The 360 Revolution.

Chuck Boyer

IBM

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Forty years ago IBM changed the worlds of computing and business – and transformed itself – with the revolutionary System/360. The spirit of that time thrives today in a new era of big bets, innovation and on demand business.

The first part of this work, the story behind IBM's development of the System/360™ during the 1960s, draws from many sources. Included are recent interviews with several key players from that period, as well as excerpts from several references, including Tom Watson, Jr.'s autobiography *Father, Son & Co.* with Peter Petre; IBM's *Think* magazine; Louis V. Gerstner, Jr.'s, *Who Says Elephants Can't Dance?;* Bob O. Evans' unpublished manuscript of his memoirs; and several others. But the primary source for the narrative line for the System/360 story derives from an extraordinary body of technical research compiled and written by now retired IBM employee Dr. Emerson W. Pugh. These include: *IBM's 360 and Early 370 Systems*, with Lyle R. Johnson and John H. Palmer; *Building IBM – Shaping an Industry and Its Technology;* and *Memories That Shaped an Industry – Decisions Leading to IBM System/360*. (Please see the bibliography for a complete list of references.) The senior editor and manager on this project, Will Runyon of IBM's Systems & Technology Group, Phil Carapella also of IBM's Systems & Technology Group and Paul Lasewicz and his team at the IBM Archives, respectively conceived, supported and added immeasurably to this project.

CHB

"[System/360] was the biggest, riskiest decision I ever made, and I agonized about it for weeks, but deep down I believed there was nothing IBM couldn't do."

Father, Son & Co. 1990
Tom Watson, Jr.
IBM President 1952
IBM President and CEO 1956
IBM Chairman and CEO 1961-1971

Nick Donofrio, senior vice president, IBM Technology & Manufacturing

IBM's System/360 and its modern lineage succeeded beyond the imaginable dreams of the people who designed and built the introductory models. It changed the fortunes of our clients and of IBM, and to this day carries an extraordinary portion of the world's work on its back.

This book pays tribute to those legendary accomplishments. Reliving the story of the System/360 reveals the struggle, the personalities – and the values – that helped IBM create this landmark contribution, an advance in both technology and business that, to a significant degree, reshaped IBM.

To me, the most striking, even astonishing realization about the birth of System/360 was how something that today seems inevitable, almost like an act of nature, came about because of a very conscious and extremely risky decision by a relatively small group of people. IBM managers and engineers had a choice in the early 1960s. They could have continued to refine and develop already successful products. And indeed, there were sound technical and marketing arguments for doing just that. But after debates that can only be described as "fierce," they decided on a much more ambitious and difficult path.

Getting the System/360 launched and safely on its feet would eventually cost the company upwards of $5 billion ($30 billion in 2004 dollars). It would be the largest privately financed commercial project ever undertaken. (Watson 1990, 347)

That's what leaders do. Putting everything they had on the line – literally betting the business – they chose to develop a new family of computers and peripherals that would make it easier and more effective for IBM customers to tap into the power of modern computer technology. The result was the System/360 family of compatible mainframe computers, and a complementary array of extraordinary innovations in storage, memory, and integrated circuit technology.

As you'll learn in this story, System/360's success wasn't just the sum of technical innovations and tough-minded management. IBM at that time put its 50 years of values, culture and heritage on the line to make it work. When the going got rough – and the going got very rough – it was these values, exerted through the will power and determination of 190,000 IBM employees, that brought it across the finish line, delivering an important moment in history.

Once again today, as in 1964, we are concentrating the entire resources of IBM and focusing them on the most urgent issue facing business. Back then, it was the burgeoning and complex "back office." Today, it is the need to sense and respond to

the opportunities and threats of a volatile, globalizing marketplace. The solution back then was a business-and-technology capability embodied in the mainframe. The solution today is a business and technology solution embodied in creating the "on demand enterprise."

Much is different today about technology, business and the world at large. But for IBM, some things are very much the same.

We still understand that this kind of deep, game-changing innovation isn't achieved by inventing technologies in a vacuum and throwing them over the wall, but by an intimate collaboration between technology and business needs, between IBM, our clients and our Business Partners.

Most important, we are still motivated by the aspiration to make a difference in the world, and to shape our work and run our company by values. Those values – dedication to every client's success, innovation that matters for our company and for the world, and trust and personal responsibility in all relationships – will determine how well we will accomplish this new goal, and how we will weather the difficulties and challenges ahead.

Nick Donofrio, senior vice president, IBM Technology and Manufacturing

IBM is committed to making history once again – by once again helping our clients do the same.

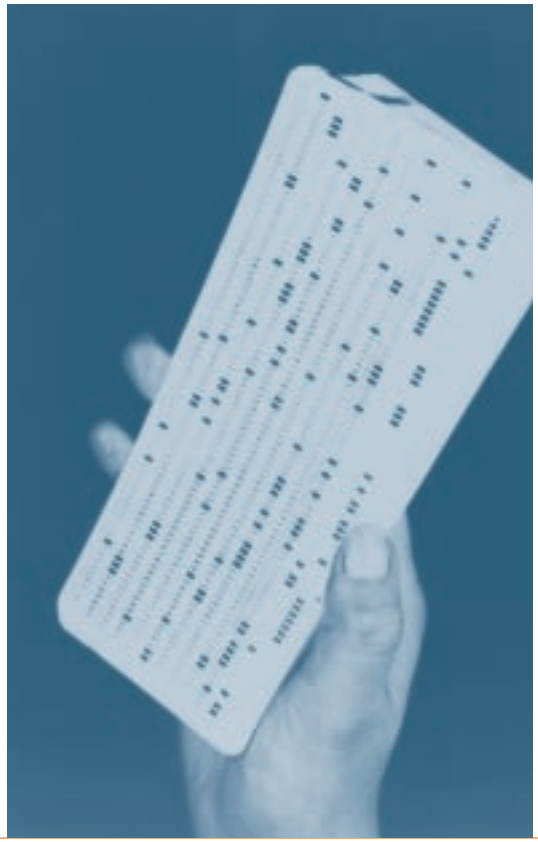
Betting the Company

I. The Stakes

Historians might quibble, but a credible case can be made that the "computer age" we live in today began at 8:30 Eastern Standard Time on the evening of November 4, 1952.

That was the moment Remington Rand's UNIVAC I general purpose computer – represented by a false front in a CBS television studio in New York – accurately predicted the outcome of a U.S. national election. It said front-runner Adlai Stevenson would lose the U.S. presidential election in a landslide to Dwight D. Eisenhower. This accurate forecast was made just two and a half hours after the polls closed on the East Coast of the United States, and with only 5 percent of the votes tallied.

IBM at that moment was the undisputed world leader in electro-mechanical accounting machines, symbolized by the 80-column punched card. Since 1914, when Thomas Watson, Sr. took over the sputtering CTR Company in New York, the business had grown extraordinarily well. Concentrating on a line of tabulating machines inherited from inventor Herman Hollerith, Watson Sr. had built IBM (renamed in 1924) into the market leader, growing from a gross income of less than $4 million and 1,300 employees in 1914 to become a $2 billion powerhouse with 104,000 employees by the end of 1960.



IBM at that moment was the undisputed world leader in electro-mechanical accounting machines – a stature that was fast becoming quaint.

This stature, however, was fast becoming quaint. A fully electronic, stored-program computer like the UNIVAC didn't need punched paper cards. It used high-speed magnetic tapes to enter and store programming information.

Fortunately, another important event of 1952 – the naming of Tom Watson, Jr., son of the company's founder, as president – signaled the arrival of a new generation of managers and engineers at IBM, and they were well aware of their predicament. They had already been scrambling to do something about it. IBM entered the computer age late that year, too, with its 701 Electronic Data Processing Machine. It built and sold 19 of them.

IBM entered the "computer age" late in 1952 with the 701 Electronic Data Processing Machine.

To all appearances, the company's move into the emerging market was a success. From 1950 to 1962, the company's revenues and earnings had both grown nearly tenfold to net earnings of $305 million on revenues of nearly $2.6 billion. The employee population had grown from 30,000 to 127,000. IBM was now the clear market leader, and *Fortune* magazine writers talked about "Fortress IBM."

But to observant insiders, the picture was a bit different. The future didn't look quite as bright as its past. "Paradoxically," wrote Tom Watson, Jr. in his memoir *Father, Son & Co.*, "there also was a feeling in the early '60s that IBM had reached a

plateau. We were still expanding, but less quickly than before… As we reached the two-billion-dollars-a-year mark people began to speculate that we'd gotten so big that naturally our growth rate had to fall. But given the bright prospects for computing, that seemed illogical, and I thought it was probably our own fault that we were slowing down." (Watson 1990, 346)

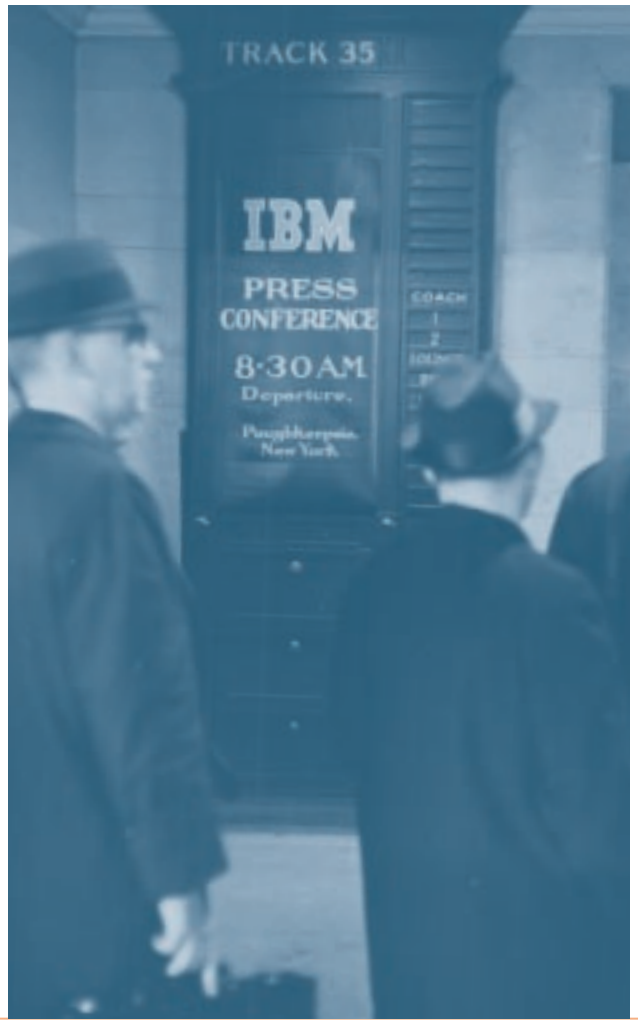
Growth tapered off substantially in 1960. Smart new competitors, fueled by research and investments from World War II and the Cold War, had entered the field with fully electronic computers. By 1963 Burroughs, Honeywell, Remington Rand, Control Data, and General Electric had introduced computers superior in some ways to IBM's existing line at the time.

Worse, IBM's "management by contention" style – which pitted engineers, departments, and laboratories against each other – had created a hodge-podge product line of eight computers, all excellent machines in their own right, but with incompatible architectures. This was emblematic of the whole industry. IT customers who wanted to move up from a small to a larger system had to invest in a new computer, new printers, and storage devices, and entirely new software, most of which had to be written from scratch.

Much of the balance of the company's success over the next 42 years can be traced to that fateful decision in 1962 to replace the company's entire product line of computers and build a new family of compatible (and unproven) machines called the System/360 – along with the go-for-broke effort that eventually made it work.

It [System/360] changed the IT industry forever, and it changed how much of the world's work gets done even today.

