Sperry Rand's Third-Generation Computers 1964–1980

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The change from transistors to integrated circuits in the mid-1960s marked the beginning of third-generation computers. A late entrant (1962) in the general-purpose, transistor computer market, Sperry Rand Corporation moved quickly to produce computers using ICs. The Univac 1108's success (1965) reversed the company's declining fortunes in the large-scale arena, while the 9000 series upheld its market share in smaller computers. Sperry Rand failed to develop a successful minicomputer and, faced with IBM's dominant market position by the end of the 1970s, struggled to maintain its position in the computer industry.

A latecomer to the general-purpose, transistor computer market, Sperry Rand first shipped its large-scale Univac 1107 and Univac III computers to customers in the second half of 1962, more than two years later than such key competitors as IBM and Control Data. While this lateness enabled Sperry Rand to produce relatively sophisticated products in the 1107 and III, it also meant that they did not attain significant market shares. Fortunately, Sperry's military computers and the smaller Univac 1004, 1005, and 1050 computers developed early in the 1960s were sales successes, delivering enough revenue to keep the company alive for the era of integrated-circuit (third-generation) computers.

After the transistor's development, further electronics research provided engineers with ways to put the equivalent of several transistors on one chip of semiconductor material. In 1958, Jack Kilby of Texas Instruments built a five-component IC using germanium. The following year, Robert Noyce of Fairchild Semiconductor produced an improved IC that used silicon. By 1961, both Texas Instruments and Fairchild were selling ICs with as many as 12 transistors. RCA in 1962 produced a chip that contained 16 transistors.

The switch from transistors to ICs resulted in the third generation of computer hardware. As it became clear that ICs would eventually replace transistors, IBM formed a special internal committee in 1961 to consider its plans for computer development. In January 1962, the committee proposed that IBM's various transistor-based scientific and business computers be replaced by one family of machines that would be suitable for all types of processing. With its top management having accepted the recommendation, IBM began work on the System/360, so named because of the intention to cover the full range of computing tasks.

The IBM 360 did not rely exclusively on integrated circuitry but instead employed a combination of separate transistors and chips, called Solid Logic Technology (SLT). IBM made a big event of the System/360 announcement on 7 April 1964, holding press conferences in 62 US cities and 14 foreign countries. The System/360 comprised six models, which ranged from the small 360/30 up through the large 360/70.

The CPU had a set of 144 instructions, which provided for fixed-point binary, floating-point binary, and decimal arithmetic. The word size was 32 bits, but many of the instructions could operate on single characters (8-bit bytes).

Shortly after the original announcement, IBM revised the product line by adding the large 360/65 and 360/75 to replace the line's three largest machines. IBM shipped the first System/360 machines to customers between April 1965 and January 1966.

Development of the 360 was a very bold move on IBM's part, because it replaced all of IBM's second-generation business and scientific computers but was not compatible with any of them. This forced customers to run emulators or convert their applications. There were significant delays in producing key software components for the 360s, so that the OS/360 operating system was not delivered until mid-1967.[1]

These early problems were overcome within a few years, and the 360 sold very well. IBM

 1058-6180/01/$10.00

Figure 1. The Nike-X Central Logic and Control module here shows operator control panels in the foreground and a maintenance panel at the back left.

maintained its market share at about two-thirds of the mainframe computing market.[2] In 1970, IBM announced its System/370, which was an upgraded 360, incorporating monolithic ICs, newer disk drives, and semiconductor memory.

IBM's initial difficulties with the 360 provided an opening for Sperry Rand to recover both prestige and market share. Many people who started using computers during the early 1960s had formed an image of Sperry Rand as being a terribly backward company. In 1981, for example, one of the authors met a person who had departed the computer industry in the early 1960s yet still regarded Univacs as being vacuum-tube computers! The advanced features of the Univac 1107 presented an opportunity for Sperry Rand to upgrade it and move quickly into the marketplace with an IC computer.

The Univac 1108

Sperry Rand announced the Univac 1108 in the summer of 1964 and delivered the first one in late 1965. The company's St. Paul, Minnesota, development group had created it as an improved version of the 1107, carrying forward the use of ones-complement arithmetic, a 36-bit word, and the 1107 instruction set.

Like the IBM 360, the Univac 1108 used a combination of transistors and ICs. Thin-film memory for the general register stack was replaced by ICs. (Thin-film memory was a technology that Sperry Rand had developed under a National Security Agency contract between 1957 and 1962; a thin film—four millionths of an inch—of iron-nickel alloy was deposited in a grid pattern on a 2-inch by 2-inch glass plate, providing a very fast access time of 670 nanoseconds.)

The use of ICs reduced access time to 125 nanoseconds. The 1108's main memory used smaller and faster cores, so that its cycle time (750 nanoseconds) was five times faster than the 1107's.[3] The original 1108 version had 65,536 words of memory organized in two banks.

In addition to the faster components, the 1108 incorporated two major design improvements over the 1107—base registers and additional hardware instructions. The 1108 hardware had two base registers, so that all program addressing was done relative to the values in the base registers, which permitted dynamic relocation. Over the duration of its execution, a program's instructions and its data could be positioned anywhere in memory each time it was loaded. Since the base registers were 18 bits, they allowed a maximum address space of 262,144 words.

The additional hardware instructions included double-precision floating-point arithmetic, double-precision fixed-point addition and subtraction, and various double-word load, store, and comparison instructions. The 1108 processor had up to 16 input/output channels to connect to peripherals. The programming of these channels was done with specific machine instructions, and there was no capability to build multiple-step channel programs.

Just as the first Univac 1108s were being delivered, Sperry Rand announced the 1108 II (also referred to as the 1108A), which had been modified to support multiprocessing. This development arose from the company's work on missile guidance computers. The Athena ground guidance computer for the Titan ICBM (1957) had evolved into the Target Intercept Computer (1961), which was used with the Army's Nike-Zeus anti-aircraft missile.

When the Army was authorized in 1963 to develop the Nike-X anti-ballistic missile (ABM), Sperry Rand received the contract from Bell Telephone Laboratories to provide a computer for its guidance and control system. The Central Logic and Control (CLC) module (see Figure 1) was composed of multiple processors (a maximum of ten), two memory units, and two I/O controllers (IOCs). Unlike the 1100 series, the CLC used twos-complement arithmetic and a 32-bit word. The memory units were for program storage and data storage, each holding up to 262,000 64-bit words.

