translator (VAST) developed by Pacific-Sierra Research that operates as a Fortran preprocessor. VAST locates operations it can vectorize and inserts the appropriate code which activates the vector processing hardware. It alleviates the necessity to recode existing programs in order to use the system's vector processing capabilities. VAST enables users upgrading to these processors to retain their present base of IBM 370 software. In addition to VAST, NAS has acquired rights to Math Advantage from Quantitative Technology Corporation. Math Advantage is a library of mathematical subroutines used for numerically intensive engineering studies. All of the AS/91X0 processors support both the MVS and VM operating systems. ▷

▶ programs that include sequences requiring the same single operation to be performed over a large array of data.

The AS/6600 Series uses a 72-bit RCS word length. Although the execution unit is not pipelined, it has an instruction prefetch facility that operates in parallel with instruction decoding and execution. This facility prefetches instructions, updates program counters, and provides associated units with instruction fields to be executed. There is no vector processing facility.

The AS/80X3 Series uses a 126-bit RCS word length. In addition to a dual prefetch, which handles branches more efficiently, it has a sophisticated four-level pipeline that simultaneously can decode the instruction to obtain microinstruction and operand addresses, request the operand, load the operand and microword, and execute. This allows four instructions to be in process at the same time. There is no vector processing facility available.

The AS/9XX0 Series uses a 160-bit RCS word length. It has the same type of pipeline as the 80X3 Series has. In addition, the 90X0 units can attach an integral vector processor, which changes the series label to the 91X0 Series.

Whether a product line is oriented toward either 24-bit or 31-bit real memory addresses is a primary element of its identity. The AS/6600 Series can only handle 24-bit addresses, and hence cannot run XA software. The other NAS processors can handle both types of addressing, and a wider compatibility range.

The ECPS:VSE microcode, which establishes the native VSE operational mode on the AS/6600 Series, has a single-level virtual memory addressing facility that is highly efficient for VSE systems. However, it excludes the possibility of implementing other operating systems that need dual-level virtual memory addressing in order to handle multiple virtual storage areas or virtual machines. This operational mode allows addressing a total of up to 16M bytes of real memory and 16M bytes of virtual memory; it requires 2K storage protect keys. It is not available to AS/80X3 and AS/9XX0 Series systems.

The System/370 microcode, common to all the NAS processors, has a dual-level virtual memory addressing algorithm that is not only suited to MVS and VM systems, but can also handle the simpler single-level VSE memory addressing. Of course, when VSE runs in 370 mode, the more elaborate ▶

## NAS AS/66X0, AS/80X3, and AS/9XX0

TABLE 3. INPUT/OUTPUT UNITS

Magnetic Tape Units	Number of Tracks	Recording Density, Bits/Inch	Encoding	Tape Speed, Inches/Sec.	Transfer Rate, Bytes/Sec.
7420-44	9	1600	PE	80	128K
7420-66	9	6250	GCR	80	500K
		1600	PE	125	200K
7420-77	9	6250	GCR	125	780K
		800	NRZI	200	160K
7420-88	9	1600	PE	200	320K
		1600	PE	200	320K
		6250	GCR	200	1250K

### COMPETITIVE POSITION

The NAS AS/6600, AS/80X3, and AS/9XX0 product lines compete in performance directly with all of the IBM 4381, 3080, and low-end 3090 Series, excluding the 3084, 3090-200, and 3090-400 models, which are in the NAS AS/XL league. The IBM 4361-5 and 4341-12 ceiling models for the 4341 and 4361 product lines are just below the AS/6620 in performance. To an IBM user who wants to upgrade, NAS offers full IBM compatibility and better price/performance for most applications, with processors that are either lower in cost than an IBM system of comparable performance, or more powerful than an IBM system of comparable price. Even though the NAS processor architecture is the same as IBM's, the implementation of that architecture differs, so that there will be users who find that benchmark results of their applications will vary above and below the vendor's performance claims. The degree of variance is nowhere near that found for a different architecture, and of course it is much, much easier to do benchmark comparisons, since software written for an IBM machine will run on an NAS machine, and vice versa, without need for alteration.

Next to IBM itself, Amdahl is the primary competitor over the range of power just described. Although there are some vendors of non-IBM architectures who offer systems in the same performance class, they do not really compete with NAS and Amdahl in persuading an IBM user to switch vendors. Except in extremely rare situations, large users have too much money invested in software to consider rewriting it for an alien architecture, as long as there are completely compatible PCM alternatives. NAS AS/6600 systems experience some competition with high-end IPL systems, but IPL is primarily oriented toward providing a PCM alternative at the lower and middle levels of the 4300 line, so the overlap does not seriously affect NAS.

Although it has lost the extra visibility that the top of the line always has, because of the addition of the AS/XL Series, the AS/9XX0 Series is likely to be actively marketed and well received for a considerable length of time. It is an XA-compatible product with plenty of flexibility for changing in response to IBM's midline 4381 and 308X changes. This is true of the XA-compatible AS/80X3 line, but its similarity to AS/9XX0 Series' overall capabilities, and its overlapping of the low-end AS/9XX0 performance levels, suggests that its market potential will not be quite as broad. Some users will prefer to buy a low-end AS/9XX0 proces-

addressing scheme means that it performs more slowly than when it runs in native VSE mode. The 370 mode, in its simplest form, can address up to 16M bytes of real memory, and 16M bytes of virtual memory per user (given the proper operating system at the proper release level). An additional Extended Facility microcode assist allows addressing of more than 16M bytes of real memory in 370 mode, but with no change to virtual memory limits. The Extended Facility for 370 mode should not be confused with the Extended Architecture microcode that provides the base for 370 XA mode.

The 370 XA (Extended Architecture) microcode expands and revises System/370 addressing in such a way as to allow 31-bit addressing (up to 2G bytes) and yet to permit almost all 24-bit-based programs to run without requiring a change of processor mode. The change in both real and virtual memory ceilings requires XA operating systems to be fully exploited. Auxiliary microcode assists like the Extended Facility allow operating systems originally designed for the 16M-byte ceiling to handle larger memories (64M bytes for MVS/SP V.1), but cannot change the virtual memory ceiling without affecting compatibility. XA mode runs on the AS/80X3 and AS/9XX0, Series but not on the AS/6600.

**SPECIAL FEATURES:** The *AS/91X0 Series Vector Processor* enhances the AS/90X0 processor by adding an internal vector processor that gives the ability to perform far more efficient array processing. Field upgradable from existing AS/90X0 Series models, the AS/91X0 Series is designed to accelerate vector processing at a rate that is eight times faster than other large-scale mainframes that do not have internal vector processors or attached array processors. With the architectural expansion of the AS/91X0 Series, a vector instruction unit with 46 order codes processes data and stores the results in the central processor. A parallel processing execution element is added to the execution unit of each instruction subprocessor to implement vector processing functions. Vector Address Generation elements, Vector Data elements, and a microcoded engine perform parallel arithmetic operations that provide the performance increase. The AS/9140, AS/9150, AS/9160, AS/9170, and AS/9180 processors utilize a Fortran preprocessor called VAST (Vector and Array Syntax Translator) which enables the systems to execute vectorized Fortran programs yet remain compatible with IBM architecture. All existing 370 business-oriented software can be run without modification and the entire series support both MVS and VM operating systems. Also available is a software library of mathematical subroutines called Math Advantage, from Quantitative Technology Corporation. See SOFTWARE, later, for more information. Users who upgrade to the AS/91X0 Vector Processing Series will find it useful for numerically intensive engineering studies.