II. The Decision



As part of the gala System/360 kickoff, a train was chartered from Manhattan to Poughkeepsie for hundreds of customers, media and dignitaries.

The decision to commit IBM's fortunes and future to the 360 was "gut wrenching." Careers were made and broken, and, sometimes, made again. A company psychiatrist tinkered with the notion of making "demotions" socially acceptable events. Bright minds and strong personalities argued for and against the System/360 decision, almost right up to announcement day. Even at that hour few understood how difficult it would be to make the 360 a success. Fewer still could have realized the monumental consequences of just how big that success was going to be.

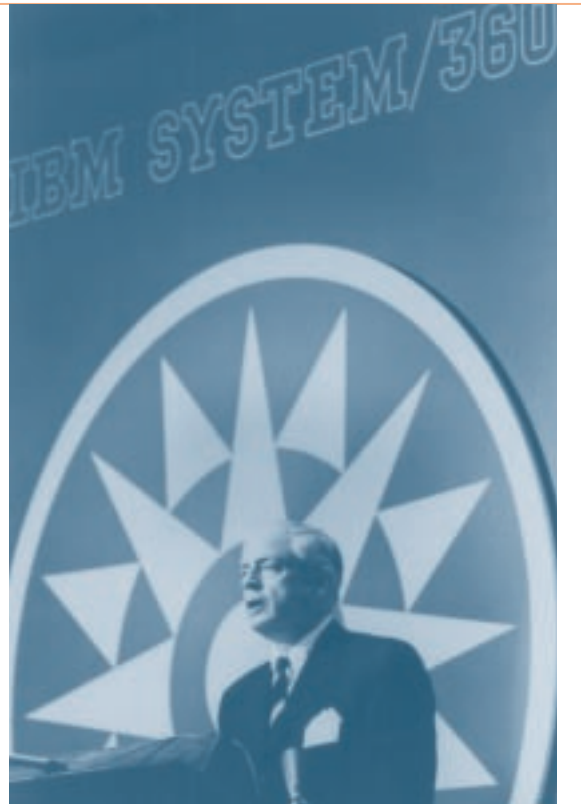
The vision was both sweeping and dauntingly granular. Code written for the smallest member of the family would be upwardly compatible with each of the family's larger processors. Peripherals such as printers, communications devices, storage and input-output devices would be compatible across the family. In addition to solving the compatibility problem for its customers, IBM planned that each member of the new 360 family would exceed competitor offerings in each size and price range.

No one at the time, including IBM, had ever written operating software for a compatible family of processors. Many of the plug-compatible storage and peripheral devices still needed to be invented. And the core logic modules, called Solid Logic Technology, upon which everything depended, were still in

development – as was fundamental software technology that preceded today's relational databases. There were also lingering doubts about how easily competition might be able to take advantage of a compatible product line by quickly introducing look-alike products.

Despite all that, IBM wasn't going to let the System/360 fail because of modest beginnings. IBM planned its announcement for a full year and rehearsed every move for six months leading up to April 7, 1964. In addition to a gala kickoff at IBM's Poughkeepsie plant in upstate New York – including a chartered train with hundreds of customers, media, and dignitaries coming from Manhattan – press conferences were held that same day in 165 U.S. cities and in 14 other countries.

At the time this photograph was taken at the System/360 announcement in Poughkeepsie on April 7, the saga of what *Fortune* magazine writer T. A. Wise would later call "IBM's $5,000,000,000 Gamble" was well under way.



Tom Watson, Jr. at the System/360 press conference.

III. The World in 1960

By early 1945, the budding field of "electronics," sparked by the WWII-driven buildup of technology and manufacturing, was opening the possibility that someday, perhaps soon, new machines would far outpace the tabulating power of any electro-mechanical device. When IBM engineer Ralph L. Palmer returned to IBM from duty in the Navy, he was called in to see IBM Executive Vice President Charles A. Kirk. "I understand you think IBM is falling way behind in electronics," Kirk told him. "That's right," said Palmer. "Well," said Kirk, "why don't you go to Poughkeepsie, and do something about it." (Pugh 1995,150) And so was born IBM's first department devoted to electronic computers.

IBM's SSEC super calculator pointed up a critical problem: electro-mechanical input, output, and memory sources could not keep up with the new computing speeds.

That same year, Tom Watson, Sr., after helping Harvard University build its groundbreaking Mark I computer, decided to build a "super calculator" for "automatic scientific computation." He hired Columbia University's Wallace Eckert to write the specifications for the Selective Sequence Electronic Calculator. Under IBM engineers Frank Hamilton and Robert Seeber, the SSEC was set up and dedicated at IBM headquarters at 590 Madison Avenue in Manhattan in 1948.

Employing continuous loops of paper tape to handle programs and input data, the SSEC was the first computer capable of modifying its programs while it ran. The system was so large, taking up all the wall space in a room 60 feet long and 30 feet wide, that the dedication ceremony was actually conducted "inside" the machine. But IBM's new super calculator pointed up a critical problem: electro-mechanical input and memory sources, such as paper tapes, could not keep pace with the new computing speeds. If these new electronic computers were ever going to be useful, they needed high-speed memory and storage.

The struggle to develop high-speed memory, memory buffers and storage is a story in itself. IBM's early computers, called electronic calculators, used hybrid combinations of punched cards and paper tapes to serve as input-output devices, main

memory and stored memory. By the early 1960s, though, IBM had become the world leader in ferrite core memory technologies. It was producing some of the fastest, largest, and most reliable in the industry, and its accomplishments in reducing manufacturing costs were unmatched. (Pugh 1985, 262-263)
Some highlights:

- A programmer at the Bank of America remembers watching IBM technicians come in to service their IBM 702 (one of IBM's first large-scale general purpose computers.) "They took out banks and banks of electrostatic storage tubes and replaced them with a small metallic box with a glass window, revealing the ferrite core memory with twice the storage capacity." (Pugh 1985, 142)

- IBM's innovations with Magnetic Tape Drives helped to keep it ahead of tough competition at the time, mainly Remington Rand's UNIVAC. In trying to solve the problem of magnetic tape breaking at high speeds, IBM engineer James A. Weidenhammer used a reversed vacuum cleaner to blow air on the tape, to prevent it from binding and breaking. It didn't work. On a whim, he turned the vacuum hose around and created a slight vacuum in the tape drive. It worked. (Pugh et al. 1991, 22) This vacuum-driven tape would soon give IBM a competitive edge in the new electronic computer area.

By the 1960's, IBM had become the world leader in ferrite core memory technologies.

Tiny washer-shaped ferrite cores were the heart of memory technology at the time.

III. The World in 1960

History rarely travels in a straight line – progress never does. When Tom Watson, Sr. first heard that competitor Remington Rand was going to use magnetic tape to input and store information, he wanted to know why IBM didn't have magnetic tape. Later, when IBM engineers presented a plan for just such a machine, the elder Watson, putting himself in the customer's shoes had second thoughts. He told them: "You might be going ahead and thinking you are storing information on that magnetic tape and when you try to get it off, you might find you have nothing there." (Watson 1990, 194) A few years later, Tom Watson, Jr. would pick up the idea and run with it.

- In the summer of 1960, in a race to meet a deadline for a special-purpose computer for the U.S. Government's National Security Agency, IBM engineers ran into a tough problem with the ferrite core memory arrays. The tiny washer-shaped ferrite cores started to vibrate when the system ran at high speed. This caused "magnetic noise" in the system. Out of time to make a detailed study of the problem, the engineers set up a big tub on the lawn at the IBM lab at Poughkeepsie, held the memory arrays over the tub and drizzled polyurethane fluid over them. The hope was that the polyurethane would create a soft coating and dampen the vibrations. "It was kind of a gamble," said IBM engineer Robert M. Whalen. "We were afraid it might change [the] switching characteristics [of the memory arrays], and we had no solvent to remove the material from the cores." (Pugh 1985, 181) But the gambit worked, and was later used on other memory cores.

Finding a way to keep main memory and stored data flowing into and out of a computer at speeds that could match high-speed logic circuits was the dominant problem in developing useful electronic computers. Much of IBM's success in the modern computer era can be traced to its pioneering breakthroughs in magnetic disk storage.

The IBM 350 Disk Storage Device,™ developed by engineers at IBM's lab in San Jose, California, and introduced as part of the IBM 305 RAMAC (Random Access Memory Accounting Machine) in 1956, set the standard for high-speed, high-density random access. Thus began an illustrious chain of innovations that eventually included removable disk packs, the floppy disk, super-high-speed Winchester files and thin-film heads. The 350 Disk Storage Device became an International Historic Mechanical Engineering Landmark in 1984.

III. The World in 1960

SAGE, an early warning air defense system, pioneered realtime operating systems and digital data transmission.

In helping NASA get to the moon, IBM developed realtime data processing.

Stretch, an early IBM supercomputer, inaugurated the use of solid-state technology.

Challenge and Response

It's intuitive that major innovations, such as the System/360, are built on cumulative advances in technology and manufacturing. But a lot of those innovations occur when companies tackle extraordinary challenges. Four huge projects undertaken by IBM helped shape the future that became the System/360. Both the successes and the failures from these projects helped build the 360.

SAGE

When the Soviet Union exploded its first atomic bomb in 1949, the United States quickly stepped up its effort to develop an enormous early warning defense system called, awkwardly, Semi-Automatic Ground Environment. It became the first real-time, online use of integrated computer systems over a wide area – in this case all of North America. At the project's peak in the late 1950s early 1960s, some 7,000 IBM employees were building, installing, and servicing SAGE's massive 250-ton computers, each employing some 60,000 vacuum tubes in its circuitry. In the process, IBM became adept at mass-producing, testing, and servicing electronic computers. The entire project, which was led by MIT and involved dozens of major companies, advanced developments in magnetic-core memories, large, realtime operating systems, program structure and development, input-output functions, and digital data transmission over telephone lines, to name a few. (Pugh 1995, 219)

SABRE

Using much of what they learned on the SAGE project, IBM engineers developed the world's first large, online computer network for airline reservations. When it went online for American Airlines in 1964, the system linked 1,100 reservation desks in 60 U.S. cities across 12,000 miles of high-speed telephone lines. (Think 1989, 47) Much more than just a computerized reservation system, SABRE also handled passenger data, rental car information, crew scheduling, flight planning, fuel management, waiting-room displays, stand-by passenger lists, and aircraft maintenance reporting. Originally called SABER (for Semi-Automatic Business Environment Research) the name was later changed to SABRE for copyright reasons. (Pugh et al. 1991, 572) Pan American Airways and Delta Airlines immediately ordered similar systems from IBM.

Space: Projects Vanguard, Mercury, Gemini, Apollo, and the Race to the Moon

The most dramatic demonstration of "realtime data processing" was NASA's race to the moon, beginning with satellite launches in the early sixties. IBM's Federal Systems Division provided a wide range of critical support for the extended effort. IBM computers helped track orbits for the early Mercury astronauts, guided the Gemini flights, including the first spaceship rendezvous, powered NASA's space center in Houston, computed the moon's orbit and helped land astronauts on the moon and return them safely to earth. Along the way, IBM engineers developed multiprogramming and multiprocessing skills that would become important contributions to the System/360 operating systems.

Stretch

IBM engineers called it Stretch because they meant to literally stretch IBM's capabilities in every facet of computer technology. The assignment was to build a supercomputer for the Atomic Energy Commission's laboratory at Los Alamos. The project became, in effect, a litmus test for development of the System/360 family. The Stretch system, which became the IBM 7030, advanced IBM's expertise in ferrite core memory, employed highly reliable and easy to produce solid-state transistor circuit cards (called Standard Modular System, or SMS, technology), introduced a new type of circuit for high-speed switching, and achieved computing speeds three times faster than the systems developed for SAGE, and 200 times faster than the IBM 701. For more than a year after it was delivered in April of 1961, Stretch was the fastest computer in the world. Even before the supercomputer was completed, IBM engineers used its new advanced circuit design and memories to launch a commercial system named the IBM 7090. As good as it was, the Stretch computer's performance was only about half as good as had been predicted at the beginning of the project.