The CLC could be operated as one computing entity or be dynamically partitioned into two environments. It was completed in 1965, and machines were delivered to the White Sands Missile Range in New Mexico, Bell Telephone Laboratories, and Kwajalein Atoll in the Pacific Ocean test range. The first missile firings were in November 1965. Various features (including multiple CPUs, separate I/O processors, and lockout mechanisms to control memory access) of the CLC were adapted for use in the 1108.[4]

A multiprocessor 1108 could have up to three CPUs, four memory banks totaling 262,144 words, and two IOCs. (A system with four CPUs and three IOCs was installed at United Airlines, but that configuration was never again offered to customers.)

The IOC was a separate processor, functionally equivalent to the CPU's I/O channel section, which could take over the task of handling I/O. If an IOC was used, it connected to one of the channels in the CPU, so that the CPUs could load channel programs into the IOCs. Since the IOCs had their own paths to memory, once a CPU issued an I/O request, the IOC took full control of the I/O, transferring data to or from memory without further CPU intervention.

Each IOC had up to 16 channels, so an 1108 multiprocessor could be very busy. At the maximum configuration, five activities could be taking place at any given moment—three programs executing instructions in CPUs and two I/O processes being performed by the IOCs. A test-and-set instruction, added to provide synchronization between processors, gave the instruction set a total of 151 instructions.

The Univac 1108 reversed Sperry Rand's decline in the large computer market. The first 1108 was shipped to Lockheed in Sunnyvale, California, toward the end of 1965. Lockheed had already installed an 1107 as an interim machine and ultimately replaced two IBM 7094s with two 1108s. Other early 1108 orders came from the French National Railroad, the Scottish National Engineering Lab, Boeing, the Naval Ordnance Test Station, NASA (three machines in Huntsville, Alabama; two in Slidell, Louisiana; and four in Houston, Texas), the University of Utah, the US Environmental Sciences Services Administration, Air France (two machines), the Census Bureau, Carnegie Mellon University, and Air Force Global Weather Central (four machines).

Choosing the 1108 over General Electric (GE) and IBM proposals, Clark Equipment Corporation installed two machines to replace its Univac File Computer, leaping straight from first-generation to third-generation hardware. The National Bureau of Standards chose an 1108, rather than a Control Data 6600, because of the 1108's superior remote communications capabilities and lower price.

The relative smoothness of many early Univac 1108 installations contrasted sharply with various well-publicized delays for the IBM 360. The success of the 1108 was a wonderful surprise to Sperry Rand because in 1964 an internal study had forecast that only 43 would be sold.[5] The January 1967 issue of *Datamation* had a very favorable article by Douglass Williams of Lockheed describing its 1108 installation, and by the end of 1967 the total number of 1108 orders exceeded 135. Ultimately, Sperry Rand produced 296 Univac 1108 processors; the actual number of systems was smaller, since some of them were multiprocessor configurations.

While both the Exec I and Exec II operating systems (developed for the 1107) served the unit processor 1108s, it was clear that the two should be merged to provide a true multiprogramming system retaining the Exec II's ease of use and external appearance. Furthermore, the multiprocessor 1108s needed an operating system. This new operating system was Exec 8, sometimes written as Exec VIII. The specifications for it were drawn up in December 1964 and work began in May 1965.

The announcement of Exec 8 in 1966 was greeted with skepticism by *Datamation*, which had seen many big software fiascoes by other computer companies: "A step towards the quicksand: Univac, which has been doing well with about the only working large-scale software, joins the mañana crowd with a new operating system for the 1108."

At first, *Datamation* had it pegged correctly. The initial versions of Exec 8 did not work very well, and in 1967 Sperry Rand had to give one of the 1108s to NASA for free as a penalty for missing contract deadlines. The situation did improve, so that the University of Maryland was using Exec 8 in the spring of 1968, and one year later the president of Computer Response Corporation, a service bureau with an 1108 in Washington, could say of Exec level 23.25: "We're satisfied with the way it's handling our workload."[6] However, it was not until 1970 that successive releases of Exec 8 were consistently stable.

Sperry Rand was also fortunate to have a good Fortran compiler and some program conversion tools. The Fortran V compiler for the 1108, written by Computer Sciences Corporation, produced very efficient programs. At a meeting of Burroughs engineers discussing their competitors, Robert Barton referred to it as "a polished masterpiece." Another participant said, "You sit there and watch the code that thing cranks out and just try to imagine assembly code that would be written that well."

Lockheed developed a "decompiler" that translated IBM 7094 machine language programs into Neliac (Navy Electronics Laboratory International Algol Compiler—a variant of Algol 58). One of these decompiled programs comprised 500,000 instructions. There already was a Neliac compiler for the 1107 (and later for the 1108). At Air Force Global Weather Central, these doubly translated programs ran much faster on the 1108 than IBM's 7094 emulation did on the 360. Sperry Rand had a program that translated 7094 assembly language programs to 1108 assembly language, and Boeing developed another program that converted IBM 7080 Autocoder programs to the 1107 and 1108. The 1108 did well in competitions. A single processor 1108 outperformed an IBM 360/65 and a GE 635 on benchmarks conducted for the University Computing Company in 1968.[7]

Many programmers who came to the 1108 after working on the machines of other computer companies were struck by how easy it was to work with Exec 8. Steve Seaquist, now a self-employed programmer, started out on a Control Data Corporation (CDC) 6600 at the University of Texas in 1967. The students were taught to use an assembly language simulator, written in Fortran. In 1969, he transferred to the University of Maryland and used the 1108. Seaquist's first class was 1100 assembly language, and he was amazed that students were allowed to write real assembly programs. He "fell in love with the 1108." He liked the fact that batch and time-sharing—called "demand" processing on the 1108—used the same commands in the Executive Control Language, and that the consistency of ECL made it easy to compile and test programs. (Seaquist soon got a job as the computer center librarian, but quit the next summer to work as a lifeguard for the higher pay.[8])

Sperry Rand blended the 1108 multiprocessor architecture with that of the CLC in its line of military computers. In December 1967, the company was awarded a contract by the US Navy to develop a multiprocessor successor to its Navy Tactical Data System (NTDS) family of computers from the early 1960s. This was the AN/UYK-7, which was frequently configured with three CPUs, two I/O controllers, and 262,144 32-bit words of memory. The first AN/UYK-7, delivered in 1970, became the basis of the Navy's Aegis ship defense system. An airborne version, designated the 1832, was used in Navy antisubmarine aircraft. Sperry Rand also produced the AN/UYK-8, which was a compatible (30-bit word) multiprocessor replacement for the older NTDS transistor computers.[9]

The Univac 9000 series and the RCA acquisition

The IBM 360 announcement was the beginning of the end for the transistor Univac III. J. Frank Forster, president of the Univac division of Sperry Rand, set up a product line task force to decide how to proceed. The runaway success of the 1108 could not be ignored, and when Forster moved up to the Sperry Rand corporate level in 1966, he was succeeded by Robert McDonald, head of the St. Paul, Minnesota, operations that had produced the 1108. Forster had already decided that the 1108 would be the only large-scale Univac computer line. This left Sperry Rand's Philadelphia development group (which had moved to suburban Blue Bell during the early 1960s) out of the big computer area, and the engineering sections there designed a family of smaller computers that used the same instruction set as the IBM 360.