The AS/66X0 and the AS/80X0 have the following special features in common with the AS/90X0. The *Timing Features* of the System/370 architecture are included in the AS

## NAS AS/66X0, AS/80X3, and AS/9XX0

➤ sor that can be field upgraded over a longer period of time, rather than a high-end AS/80X3 system that would involve dual processors or a processor swap at an earlier point in the growth cycle.

In spite of its more mature status and its smaller performance range, the competitive position for the AS/6600 Series should be quite viable for now, because of the price/performance advantages it can provide for upgrading 4341 and 4361 VSE users. VSE is supported in 370 mode on the larger systems available from IBM, NAS, and Amdahl, but these systems are really more oriented toward MVS and the larger VM installations, and have price tags to match. The AS/6600 Series provides the extra performance benefits inherent in the VSE mode, more power, and a price/performance ratio better than that of the 4300 Series. Its future is uncertain because the future of the 4300 Series architecture in its current form is questionable. When IBM introduces the replacement series for the 4300 low-end power range, it is almost certain to be an XA architecture, especially since VSE has been "stabilized," and unlikely to undergo further development, in spite of the huge DOS/VSE & VSE user base.

In earlier comparisons of the NAS processor family with their IBM counterparts, NAS products tended to fit in the performance "holes" in the IBM lines, so that NAS justifiably claimed to have the edge on performance ratings. However, IBM has altered the performance and model labelling on the 4381 and 3080 Series to provide either more "granularity" or better performance, so straight performance comparisons are not so easily generalized anymore (although it is still always true that for most applications, price/performance ratios are better with NAS).

Specifically, according to NAS benchmarks, the performance ratings of the AS/6620 and AS/6630 are 20 and 55 percent better, respectively, than IBM's 4361 Model Group 5, which is about the same level as is now occupied by the 4381-11. The AS/6650 and AS/6660 have performance ratings equal to or better than the IBM 4381 Model Group 1, a model that has been withdrawn by IBM, leaving the NAS model to fill the rather sizeable "hole" between the 4381-11 and 4381-12. Again according to the NAS benchmark study, the AS/8043 provides 10 percent better performance than the IBM 3083 Model Group EX, and has equivalent processing power to the IBM 4381 Model Group 3. The AS/8053 shows the same performance rating as the IBM 3083 Model Group BX, the AS/8063 is comparable to the performance of the IBM 3083 Model Group JX, the AS/8023 is equal to IBM's 4381 Model Group 2 (which IBM has relabelled the 4381 Model Group 12), and the AS/8083 competes with the IBM 3081 Model Group KX.

In the AS/90X0 Series, which overlaps with the high end of the 80X3, NAS targets the AS/9040 at IBM's 3083 Model Group BX, and the AS/9050 at IBM's 3083 Model Group JX. The AS/9040 is comparable to or slightly below the high-end AS/8063 uniprocessor, and the AS/9060 is some-

➤ central processors. These include a CPU Timer and a Clock Comparator; the latter provides a means for causing an interrupt when the standard Time-of-Day Clock reaches a program-specified value. Additional instructions are provided to set and store the Time-of-Day Clock, Clock Comparator, and CPU Timer.

The *Direct Control Feature* provides six external interrupt lines which operate independently of the normal data channels, plus the Read Direct and Write Direct Instructions which provide for single-byte data transfers between an external device and main storage. Direct Control is optional on all AS models.

The optional *Preferred Machine Assist* feature is a hardware/microcode assist which is used in conjunction with VM/HPO to provide a high-performance "preferred" capability for one MVS/SP guest machine achieving near native performance.

The *Virtual Machine Assist* feature is a microcode enhancement that is designed to improve the performance of operating systems running under the control of VM/370. VMA handles system interrupts caused by privileged instruction execution and supervisor calls.

The *Floating-Point Arithmetic* feature provides instructions to perform floating-point arithmetic operations on both short (1-word) and long (2-word) operands.

The *Extended Precision Floating-Point* feature provides seven instructions for performing floating-point arithmetic on 4-word (16-byte) operands that provide a precision of up to 28 hexadecimal or 34 decimal digits.

The *High-Speed Arithmetic* feature provides faster execution of fixed- and floating-point arithmetic instructions as well as certain packed decimal instructions on AS/66X0, systems. Designed to improve system performance by up to 50 percent, this option is suited for engineering and scientific applications. The capability is standard to the larger AS/80X3 and AS/9XX0 product lines.

The *Channel-to-Channel Adapter* permits direct communication between an AS processor and a System/370 via a standard I/O channel. It can be attached to either a selector channel or a block multiplexer channel and uses one control unit position on either channel. Either system can be equipped with the optional Channel-to-Channel Adapter, and it is required on only one of the interconnected channels.

*Dynamic Address Translation* for calculating virtual memory addresses is standard on all AS processor models. Instruction retry, command retry, and channel retry are also standard on all models. The AS/80X0 Series, and AS/90X0 Series also feature enhanced I/O logout and a stage tracer for fault logging. On the AS/90X0, a Log-Out Analyzer speeds fault diagnosis and verification. In addition to the error-logging facility supported by the operating system, up to 9K bytes of status information is logged to the console diskette whenever there is a CPU or channel malfunction. The status information can be recalled and analyzed by a field engineer without affecting normal system operation. The AS/66X0, AS/80X0, and AS/90X0 Series also have a remote support capability that allows information from a failing CPU to be accessed by a remote support site through a telecommunications link. This capability enables the remote support site to receive logout information from, and assume control of, the service processor of the failing CPU. The remote facility can then process the information to diagnose the problem.

**PHYSICAL SPECIFICATIONS:** The dimensions and weights of NAS' processor models are as follows: ➤



## NAS AS/66X0, AS/80X3, and AS/9XX0

▷ what below the performance of the AS/8083 dual processor, so that the AS/9050 and AS/9060 fit neatly into the usual 180 percent performance gap between a single and a dual processor, providing a great deal of granularity in the choice of performance levels for the 370 XA architecture. NAS rates the AS/9060 as equal to the IBM 3081 Model Group GX, while the AS/9070 and AS/9080 dual-processor versions of the AS/9050 and AS/9060, respectively, range in performance from IBM's 3081 Model Group KX to about halfway up to the IBM 3084.

Amdahl's continued expansion of its 580 Series, and the company's enhancement of the existing models, provides serious competition to NAS for those IBM users interested in changing to a PCM machine. The 580 Series now has a main memory capacity of 128 megabytes for the 5840, 5850, 5860, 5867, and 5870 processors; 256 megabytes for the 5868 and 5880 processors; and the availability of 32, 48, 64, or 128 input/output channels, depending on model. In addition, Amdahl's introduction of its three-model 5890 Series mega-mainframe and the expansion of its vector processor series has improved its competitive posture with regard to NAS' AS/XL Series.