Life on the Bleeding Edge. Embarrassed that the IBM 7030 (Stretch Supercomputer) didn't live up to anticipated performance specifications, Tom Watson, Jr. reduced the computer's selling price from $13.5 million to $7.8 million – below what it cost to build the system. "If we get enough orders at this price," he quipped at the time, "we could go out of business." Eight units were sold.

Over time, however, Stretch's contributions to later IBM successes became better understood, and the engineers leading the project, Stephen W. Dunwell and Erich Bloch, were recognized and rewarded – five years late. In addition to the introduction of solid-state technology, Stretch helped pioneer IBM's use of multiprogramming, memory protect, generalized interrupt, interleaving of memories, the memory bus, standard interfaces for input and output, and the 8-bit character, called a byte.

The Stretch experience provides an insight into the prevailing mindset at IBM: To a person, IBM people believed that if a project was too easy, they weren't trying hard enough. Glowing reports on laboratory successes sent to IBM Headquarters often aroused suspicion that perhaps a laboratory or department wasn't really pushing. This feeling was true not only among managers and engineers, but was also felt and understood by sales and support people as well. Sales people, in fact, often complained that the development labs needed to go farther.

Even more important, everyone in the company knew that to succeed you had to beat the competition. They obsessed over it. When Tom Watson, Jr. heard that Remington Rand had sold a UNIVAC computer to the United States Census Bureau (and shoved a couple of IBM punched-card tabulators off to the side to make room for it) he recalled becoming "terrified." He called a meeting that same afternoon to discuss what happened and what IBM was going to do about it. The meeting, said Watson, "lasted long into the night."

Project Stretch also reveals one of the major elements contributing to IBM's abiding success: IBM then and today continually evaluates and refines development programs against market assessments and the company's technical capabilities until well-defined goals are established. (Pugh et al. 1991, 628) *Frequently, these goals are then set to push the limits of technology.*

IV. The Scene is Set: The Business, The Culture, and The Products

The competition in the 1950s and 1960s between the IBM laboratories and manufacturing facilities in Endicott and Poughkeepsie was intense. Endicott was the source for IBM's spectacular success in the electro-mechanical tabulating machine area. Nearly half of IBM's double-digit growth from the 1950s to the early 1960s still came from electro-mechanical products. Poughkeepsie was charged with bringing IBM into the new world of fully electronic computers. Engineers from the two labs not only didn't communicate well with each other, they actively worked to keep their projects secret from each other.

> *Internal secrecy and rivalry goes back to IBM's earliest days under Tom Watson, Sr. He frequently assigned the same project to several engineers – each unaware of the others' assignments. As this practice became known, engineers and inventors in the company jealously guarded their work, to the point of being careful not even to be seen in the company of engineers from other departments, lest they be suspected of passing secrets.* (Pugh 1995, 47) *Erich Bloch, who later headed component and memory development for the System/360, was asked early in his career to work on a memory buffer for the IBM 702. After consulting with other engineers working on similar projects, he broke*

North Street Laboratory, Endicott, N.Y.

The competition between the IBM laboratories and manufacturing facilities in Endicott and Poughkeepsie was intense.

IBM Laboratory, Poughkeepsie, N.Y

off communications with them and went to work. He wanted to be the first to make a magnetic core memory for IBM – that worked. (Pugh 1985, 58)

By 1960, the Data Systems Division, with its laboratory and manufacturing facilities in Poughkeepsie, was responsible for developing large computer systems – those typically renting for $10,000 or more a month. The General Products Division, with plants and labs in Endicott, San Jose, Burlington, and Rochester, Minnesota, was responsible for developing systems that rented for less than $10,000 a month.

Poughkeepsie had built IBM's first fully electronic products – the 700 series of computers (then called Electronic Data Processing Machines) – and had eventually beaten front-runner Remington Rand and its much-vaunted UNIVAC. Old-line Endicott, however, once disparaged by Tom Watson, Jr. as a "bunch of monkey-wrench engineers," had built the low-cost IBM 650 Magnetic Drum Calculator, the company's first computer to ship in numbers greater than 1,000. And in 1960, they had started shipping the IBM 1401, the first IBM computer to sell in quantities exceeding 10,000. Revenues from computer systems were about to exceed revenues from electro-mechanical accounting machines.

The Cultural Factor

Despite or because of this rivalry, IBM as a whole had gained a prominent place in the new world of electronic computers. Although the infighting sometimes left bitter personal feelings, the company continued to put one unified face in front of the customer and the competition. IBM also maintained, by force of long habit, a close connection between the customer, the manufacturing team, and the development engineers. One of the important reasons MIT chose IBM over Remington Rand for the air defense SAGE project – despite UNIVAC's superior performance – was, they said, "In the IBM organization we observed a much higher degree of purposefulness, integration and esprit de corps than we found in the Remington Rand organization. Of considerable interest to us was the evidence of much closer ties between research, factory, and field maintenance in IBM." (Pugh et al. 1991, 618)

Tom Watson, Jr. credits the company's ingrained basic beliefs for the company's success in those days. Though not formalized until 1962, the company's fundamental beliefs were well understood: respect for the individual, superior customer service, and excellence in all activities. Said Watson, "The third belief is really the force that makes the other two effective. We believe that an organization should pursue all tasks with the idea that they can be accomplished in a superior fashion. IBM expects

and demands superior performance from its people in whatever they do."

> *Years later, when Lou Gerstner was guiding IBM out of its near-death crisis in the mid 1990s, he, too, recognized the intangible spirit of the company as being most important. "I came to see in my time at IBM," he wrote in his memoir, "that culture isn't just one aspect of the game – it is the game. In the end, an organization is nothing more than the collective capacity of its people to create value. Vision, strategy, marketing, financial management – any management system, in fact – can set you on the right path and can carry you for a while. But no enterprise – whether in business, government, education, health care, or any area of human endeavor – will succeed over the long haul if those elements aren't part of its DNA."* (Gerstner 2002, 182)

One of the arguments against the System/360 was the 1400 family of IBM computers: they were selling well.

The Product Line in the early 1960s

General Products Division

At the low end, the IBM 1401, and its follow-on (and compatible) 1410, were selling in record quantities. More than anything else, they were helping IBM establish itself as the clear leader in the new world of computers. They had also announced a larger system called the 1610.

Data Systems Division

The company's high-end 700 series, which used vacuum tubes, had evolved to the 7000 series when transistors began replacing the cumbersome and slow tube-based circuits. The 700 series had helped IBM overtake Remington Rand's early market leadership in computers. An entirely new 8000 series of computers was well into development, with at least one model approaching the product announcement stage.

IBM World Trade Corporation

In 1960, IBM World Trade was contributing 20 percent of the company's total revenue, and growing faster than IBM United States. The IBM laboratory in Hursley, England, near Winchester, was working on a small scientific computer called SCAMP, as well as larger, follow-on versions for commercial computing. Their progress with SCAMP, which wasn't produced, would later

contribute stored programming memory for the System/360. Hursley's John W. Fairclough, who managed the SCAMP project, would become a key player on the System/360 development team. The Hursley lab would eventually test and ship the first System/360, the model 40. (Fairclough went on to serve Britain's Prime Minister Margaret Thatcher as a technology advisor, and was knighted for his service to the country.)

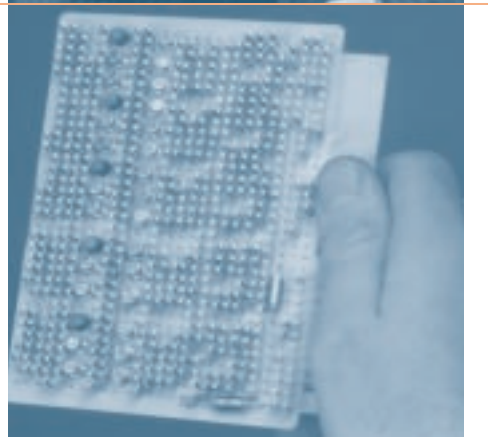
Disk Storage

The popular IBM 350 Disk Storage Unit, capable of handling 10,000 characters per second, had been selling well since 1956. The 1301 Disk Storage unit came out in 1961 with 13 times more storage density and three times faster data access. Two years later the 1302 increased storage density yet another fourfold.

Components

A handful of transistors mounted on 2.5-inch by 4.5-inch cards, called Standard Modular System (or SMS technology) was the prevailing circuit technology in the early 1960s, having replaced vacuum tubes in Project Stretch. The 7000 series computers and the relatively new 1401 computer were using SMS. Competitor RCA at that time was working on a ceramic cube that would pack up to 200 components in a cubic inch – 100 times the component density of IBM's SMS. (Pugh et al. 1991, 55) In response, IBM began development of a hybrid integrated technology that would package circuits on a half-inch ceramic module. Called Solid Logic Technology, it promised three to six times the logical function of the densest SMS cards, and up to 100 times improved reliability. The big questions were, when would SLT be ready, and would it work as promised?

Sir John Fairclough



SMS, or Standardized Modular System, technology replaced vacuum tubes.

V. Making the Big Leap

As Tom Watson, Jr. noted at the end of 1960, "Our computer product line had become wildly disorganized." IBM had three organizations running in divergent directions: Data Systems Division with its 7000 series and proposed 8000 series, World Trade with its SCAMP series, and the General Products Division with its 1400 and 1600 series. In addition to this, the company was already supporting installed machines with as many as six different architectures and designs. (Pugh 1985, 190)

Customers were beginning to feel the strain of all this incompatibility. Not only did they have to rewrite their software applications every time they moved to a larger system, but none of the peripherals – such as printers, tape drives, and disk storage – would work on their new system without extensive modification. The huge success of the IBM 1410, a compatible upgrade from the popular 1401, clearly showed IBM just how much customers valued compatibility.

Lack of compatibility across the product line wasn't just a problem for customers. It caused numerous and expensive problems for IBM itself. The company had to train sales and service personnel and provide programming support for each of the incompatible systems. The process was costly and chaotic. Economies of scale in engineering and manufacturing were reduced. Also, the engineers who had designed each of the computers and the customers who used them were committed to them and to their extensions. (Pugh 1995, 267)

Deciding on System/360: The Play-By-Play Scenario

Tom Watson, Jr. called on T. Vincent (Vin) Learson to do something about the computer product line mess. A six-foot, six-inch Harvard graduate with a degree in mathematics, Learson was an imposing figure – both physically and mentally. (Pugh 1995, 175) He joined IBM in 1935, rose quickly in the sales ranks, and by 1961 was Group Executive in charge of the Data Systems Division, General Products Division, Advanced Systems Development, and the new Components Division. He practiced a style of management he called "abrasive interaction."

> *Tough problems sometimes bring out tough leaders. To this day, some veterans from the System/360 days insist on telling their "Vin Learson abrasive interaction" stories strictly "off the record."* Fortune *magazine in 1966 described him this way: "…Learson has a reputation as a searching and persistent questioner about any proposals brought before him; executives who have not done their homework may find their presentations falling apart under his questions – and may also find that he will continue the inquisition in a way that makes their failure an object lesson to any spectators."*

V. Making the Big Leap

In September of 1960, IBM Endicott announced the 1410, and IBM Poughkeepsie was getting ready to announce a new 8000 line. The 8000 series would feature a processor more powerful than the Stretch Supercomputer – which itself was still months away from delivery. Learson needed to act quickly, or IBM's two major computer divisions would have fresh but incompatible product lines battling it out in the marketplace. (Pugh 1995, 268)

Learson put his abrasive interaction technique to work. He removed the Poughkeepsie systems development manager working on the high-end 8000 series, and replaced him with Bob O. Evans, the engineering manager for Endicott's low-end 1401 and 1410 projects. Since Evans was already committed to the compatibility concept, Learson wanted to see what he would do with the 8000 series.