This family of smaller computers was the Univac 9000 series, starting off with the 9200 and 9300, both announced in the spring of 1966. It should be emphasized that while the 9000 computers used the IBM 360 instruction set and IBM's EBCDIC character code, they had their own operating systems and software developed by Sperry Rand. So while there was a high degree of program compatibility, it was not complete, and some changes were required to move from IBM to the 9000s.

The 9200 was a card-oriented machine with a maximum of 16,384 8-bit bytes of memory and a cycle time of 1,200 nanoseconds. In keeping with its IBM orientation, the quantity of memory was reported in bytes, not words.

The 9300 added the capability to have tape drives and could go up to 32,768 bytes of memory, with a cycle time of 600 nanoseconds. These machines used plated-wire memory, a technology developed by Bell Telephone Laboratories at the end of the 1950s. Copper wire was plated with an iron-nickel alloy that could be magnetized for data storage.

The principal programming language was RPG (Report Program Generator, developed by IBM for the smaller 360 models). Scaled-down versions of Fortran and Cobol, however, could be run on systems that had tape drives and at least 16,384 bytes of memory.

The purchase prices ranged from $39,000 to $98,000, while rentals were about $1,000 per month for the smallest 9200, $2,000 for a basic 9300, and $6,000 for a 9300 with tapes.[10] The aim of the 9200 was to ease customers, who had previously used only tabulating equipment, into using computers with little or no increase in cost. Then, as their needs increased, they could move up to the 9300.

The first 9200s were shipped in June 1967. To expand the line's range, Sperry Rand announced in January 1968 the larger 9400, which had up to 262,144 bytes of memory and could run five programs simultaneously. It sold for $170,000 and rented for $6,000 per month. The 9200 and 9300 sold briskly, and Sperry Rand announced improved versions, the 9200 II and the 9300 II, in the spring of 1969.

One of the more unusual early customers for the 9200 II was the National Pet Registration Center in New Jersey, which kept track of information on more than 10,000 show dogs. The November 1971 announcement of the 9700 (which had up to 1,024,000 bytes of memory and could handle 14 concurrent programs) extended the series again. A simple 9700 system sold for $500,000 or rented for $14,000 per month. Deliveries of the 9700 began in late 1972. With the exception of the 9700 (whose market life would be cut short by the 1973 announcement of the 90/70), there were many orders for the 9000s, and by the end of 1976 shipments had reached the levels shown in Table 1. So, over a six-year period the Philadelphia division had brought out a family of computers that paralleled IBM's 360 series, from the smallest up to the fairly large 360/65.

Table 1. Shipments of 9000 series computers by the end of 1976.

Model	Number of shipments
9200	1,500
9300	1,100
9400	600
9700	20

The existence of this partial IBM compatibility turned out to be very important in the fall of 1971 when RCA decided to get out of the computer business. Although RCA had been a leader in developing various computer technologies, such as core memory and the IC, its computer systems had never achieved much market share during the vacuum tube and transistor eras.

As one of the first commercial transistor computers, the RCA 501 had only modest sales—41 machines. The follow-on 601 system had so many problems that RCA stopped selling it in 1962 after just four deliveries. The smaller 301 system did somewhat better.[11] The RCA 3301, announced in August 1963 as a replacement for the 601, was eclipsed by the IBM 360 in the spring of 1964. RCA decided that its response to the 360 would be to develop its own family of computers, the Spectra 70 series, which used the 360 instruction set but had operating systems and software written by RCA.

RCA was following exactly the same strategy as Sperry Rand had with its Univac 9000 series, but RCA made the Spectra 70 its main (indeed, only) offering and also provided models to match the 360's full range rather than just the smaller end. RCA saw the Spectra 70 as a means to become a major factor in the computer industry and marketed it aggressively. The company also developed some very sophisticated system software that was much easier to use than the 360's and eventually came out with a virtual memory operating system (VMOS) for the larger machines.

The Spectra 70 sold well, but then RCA overreached itself. RCA hired L. Edwin Donegan Jr., a former IBM sales manager, in January 1969, and he rapidly moved to the top of the computer division. He set a goal of attaining a 10 percent share of the computer market. In the summer of 1970, IBM announced the System 370, an improved version of the 360 family. RCA's engineers were developing their own new hardware family, known internally as the new technology series (NTS), but it wouldn't be ready until 1972. Donegan decided not to wait, and repackaged the Spectras as the RCA series, with only minor engineering changes, at somewhat lower prices. Spectra customers, most of whom leased rather than owned their machines, saw a good thing and traded in their Spectras for the RCA series, wrecking RCA's financial plans. Two-thirds of RCA series orders came from Spectra customers, and outside orders dried up after IBM announced its 370/145 model at significantly lower prices than RCA had expected. The RCA computer division was forecast to lose somewhere between $60 million and $80 million in 1971.[12]

RCA panicked and decided to quit the computer business, announcing its decision on 17 September 1971. When RCA looked around for a buyer, Sperry Rand stepped up. The two companies negotiated an agreement, signed on 17 December, whereby Sperry Rand paid $70 million for the RCA customer base, taking on some 1,000 purchased and rented systems used by approximately 500 customers. In addition, Sperry Rand agreed to pay RCA a share of future revenues from that customer base.

Now that they were under the Univac umbrella, the Spectra 70 and RCA series machines were referred to as the Series 70. Sperry Rand appointed John Butler vice president of Series 70 operations, and he began a vigorous campaign to keep the new customers by committing to provide a high level of hardware and software support. He was successful: In the first six months Sperry Rand lost less than five percent of the RCA base and shipped $27 million worth of Series 70 equipment to meet existing orders. Enhancements to the Series 70 software, including a new level of VMOS, were brought out on time. Sperry Rand still faced the longer term tasks of integrating the 9000 series with the Series 70 and of figuring out how they both would fit in with the 1100s.