The vector processing facilities supplied by IBM, NAS, and Amdahl can perform in the neighborhood of 50 MFLOPS, although a great deal depends on how much code is vectorizable in a particular application. The performance level of the AS/91X0 Series and its competitors, while significantly less than that of CDC and Cray supercomputers (100 MFLOPS or more), can be attractive for users that have smaller scale or less frequent scientific/engineering requirements of the type that benefit from vector processors. NAS provides an AS/91X0-type vector processor for the AS/XL Series as well. This fact, coupled with integration of the NAS vector processors into the already firmly established AS/90X0 product family, provides NAS with continuing equal compatibility and additional ammunition in the price/performance battle with IBM and the other IBM plug-compatible vendors.

In addition, when comparing two systems with vector processors, the one with the higher speed uniprocessor (NAS) can have significant advantages over a dyadic processor of comparable system throughput (IBM), since that would mean each individual processor had slower speeds. Cray's early successes against Control Data were attributed in part to the extremely fast 50 MIPS scalar processor that was coupled with the vector processor on the Cray-1, because the high processing speeds for the vectorizable segments of a program were not offset by slow processing of the inevitable scalar sections.

### ADVANTAGES AND RESTRICTIONS

The primary advantage of buying any PCM system is obtaining full IBM compatibility and equal or better reliability, but at a lower price/performance ratio. NAS consequently offers comparable performance at a lower price or better performance at a comparable price than IBM does. NAS processors have a number of secondary advantages ▷

	Width (in.)	Ht. (in.)	Depth (in.)	Wt. (lb.)
<b>AS/66X0 Series:</b>				
Models 6620, 6630	32	66	48	818
Models 6650, 6660	32	66	80	974
<b>AS/80X0 Series:</b>				
Models 8023, 8043, 8053, 8063	32	66	56	860
Model 8083	32	66	276	2,900
<b>AS/90X0 Series:</b>				
Models 9040, 9050, 9060	94	66	179	9,607
Models 9070, 9080	156	66	181	16,683

The specifications given above are for the CPU and memory only. Additional floor space and loading requirements must be considered for the console display station(s), power distribution unit(s), and the input/output unit(s). Weights and dimensions of specific hardware configurations will vary with the amount of main memory, number of I/O channels, type and number of peripheral devices, and optional features that are added. Datapro suggests that the user work closely with the NAS customer engineer to assure that sufficient floor space is available, and that the load rating of the floor is not exceeded.

### CONFIGURATION RULES

The basic configuration for any of the single-processor AS Series complex includes a single CPU, a Main Storage Unit (MSU), an Input/Output Processor (IOP), a Power Distribution Unit (PDU), one or two system consoles, and a Multifunction Service Processor (MSP). The IOP handles all I/O operations to and from main storage and the I/O devices. The MSP is an independent processor that is linked to the CPU and controls the console display. The MSP also enables communication between the computer operator and the central processor for system maintenance and operator command functions. In addition to these basic components, system software usually requires disk storage, a magnetic tape drive, a printer, and sometimes either a card reader or a device emulating a card reader.

For multiprocessor configurations, (Models AS/8083, AS/9170, AS/9180, AS/9070, and AS/9080) each complex consists of two independent processors that share a common main memory, and the appropriate number of IOPs, MSUs, PDUs, system consoles, and MSPs. All AS multiprocessor models are capable of running in a single-system mode or a partitioned two-system mode. If one processor fails, the system can be reconfigured as a uniprocessor system through the operator console or the operating system commands. A Channel Cross-Call feature allows control of input/output operations to be switched to the available processor.

### INPUT/OUTPUT CONTROL

All I/O transfers that occur in VSE mode (AS/6600) and 370 mode (AS/6600, AS/80X3, AS/9XX0) must use some cycle stealing to gain control of the CPU execution unit and perform I/O operations. This is because a high proportion of the logic needed for I/O resides in CPU microcode and programs, and relatively little in the channel control units or subsystem controllers. In the 370 XA mode (AS/80X3, AS/9XX0), the amount of this cycle-stealing activity has been greatly reduced because many of the operations performed by the central processor in other modes are performed in the I/O processor in 370 XA mode. There are other significant differences in the way that I/O channels are handled in the VSE, System/370, and 370 XA operational modes. ▶

## NAS AS/66X0, AS/80X3, and AS/9XX0

▷ that can weigh heavily in individual buying decisions. Their processors are air-cooled and are manufactured with fewer components than their IBM counterparts. This enables the processors to operate using less power, floor space, and maintenance, while producing less heat. For every NAS user there results a savings in ongoing operating costs over comparable IBM equipment. The compact nature of the system can be an especially significant advantage to a crowded company that suddenly finds itself running out of space and needing another building unless it can consolidate. The air-cooled technology is also significant to users who have been running IBM air-cooled systems and find that an upgrade to the next larger IBM system involves the addition of a plumbing network that not only requires a large financial outlay, but also condemns future CPUs to the same location because of the need to connect to the plumbing.

Users new to PCM products may worry about the stability of the vendor, in view of the need for ongoing maintenance and support, so the reputation of the vendor is of considerable importance. NAS was the second large PCM vendor to enter the highly competitive top end of the mainframe marketplace, and suffered in the past from a somewhat unstable image for a number of reasons. Originally, the Intel organization marketed and serviced Hitachi-built PCM CPUs under its own label, but then sold this part of its business to National Semiconductor to compensate for losses in its leasing business. National Semiconductor renamed the company National Advanced Systems (NAS), and continued the relationship with Hitachi; after a while it decided to abandon its own attempts to manufacture PCMs in favor of an all-Hitachi-built product line. Hitachi itself, although it is a huge diversified manufacturer in a number of fields, is second in the Japanese computer market to Fujitsu in the size of the installed base.

Although NAS' chief PCM competitor, Amdahl, also suffered image problems when its founder left the company, that company is still the first successful PCM vendor, has the largest installed base of CPUs, does some of its manufacturing in the United States, has retained its name and its associations with excellence, and continues to be allied with Japan's number one computer vendor, Fujitsu. NAS suffers by comparison in being second to enter the market, in being allied with Japan's second, in being the second in installed CPU base, in having changed its name, and in having abandoned its U.S. manufacturing facilities.

However, both Hitachi and NAS have been visibly strengthening their position in the last few years. The simultaneous, uneventful delivery of the AS/XL Series in the U.S. and the 680H series in Japan suggests a well-organized, solidified partnership. The NAS base in the U.S. and the Hitachi base in Japan have been growing at rates that suggest that they may pass their Fujitsu/Amdahl competitors. Previous NAS/Hitachi machines have clearly lived up to the vendors' claims, and their reputation for reliability is unequalled. The new product line is based on a processor that is nearly twice as fast as all other business uniprocessors not only in the U.S. but also in the entire

▶ In VSE mode, the same single-level internal mapping function for address translation is used for both CPU and channels, and the same set of virtual addresses are used to address the translation facility. The CPU and channels do have different lookaside buffers to speed up address translation.