An electrical engineering graduate from Iowa State College, Evans was widely respected for his technical abilities and for his "huge appetite for work." (Pugh et al. 1991, 121) He'd begun his IBM career at Poughkeepsie ten years earlier, and had worked there just a few months before helping to launch a 7000 series system. Since he was a familiar face in Poughkeepsie, it didn't take him long to size things up. Within three months he made a crucial decision. Work on the 8000 series should be terminated. In fact, he thought the project was "dead wrong." (Pugh 1985, 191)

In its place, IBM, he said, should make a company-wide effort to develop what he called "a total cohesive product line." (Pugh 1995, 268)

"Earlier in my work at GPD," said Evans, "a new computer was being designed, dubbed the 310. It, too, was a unique design, as each engineering group loved to design their own instruction set. Ralph Palmer, Director of Engineering, had the project transferred to me in Endicott. I had just completed a tour of customers across the country and the message that was nagging at me was that the lack of compatibility was hurting the customers. Therefore, after some study on performance, I ordered the unique architecture killed, and developed the product as the 1410, which would be upwardly compatible with the 1401 series. That was my beginning in compatibility, and it was one of the underlying reasons I concluded that the proposed 8000 series would be a major blunder, as the different systems in that proposed family were incompatible."

According to Evans, the genius behind the compatibility idea was Donald T. Spaulding. A bright sales star, Spaulding had worked with Evans at Endicott before becoming Vin Learson's chief of staff. As Learson's key advisor, he set both the technical and political wheels in motion toward what became the System/360.

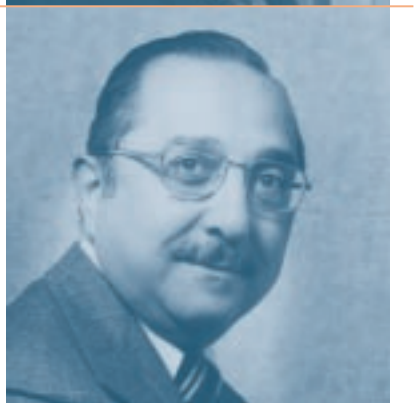
V. Making the Big Leap

Enter Frederick P. Brooks, Jr. Still in his twenties, Brooks had a PhD in computer science from Harvard and had studied under computing pioneer Howard Aiken. Brooks was the lead designer on the 8000 series, and, though quite junior to Bob Evans, took his case all the way to IBM's Corporate Management Committee (which comprised, among others, Tom Watson, Jr. Vin Learson, Arthur K. (Dick) Watson, Tom's younger brother and head of IBM World Trade). Brooks and Evans battled back and forth six long months. Once again Learson used his abrasive interaction technique. He replaced Evans' immediate manager with Jerrier A. Haddad, who had been head of the company's Advanced Systems Development Division, and asked him to review the arguments put forth by Evans and Brooks. Haddad sided with Evans, and in May of 1961, the 8000 series project was terminated.

An electrical engineering graduate from Cornell, Haddad had joined IBM in 1945. He led engineering development on the 701, and had worked closely with Don Spaulding. "We were concerned," Haddad said recently, "that the 8000 series would be a run-of-the-mill update on the 7000 family – and not a significant step forward. Also, Spaulding, others and myself were concerned about our long-range plans. There was a strong feeling that we shouldn't improve our technology arbitrarily. Such efforts often caused our systems engineers and systems

Bob O. Evans

Fred P. Brooks, Jr.



Jerrier A. Haddad

programmers to jump through hoops each time a new feature came out. I agreed with Bob Evans. We needed a more comprehensive plan."

Haddad to this day doesn't share the view that Vin Learson's management style was "difficult." "A lot of people were scared to death of Learson," he said. "But the truth is there wasn't a mean bone in his body. He always considered everyone's point of view. When confronted with a tough problem, he would reach way down in the organization, three or four levels down, to find people whose judgment he respected, to get their opinions. Those were opinions that might otherwise have never surfaced. He was tough, but he was never brutal toward an individual."

Bob Evans gathered the key team members on the 8000 project and told them the news. The 8000 series would be replaced by more advanced technologies and systems. What that would be was yet undetermined. The news was met with dejection, bitterness, and rage. (Pugh 1985, 194) But then Evans did an astonishing thing. He immediately asked Brooks to lead a search for the "ultimate" family of systems to serve all customers. "To my utter amazement," Brooks later recalled, "Bob asked me to take charge of that job after we had been fighting for six months. I was dumbstruck." But Brooks eagerly accepted, and his infectious enthusiasm and competence soon won the support of others. (Pugh 1995, 268)

Key to developing the "ultimate" family of systems would be the logic technology. Another young IBM engineer, Erich Bloch, had been hard at work on this problem. A German native, Bloch had studied electrical engineering at the Federal Polytechnic Institute of Zurich, and had a B.S. in electrical engineering from the University of Buffalo. He'd been a lead engineer on the Stretch supercomputer project. Early in 1961 he'd been asked to head a study to determine what logic component technology IBM should use in future system.

Bloch's team looked at three choices:

1. *Continue to refine SMS technology, basically transistors mounted on hand-size cards. SMS was currently being used in the IBM 1401 and high-end 7090 series.*

2. *Switch to a hybrid integrated technology that attached transistors to a small ceramic substrate, about a half-inch square. This Solid Logic Technology, SLT, if it worked, would be 10 times as dense as SMS, and 100 times as reliable.*

3. *Or, reach for fully integrated circuit technology, called monolithic circuits, which would compress a whole circuit or even several complete circuits onto a silicon chip.*

V. Making the Big Leap

Erich Bloch

SLT technology, scheduled for use in the System/360, would have three to six times the logical density of SMS, and 100 times more reliability. SLT chips on a pencil eraser.

Bloch's report recommended SLT. Monolithic circuits were unproven, and IBM had been working on SLT for some 18 months. Still, production level SLT was deemed to be a few years away. "The important factor was 'time to market,'" said Bloch. "SMS was old technology and could not meet the demands of System/360. Going with fully integrated circuits, monolithics, would have meant delaying the entire project two or three years. And that just would not do. As it was, we had plenty of work that needed to be accomplished: developing the SLT technology, building a pilot line, building a new plant for it, and scaling up to production volumes."

Bob Evans: "There was a project underway in Poughkeepsie under Robert Domenico called COMPACT, utilizing micro miniaturization. I believed that advanced technology was 'ready enough' to proceed and it gave us giant gains in power, cost, and reduction in size. Dr. Emanuel Piore was head of IBM Research and he asked the question as to whether COMPACT was the correct choice or should we wait for integrated circuits, then embryonic? Dr. John Gibson, Erich Bloch and I were charged with evaluating the options of COMPACT versus integrated (monolithic) circuits; the contemporary SMS, long in production, was not an option. Our investigation concluded that integrated circuits were at least three

years from production. The hybrid micro miniaturization of COMPACT was a great leap forward, and we felt that the new product line should be built in COMPACT, later named Solid Logic Technology."

So the decision was made to launch the next round of computers with SLT technology. But what new computers?

Engineers from Endicott, led by John W. Haanstra, were more or less behind the System/360 concept – as long as it didn't interfere with their plans for their highly successful 1400 series. Again, this wasn't what Learson wanted to hear, and again, on Spaulding's advice, he applied his abrasive interaction technique. He made Haanstra the head of a corporate-wide task group to "establish an overall IBM plan for data processor products."

A bold, much-respected, and somewhat flamboyant engineer, Haanstra told his Endicott engineers not to bring their viewpoints to him "unless they were willing to put their jobs on the line." Good to his word, Haanstra himself lost his job as President of the General Products Division when he refused to give up on the 1400 series of computers in favor of the new System/360 family of compatible processors. He later regained favor and served in several important leadership positions. Sometime later, (after a brief stint at IBM's Federal Systems Division) he left the company.

Evans co-chaired this new task group with Haanstra. Fred Brooks and John Fairclough – who both played key technical roles – were also part of the eleven-member team. (Pugh 1995, 270) The group was called SPREAD, an acronym of convenience standing for Systems Programming, Research, Engineering and Development. To lighten the otherwise serious nature of their work, some SPREAD team member referred to their task force as "Spaulding's Plan to Re-organize Each and All Divisions."

The SPREAD Report

The SPREAD team's commission was daunting. They were to examine everything IBM was doing with computers and peripherals, and then determine development and product direction for the company for the next ten years. They started work in the fall of 1961. Haanstra, the task group leader, was unwilling to compromise on Endicott's highly successful 1401 architecture. In November, Haanstra was promoted to president of the General Products Division, and left the group. With Evans leading the group, and Brooks and Fairclough asserting themselves as technical leaders, SPREAD started to make some progress.

V. Making the Big Leap

Finally, the team went to a remote hotel in Connecticut in December to avoid the interruptions of normal business. According to Tom Watson, Jr., "Vin got impatient. Two weeks before Christmas he sent them to a motel with orders not to come back until they'd agreed." (Watson 1990, 348) They emerged on December 28, with their 80-page SPREAD report. Bob Evans doesn't remember the moment as being quite so dramatic. "I recall having a regular Christmas with the family," he said.

The report's recommendations were bold – bold even for a company that prided itself in making big bets in the market. It recommended:

- Developing five processors, with the largest one 200 times more powerful than the smallest.
- This range of performance would be achieved using SLT technology of differing speeds, data paths of differing widths, memories of different sizes and widths, and other engineering trade-offs.
- Each processor would have high-speed memory with permanently stored information to control the system.
- Each processor's software would be compatible with larger and smaller systems – upward and downward compatibility. (Evans)
- Each processor would be "economically competitive" in the marketplace on its own.
- The entire line would use standard interfaces for input-output equipment such as tape and disk storage, printers and terminals. This would permit customers to upgrade their systems gradually. It would also reduce engineering design and field service costs.
- And finally the report had this bombshell:

"Since such processors must have capabilities not now present in any IBM processor product, the new family of products will not be compatible with our existing processors."

The task group knew that this would make the new line, dubbed NPL (for New Product Line) a tough sell. However, they expected that the NPL's advantages would overcome this barrier. (Pugh 1995, 272-273)

> "We had engineering teams all over America and Europe working simultaneously on six new processors and dozens of new peripherals – disk drives, tape drives, printers, magnetic and optical character readers, communications equipment, and terminals – but in the end all this hardware would have to plug together."
>
> *Tom Watson, Jr.*

The Advantages

The New Product Line would offer customers a much easier upward migration path, protect their investments in applications programming, and make it easier to train their staff. For IBM, it would greatly improve the effectiveness of the sales force, and make it easier to educate and train users and service personnel.

The Disadvantages

Once committed, it would be difficult for IBM to change its strategy of compatibility. Also, compatibility would make it easier for competitors to introduce similar products, and anticipate IBM's future product line.

IBM senior managers saw other potential problems on the horizon. Said Tom Watson, Jr. in his memoir: "From the beginning we faced two risks, either of which alone was enough to keep us awake nights. First there was the task of coordinating the hardware and software design work for the new line. We had engineering teams all over America and Europe working simultaneously on six new processors and dozens of new peripherals – disk drives, tape drives, printers, magnetic and optical character readers, communications equipment, and terminals – but in the end all this hardware would have to plug together. (By announcement day in 1964, the number of proposed processors had grown from five to six.) The software

was a bigger hurdle still. In order for the System/360 to have a consistent personality, hundreds of programmers had to write millions of lines of computer code. Nobody had ever tackled that complex a programming job, and the engineers were under great pressure to get it done. Our other source of worry was that we were trying for the first time to manufacture our own electronic parts. (The SLT logic circuits.) Nobody was using integrated circuits in computers yet, but the System/360 called for a lot of them." (Watson 1990, 349-350)

One week after the SPREAD task force completed their report, it was presented to IBM's top executives and their staffs at a special meeting held at the then new T. J. Watson Research Center in Yorktown Heights, N.Y. Reaction was mixed. But Learson concluded at the end of the meeting that the SPREAD report offered the best available plan. Nothing better had been put forth, he's reported to have said. Therefore, development would accept SPREAD's plan and "do it."