The 1106 and the 1110

The 1108 was not a series or family of computers. A customer could get a unit processor machine or, in the multiprocessor version, expand up to a maximum of three CPUs and two IOCs, but that was it. There was no small model. The unit processor 1108 for Carnegie Mellon University, as an example, cost $1.8 million, $1 million of which was covered by a grant from the Richard King Mellon Charitable and Educational Trust.

Not everyone had a charitable and educational trust, so it was clear that there needed to be a less expensive entry into the 1100 world. The 1106 was announced in May 1969 to meet this need. The first few machines shipped as 1106s were really 1108s with a jumper wire added to the backpanel to introduce an additional clock cycle into every instruction. Astute customers soon learned which wire they had to clip to speed up their 1106s.

The real 1106 used a slower and less expensive memory with a cycle time of 1,500 nanoseconds, half the speed of the 1108, and was packaged in 131,072-word modules referred to as unitized storage. On a system with just one memory module, it was not possible to overlap the operand access of one instruction with the fetch of the next instruction, so the basic add time was 3,000 nanoseconds. Systems with two modules could do the overlap and achieve faster operation. Later on, a faster memory unit was built in 32,768-word modules, and systems using that memory were called the 1106 II. A single-processor 1106 sold for around $800,000, which still was not entry level but considerably less expensive than the 1108. Sperry Rand sold 1106 systems amounting to 338 processors.

These were prosperous times for Sperry Rand, given the success of the 1108 and the 1106. One key exception to this bright picture was the failure of the airline reservations project at United Airlines. Sperry Rand and United had embarked on a joint venture at the beginning of 1966 to develop an airline reservations system based on the 1108, and a three-CPU 1108 II was installed at United's Elk Grove Center outside of Chicago two years later.

By the summer of 1968, the problems with Exec 8 had already put the project six months behind schedule and trouble continued. The original specifications were overly ambitious, and they kept changing as the project went along. The project also got bogged down in making extensive modifications to Exec 8, which eventually amounted to half the code. Even with additional processor power, the system was unable to meet the goal of 39 transactions per second, reaching only around 10. United terminated the project in the spring of 1970, and purchased the IBM-based PARS software that had been developed at Eastern Airlines. United decided to keep the 1108 and use it for message switching, materials control, and flight information.

Although Univac did regroup and get a reservations system going successfully at Air Canada two years later, the failure at United was a significant lost opportunity. On the bright side, 1970 saw the implementation on two 1108s of the automated stock market quotation system for the National Association of Securities Dealers (NASD). This project, coordinated by Bunker-Ramo, went into operation in January 1971 and has run on 1100 (later, 2200) series computers ever since.

A set of Univac 1100 account profiles from the early 1970s has made it possible to take a closer look at this time when companies and government agencies were actually switching from IBM and other vendors to Univac computers. The account profiles cover thirty-five 1106 and four 1108 sites where a new computer had been acquired in the early 1970s. There were 11 government agencies (local, state/provincial, and national), three universities, seven utility or communications companies, a savings and loan, and a newspaper. The other 16 were various manufacturing and business enterprises.

The Univac replaced an IBM 360 or 370 at 14 of these customers, Honeywell/GE computers at five, RCA at four, and Burroughs at two. The RCA replacements arose from Sperry Rand's purchase of the RCA customer base in 1971. They are still significant since those four companies could well have chosen IBM to stay with that architecture instead of switching to the 1100. In two of these sites, the customer was converting from a Univac III to an 1106.

Various strengths of the 1100 helped make these sales. Exec 8 was superior to IBM's OS and DOS in several areas, including scheduling, the ability to handle a mix of batch and demand runs, time-sharing capabilities, and the simplicity of Executive Control Language (ECL) as compared with IBM's Job Control Language (JCL). Programmers who had worked only on IBM sometimes thought they were being tricked when they were first shown an ECL runstream: It had to be more complicated than that, they thought.

Greg Schweizer, a programmer at the Portland *Oregonian*, started out on the IBM 360 as a student at Washington State University and at his first job. The first time he used a Univac 1100 was in the mid-1970s when he started work at a computer center for the State of Washington, which was converting from an RCA Spectra 70. He was impressed by how much easier it was to work on the 1100; his first reaction to ECL was: "This is fantastic; why couldn't IBM do this?"

On IBM, the complexity of JCL led to the frequent embarrassment of having to rerun jobs because of JCL errors. At his previous company, Greg had been struggling for weeks to get an IBM CICS (Customer Information Control System) transaction program to work, and it still wasn't working when he left. On the 1100 he found that "Univac knew how to do transactions."

It was easy to write transaction programs with Univac's Transaction Interface Package (TIP), a generalization of the routines used at Air Canada.[13] The existence of two operating systems (DOS and OS) was another disadvantage for IBM. Customers who wanted to move up to larger models in the IBM 370 hardware line were faced with a laborious conversion from DOS to OS, and some chose to convert to other vendors. By this time, Sperry Rand had completed its move from Exec II to Exec 8, and Exec 8 had settled down to be a stable operating system.

Univac computers had an advantage in their multiprocessor architecture, an area in which Burroughs was the only other serious contender. This permitted easier, incremental hardware upgrades and was the beginning of the shift toward today's fully redundant systems. At this point, IBM was not yet delivering effective multiprocessor machines as part of its standard product line. This fact, combined with the scheduling flexibility of Exec 8, meant that the 1106 outperformed IBM 370/135 and 370/145 computers in benchmarks conducted for several of these customers (such as Consolidated Papers, Ontario Hydro, Pace University, and Texas Water Development Board).

Another advantage for the Univac was its remote job entry (RJE) capabilities. In 1964, an 1107 at Cleveland's Case Institute of Technology had been linked to a 1004 at a hospital 10 miles away, and the following year another 1004 one hundred miles away was also connected. By the end of the 1960s, this capability was widely used, although 9200 and 9300 computers had begun to displace the 1004 as the preferred remote device. One of these new customers tied its 1106 in Missouri to remote 9200/9300s in Houston and Fort Worth, Texas, and in Kansas, while another implemented a network of an 1106 connected to fourteen 9200s spread across a state.