In System/370 mode, even though the I/O operation is largely handled by the CPU execution unit, the channels do not use the dual-level dynamic address translation facility used by CPU programs. Therefore, all virtual storage addresses have to be translated to real addresses before execution. System/370 mode is capable of addressing sets of up to 16 channels per CPU (two channel groups), but in multiprocessor configurations, a specific channel is always seen as part of one set or the other.

In 370 XA mode, the dynamic channel subsystem is activated and controlled by the CPU, but otherwise processes I/O requests with a great deal of independence. XA mode is inherently capable of handling up to 256 independent channels, which are not organized into sets related to a specific processor in multiprocessor configurations. This mode can potentially handle up to 4,096 devices concurrently, with 8 paths to each device, although on these product lines, a maximum of 4 paths per device and 48 channels (Models AS/9070, AS/9170, AS/9080, and AS/9180) have been implemented.

The operator communicates with the system via the main console, which also serves as a diagnostic tool for maintenance purposes. The AS/80X0, AS/90X0, and AS/91X0 systems include two 7-color display units, as well as a service processor console (two 20-inch, four-color display units), and two diskette drives. Additionally, a remote diagnostic capability and up to four service processor consoles are provided as standard.

The AS/66X0 Series basic processors have a single IOP and 5 integrated I/O channels: 1 or 2 byte multiplexer channels and 3 or 4 block multiplexer channels. The basic configuration can be expanded up to 8 channels, using a maximum of 2 byte multiplexer and 6 block multiplexer channels.

The basic AS/80X0 Series processors have one IOP per CPU, with each IOP controlling 8 channels. One or 2 channels can be byte multiplexer or all 8 can be block multiplexer channels. This set can be expanded to 24 channels, 0 to 6 byte multiplexer and the rest block multiplexer channels on single-processor models. The dual processor model can be expanded up to 32 channels, 0 to 8 byte multiplexer and the rest block multiplexer channels.

AS/90X0 and AS/91X0 Series models have one microprogram-controlled IOP per CPU, with each CPU attaching up to 24 I/O channels: 1 to 6 byte multiplexer channels and the remaining block multiplexer channels. The dual processor model thus has a maximum of 48 I/O channels: 2 to 8 byte multiplexer and the remaining block multiplexer channels.

Expansion of channels on the AS/80X0 and 90X0 Series processors is done through the extended channel group, which provides an additional I/O Processor with channels. The AS/66X0 System has a separate channel group which allows expansion up to 12 channels.

Datastreaming support is standard on all Advanced System models. Each I/O channel implements the standard IBM interface and is provided with 256 Unit Control Words. All systems support block multiplexer channels that can operate at up to 3.0 megabytes per second, although differences in the aggregate data rate supported by individual models may mean that certain block multiplexer channels will have to be implemented at slower speeds. The data transfer rate for byte multiplexer channels is 100K bytes per second for

## NAS AS/66X0, AS/80X3, and AS/9XX0

▷ world. These achievements “rub off” on all other product lines that NAS sells, partly because of the continuing developmental capabilities and ongoing support that it implies, and partly because users who prefer to stick with one vendor rather than swap back and forth, find that they have an unparalleled growth path. The enormous financial resources at Hitachi’s command for future development and the company’s existing track record are additional factors that inspire a vote of confidence. NAS’ commitment to its user base was further demonstrated by the announcement of upgrade plans and lease options that allow customers leasing a low-end AS/66X0 system to apply a portion of their accrued lease payments towards the purchase of a high-end AS/80X3 mainframe.

The addition of reliable, cost-effective PCM disk and tape drives has added to NAS’ aura of reliability and solid growth, as well as providing more possibilities for future CPU sales. An examination of our User Reaction section shows that, whether it is logical or not, users tend to lump all of a manufacturer’s equipment together in their minds when asked about reliability and service. If they own reliable disk and/or tape drives, they are more favorably inclined towards purchasing a CPU. If they have owned one satisfactory CPU, most are inclined to buy another.

The track record of both NAS and Amdahl in keeping up with IBM enhancements that affect compatibility serves to reassure users that worries in this regard are not in order, for the most part. For major enhancements like the introduction of the XA architecture, there can be a significant implementation lag, but the U.S. rumor mill is sufficiently accurate that PCM vendors are likely to provide architectures that are filled with flexibility features enabling a reasonably quick response. As our User Reaction section shows, some users no longer fear their shop might not be able to keep up if they buy PCMs, and fully anticipate being able to upgrade from IBM to NAS (or Amdahl) to IBM to NAS (or Amdahl), back and forth, depending on whatever is most beneficial at the moment.

### USER REACTION

In the 1986 User Ratings of Computer Systems Survey, we received twenty-one responses from the users of installed NAS computer systems. These represented a good sampling of the different models in the currently marketed 6000/8000/9000 NAS product lines, including one 6620, two 6630s, two 6650s, two 8043s, four 8053s, one 8063, one 9000-2, one 9050, two 9060s, one 9070, and four 9080s. Six systems had been purchased, five were leased from the manufacturer, eight were leased from third parties, and two were part of a large multivendor shop with a variety of acquisition methods for the different systems. Only one user used third-party maintenance. These twenty-one installations primarily served manufacturing, banking, public utilities, and service bureau industries, but individual installations represented organizations in education, insurance, government, union benefits, and Christian ministries. The most common applications mentioned were account billing, payroll/personnel, order processing/inven-

▶ all processor models, except the 6620 and 6630, which use 80K byte-per-second channels. The aggregate data rate for the combined maximum channels on a system varies, as follows:

- 13M bytes per second: Models AS/6620, AS/6630.
- 16M bytes per second: Models AS/6650, AS/6660.
- 37.3M bytes per second: Models AS/8023, AS/8043, AS/8053 (370 mode).
- 40M bytes per second: Models AS/8063, AS/9X40, AS/9X50 (370 mode).
- 48M bytes per second: Model AS/9X60 (370 mode).
- 55.9M bytes per second: Models AS/8023, AS/8043, AS/8053 (XA mode).
- 60M bytes per second: Models AS/8063, AS/9X40, AS/9X50 (XA mode).
- 72M bytes per second: Model AS/9X60 (XA mode).
- 80M bytes per second: Models AS/9X70 (370 mode), AS/8083 (either mode).
- 96M bytes per second: Model AS/9X80 (370 mode).
- 120M bytes per second: Model AS/9X70 (XA mode).
- 144M bytes per second: Model AS/9X80 (XA mode).

### MASS STORAGE

See Table 2, and Datapro’s report “NAS Disk Subsystems” (Report 70D6-638XM-101) in Volume 2, for details on NAS-supplied disks. In addition, any IBM or IBM plug-compatible 3350, 3370, 3375, or 3380-type disk storage device may be used in support of AS Series processors.