A few months after the SPREAD team completed its work, a similar effort, called STORE, was led by Jerrier Haddad to determine if similar unity could be built into IBM's storage products. It turned out that there were far too many such devices and requirements to mirror the 360's compatible family approach. The STORE effort, though, did uncover a critical cost trade-off: Often, by limiting the size of core program memory – a very expensive item in a processor – much more money was spent later on developing programming.

How System/360 Got Its Name

As the months wound down to announcement, the New Product Line needed a name. Chuck Francis, who later was director of advertising for IBM, was director of information at the company's Data Processing Division at the time. DPD was responsible for sales and marketing in the United States.

"They were going to call it the System 500," he said. "We didn't think that was a suitable name. So I assigned Tom Deegan and a couple others to brainstorm and come up with a better name. We needed a number in the name, so it became the 360, for each degree on the compass. This was to indicate the new processors were useful for any job, any size. Bert Reisman, who worked with me, added the word 'System' and the slash, for System/360. There was no particular reason for the slash, it just looked nice.

"We put the proposed new logo on a board and carried it up to Dick Warren's office, the vice president of marketing for DPD. Everyone was so busy getting ready for the announcement in those days that it was hard to get in to see anyone. You kind of

had to wait around in the hallways and ambush people. We went right in to Warren's office. He was there with one of the systems managers for the new line. They said to us, 'Get out of here. We're doing something important. And anyway the name is going to be the System 500.'

"But Warren did ask me to take the logo up to Warren Hume, president of DPD. Hume said to us, 'Well, it's O.K, I guess. But I don't think it makes very much difference what we call it. Why don't you take it to Corporate and show it to Dean McKay (the IBM vice president of Communications.)'

"So I showed it to McKay, and he asked, 'What does Hume think of it?' I told him, 'Hume likes it very much.' And McKay said, 'Well, I guess there is nothing wrong with it.'

"There may have been some other meetings about the name later on, but I wasn't included in them. However, when I heard that they were painting the name 'System/360' on the nose of the corporate airplane, I decided it was all right to begin releasing our press kits and other materials with the name System/360."

The new System/360 line provided a much easier migration path for customers, and helped protect their investment.

VI. The Struggle for Success

The total cost of the development and manufacturing effort for System/360 was estimated in 1962 – two years before announcement – to be $675 million. (Pugh 1985, 206) This estimate was wrong. The actual cost of developing, manufacturing, and nursing the System/360 to success was closer to $5 billion. "The expense of the project was indeed staggering," Tom Watson, Jr. later recalled. "We spent three quarters of a billion dollars just on engineering. Then we invested another $4.5 billion on factories, equipment and the rental machines themselves. It was the biggest privately financed commercial project ever undertaken." (Watson 1990, 347)

For a company that prided itself on fifty years of sound financial management, IBM was going broke. With a continuous stream of income from rentals, IBM was used to swimming in cash. But System/360 development expenses were running well ahead of income by the spring of 1966, and IBM was in danger of not being able to meet the payroll for the first time in its history. "We didn't tell the public about our cash shortage," said Watson," but it was the big reason we unexpectedly sold another $370 million of stock that spring." (Watson 1990, 358) *Fortune* magazine would later capture the effort for history with an article titled "IBM's $5,000,000,000 Gamble."

> *That IBM was willing – given the amount of dissension and argument – to abandon its entire electronic product line for the sake of compatibility – and its value for the customer as well as for IBM – reveals one of the strongest codes in the company's DNA. The relationship between and among IBM field, development, and manufacturing people tends, over time, to accomplish two things. First, it keeps an eye on the customer and particularly the point at which the customer and information technology intersect. This was the driving force that instigated the chain of events leading to System/360. And second is the explicit question always hanging in the air, "Are we trying hard enough? Should we use SMS or try SLT? Should we upgrade the 7000 series or strive for something entirely new?" These same questions, often more implicit than explicit, would later help IBM find its way to open standards, the IBM eServer™ family, and the new era of on demand business.*

Long before the System/360 was officially introduced on April 7, 1964, competitive pressures outside and outright insurgencies inside the company had to be dealt with and defeated.

Honeywell in late 1963 announced their low-cost H-200 computer with a special "Liberator" program. This program could translate

applications made for the IBM 1401 and make them run on Honeywell's machine. IBM sales offices, starved for new products while waiting for the System/360, reported losing 196 customers within two months of the Honeywell announcement. (Pugh 1995, 273) The head of IBM's sales at the time added a personal note on his official report to the product division executives: "Help, I'm being slaughtered."

"Our salesmen were hamstrung," Watson recalled. "We'd miscalculated how much time we had, and the flaws in our existing product line caught up with us a year or two sooner than we anticipated. By the middle of 1963, sales offices were sending in panicky reports that they could no longer hold the line against the competition. Even though demand for computers increased by well over 15 percent that year, IBM grew only seven percent, our lowest growth since World War II." (Watson 1990, 250)

Bob Evans had put in place what he called a "temporizing plan" to upgrade the existing 7000 series products while waiting for the System/360. The technology used in the 7000 products was well proven, and the manufacturing teams were well trained on it. For John Haanstra at the Endicott lab, however, temporizing meant full steam ahead with the IBM 1401 and its follow-on systems. By adding additional circuits and the new SLT logic – scheduled for introduction with the System/360 – Haanstra and his team scheduled the announcement of a powerful new addition to the 1400 series for February of 1964. It was an out-right challenge to Evans, Brooks, and Bloch and their System/360 development work. Haanstra, after all, was considered one of IBM's best engineers. Self-assured and hard driving, he was famous in the company for establishing and then achieving barely reachable goals. (Pugh et al. 1991, 164)

Evans was at once both angry and chagrined. Such an announcement would undermine demand for the high-volume, low-end models of the proposed System/360. The economic model for the new family of computers would come apart.

Haanstra wasn't alone in his challenge to the System/360. John Backus, IBM's leading programmer and inventor of the world's first programming language, FORTRAN, thought the 360 project was "misguided." "He thought we had too many eggs in one basket", said Evans. Others questioned how the System/360's compatible architecture – developed by Fred Brooks, Gene Amdahl, and Gerrit Blaauw – would handle the technical trade-offs around addressing methods, processor register usage, and instruction and data formats. (Pugh et al. 1991, 145 and 164)

At one point, said Evans, the "anti-360 forces" got to senior management, and "it looked like the 360 was dead. I went off

to our labs in Europe, at Hursley and Boeblingen, just to get away. I was in a funk." While he was at Hursley, Evans got a call from Fred Brooks. The System/360 project was back on, and "we were to do everything in our power to get it announced as soon as possible."

Cool heads and some solid engineering work had saved the hour. With the addition of a few extra lines of micro code and more circuitry, engineers in Poughkeepsie and Endicott determined that they could bring out the new 360 family with emulators that could run existing customer programs even faster on the new line than on the current installed systems. Now it would be easy and advantageous for customers to buy into the new 360 line. "It was," wrote Emerson W. Pugh, in one of his several histories of IBM product development, "a salesman's dream come true." Within a month, Haanstra lost his job as president of the General Products Division. That action sent a silent message across the corporation: Every manager and every team would be judged by their commitment and contributions to the new System/360. (Pugh 1995, 279)

> *As Evans recalled it: "For several months in 1962, Fred Brooks led the work on program translation. However, the deeper they got into it, it became unlikely that we would have comprehensive tools for moving code efficiently from one architecture to a completely different architecture. Just as we became frustrated and worried about customer migration to the new series, a magic bullet appeared. John Fairclough had been instrumental in our selecting read only memory for control stores, instead of conventional random logic– which is a rat's nest when changes are required. Two engineers, Stuart G. Tucker and Larry M. Moss, noted that the 360 had all of the data paths and registers of all the contemporary products – and more; it just did not have the instruction set of the contemporary products. The read-only memory controls allowed us to economically add older system instruction sets. Thus the new product line – System/360 – could, at literally the flip of an electronic switch, appear to be a 1410, or a 7090 or a 7080. That was the second most important breakthrough in 360 development. The first was the upward/downward compatibility."*

Finally, on April 7, 1964, before a large crowd of customers, reporters, and dignitaries at the company's auditorium in Poughkeepsie, IBM presented the System/360 to the world. The announcement was paralleled with press conferences in 165 other U.S. cities and in 14 other countries, for an estimated audience of 100,000 customers and prospects.

VI. The Struggle for Success

The press release was simple, straightforward, and easy to understand (a rare achievement in corporate product announcements):

> *"A new generation of electronic computing equipment was introduced by International Business Machines Corporation.*
>
> *IBM Board Chairman Thomas J. Watson, Jr. called the event the most important product announcement in the company's history.*
>
> *The new equipment is known as the IBM System/360. It combines microelectronic technology, which makes possible operating speeds measured in billionths of a second, with significant advances in the concepts of computer organization.*
>
> *System/360 is a single system spanning the performance range of virtually all current IBM computers – from the widely used 1401 to nearly twice that of the most powerful computer previously built by the company. It was developed to perform information-handling jobs encompassing all types of applications.*
>
> *System/360 includes in its central processors 19 combinations of graduated speed and memory capacity. Incorporated with these are more than 40 types of peripheral equipment, which store information and enter it into and retrieve it from the computer. Built-in communications capability makes System/360 available to remote terminals, regardless of distance…*

Bob Evans describing the System/360 to visitors on announcement day, April 7, 1964.

At the announcement press conference in Poughkeepsie, Watson told the crowd: "System/360 represents a sharp departure from concepts of the past in designing and building computers. It is the product of an international effort in IBM's laboratories and plants, and is the first time IBM has redesigned the basic

internal architecture of its computers in a decade. The result will be more computer productivity at lower cost than ever before. This is the beginning of a new generation – not only of computers – but of their application in business, science, and government."

> *The gala announcement of April 7, 1964 had been very nearly compromised months earlier. Bert Reisman, an information manager in the Data Processing Division (he would later become the IBM director of communications operations) was taking a* Fortune *magazine writer on a plant tour. The plant manager, in a gesture meant to impress the magazine writer, reached into his desk drawer and tossed a handful of then-secret SLT modules across the desktop. "You want to see state-of-the-art technology," he told the writer, "take a look at these." Years later, Reisman recalled, "For a second I considered throwing my body on top of the desk to protect the secrecy of our new SLT technology, scheduled for use in the System/360. But we ended up pleading with the writer to hold his story until after the 360 was announced. Fortunately, he agreed to do just that."*

Even by IBM's standards this was an unprecedented announcement: Six completely new processors and 44 peripheral devices – including tape drives, disk storage, printers, visual display

Reporter with a System/360 press release.

units – many of them every bit as complex and advanced as the new processors.

Within four weeks of the announcement customers had ordered well over one thousand machines. (Pugh 1995, 277) And four weeks after that, another one thousand orders came in. (Pugh 1995, 289) The flood of orders was reassuring. But it would take all the resources of the company working 60-hour weeks, and in some cases round-the-clock shifts, for nearly two years before the System/360 would be called a success.