Sperry Rand did not have every advantage, as IBM was clearly ahead in disk drive technology. The 1100 series had just started using disks (as opposed to drums) in 1970, and the 8414 disk was a slow performer compared to IBM's 3330s. Burndy Corporation in Norwalk, Connecticut, had severe problems at first with its 8414s, but the system did settle down and a large database application was implemented.

In the area of software, the availability of Sperry Rand's DMS-1100 database system was a factor in 12 of these sales. While still rudimentary, it provided greater data-handling capability than IBM's IMS (Information Management System). GE (and then Honeywell, after it acquired GE's computer business) was a more serious contender with its Integrated Data Store (IDS) developed by C.W. Bachman and others in the mid-1960s.

Both the IDS and the DMS-1100 had the additional glamour of complying with the database standard of the Committee on Data Systems Languages (Codasyl), while IMS did not. Demonstrations of time-sharing programs accessing DMS-1100 databases impressed several early customers and they began using it. At two other companies, an older data management tool, FMS-8, was a key factor in the choice of the 1100.

Since so many of these sales involved conversions, it is not surprising that conversion software, such as a 1401 simulator and an IBM-assembly-language-to-Cobol translator, played an important role. At the time of these sales, few computer users had ventured far into transaction processing and screen formatting. This meant that most Cobol or Fortran programs were batch oriented and thus relatively easy to convert. Sperry Rand's edge over IBM in easy time-sharing access also facilitated program

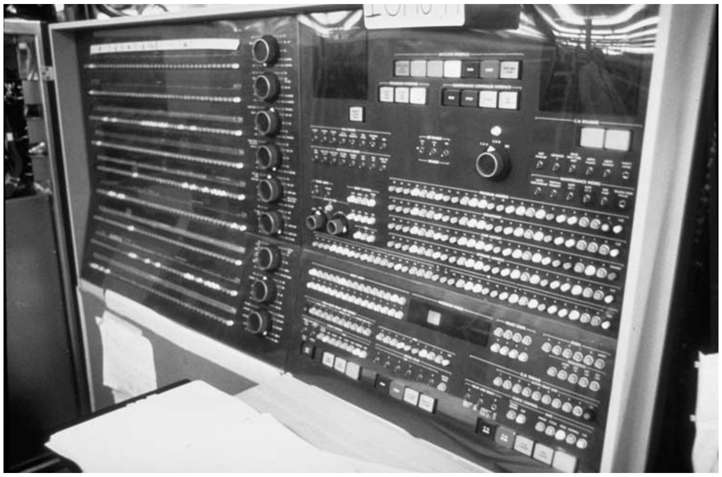

Figure 2. The 1110 was the last system with a full maintenance panel.

Figure 3. The 1110 was also the last system with a wire-wrap backpanel.

conversions. Program card decks could be read into disk files and changed with the ED (editor) processor, which seemed very powerful at the time, particularly on the Uniscope 100 and 200 screen terminals.

Situations like the one at United Airlines showed that something more powerful than the 1108 would be needed for very large applications. Work on a bigger system began in the late 1960s, but it was delayed by various engineering design problems as well as difficulties in establishing business relationships with IC manufacturers. Sperry Rand did not have the resources to build its own ICs in the quantities needed and had to buy them from Raytheon, Fairchild, Motorola, and Texas Instruments.[14]

The problems with the ICs were resolved, and the Univac 1110 was announced on 10 November 1970 (see Figure 2). The announcement had been delayed for several weeks so that it could happen specifically on the date, 11-10, which matched its name. The 1110 processor was constructed entirely of ICs, but they were only about 25 percent faster than the transistors used in the 1108.

The design of the 1110 incorporated several features to give it greater throughput than the 1108. The first was the use of plated-wire memory. Plated wire had already been used in the 9000 series, but it was too expensive to use for all the memory needed in the 1110. Therefore, the 1110 was designed to have a relatively small amount of "primary" memory using plated wire and a larger amount of "extended" memory using core (see Figure 3). The plated-wire memory had a read cycle time of 500 nanoseconds and a write cycle time of 500 nanoseconds; it came in cabinets of 65,536 words, and up to four cabinets could be used in a full system. The core memory had a cycle time of 1,500 nanoseconds and came in 131,072-word cabinets, with a maximum of eight cabinets (1,048,576 words) on a full system. Elaborate algorithms were added to Exec 8 to move programs between primary and extended memory depending on their relative compute-to-I/O ratios. The processor base-addressing registers were expanded to handle 24-bit addresses, and the number of registers was increased from two to four so that a program could have four banks based at one time.

The 1110 also increased throughput by having separate I/O processors and more instruction processors. Following the method used on the 1108 II, all 1110s had separate I/O processors called IOAUs (I/O access units) to handle I/O operations. The CPUs, which no longer had any I/O capability of their own, were called CAUs (command-arithmetic units). As originally announced, 1110s ranged from a minimum of one CAU and one IOAU (a 1 × 1 system) up to four of each (a 4 × 4). Later, the capability to go up to six CAUs was added. Each IOAU contained up to 24 channels.

Another feature was increased instruction overlap. On the 1110, instruction overlap was increased to a depth of four instructions. This made the design more complex because of the need to check for conflicts. If one instruction changed the value in a register that would be used to index a memory access in the next instruction, then that instruction's operand fetch had to be delayed until the register value was established. The 1110 also added 24 byte-handling instructions to the instruction set to improve the execution speed of Cobol programs.[15]

Sperry Rand planned for the Univac 1110 to be a competitor at the high end of the IBM 370 series. Accordingly, a 2 × 1 1110 rented for about $60,000 to $65,000 per month, which was about $10,000 less than an IBM 370/165. At first, the response was disappointing, with only six orders during the first year.[16] The pace picked up as 1110s replaced or supplemented 1108s at existing customers (Lockheed, Air Force Global Weather Central, Shell Oil, and the University of Wisconsin) and added some new customers as well. The Environmental Protection Agency's center in North Carolina, which had been an all-IBM site, got a 2 × 1, as did Arizona State University, where the 1110 replaced a Honeywell (General Electric) 255 and some smaller computers.

Both Arizona State and the University of Wisconsin installed 1110s in 1973. Arizona State was trying to do really large scale time-sharing using several new software packages, and it encountered severe problems during the first few months while the bugs were being worked out. Wisconsin fared better using older software.[17] Shell Oil made extensive use of the 1110, having three 4 × 2 systems in place by the end of 1975. In all, 290 1110 processors were produced.