### INPUT/OUTPUT UNITS

See Table 3, and the report on the NAS 7803/7420 tape subsystem (Report 70D6-638XM-201) in Volume 2, for details. In addition, any IBM or IBM plug-compatible tape storage device may be used in support of AS Series processors. In addition to the standard disk devices in the table, NAS offers the 7900 Series add-on semiconductor memory that emulates the 3330, 3350, or 3380 disks or the 3880-13 disk cache. Older models ranged from 32 to 128 megabytes in capacity. Recently, the range has been expanded, from 128 to 512 megabytes.

### TERMINALS

Not available from the vendor, but any IBM or IBM plug-compatible terminal may be used in support of AS Series processors.

### COMMUNICATIONS

Since NAS neither manufactures nor markets communications hardware or software, an IBM 3705, 3725, or an IBM plug-compatible, 3705- or 3725-type communications controller can be used in support of AS Series processors. Additionally, any IBM communications software product (i.e., CICS or TSO) may also be used.

### SOFTWARE

All AS Series processors are IBM plug compatible and can run any IBM-compatible software, providing the processor

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▷ tory, purchasing, statistics, manufacturing, and sales/distribution.

The three major IBM operating system families were all represented in this survey of NAS installations. Five were DOS or DOS/VSE installations, with two VSE operating systems running as guests under VM; thirteen were MVS/370 installations, with two running as guests under VM; and three ran under MVS/XA. Five of the processors were upgrades from previous NAS systems, thirteen were conversions from IBM systems, one was new rather than an upgrade of a previous system, and two were not clearly described. IBM systems replaced included the 4341, 4381, 3033, 3083, and 3081.

Memory sizes were grouped into four installations with more than 64M bytes, four in the 32M-to-64M byte range, seven in the 16M-to-32M byte range, and six in the 8M-to-16M byte range. Two-thirds (i.e., fourteen respondents) had more than 10G bytes of disk storage; the remainder were spread rather evenly across ranges extending from 4.8GB to 10GB (one system), 1.2GB to 4.8GB (two systems), 600MB to 1.2GB (two systems), 100MB to 600MB (one system), and one with less than 100MB. Sixteen processors were running data base management systems, and thirteen supported an information center. The majority of respondents reported that more than 60 local and 60 remote terminals or workstations were installed, which was the highest number we specifically queried about; one respondent volunteered that they had 4,000 terminals.

As part of the survey, the users were asked to rate NAS and its equipment as Excellent (4.0), Good (3.0), Fair (2.0), or Poor (1.0) in a number of respects. A weighted average was then calculated based on the total number of responses. A summary of these ratings is included in the following table.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	14	7	0	0	3.67
Reliability of mainframe	21	0	0	0	4.00
Reliability of peripherals	15	6	0	0	3.71
Maintenance service:					
Responsiveness	17	4	0	0	3.81
Effectiveness	17	4	0	0	3.81
Technical support:					
Troubleshooting	15	5	1	0	3.67
Education	4	10	6	1	2.81
Documentation	4	15	2	0	3.10
Ease of programming	1	12	0	0	3.08
Ease of conversion	3	7	3	0	3.00
Overall satisfaction	1	12	0	0	3.08

\*Weighted Average on a scale of 4.0 for Excellent.

Datapro talked with three NAS users to find out more details about how well their systems performed. We spoke to a pension insurance company in Tacoma, Washington; a manufacturer of communications equipment in Youngstown, Ohio; and a large manufacturer of office equipment in Webster, New York. All three respondents attested to the complete compatibility of the IBM software. They were particularly enthusiastic over the reliability of the system and its ease of installation. Like NAS users we have inter-▷

▶ implements the operating mode (ECPS: VSE, S/370 or 370 XA) required by that software. For detailed information on IBM software see the CHARACTERISTICS section of Datapro's IBM 308X product report (Report 70C-504MK-601) in this volume.

**OPERATING SYSTEM:** The Advanced Systems Series offers complete functional compatibility with IBM's OS/VS1, SVS, VM/SP, VM/370, ACP/TPF2, DOS/VSE, DOS/VS, MVS, MVS/SP V.1, and MVS/XA operating system software. NAS supports users of current IBM system software by supplying software support services for its customers. In addition, AS systems include firmware that supports the following IBM operating system enhancements: System/370 Extended Facility (370 EF), which allows the use of the MVS/System Extensions (MVS/SE) and MVS/System Product (MVS/SP); OS/VS1 Extended Control Program Support (VS1:ECPS); Virtual Machine Assist (VMA); Virtual Machine Extended Control Program Support (VM:ECPS); and MVS/SP Assists, which consist of the Cross Memory Services Assist, Auxiliary Storage Management Assist, Real Storage Management Assist, and I/O Assist features. All of these enhancements improve system throughput by implementing a number of frequently used system routines in microcode. AS processors in 370 XA mode fully support MVS/SP Version 2 and the VM/XA Systems Facility, which is a cross between an operating system and a Migration Aid. With MVS/SP and its associated products (collectively known as MVS/XA), the AS processors provide every feature of the comparable IBM processors in 370-XA mode.

**PROGRAMMING LANGUAGES:** Programming languages available for the AS Series include Pascal/VS, Cobol VS II, Fortran, PL/1, Basic, APL/VS, Assembler, and any others implemented for an IBM 370-type mainframe environment.

**DATA BASE MANAGEMENT:** Not offered by the vendor, but any IBM or IBM-compatible data base manager may be used.

**DATA MANAGEMENT:** Not offered by the vendor, but any IBM or IBM-compatible data manager may be used.

**PROGRAM DEVELOPMENT:** The Advanced Conversational Editing and Programming System (ACEP) is an on-line programming system that permits programmers to create, modify, and maintain programs and systems. It can be used with IBM or IBM plug-compatible processors running under OS/VS1 or MVS. ACEP has an on-line reference manual, and a TSO-like language that is easy to use. It builds and edits all programming languages, output files, JCL, and test data. In addition, ACEP can support over 100 programmers, has full- and split-screen capability, and can dynamically allocate data sets.

An optional System Productivity Facility (SPF) enables users to work with easy-to-understand screens and menus to arrive at programming decisions. The ACEP/SPF system includes capabilities for entering, editing, compiling, and saving source programs.

In addition to the above, any IBM or IBM-compatible program development tool may be used.

**UTILITIES:** Along with all the IBM utilities available for AS Series processors, NAS offers the following utility systems to its users.

The *DP Technician* is a DASD management utility. Capabilities include volume configuration/dump/restore, catalog management, file management, file record retrieval, and DASD management. DP Technician can be used with all OS and OS/VS operating systems and supports IBM 3330, ▶

## NAS AS/66X0, AS/80X3, and AS/9XX0

▷ viewed in prior years, all three stated that “once the machine was cabled in, all we had to do was hit the button and go.”

The corporate director of MIS in the manufacturing company in Ohio was running an NAS 6630 system that had replaced an ITEL AS/3-5. Their decision to buy NAS was based on price/performance comparisons with Amdahl and IBM. They did not do benchmarks in this analysis, but used vendor-supplied performance claims. The 6630 was running IBM's VM/SP Release 4 with DOS/VSE/SP on a configuration that included only one piece of IBM equipment in the central complex, a purchased 3705 communications front end that controlled about 150 terminals. Aside from the CPU, NAS supplied all the tape drives and most of the 16 volumes of disks, which were of the double-density 3350 type. The company was planning to eventually replace those disks supplied by Amdahl and STC with more NAS volumes. They felt that the NAS equipment performed well and was very, very reliable; in the 2-1/2 years that they had had the 6630 and the NAS peripherals, they had not had a single failure. NAS software support is not as good as its hardware support, according to this respondent, but when they have software problems, they can consult both NAS and IBM, and thus have the advantage of two different sources of help.