> *"Within IBM there was a great feeling of celebration because a new era was opening up," Watson wrote in his memoir. "But when I looked at those new products, I didn't feel as confident as I'd have liked. Not all of the equipment on display was real; some units were just mockups made of wood. [It was] an uncomfortable reminder to me of how far we had to go before we could call the program a success." (Watson 1990, 351)*

Three Major Problems

Getting System/360 up and running properly in customer businesses took two more years and a struggle every bit as epic as the new system was innovative. One engineer who lived the experience said he couldn't remember any of the details from that time, "It was a blur of sleepless near 24-hour days that went on for months and months."

The technology, the logistics, and the software required to make the System/360 all created dramatic, and in some cases, book-length problems in their own right. Untried innovations in memory, disk storage, components, packaging (the cards and boards the SLT modules were mounted on), software and architecture all had to come together in a very short time – and they all had to work together. Each one alone might have derailed the project; collectively they created a two-year nightmare that required heroic efforts by thousands of overworked engineers, programmers, managers, and field support people.

Ingenuity and resourcefulness on the part of individuals and small teams often saved the day. The spirit of competition between engineers that Tom Watson, Sr. had fostered in the early days of the company helped fill in the gaps needed to make this massive new product line a competitive success. Many engineers, already working extra-long days, devoted hours of their free time to finding ways to solve problems. But the 360 project created an entirely new atmosphere at IBM. Competition among engineers was no longer secretive. Information was broadly and eagerly shared across the company. (Pugh 1995, 289) Given the extent of the problems, this new ethos couldn't have happened at a better time.

The Solid Logic Technology Problem

To meet the expected demand for SLT modules, IBM built a 100,000 square-foot facility in East Fishkill. The decision to buy or build the technology had been as difficult and as hard fought as the decision to develop the System/360 itself. Corporate management eventually saw that component technology would be critical to the company's long-term success. "Our component vendors in the early 1960s," said Erich Bloch, "were struggling with the new technology themselves. And we were not their first priority. The best technology was being sold to the government for defense work. Our volume requirements would outstrip the capability of our vendors. Also, components were becoming high-margin items. Technology became a differentiator in the marketplace and the quality of components was directly related to the reliability of the system. Rather than investing in somebody else's plant, it made sense to start thinking about building our own facilities and manufacturing our technology in-house."

IBM formed a new Components Division, headed by components pioneer Dr. John W. Gibson, placed it under Vin Learson's product group, and made Erich Bloch head of SLT and memory development.

East Fishkill produced a half-million SLT modules in 1963, and was to increase this sixfold to 12 million in 1964. The plant was expanded to three and a half times its original size over the next three years. By 1965, it was turning out 28 million SLT modules. The plant manager was then asked to double that number for 1966. He said no, and was replaced by a manager who said yes.

The result was a near disaster for the System/360 program. By the end of 1965, by pushing the production line so hard, more than 25 percent of the plant's output failed to pass quality inspections. Scientists from IBM research and engineers from throughout the company were called in to find and fix the problem. They did. But the delay in SLT production caused IBM to announce an embarrassing and critical two- to four-month delay in product shipments. By 1966, East Fishkill was turning out 90 million modules – more semiconductor devices than were being produced by all other companies in the world combined. By that time, too, new IBM technology facilities in Burlington, Vermont, and Essonnes, France, were turning out more than 26 million modules each. (Pugh 1995, 290) The major crisis surrounding System/360's component technology was over.

The Logistics Problem

Following the System/360 announcement, Tom Watson, Jr. believed the hard job now would be to sell the new family of computers. He transferred Vin Learson to sales, and put his younger brother, Dick Watson, in charge of the engineering and

manufacturing teams that Learson had steered through the massive ramp up for the System/360. The assignment was meant to prepare the younger Watson to take charge of the entire company some day.

But as the orders for the new System/360 continued to pour in, the logistical problems went from bad to worse. The component delays, software delays, and clever competitors announcing niche machines to take advantage of perceived weaknesses in the System/360 line created enormous headaches for Dick Watson. Having successfully and brilliantly guided the World Trade Corporation for years, he was unprepared for the minute-by-minute crisis atmosphere of engineering and manufacturing. The sales organization, under the aggressive Learson, demanded more and more changes to the System/360 line to meet competitor moves. At one point the company ran out of copper circuit breakers – bringing manufacturing to a halt. Engineers were put on planes and sent all over the country to find more supplies. (Watson 1990, 355) The software problems appeared to be intractable. The friction between Learson and the younger Watson, even between Tom and his brother, simply became untenable.

"Everybody was scared," Tom Watson, Jr. wrote in his memoir. "Al [Williams, IBM's president] and I agreed that if the 360 program was ever to get off the ground, we had to put it under a single manager, a dictator, and we knew it had to be Learson." Tom called his brother Dick into his office and told him the news. Dick would be made head of corporate staff. Dick's career at IBM and the friendship between the two brothers, by Tom Watson's account, was never the same.

The Software Problem

Of all the challenges presented by the System/360, none was more challenging than the software. The upward compatibility requirements plus the innovation of multiprogramming (running two or more programs at the same time, as opposed to the then-current practice of waiting for one program to end before another starts), and the ability to handle simultaneous interactive users presented enormously difficult problems for Fred Brooks and his programming team. In addition, the overburdened programmers had to develop software for the interim products meant to hold off competitors until the System/360 was ready.

As the software delays grew, the company threw more and more people at the problem. Eventually, there were well over 1,000 people working on software – a fact that, in Brooks' estimate, didn't help things along. According to his own

VI. The Struggle for Success

"Brooks' Law," adding manpower to a late software project makes it later. "It's like throwing gasoline on a fire," he said.

> *"Everything looked black, black, black," Watson, Jr. recalled. "Everybody was pessimistic about the program. We were clinging to our production schedule, but morale was going down. Some sections of our factories had been working sixty-hour weeks for six months, and the employees were worn out…The engineers were in the worst shape of all. I remember going up to Poughkeepsie to check on the software problem. We had a huge building filled with programmers, and their manager was a fellow named [Don] Gavis. He'd never been to college but he really knew programming. I went to his office and found him sitting at a desk with a rumpled cot next to it where he slept. I said, 'Why can't you get this programming out faster?" He didn't give a damn that I was chairman. He snarled, 'Well, if you'd get the hell out of here and leave us alone, we would!' I made a hasty retreat."* (Watson 1990, 356)

To be fair, the software requirements had been a moving target during much of the early development period. And, too, never before had any organization, even the SAGE program, undertaken an effort this big to develop an original and compatible operating system for so many processors and peripheral

Developing programming for the System/360 would become the largest single expenditure in the entire program.

devices. The basic measuring stick for software size is the number of lines of code produced. The IBM 650 Magnetic Drum Calculator came with 10,000 lines of code. The popular IBM 1401 came with 100,000 lines of code. The System/360 came with 1,000,000 lines of code initially, and grew to 10,000,000 lines of code. (Campbell-Kelly 2003, 91)

Eventually, the money spent on software development, originally estimated at $30 to $40 million, grew to $500 million, the largest

single expenditure in the entire System/360 program. It was, in fact, the single largest expenditure in IBM's history up to that time. Even so, despite a sustained intensive effort, the various parts of the Operating System.360™ (OS/360™) were delivered months late. Improving the software performance continued to be a major effort as subsequent releases were developed. (Pugh 1995, 295)

Developing the operating system software for the lower-end System/360 offered particularly difficult problems, in part due to Poughkeepsie's limited experience with small systems. Programmers at the General Products Division in Endicott and San Jose picked up this challenge, and eventually developed three operating systems: Basic Operating System (BOS), Tape Operating Systems (TOS), and Disk Operating System, or DOS – which would live on to become the most widely used operating system in the world. (Pugh 1995, 295-296)

IBM field support people all over the world played an heroic role in the early days of System/360 shipments. The large reservoir of programming talent and experience in IBM's sales division was critical to the new system's success. They not only installed the operating systems, they developed many general-purpose programs useful to customers. Foremost were the Information Management System™ (IMS) and Customer Information Control System™ (CICS). These two programs helped users bridge the gap between their own applications and the generalized data-management functions in OS/360. (Pugh et al. 1991, 638)

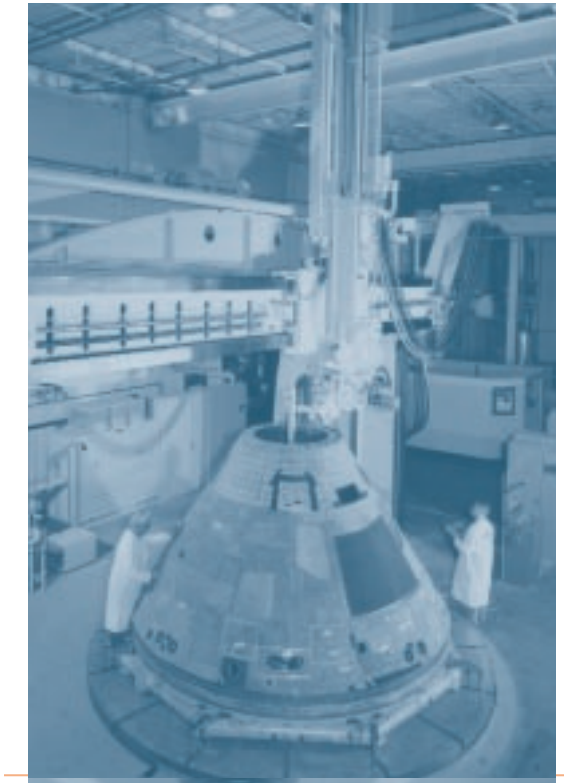
The Bloom is on the Rose

By the end of 1966, many more things were going right with the System/360 than wrong. Between seven and eight thousand systems had been installed, generating more than $4 billion in new revenue for IBM, and a billion dollars in pre-tax profits. Suddenly, the rose was starting to bloom. (Watson 1990, 359)

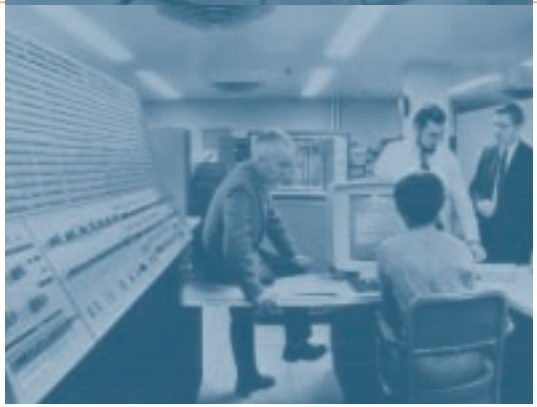
To meet the demands of this bonanza, IBM in 1966 alone hired 25,000 new employees and began building 3 million square feet of additional manufacturing space in the United States and Europe. By the end of 1966, the company was producing 1,000 System/360 units a month. (Think 1989, 53)

From 1964 to 1970, the year the follow-on System/370™ (an enhanced 360 line) was introduced, IBM's revenues more than doubled, from $3.2 billion to $7.5 billion, and earnings jumped from $431 million to more than $1 billion. The employee population grew almost 120,000 to 269,000.

VII. The System/360 Legacy



Run by an IBM System/360, a massive turret lathe shapes a heat shield for an Apollo spacecraft.



Goddard Space Flight Center used one of two System/360 model 95 supercomputers.

System/360's most significant contribution to the world of computing was its compatibility. The six models announced in April of 1964 had a performance range of roughly 25 to 1 – the largest model being about 25 times more powerful than the smallest. The smallest model could perform 33,000 additions per second; the largest more than 750,000 additions per second. (IBM Archives 2004) Six years later, after the introduction of more models, the range jumped to 200 to 1.