The series 90

After purchasing the RCA installed base in 1971, Sperry Rand moved fairly quickly to integrate its 9000 series computers (9200, 9300, 9400, and 9700) with the former RCA machines, now designated the Series 70. The new family was called the Series 90, and the company announced the 90/70 (a repackaged 9700 with a base price of $500,000) and 90/60 (a slower, less capable 90/70 for $300,000) in 1973. Aside from replacing the plated-wire memory with semiconductor memory, there was nothing particularly new about them, and customer shipments began before the end of 1973.

Initially, these machines could run either of two operating systems: OS/4 (essentially the same as the Disk Operating System for the 9400) and OS/7. In 1975, the VS/9 operating system became available as an improved version of RCA's VMOS and could be run (with some difficulty) on them. To overcome the VS/9 problems, some customers had to add memory or upgrade from 90/60 to 90/70 processors.

Sperry Rand announced the entry-level 90/30 to replace the 9200, 9300, and 9400 in 1974 and began deliveries in February 1975. The 90/30 came in a wide range of configurations, priced from $80,000 (at 32,768 bytes of memory) up to $180,000 (at 262,144 bytes). A new multiprogramming operating system called OS/3 had been written for it, and while RPG continued to be the primary language, Cobol, Fortran, and an assembler were available. In addition, the 90/30 had the optional IMS/90 transaction processing software module. The 90/30 provided a logical upgrade path for existing 9200 and 9300 customers and also did fairly well at attracting new customers. By the end of 1976, approximately 700 90/30s had been shipped.

These small and medium-range machines did not really address the needs of those customers with the largest RCA computers, especially the virtual memory 70/61 and 70/7 models. In 1976, Sperry Rand announced the 90/80, which provided from 524,288 to 4,194,304 bytes of memory with a cycle time of 450 nanoseconds. Adopting the architecture of the Larc and the 1110, the 90/80 had separate instruction and I/O processors—one of each on the original model. Although the 90/80 could run OS/4 (with some additional microcode and software called the Integrated Control Facility) and OS/7, it came into its full power with VS/9.

The 90/80 provided competition for IBM's 370/158 at a considerably lower price: $1.1 million versus $1.9 million for systems with 524,288 bytes of memory. In 1978, the 90/80 was upgraded to provide up to 8,290,304 bytes of memory. The 90/80 sold well, since many of the large RCA sites were ready to move up. Customers included the District of Columbia Schools, United Press International (two systems), the California Department of Motor Vehicles (two systems), the California Department of Justice (three systems), and the Hoechst AG chemical firm in Germany. Users found the VS/9 control language and text editor (EDT), both inherited from VMOS, much easier to use than their IBM counterparts.

The 1100 series during the 1970s

During the early 1970s, metal oxide semiconductor (MOS) memory chips became available as a replacement for core memory. IBM used them on its 370/145, which was introduced in September 1970. Sperry Rand followed suit in 1975 and 1976 by bringing out semiconductor memory replacements for the 1106, 1108, and 1110 called the 1100/10, 1100/20, and 1100/40.

The maximum memory on the 1106 and 1108 had been limited to 262,144 words, but changes to the size of fields in the addressing structure increased the maximum to 524,288 words on the 1100/10 and 1100/20. Cable length considerations had confined the 1110 to 262,144 words of primary storage, but the use of bipolar memory chips made the memory more compact than plated wire, so the maximum was increased to 524,288. The 1100/40, like the 1110, could have 1,048,576 words of extended storage, and the use of semiconductor chips made it faster, cutting the access time from 1,500 nanoseconds to 800.

Sperry Rand had started work on a follow-on system even before the 1110 was shipped to customers. Internally, it was originally referred to as the 1112, but complications ensued. During the 1960s, the St. Paul, Minnesota, development group had taken its NTDS.

computer and produced commercial versions of it as the 490, 491, and 492. After the introduction of the 1108, this series was upgraded with 1108 components to become the 494. The 494 sold well, with 125 machines having been shipped by 1976, but the company was faced with the burden of supporting yet another line of software (operating system, compilers, and utilities) for it.

An internal report in 1969 noted:

> Although we seem compelled to continue to invest millions of dollars in 494 software, this will not contribute to Univac growth. Univac must solve the problem of the 494. In the meantime, its proliferation especially in the software area is robbing limited resources from other efforts.[18]

St. Paul decided to have the 1112 provide a 494 emulation mode, and it blended the 1112 and 495 to come up with the 1195.

By the time the 1195 was announced, the name had changed to 1100/80 to fit in with the nomenclature of the other 1100s. The 1100/80 used a new circuit technology known as emitter-coupled logic, which brought about a considerable increase in speed. The considerations of chip placement on boards and the wiring connections among them had become so complex that the engineers developed new software to do the circuit designs.

The 1100/80 was the first 1100 to use cache memory. (IBM had introduced cache memory on its 360/85, announced in 1968.) This was a relatively small (maximum of 16,384 words), very fast (45-nanosecond access time) memory in a separate module that could be accessed by any processor in the system. On any reference to memory, the hardware would first check to see if the request could be satisfied from cache; if not, eight words at the main memory address would be read into cache and then the requested item passed on to the processor.

The use of cache memory and faster components made the 1100/80 about twice as fast as the 1110. The original 1100/80 could have up to two instruction processors, two I/O processors, and four million words (4 MW) of memory. A later version could have up to four of each processor type. The 1100/80 introduced industry-standard byte- and block-multiplexer I/O channels into the 1100 product line. The 1100/80 was first delivered in 1977 and was very successful, with more than 1,000 processors produced.

While the 1100/80 was being developed, researchers at Sperry Rand's Corporate Research Center in Sudbury, Massachusetts, established the feasibility of using multiple microprocessors to build a mainframe computer processor. St. Paul started a project under the code name Vanguard to design a new 1100 processor using Motorola 10800 microprocessors. This design turned out to have a significantly lower cost, and the designers decided to enhance the system's reliability by totally duplicating each instruction processor—the two halves would check each other. This was a return to the concept used in the Binac and the Univac I. The lower cost made it possible to bring out a smaller, less expensive machine in hopes of broadening the user base of the 1100, and this is exactly what happened.

The Vanguard was announced on 5 June 1979 as the 1100/60, which had its first delivery later that year. Its availability coincided with the first widespread use of the Mapper software, which provided a simple database and reporting capability. The combination of Mapper and the lower price attracted many new customers. Sperry Rand exceeded its sales target in the first year, shipping systems amounting to 528 processors. The original model provided for a maximum of two instruction processors and two I/O processors (2×2), but this was subsequently increased to a maximum of four of each (4×4). The switch to a denser main memory in 1981 was the occasion for changing the name to the 1100/70. Between the 1100/60 and the 1100/70, nearly 4,000 processors were delivered.