The system installed in the pension insurance company was an 8043 that was also running VM/SP Release 4 with a VSE guest. The 8043 had replaced an NAS 6650 ten months previously, after a brief study of IBM and PCM alternatives. The decision was made based on vendor price/performance claims, and on the user's prior experience with the NAS 6650. The 6650 had replaced an IBM 4331 in 1983 after a somewhat lengthier study that included consulting with other 6650 users in Denver, the East Coast, and Sweden, because the 6650 was new on the market at that time. According to this respondent, they had never had problems with any NAS equipment until the week we called, but had just recovered from a head crash on a 7380 drive two days earlier. They expressed some concern over how the problem had been handled; the system was down from 4:00 p.m. until 10:30 p.m. Nonetheless, they felt that this was an atypical event, in the light of their experience with NAS equipment and support. There were definite plans to acquire more equipment from NAS in the near future.

We interviewed the Manager of Software and Hardware Support in a large, New York-based manufacturer of office equipment, which had replaced an IBM 3081K with an NAS 9080 system. The NAS system was running MVS under VM in an APL-oriented interactive environment with upwards of 4,000 terminals. The NAS system had been chosen as a result of a benchmark in which the 9080 performed 21 percent better than the IBM for their application. Although they felt the 9080 had performed exceptionally well during the 27 months they had it, with less than 2 hours outage, they were in the process of replacing it with an IBM 3090-200, again because of the results of a benchmark in which the IBM system had outperformed an AS/▷

▷ 3344, 3350, 3375, and 3380 disk subsystems. The IBM 3420 magnetic tape units are also supported.

*Discern* is a VS1 system monitor designed to improve performance by graphically illustrating the system's performance. It aids in locating and analyzing system problems, and provides system statistics on page faults, I/O activity, system data sets, DASD cylinder maps, 3270 response time, and link pack usage by virtual page number.

*Extend* is an MVS performance product designed to be used with IBM's MVS/System Extended Facility Function to boost performance by 12 to 20 percent without the delay and expense of ordering additional hardware.

Extend simulates the System/370 Extended Facility by substituting standard System/370 instruction set sequences for the machine instructions in the Extended Facility. It is designed to enable System/370 users to take advantage of MVS/SP V.1 R.3 without making hardware modifications. According to NAS, Extend, when used in conjunction with IBM's MVS/SE or MVS/SP operating systems, offers a 12 to 20 percent improvement in performance.

The NAS Performance Monitor comprises three program products designed to track any event that occurs within and between the components of the user's NAS, IBM, or IBM plug-compatible processor running MVS, MVS/XA, OS/VS1, or VM/370 operating systems. Each of the three program products uses a common Event Accumulator which identifies, counts, and measures the duration of realtime events, and periodically logs the data to disk storage.

- *System Performance Interrogator (SPI)* is a direct, interactive, on-line, realtime system monitoring and evaluation tool. SPI also allows the user to establish operating threshold parameters for the system. When these parameters are exceeded, SPI will notify the user to take corrective action before system degradation takes place.
- *System Performance Module (SPM)* comprises four program routines which use the data stored in the Event Accumulator to generate analysis of CPU usage, channel utilization, control unit activity, device utilization, I/O activity, and system degradation by task. SPM can also display or print (in the form of graphs, charts, tables, or calendar reports) realtime conditions from data accumulated since the last *n* period.
- *Job Analysis and Billing (JAB)* is a job accounting and work load analysis program that identifies who used the system, for how long, and for what purpose. JAB can issue user invoices, identify exceptional performance (good or bad), and establish either a break-even or profit-center philosophy.

### PRICING AND SUPPORT

**POLICY:** The National Advanced Systems (NAS) devices are all available for purchase, or variously for lease under 24-month, 36-month, 48-month, or 60-month noncancelable lease terms. Not all lease types are available for each piece of equipment; an examination of our price list will show which devices permit 2-year or 3-year leases. Data on 4-year and 5-year leases is not given. An upgrade plan allows low-end AS/66X0 Series users on a 48-month lease to upgrade at any time after the 24th month to a high-end AS/80X0 or AS/90X0 Series computer. An additional upgrade option enables users signing up to lease an AS/66X0 computer to apply a percentage of the accrued AS/66X0 lease payments toward the purchase of an AS/80X0 mainframe at the end of the leasing term.

**SUPPORT:** NAS offers two levels of software support. The Central Program Support Center in Mountain View and San ▷

## NAS AS/66X0, AS/80X3, and AS/9XX0

▷ XL 60 for their application. However, they stated they could easily switch back to NAS when they need to upgrade again. The systems from both vendors were so compatible that they didn't need to worry about anything except the benchmarks and the resulting price/performance. □

▶ **Diego, California, provides a Central Program Support Service, which includes telephone assistance 24 hours a day, 7 days a week; customer guidance in IPAR (Incident Program Analysis Report) preparation; problem diagnosis advice; temporary fix or bypass service; and PTF selection and application assistance. The Local Program Support Service at the customer site includes problem diagnosis, IPAR preparation and submission assistance, local fix or bypass development and assistance, and PTF/PUT application problem assistance. The Local Program Support Service is available as an option. Customers can elect to pay a monthly program support charge or to pay hourly rates.**

NAS has a Support Agency service for selected IBM Licensed Programs. Under the terms of an agreement between NAS and IBM, licensed users can select NAS as their support agent. The agreement permits NAS to use the IBM support centers on behalf of the users. NAS is offering a combined Central and Local Program Support Service for the designated IBM programs. A remote, first-level interface is provided via a toll-free telephone number, and local support is provided via local NAS Systems Support Representatives. The Support Agency service provides support for the following licensed programs: MVS/SP Version 1,

VM/SP Release 1 and up, DOS/VSE Advanced Functions Release 3 and up, Data Facility/Device Support, Data Facility/Extended Function, Data Facility/Data Set Services, RMF, SAM-E, ACF/VTAM, ACF/NCP, SPF, Information System, VSE/VSAM, VSE/POWER, VSE/OCDF, VSE/IPCS, VSE/IPF, VSE/ICCF, VSE/Fast Copy, VSE-/DITTO, BTAM-ES, VM/IPCS, RSCS, SPF/CMS, and IPF.

**EDUCATION:** NAS offers a number of software educational courses designed to meet the needs of both experienced and novice data processing personnel. The software application curriculum includes courses on operating systems and facilities, and data base/data communications application techniques. In addition, general course work covering subjects such as capacity planning, DP management, project management, office automation, computer literacy, and management of microcomputers, among others, are also available. NAS offers these courses in a number of U.S. and Canadian cities, and maintains an Education Center in Washington, DC.