One model of the System/360, the 95, was built especially for NASA, and only two units were made. One went to Goddard Space Flight Center in Maryland; the other to the Goddard Institute for Space Studies on upper Broadway in Manhattan. David B. Soll, who is currently a senior technical staff member for IBM's Business Continuity and Recovery Services, was a NASA contractor at GISS in New York in the 1970s and 1980s. "The model 95 was a supercomputer of its day," he said recently. "With it, we carried out research in Meteorology and Climatology, developed instrumentation for a Landsat satellite to measure agricultural data, and instruments that traveled to Venus and Jupiter aboard the Pioneer Venus and Galileo spacecraft."

The UFJ Bank, a leading bank in Japan, formed two years ago with the merger of Sanwa Bank and Tokai Bank, has capital assets of one trillion Yen. When the Tokai Bank received their

VII. The System/360 Legacy

first System/360 in the 1960s, all the banking operations were being done by hand. "Back then, the calculation of interest for ordinary accounts at a bank was done manually with an abacus. So it was common for those people doing the calculations to stay at work until very late every day. (I understand that employing) this system allowed those people to go home earlier, so they were very happy," recalled Satoshi Murabayashi, general manager, Computer Systems Planning Department, UFJ Bank LTD. "The IBM mainframe system has been very helpful in supporting our banking business. The banking system has had to support rapidly increasing volumes of data for the past 30 years, as well as the customers' expectations of reliability. UFJ Bank has intended to expand its business to the "integrated financial services provider" by offering greater customer satisfaction with higher quality financial services. The role of mainframe systems has been substantial, so it has accomplished its goal, and we very much appreciate it."

The System/360's standardized input and output interfaces made it possible for customers to tailor systems to their specific needs. Introduction of the 8-bit byte, over the prevalent 6-bit standard, made it easier to handle both business information processing and scientific data processing. The era of separate machines for business and science was over. System/360 could handle logic instructions as well as three types of arithmetic instructions (fixed-point binary, fixed-point decimal, and floating-point hexadecimal). (Pugh et al. 1991, 640)

The system's architectural unity helped lower customer costs, improved computing efficiency and, quite frankly, took a lot of the mystery out of the art of computing. For the first time, customers could compare price and performance across a whole product line. (Pugh et al. 1991, 641)

A System/360 being delivered to Tokai Bank in Japan.

VII. The System/360 Legacy

Arthur (Art) Nesse and Jerry Meach worked for the Ford Motor Company for 36 and 28 years, respectively, and both were there during the company's System/360 days. At that time, Nesse was manager of Computer Planning and Control, and Meach was manager of Planning and Development in the Commercial Data Center. By the time System/360 arrived at Ford, the company had acquired a considerable amount of data processing experience with early 1401 and 702-705 systems, as well as units from a variety of other computer makers. Ford had pioneered large-company computer-based payroll, and ran production control for 22 assembly plants on its IBM 705.

"We were already doing a lot on older systems," said Nesse. "But the 360 was a radical improvement in the scope and capabilities of what we could do. It was the first time we had an operating system to manage everything." With the new 360s, Ford introduced a central warranty system and a retail loan system for Ford Motor Credit – to name a few. Jerry Meach even presented to IBM a better means for managing 360 workload balancing among several computers, shared tape drive pools and disk packs. "They accepted my concept for upgrading the scientific workload based Attached Support Processor, or ASP, software" said Meach. "The enhanced ASP software became the foundation for IBM's Job Entry System (JES) offerings."

Success, of course, attracts a lot of attention, particularly from competitors. This was accelerated by the open nature of the platform in the early days. In some ways, the early 360 was a seminal experiment with open source. The operating system source code and hardware specs were both open for a time. The innovation during that period driven by clients and others was extraordinary. Of the estimated $10 billion worldwide inventory of installed computers in 1964, IBM accounted for about $7 billion. The other $3 billion belonged to Burroughs, Control Data, General Electric, Honeywell, NCR, RCA and Sperry Rand. Five years later, IBM's inventory had increased more than threefold to $24 billion, but the seven smaller players had also increased their installed inventory threefold, to $9 billion. (Pugh 1995, 296)

RCA jumped in with a series of four 360-compatible computers called the Spectra 70. Not only were the Spectra 70 processors compatible with each other, they were designed to be compatible with System/360 as well. This feat was accomplished, presumably, through careful study of IBM's publicly available documentation. (Pugh 1995, 297) The Soviet Union brought out the Ryad, a series of 360-compatible systems. Gene Amdahl, an IBM engineer who helped develop the System/360 architecture, started the Amdahl Corporation, the first of several companies in the United States,

Japan, and Western Europe that began marketing 360 – and later 370 – compatible processors. Fujitsu Limited and Hitachi Limited also became major players in this market.

An even larger industry grew up around plug-compatible peripherals for 360 and 360-compatible processors. Telex, with tape drive units, and Memorex with disk storage were the early leaders in this industry. Twelve IBM employees from San Jose founded Information Storage Systems; four IBM employees from Boulder founded Storage Technology; and one IBM employee, Alan Shugart, started two storage-product companies, Shugart Associates and Seagate Technology. (Pugh et al. 1991, 641) (Pugh 1995, 299-300) Between just 1965 and 1970, some 80 competitors announced more than 200 products compatible with the System/360 architecture and its peripheral devices. (Think 1989, 53)

By the end of the 1960s, more than 3,000 different types of businesses and scientific research – from rockets to railroads to Wall Street – were using one of System/360's 19 models.

(Think 1989, 53)

And it was just the beginning.

VII. The System/360 Legacy

National Medal of Technology

In 1985, President Ronald Reagan presented Erich Bloch, Fred Brooks and Bob Evans with the National Medal of Technology, in a ceremony at the White House. The citation for their medals read: "Companies in 1965 could easily upgrade to faster, more powerful computers thanks to these innovators. In that year they revolutionized the computer industry with a "family" of computers known as the IBM System/360. The 360 family featured compatible machines with standard interfaces and interchangeable add-ons. These computers also offered more reliable hardware and new operating systems for better software support."

President Ronald Reagan presenting Fred Brooks with the National Medal of Technology. Bob Evans and Erich Bloch also received the honor.

Building the Future

VIII. From Revolution to Evolution: Stepping Stones to a New Era

System/370, announced in June of 1970, introduced fully integrated monolithic memory.

System/390 model 190, brought out in 1990, was 353 times faster than the System/360 model 30.

Stunning progress in circuit miniaturization and packaging, memory, disk storage density, and processor speed happened so fast and so often after the System/360 that major breakthroughs in mainframe technology began to look common.

System/370, announced in June of 1970, introduced the first mainframe with fully integrated monolithic memories and 128-bit bipolar chips. Early 370 machines were five times faster and 70 percent cheaper. Later 370 models introduced 64K chips, then 288K chips, then one mega-bit chips. The 3081 processor introduced the Thermal Conduction Module for high-density chip packaging. The 3084 utilized four processors simultaneously. The 4341, introduced in 1979, was 26 times faster than the System/360 model 30.

The System/390™ model 190, brought out in 1990, was 353 times faster than the System/360 model 30. Price per instruction per second had gone from $6.13 with the 360 down to ten cents. The System/390 models added high-speed fiber optic channels, ultra-dense circuits and circuit packaging, integrated encryption and decryption capability for handling sensitive data, and high-end models that weighed in as true supercomputers of their day.

Near Death Experience

However, despite the continual leaps in capability for the mainframe platform, by the 1980s and 1990s it had come to look like yesterday's news. What the mainframe had done for "back office" or administrative productivity, smaller distributed (client/server) systems and personal computers were now doing for department and personal productivity – providing tools to a new generation of "knowledge workers."

Few at the time saw what the future held: a need to tie everything together for enterprise-wide or organization-wide productivity. In fact, the conventional wisdom at the time was that disaggregation and fragmentation were the wave of the future. The IT industry was simultaneously expanding exponentially and breaking up into a bewildering array of different technology-specific, application-specific and point-solution-based vendors.

For some industry pundits it didn't look like the mainframe was going to survive the early 1990s. With the rapid growth in personal computers, mini-computers and UNIX® systems – and all the attention they were getting at the time – it simply looked to some industry analysts as if the day of the 360-compatible system had come and gone. People didn't need "big iron" anymore. One such analyst, Stewart Alsop, wrote in the March 1991 issue of *InfoWorld*, "I predict that the last mainframe will be unplugged on March 15, 1996."

The "mainframe," circa 1989, seemed at a dead end. But IBM believed (along with many of its customers) that highly secure, industrial-strength computing would always be a core requirement for large enterprises. Unfortunately, the company's own financial, competitive and cultural problems – spawned by its inability during the 1980s, for the first time in its history, to reinvent itself in response to a changing world – presented a huge, potentially fatal obstacle to selling the vision of enterprise-wide integration and computing power. It was a combination of visionary leadership and the emergence of the Internet that helped not only IBM but also its clients and the IT industry re-examine some of the limitations of early 1990s conventional wisdom.

Beginning with the 390, IBM began a re-invention of the mainframe from the inside: infusing it with an entirely new yet backward-compatible core leveraging less costly CMOS processor technology and beginning to open up the platform to accommodate the new and emerging client workloads.

Just over a decade later, this process was accelerated with the introduction of the IBM eServer zSeries® combining one of the most sophisticated virtualization, automation and cryptographic technologies, along with a complete embrace of the new software standards of the open movement. Web serving, enterprise applications, and Linux workloads brought new

attention and relevance to the mainframe in the context of e-business and the Internet.

By 2002, the same *InfoWorld* pundit, who in 1991 predicted the death of the mainframe, wrote in February of that year: "It's clear that corporate customers still like to have centrally controlled, very predictable, reliable computing systems – exactly the kind of systems that IBM specializes in." Alsop himself appeared in IBM's 2001 annual report, good naturedly eating his words with a knife and fork.

And as recently as March of 2004, *BusinessWeek*'s Steve Hamm reported: "Even today, a decade after pundits declared the mainframe dead, more than 70% of the world's digital information resides on the machines. And last year, IBM's sales of big iron actually increased 6%, to $4.2 billion, according to IDC. What's more, the mainframe computing model – the idea of tapping into powerful central computers – has made a comeback. While PCs and small PC server computers remain important, many new tasks are now handled by powerful servers tucked away in data centers that serve the purpose mainframes did 40 years ago. Send an e-mail from your PC. Download music for your iPod. Order airline tickets on your Web-surfing cell phone. Somewhere, there's a muscle-bound server doing the heavy lifting."

"Even today, a decade after pundits declared the mainframe dead, more than 70% of the world's digital information resides on the machines. . ."

Steve Hamm, BusinessWeek, March 2004

IBM Software Group executive Steve Mills: "The mainframe is the only system that can handle the world's most complex transactions, respond to huge fluctuations in volume and workload, and continue to run 24 hours a day for years and years without a failure. For many years, business did not have the telecommunication bandwidth to use the mainframe in every part of their organization. Now we have it. Today, the mainframe not only supports administrative productivity in the back office but plays a role in delivering both personal productivity solutions and end-to-end organizational productivity."

Steve Mills

"Today, the mainframe not only supports administrative productivity in the back office but plays a role in delivering both personal productivity solutions and end-to-end organizational productivity."

Steve Mills, senior vice president and group executive, IBM Software Group

Milan Vidic in Slovenia sees the zSeries as crucial to his company's future. He's the deputy director of Informatics at Informatika, an electricity distribution company. His was the first company in the former Yugoslavia to take delivery of a System/360. Because of the way business is changing," he said recently, "you can't do business now without the Internet, Intranet, databases and other information. You have to have a lot more than just financial information. You have to know what your customers like and don't like. Without such a big system, we couldn't run our business."

The Mainframe as a Big Server

With the benefit of hindsight, we can see today that the need for mainframe-level computing never disappeared. Indeed, it has continued to grow. The fact that it has been pronounced

dead many times seems surprising now – and not only because the machines themselves are so obviously valuable, or because the needs they address are so obviously continuing.