The Mapper software package originated on a Univac 418 computer, which was used to track the Sperry Rand factory production line in Minnesota. The software, called Remote Processing System (RPS), made it possible for anyone connected to the 418 to monitor the status of production and to print status reports.

In the early 1970s, a new corporate policy required that internal use of the 418 be discontinued. A software development group started working on a new version of RPS for the 1100, but they took a very ambitious approach, basing their product on the DMS-1100 database software. The factory users of RPS—fearing that RPS-1100 would be slow, difficult to use, and look different to users on the terminal—decided to do their own rewrite. Since the name RPS had already been given to the new product, they called their version Mapper (for maintaining and preparing executive reports). RPS-1100 was released as a product in December 1974, but it never was widely used. The factory used Mapper and was happy with it.

Over the next few years, several existing and prospective customers who were touring the factory saw Mapper being used there and wanted it for themselves. For a time, Sperry Rand resisted these requests, but when the Santa Fe Railroad asked for Mapper to keep track of its freight cars (and proposed to make a large 1100 purchase) the company gave in, and Mapper was announced as a product in the fall of 1979.

Subaru of America was another one of the major early Mapper customers. In 1979, Subaru selected a Univac 1100/60 to replace its 90/30. Sperry Rand narrowly beat out IBM in the competition, because IBM's 4300 computers (replacements for the smaller 360s and 370s) weren't quite ready. Subaru, however, took the plunge into the 1100 world, interested in Mapper's potential. Sperry Rand delivered an 1100/61 in 1980, and Subaru started out as an all-Mapper environment.

Bill Krewson, Subaru's database administrator, was impressed with Mapper: "It was so much easier to deal with than the IBM and 90/30 environment. We wondered, Why doesn't everybody do it this way?" Mapper was so easy to use and such a big consumer of machine resources that the 1100/61 was swamped within six months, and an 1100/62 had to be installed at Christmas of 1980. Subaru continued to be a major Mapper user, integrating it with the 1100 relational database software (RDMS), and kept advancing into bigger 1100 computers over the following years.[19] Mapper was used extensively at both large and small 1100 customers. A survey of 224 customers in 1989 found that 140 were using Mapper.[20]

Other products and projects

While the Series 90 combined the 9000 series with the former RCA machines of the Series 70, Sperry Rand still had two major product lines whose central complexes (processors and memory) were incompatible. The 1100 series had a 36-bit word and was in the middle of changing from Fieldata (an old military standard) to ASCII as its primary data code, while the Series 90 had a 32-bit word and used EBCDIC as its primary data code. The two instruction sets were radically different. The support of two environments created significant costs. By the mid-1970s, Sperry Rand was spending about $16 million per year on hardware/software development for the 9000 and 90 machines (which brought in revenues of $31 million) and $15 million per year on the 1100 series (with revenues of $34 million).

In 1972, the company started a project to develop a new computer line that would encompass both the 9000 and 1100 series. The initial meetings were held at the Roanoke Building in downtown Minneapolis, so the effort was frequently referred to as the Roanoke project, although its official name was UPL (Unified Product Line). The project went through several evolutions of architecture and strategy, but there were some continuing themes—a 64-bit word, a stack architecture like that of the Burroughs 5000, and a higher level language orientation through macro instructions and microcode to emulate the 1100 and 90 architectures. Plans were made for two new operating systems: RMS (resource monitor system) to control all physical resources of the system, and NOS (new operating system) to sit on top of RMS and interface with programs and users.

The project was canceled in the fall of 1976, when it was clear that it was way over budget, a couple of years behind schedule, and had no prospect of obtaining decent performance for the 1100 and 90 emulation modes. In later years, Sperry Rand took a much less ambitious course in trying to unify the two product lines, which amounted to termination of the high end of the Series 90 and the provision of some minor aids to assist conversion to the 1100.

Sperry Rand was not the only company to back away from introducing a radically new system during the 1970s. IBM had started its FS (future system) project in August 1971 to produce a major new system to replace the 370, but the task grew so complex and fell so far behind schedule that the project was canceled in February 1975.[21]

Sperry Rand was so busy struggling to keep the Univac 1100 and 90 lines up to date, as well as trying to merge them, that it was totally absent from the development of the minicomputer. Terminology is important here, because the company did make smaller computers—the

9200, 9300, and 90/30. However, the minicomputer, as pioneered primarily by Digital Equipment Corporation (DEC) with its PDP-8 and PDP-11 models, was more oriented toward scientific processing, time-sharing with a small number of users, and process control.

By the mid-1970s, DEC and its rival, Data General, were selling large numbers of 16-bit machines. Their timing was perfect, since at many large companies, universities, and government agencies the large mainframe computers were so saturated with work that individual departments wanted computers for their own use (and under their own control). For just $50,000 or $100,000 they could do this, and, in circumstances where central computer use had to be paid for, they might even reduce their computer budgets.

By 1978, DEC was the leading computer supplier to the US government in number of machines (2,992), with Sperry Rand second (1,749). Since the Univac machines were larger, their dollar value ($656 million) was much greater than that of DEC's computers ($196 million).[22] The business-oriented 90/30 did not really fit into the minicomputer market segment.

Sperry Rand did produce two machines similar to minicomputers. One of these was the 18-bit Univac 418. It had undergone a major enhancement with the introduction of the 418-III in 1969. The 418-III provided for multiprocessing in the form of separate instruction and I/O processors, a feature that greatly increased its capability but also its price. The central complex alone cost more than $250,000; disks, tapes, and printers added even more cost.

The 1219 computer, another variation of the 418, was used in three different Navy missile programs (Talos, Tartar, and Terrier) and the Automated Radar Tracking System (ARTS-III) that was installed to handle air-traffic control at 70 US airports. Minicomputers did not reach this level of sophistication for a decade, but they were much less expensive.

The other Sperry Rand minicomputer was the 1616. It had been developed as a prototype in the early 1970s with a 16-bit word. Like the AN/UYK-7, it used twos-complement arithmetic, and instructions were 16 or 32 bits in length.