For additional information, contact National Advanced Systems, 4621-C Boston Way, Lanham, MD 20706-4393. Attn: Software Education Coordinator. Telephone (301) 459-2666 or (800) 638-8931.

**TYPICAL CONFIGURATION:** Because NAS does not offer a full line of operating system software or peripheral equipment (communications controllers, terminals, printers, etc.), a typical configuration cost is not possible.

### EQUIPMENT PRICES

#### PROCESSOR COMPLEXES

##### AS/6000 Series:

		Purchase (\$)	Monthly Maint.* (\$)	2-Year Lease (\$)	3-Year Lease (\$)
AS/6620	Processor with 8 megabytes of main memory, 64K bytes of buffer storage, 5 I/O channels, and a standalone operator console with color CRT	255,000	805	9,545	6,500
AS/6630	Processor with 8 megabytes of main memory, 64K bytes of buffer storage, 5 I/O channels, and a standalone operator console with color CRT	341,500	891	11,785	8,125
AS/6650	Processor with 8 megabytes of main memory, 64K bytes of buffer storage, 5 I/O channels, and a standalone operator console with color CRT	417,500	1,052	15,265	10,155
AS/6660	Processor with 8 megabytes of main memory, 64K bytes of buffer storage, 5 I/O channels, and a standalone operator console with color CRT	475,000	1,215	17,435	11,605

##### AS/8000 Series:

AS/8023	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, 8 I/O channels, a single power distribution unit, and color CRT	475,000	3,382	—	11,595
AS/8043	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, 8 I/O channels, a single power distribution unit, and color CRT	698,300	4,594	—	17,015
AS/8053	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, 8 I/O channels, a single power distribution unit, and color CRT	939,500	4,740	—	23,230
AS/8063	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, 8 I/O channels, a single power distribution unit, and color CRT	1,104,600	5,540	—	27,490
AS/8083	Dual processor with 32 megabytes of main memory, 64K bytes of buffer storage per processor, 16 I/O channels, a single power distribution unit, and color CRT	2,271,900	8,282	—	50,710

##### AS/9000 Series:

AS/9040	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor console with dual 4-color CRTs, keyboards, and 2 diskette drives	1,602,000	4,942	—	28,370
AS/9050	Processor with 16 megabytes of main memory, 64K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor console with dual 4-color CRTs, keyboards, and 2 diskette drives	2,012,000	5,706	—	31,445

\*Complete service for 24 hours/day, 7 days/week.

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		Purchase (\$)	Monthly Maint.* (\$)	2-Year Lease (\$)	3-Year Lease (\$)
<b>AS/9000 Series: (Continued)</b>					
AS/9060	Processor with 16 megabytes of main memory, 256K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor console with dual 4-color CRTs, keyboards, and 2 diskette drives	2,156,000	5,865	—	33,940
AS/9070	Dual processors with 16 megabytes of main memory, 64K bytes of buffer storage per processor, 2 I/O processors, 16 I/O channels, and 2 service processor consoles with dual 4-color CRTs, keyboards, and 2 diskette drives	3,041,000	7,714	—	53,930
AS/9080	Dual processors with 16 megabytes of main memory, 256K bytes of buffer storage per processor, 2 I/O processors, 16 I/O channels, and 2 service processor consoles with dual 4-color CRTs, keyboards, and 2 diskette drives	3,878,000	9,644	—	60,400
<b>AS/9100 Series:</b>					
	9140 Vector Processor with 16 megabytes of main memory, 64K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor with dual 4-color CRTs, keyboards, and 2 diskette drives	1,920,000	6,284	—	37,075
	9150 Vector Processor with 16 megabytes of main memory, 64K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor with dual 4-color CRTs, keyboards, and 2 diskette drives	2,312,000	7,037	—	40,150
	9160 Vector Processor with 16 megabytes of main memory, 256K bytes of buffer storage, I/O processor, 16 I/O channels, and service processor with dual 4-color CRTs, keyboards, and 2 diskette drives	2,456,000	7,193	—	42,645
	9170 Vector Processors with 16 megabytes of main memory, 256K bytes of buffer storage, 2 I/O processors, 16 I/O channels, and 2 service processors with dual 4-color CRTs, keyboards, and 2 diskette drives	3,641,000	10,346	—	71,335
	9180 Vector Processors with 16 megabytes of main memory, 256K bytes of buffer storage, 2 I/O processors, 16 I/O channels, and 2 service processors with dual 4-color CRTs, keyboards, and 2 diskette drives	4,478,000	12,431	—	77,805
<b>PROCESSOR UPGRADES</b>					
<b>AS/6600 Series</b>					
	AS/6620 to AS/6630 Upgrade	95,000	86	—	—
	AS/6630 to AS/6650 Upgrade	115,000	161	—	—
	AS/6630 to AS/6660 Upgrade	172,000	324	—	—
	AS/6650 to AS/6660 Upgrade	57,500	163	—	—
<b>AS/8000 Series</b>					
	AS/8023 to AS/8043 Upgrade	223,200	1,212	—	—
	AS/8043 to AS/8053 Upgrade	241,200	146	—	—
	AS/8053 to AS/8063 Upgrade	165,100	764	—	—
	AS/8063 to AS/8083 Upgrade	991,000	1,874	—	—
	"S" Upgrade (for AS/8023, /8043, /8053)	50,000	—	—	—
<b>AS/9000 Series</b>					
	AS/9040 to AS/9050 Upgrade	392,000	764	—	—
	AS/9050 to AS/9060 Upgrade	144,000	159	—	—
	AS/9050 to AS/9070 Upgrade	1,152,000	2,008	—	—
	AS/9060 to AS/9080 Upgrade	1,845,000	3,779	—	—
	AS/9070 to AS/9080 Upgrade	837,000	1,930	—	—
<b>AS/9100 Series</b>					
	AS/9040 to AS/9140 Upgrade	300,000	1,794	—	—
	AS/9050 to AS/9150 Upgrade	300,000	1,783	—	—
	AS/9060 to AS/9160 Upgrade	300,000	1,328	—	—
	AS/9070 to AS/9170 Upgrade	600,000	2,632	—	—
	AS/9080 to AS/9180 Upgrade	600,000	2,787	—	—
<b>MEMORY UPGRADES &amp; ADDITIONAL FEATURES</b>					
<b>AS/6000 Series</b>					
	Additional Memory Increment, 4 megabytes	38,000	79	1,260	870
	Additional Memory Increment, 8 megabytes	64,000	158	2,025	1,395
	Additional Block Channels Increment, 2 channels	20,000	40	845	580
	Additional Byte Channels, each	8,000	20	340	235
	High-speed Arithmetic	80,000	250	3,390	2,320
	Channel to Channel Adapter; first integrated	12,000	43	505	350
	Channel to Channel Adapter; second integrated	6,700	43	285	195

\*Complete service for 24 hours/day, 7 days/week.