Another thing that some pundits, journalists – and successful IT entrepreneurs of the PC era – failed to see was the affection many people felt toward "big iron." Lots of people *loved* these machines – and not just the IBMers who designed, built and serviced them. That love has survived a near-complete makeover of the machines themselves. Yes, the world still needs mainframe-level computing – but the machine itself is as different from its predecessors as a personal computer is from an abacus.

Mike Kahn, managing director and co-founder of The Clipper Group, calls the System/360 the beginning of the modern age. The Clipper Group is a Wellesley, Massachusetts-based consulting company that helps medium and large enterprises make IT decisions. "I never worked for IBM," he says, "but was involved with the mainframe at some pivotal points. I have been involved with many computers and architectures, from minicomputers to Grid. I consider myself open-minded, but do put on my *mainframe bigot* hat whenever the opportunity arises, because the mainframe has been the proving ground for much of the innovation in the computing industry, especially for commercial systems, and it has been the standard for comparison for competing platforms."

What's very clear today is that, with the growth of the Internet and advent of a networked economy, demand for more mainframe power started to grow again. The current high-end IBM eServer zSeries 990 mainframe, code named T-Rex by its development team, was built to handle the unpredictable demands of realtime business, allowing thousands of servers to operate within one box. The result of an investment of more than $1 billion over four years, the z990 was designed for high-speed connectivity to the network and to data storage systems, scalability in the face of unpredictable spikes in workload or traffic, and establishes new levels of availability and security. The ability to run hundreds of virtual servers within one physical box enables the z990 to consolidate and simplify environments undermined by complexity and technology sprawl.

Aetna, the Hartford-based insurance giant, pooled resources with three of their competitors in the late 1950's to buy a share in an IBM 1620. It was just too expensive for us back then," said John Connors, Sr., head of Network Operations for Aetna Information Services Department. "We threw in with Springfield, Phoenix and National insurance companies to form SPAN, and shared the system." Soon after, Aetna grew its own IT department. "Nothing else can handle the high-volume, high-transaction business that we're in," said Jon McQueeney, director of Technology Management Services at Aetna. In the process of

moving up to an IBM z990 in March of this year, Aetna, processes millions of health care and other insurance transactions every day. "America finances its health care through insurance companies," said McQueeney. "And we can only handle that volume with mainframe platforms. The IBM systems have really been a sweet spot for us."

The heart of the z990 is the IBM multichip module (MCM) – the densest, most advanced semiconductor and packaging technology in the world. The z990 scales to 9,000 million instructions per second compared with System/360 model 30's 13,000 instructions per second. And z990 has 3.2 million transistors per module. System/360 SLT technology had about three.

"The IBM zSeries establishes a new level of integration," says Erich Clementi, general manager, IBM's eServer zSeries. "What you see in industry right now is a movement from 'silo-ed' applications to dynamic workflows, and a remapping of business processes to software. We are helping clients aggregate their applications and their processes on a single system. That's very efficient. And with our Mainframe Charter and focus on infrastructure simplification, we are making the mainframe price-competitive in value and function to do this work."

Tony Mather is director of Global Information Management Services for The BOC Group, one of the largest industrial gases companies worldwide. BOC provides gaseous solutions to over 2 million customers, spanning almost all industry sectors in 40+ countries. The cost effective provision of its business based IM systems to its global operations is paramount.

"We now service most of our customers from a global data center," says Mather. "Without exploiting the mainframe capabilities for our DB2 based SAP solutions, our costs and services would be prohibitive. We would like to embrace the 'on demand' model for the future and the IBM zSeries provides us those options. "You know in my job I have a whole heap of things to worry about, but with the availability and performance of the IBM eServer zSeries infrastructure, that's one less thing I have to worry about."

Erich Clementi

IX. The New World of on demand business

The bookend to the System/360 story is neither a new product nor a denouement of business intrigue. As IBM rallied almost every resource it had in 1964 to make a success out of an entirely new way of designing and building computers, IBM today has again marshaled nearly all of its resources, to help clients exploit the new era of on demand business. That's the common ground. Once again the extraordinary effort is in response to growing client needs and a fundamental shift in the way information technology is used to create business value. And once again, the response to those challenges requires both the unification of all IBM, and the animation of its soul, its DNA.

In a very real way, on demand has begun a new era in the technology industry. "Our customers today," says IBM Chairman and CEO Sam Palmisano, "are less enamored of technology itself than in what technology can do for them. They are focused on the practical benefits, the solutions. This is why the IT industry today is driven by the users, and how they want to take advantage of all the technology that's available to them. The client is now setting the IT agenda."

Clients are now demanding that mainframe values emerge across the spectrum of distributed systems. Grid computing, system virtualization, and self-managing autonomic technologies are being adapted to improve the utilization, performance, availability and security of heterogeneous environments. Capacity on demand and shared services offerings pioneered by the mainframe are bringing users new flexibility in how they acquire and use computing resources.

IBM is teaming with Business Partners around the world to deliver solutions based on these new mainframe values. Nearly a third of IBM's annual gross revenues derive from partner-based solutions. PeopleSoft is one example. PeopleSoft and IBM have partnered for 16 years and share more than 1,600 customer relationship management and human resource management accounts. Some 2,000 IBM consultants are versed in PeopleSoft solutions. PeopleSoft chose IBM's zSeries to run their own real-time business. "In addition, the zSeries ensures us excellent performance and scalability for growth," says Jesper Andersen, group vice president and general manager, Tools & Technology, PeopleSoft, Inc. "It also provides our customers with world-class security."

Making processes more integrated, and infrastructures simpler and more automated, requires standards – open standards that everyone can use. IBM has embraced this idea. Linux is a good example. Today, Linux is the fastest growing operating system in the world, growing 35 percent a year. More than half of all mid-sized to large companies today are using Linux in some capacity. Businesses and government agencies in China, Brazil, Japan, the United Kingdom, and Germany are embracing Linux as key

to their IT growth. Java is another example, in platforms such as IBM WebSphere,® as is Grid computing. IBM has incorporated these capabilities into all of its products, services, and solutions – they are the foundation for the company's on demand strategy. (IBM WebSphere is a universal Internet software platform for e-business).

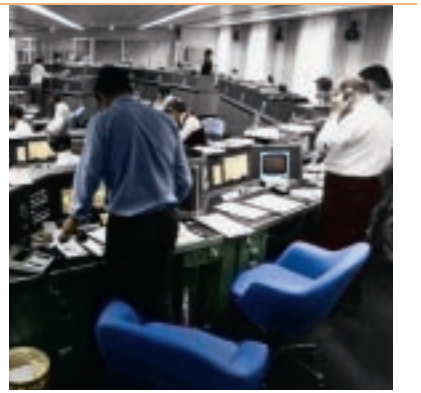
"An on-demand business is one that can respond with complete flexibility to changing market conditions in real time," says Dr. Irving Wladawsky-Berger, who heads IBM's on demand work. "On demand businesses can do this because their IT and business processes have been thoroughly integrated. They are businesses that can totally focus on what they do best; they don't have to pay a lot of attention to their IT infrastructure."

In the fall of 1965, Nick Donofrio, now senior vice president, Technology and Manufacturing at IBM, was a student at Rensselear Polytechnic Institute on an internship at IBM. Someone handed him a sheet of paper, a bunch of yellow wire, and a gadget called a wire-wrap gun. He was told to go stick the wires in their proper place in the back of a new System/360.

"The big deal then," Donofrio said recently, "was that the entire IBM company came together as one force to help our customers migrate to the future with a new form of computer. It offered better performance for the price they were paying, and assurance that their investments were going to be protected for a long time to come.

Dr. Irving Wladawsky-Berger, vice president, IBM Technology & Strategy

Linux is the fastest growing operating system in the world



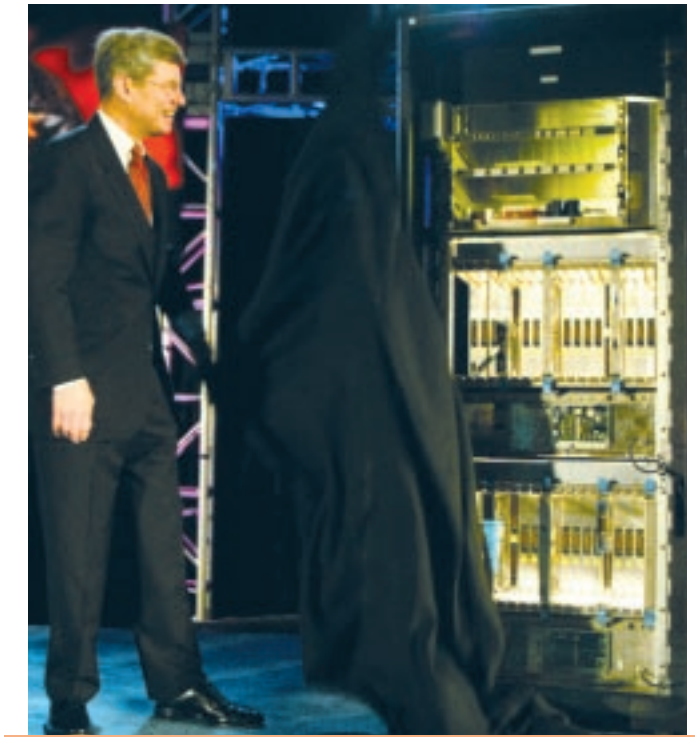
Today's customers are interested in what technology can do for them.

"The mainframes we designed and built then anticipated what we're doing today with on demand: always there, available, scalable, automatic and autonomic. They were the source for the work we're doing today. And once again, as back then, IBM has transformed itself and come together with this one goal and a set of values built around client success.

That was the bet then. This is the bet now."

Nick Donofrio

William M. (Bill) Zeitler, the senior vice president and group executive for IBM's Systems & Technology Group, joined IBM in 1969.



Bill Zeitler unveiling the top-of-the-line z990, San Francisco, May 2003.

System/360 introduced a lot of innovations, including Solid Logic Technology, compatibility, and numerous advances in storage, memory, and input and output devices. And it actually created the modern software industry.

But the most important innovation was that now we could connect people in almost any size business through a network into a system. Companies could now make and monitor transactions in real time. This capability was available earlier with the military SAGE project and the SABRE airline reservation system. The System/360, however, brought realtime transactions to administrative people in companies everywhere.

With the ability to connect transactions, people started asking bold questions: Now that I can do this, how would I run a bank differently? How would I run an insurance company differently? How would I run an airline differently?

Today, we're on the frontier of vastly larger possibilities. If we can connect everybody, every process and every device, and have access to virtually unlimited computing capacity, what would we do differently?

William M. (Bill) Zeitler

At a recent IBM Business Leadership Forum, we had leading executives asking exactly these types of questions.

At UPS: If every package is connected with RFID tags (Radio Frequency Identification), and they ship 13 million packages a day, and they also connect with the two million people who ship those packages and the seven million who receive them, How does this change the very nature of logistics?

At Mayo Clinic: If you connected information about the human genome with every MRI (Magnetic Resonance Imaging) machine and with every patient history, How would it change the course of modern medical practice?

Sam Palmisano with Meg Whitman of eBay and Jeffrey Immelt of GE at the IBM Business Leadership Forum in San Francisco, November 2003.

At GE: If you can connect everything to everything, and have unlimited access to computing technology, how would GE go about building and managing MRI's, and jet engines, and even locomotives?

This is what System/360 started 40 years ago. It created the first major intersection of business and modern technology. The seeds of what was visible 40 years ago have become the new world of on demand business. Once again, as with the System/360, the promise for the future will grow with every client innovation built on the technology and services that we and our IBM partners provide.

In this era when everything can be connected, and when people and their tools can be integrated with unlimited computing power, anything is possible.

The revolution begun 40 years ago never ended.

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