In December 1972, the Navy had issued a request for proposal for a minicomputer suitable for shipboard use. It received four proposals (from GE, Raytheon, Control Data, and Sperry Rand) that met the specifications. Sperry Rand was the low bidder and received the contract in April 1973. The AN/UYK-20 was a militarized version of the 1616 with 65,000 words of memory. Production deliveries began in 1974, at a price of $24,000 each when purchased in a quantity of 150. The first few produced had some reliability problems, but these were soon dealt with, and by the end of 1978 more than 1,000 machines were in service.

Sperry Rand developed an avionics version of the 1616, designated AN/UYK-23, which had less memory (4,096 words) but weighed only 20 pounds. The 1616 also served as the basis for various communications processors sold in the commercial marketplace, including the Distributed Communications Processor (DCP) used with the larger 1100 and 90 Series computers.[23] It is thought that Sperry Rand chose not to introduce a commercial version of the 1616 because it did not have the resources to develop a nonmilitary operating system, compilers, and other software for it.

Sperry Rand committees had studied the minicomputer situation since 1972, and in 1976 a seven-person task force recommended that the company acquire one of the existing minicomputer manufacturers. A search team narrowed the prospects down to two and in June 1977 reached an agreement with Varian Corporation to acquire its minicomputer division. Varian was at the point where it would have had to make a major investment to keep its minicomputer line competitive; instead, the company decided to concentrate on its original business of making scientific instruments.

Sperry Rand found that, while Varian's overall designs were of good quality, there were serious problems in making them suitable for mass production. Glen Haney, a Sperry Rand sales executive who had been on the search team, and Vaemond Crane, a senior engineer, were tasked with straightening out minicomputer operations (MCO). Sperry Rand rebuilt the factory in 1978, increased the MCO staff, and brought out Varian's 16-bit mini as the Univac V77.[24]

The initial sales effort placed V77s in a variety of situations, some of which were not good matches for the machine's capabilities. A V77 was installed at the Georgia Department of Agriculture, for example, to maintain the mailing list for its farmer and consumer newsletter. The scientific orientation of the V77 made it hard to use for this purpose, and the system lasted only a few months.

Other circumstances were more favorable. In 1980, when Creighton University in Omaha, Nebraska, got its first 1100 computer, Uniscope-type terminal networks were too expensive for student use. When a third-party solution to link Uniscope terminals to the 1100's General Communications Subsystem

(GCS) handler failed, Creighton turned to Sperry for help. Two Sperry programmers, Hans Hermans and Mike Godfreys, had just programmed the V77 to be a terminal concentrator (Univac Terminal Concentrator, UTC) as a test to see whether an operating system (albeit a special-purpose one) could be written successfully in Mint, a new programming language that Godfreys had written. The UTC was not a formal product, but Sperry agreed to supply the software free if Creighton bought the V77s. Desperately needing a way to support screen terminals on the university's new 1100, Creighton bought three V77s. In the fall of 1980, Hans Hermans spent about a month in Omaha, fine-tuning the UTC because it was taking frequent stops. While some problems persisted, the UTC did successfully provide terminal concentration for Creighton until Sperry brought out its Distributed Communications Processor (DCP) in the 1980s. The UTC was provided to three customers on the same terms that Creighton received.

In 1978, DEC began shipping its 32-bit VAX, which made 16-bit minicomputers obsolete. MCO had a project named Chameleon under way to produce its own 32-bit machine, but many of the lead designers quit in the first years after the acquisition. As a result, by the end of the 1970s, it became clear to Sperry Rand that the Chameleon was not buildable in a reasonable time or cost, and the project was canceled.

After an initial upsurge, the V77s did not sell very well because of their older architecture and because Sperry Rand had no experience in the US minicomputer market. A large proportion of minicomputer sales were done through third-party companies, known as value-added resellers (VARs), which packaged the mini hardware with some kind of software and sold to a specific market segment, such as pharmaceutical laboratories or engineering firms.

Sperry Rand was familiar only with direct sales and lacked a VAR network, so the minicomputer operation gradually withered away. In December 1981, the minicomputer manufacturing was moved from the old Varian location in Irvine, California, to Sperry Rand's communications terminal factory in Salt Lake City, Utah. Operations were closed out in the middle 1980s, the acquisition having been a disappointment for Sperry Rand.

In the meantime, designers at Blue Bell had become interested in a new, small-business-oriented computer being developed by an outside company. Sperry Rand bought the rights to the computer, finished it, and sold it under the name BC/7. The BC/7 was housed in a metal desk that contained the central processing unit, memory, a small operations display screen, and from one to six diskette drives. One workstation screen and keyboard could sit on the desk surface. The customer could add optional items, including a stand-alone line printer, one or two tape drives, up to eight cartridge disk drives, and up to six additional workstations.

The central processing unit was an Intel 8080A microprocessor with an 8-bit word size, and the system could have 32,768, 49,152, or 65,536 bytes of memory. The only traditional programming language was RPG, but Sperry Rand also offered a user-oriented database language called Escort and a library of applications programs for general ledger, accounts payable and receivable, payroll, order entry, and inventory management. A basic system cost about $30,000.

Sperry Rand announced the BC/7 in early 1977, set up a separate sales force to market it, and began customer shipments in 1978. The BC/7 was modestly successful, but sales did not meet the company's expectation when it adopted the separate sales force concept. When *Unisphere*, a magazine for users of Univac computers, was started in 1981 it had monthly articles on BC/7 programming that were warmly received by the customer community.

As time went by, many BC/7 customers outgrew their machines and upgraded to the Univac 90/30 and its successors. The pool of new BC/7 customers dried up once usable business software became available for the IBM PC in the early 1980s, and the end was in sight for the BC/7. Sperry Rand integrated the separate sales force into its regular sales structure, and ceased marketing the system. The hardware itself, however, lived on for more than 15 years as very useful remote communications terminals (UTS-700) and support processors for various larger Univac computer systems.

Conclusion

In 1979, Sperry Rand changed its name to Sperry Corporation, but the computer division continued to be called Sperry Univac and the computers still used the name Univac. Throughout the 1970s, the company had maintained its position as the second-place producer of large-scale computers.

Particularly during the first half of the decade, Sperry was able to attract customers who converted from other vendors' machines, and, in both the 1100 and 90 series, Sperry offered products that many customers believed superior to IBM in ease of use. While the 90/30 provided a good mid-size business computer, Sperry Rand's failure to establish a large market share in minicomputers and small business computers left it in a vulnerable market position at the beginning of the 1980s.

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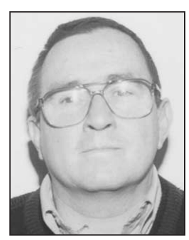

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