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	Purchase (\$)	Monthly Maint.* (\$)	2-Year Lease (\$)	3-Year Lease (\$)
<b>AS/6000 Series (Continued)</b>				
Channel to Channel Adapter; first standalone	20,000	43	840	580
Channel to Channel Adapter; second standalone	6,700	43	285	195
Direct Control	5,000	21	210	145
Operational Console	5,500	300	230	160
Extension Frame	8,100	—	350	235
Optional Console/Printer Extension	7,500	—	315	220
<b>AS/8000 Series</b>				
Additional Memory Increment, 8 megabytes (uniprocessor only)	88,150	452	—	1,345
Additional Memory Increment, 16 megabytes (uniprocessor only)	176,300	904	—	2,015
Additional Memory Increment, 32 megabytes (8083 only)	352,600	1,808	—	5,190
Additional Channel Group, 8 channels	104,000	202	—	2,390
Additional Console	29,000	300	—	835
Channel to Channel Adapter	14,000	56	—	405
High-speed Arithmetic	100,000	300	—	1,730
<b>AS/9000 Series</b>				
Additional Memory Increment for AS/9040, AS/9050, and AS/9060; 8 megabytes	95,000	452	—	2,320
Additional Memory Increment for AS/9070 and AS/9080; 16 megabytes	190,000	904	—	4,640
Additional Channel Group, 8 channels	123,000	202	—	3,020
Channel to Channel Adapter; first	14,000	56	—	410
Channel to Channel Adapter; second & third	28,000	21	—	820
Channel to Channel Adapter; fourth & fifth	28,000	21	—	820
Direct Control	1,500	21	—	45
Additional Console	29,000	300	—	845
<b>AS/9100 Series</b>				
Additional Memory Increment, 16 megabytes	190,000	904	—	4,640
Additional Channel Group, 8 channels	123,000	202	—	3,020
Channel to Channel Adapter	14,000	56	—	410
Channel to Channel Adapter; second & third	28,000	21	—	820
Channel to Channel Adapter; fourth & fifth	28,000	21	—	820
Direct Control	1,500	21	—	45
<b>MASS STORAGE</b>				
7360-A4 Double density 3350-type master disk drive with dual port	54,000	242	—	—
7360-B4 Double density 3350-type add-on disk drive with dual port	39,000	187	—	—
7860-2 Disk controller with 2-channel switch	55,000	216	—	—
Additional 2-channel switch	6,000	15	—	—
7380-A4 Single density 3380-type master disk drive with dual port	85,500	452	1,965	—
7380-B4 Single density 3380-type add-on disk drive with dual port	58,500	334	1,500	—
7380-AD Single density 3380-type upgradable master disk drive with dual port	84,350	410	2,050	—
7380-BD Single density 3380-type upgradable add-on disk drive with dual port	61,225	300	1,565	—
7380-AE Double density master disk drive with dual port	116,355	410	2,940	—
7380-BE Double density add-on disk drive with dual port	93,235	300	2,440	—
7880-3 Disk controller	58,500	245	1,420	—
7880-3S Disk controller	73,800	356	2,120	—
7880-3C Disk controller with 8MB cache and 2-channel switch	128,850	800	4,220	—
7880-3C Disk controller with 16MB cache and 2-channel switch	163,050	835	4,365	—
7880-3C Disk controller with 32MB cache and 2-channel switch	231,450	905	5,995	—
7880-3C Disk controller with 48MB cache and 2-channel switch	299,850	975	7,625	—
7880-3C Disk controller with 64MB cache and 2-channel switch	368,250	1,045	5	—
2-channel switch	5,850	15	185	—
Additional 2-channel switch	10,800	54	265	—
8-channel switch	21,600	75	530	—
Additional 8MB cache memory	47,000	35	1,110	—
Additional 16MB disk cache	68,400	70	1,630	—
Single to double capacity upgrade	41,480	—	—	—
7970-2 Controller	78,600	260	1,485	—
7990-11 32MB storage unit	128,100	1,038	3,295	—
7995-1 Battery Unit	37,400	489	850	—
2-channel switch, additional pair	11,500	54	325	—
32MB increment, upgrade to first 7990	84,900	170	2,000	—
Quad port	20,100	108	445	—
<b>MAGNETIC TAPE EQUIPMENT</b>				
7420-44 Tape drive	15,000	373	—	—
7420-66 Tape drive	17,000	398	—	—
7803-23 Tape drive controller	20,000	245	—	—
2 x 8 switch	5,000	17	—	—
2 x 16 switch	4,500	17	—	—
2-channel switch	3,500	8	—	—

\*Complete service for 24 hours/day, 7 days/week.



## NAS AS/66X0, AS/80X3, and AS/9XX0

		Purchase (\$)	Monthly Maint.* (\$)	2-Year Lease (\$)	3-Year Lease (\$)
<b>MAGNETIC TAPE EQUIPMENT (Continued)</b>					
7420-77	Tape drive	24,000	482	—	—
7420-88	Tape drive	25,000	534	—	—
7803-21	Tape drive controller 800 bpi feature	30,000	269	—	—
		2,980	30	—	—

\*Complete service for 24 hours/day, 7 days/week.

## SOFTWARE PRICES

	Onetime License Fee (\$)
ACEP (Advanced Conversational Editing and Programming System)	
VS1 Version	24,000
MVS Version	24,000
VS1 to MVS conversion feature	4,000
SPF (System Productivity Facility) Feature	4,000
EXTEND/SP System/370 Extended Facility Simulator	3,500
	to 20,000
DISCERN/VS1 Performance Analyzer	6,500
DISCERN/VM Data Analyzer	3,450
DISCERN/VM (online)	4,450
DISCERN/VM (offline and online if purchased together)	7,450
DP Technician	12,000
NAS Performance Monitor (QCM):	
Performance Monitor (required module)	14,000
SPI (System Performance Interrogator)	6,000
SPM (System Performance Module)	6,000
Performance Data Base for SAS Users:	6,000
IMS Data Option	1,000
CICS Data Option	1,000
VM Data Option	1,000
JAB (Job Analysis and Billing):	6,000
IMS Option	2,000
CICS Option	2,000
VM Option	2,000
VPARS	11,500
VAST	10,000

### LOCAL PROGRAM SUPPORT

Category A:	
AS/6620	730
AS/6630	688
AS/6650	724
AS/6660	724
AS/8023	713
AS/8043	791
AS/8053	1,005
AS/8063	1,145
AS/8083	1,660
AS/9040	1,005
AS/9050	1,145
AS/9060	1,360
AS/9070	1,660
AS/9080	2,060
AS/9140	1,005
AS/9150	1,145
AS/9160	1,360
AS/9170	1,660
AS/9180	2,060
Category B:	
AS/6620	1,040
AS/6630	982
AS/6650	1,030
AS/6660	1,030
AS/8023	1,015

NAS AS/66X0, AS/80X3, and AS/9XX0



LOCAL PROGRAM SUPPORT (Continued)

Onetime  
License Fee  
(\$)

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AS/8043	1,125
AS/8053	1,430
AS/8063	1,630
AS/8083	2,375
AS/9040	1,430
AS/9050	1,630
AS/9060	1,940
AS/9070	2,375
AS/9080	2,938
AS/9140	1,430
AS/9150	1,630
AS/9160	1,940
AS/9170	2,375
AS/9180	2,938 ■