Large-Scale Systems Directions: Disks, Tapes, and Printers

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LARGE-SCALE SYSTEMS DIRECTIONS: DISKS, TAPES, AND PRINTERS

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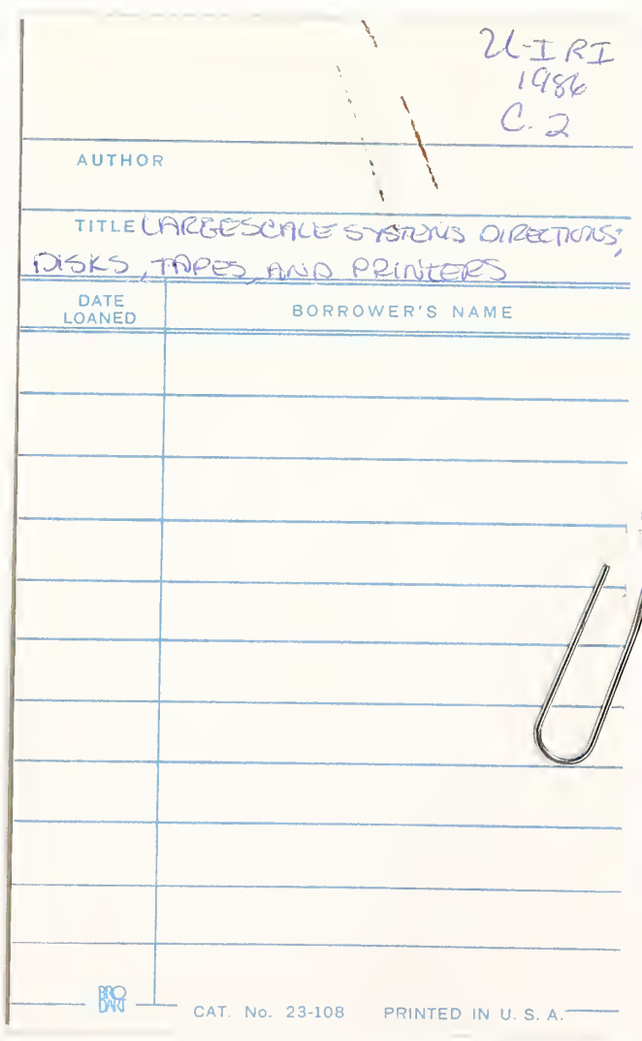

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ABSTRACT

IBM's 3090 and 4381 product directions are analyzed in this report in the context of current and projected technological and market conditions. Key system software and storage subsystems are addressed. The analysis is based on recent IBM presentations to customers and INPUT's long-term view of IBM's overall directions.

Used computer market prices as of May 1986 are presented together with projected residual values for 308X and 43XX processors, 33XX disks, 34XX magnetic tape, and 3203/3800 printers through 1991.

This report contains 45 pages, including 7 exhibits.

LARGE-SCALE SYSTEMS DIRECTIONS: DISKS, TAPES, AND PRINTERS

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LARGE-SCALE SYSTEMS DIRECTIONS: DISKS, TAPES, AND PRINTERS

EXHIBITS

I INTRODUCTION

- INPUT first started forecasting detailed residual values for IBM and software compatible mainframes in 1977, and in 1979 extended these forecasts to include selected peripheral products. From the beginning, INPUT emphasized analysis and technological forecasting to support these residual value forecasts, and, in 1984, the name of the report series was formally changed to Large-Scale Systems Directions to reflect this emphasis.

- Six reports have been published since the change of title, and they have represented a comprehensive overview of:

  - Technological trends in storage systems, including optical media (1984).

  - The importance of IBM systems software in controlling the network processing hierarchy, including the emergence of large IBM mainframes as "enormous data base machines" (1984).

  - The impact of the von Neumann architectural "bottleneck" in today's large-scale systems, and the need for differentiation and mechanization of function (1984).

- Historical trends in large-scale processor and storage growth, and possible problems associated with IBM's highly centralized hardware/software architecture (1985).

- How Sierra (3090-XXX) fits (or does not) with all of the above, with special emphasis on hardware performance measurement and potential problems (1985).

- Major issues in determining the value of large-scale systems with special emphasis on white collar productivity improvement, and the need for measuring performance at multiple levels (hardware/software, human-machine dyad, work unit, and institutional).

- The fundamental conclusion reached in the last report was that there are certain residual expenses associated with the implementation of today's complex computer/communications networks, and, that when considering implementation of such networks, the residual value of hardware is a relatively trivial consideration compared to these residual expenses. If this conclusion is accepted, it then becomes a question of determining whether the potential (or promised) value of the information system can be justified against those residual expenses through improved performance at the institutional level.

- It is INPUT's belief that management (and financial management in particular), tends to focus on residual value of hardware because it is viewed as a capital expenditure and is a familiar measure. The value of the product of this expenditure (fundamentally information) cannot be quantified, and the elements of residual cost are not clearly enough identified to permit the framing of even semi-intelligent questions. Therefore, an awful lot of hardware has been installed on faith alone, and unanticipate expenses combined with unrealized benefits are beginning to erode that base of faith. The classic cycle of first overrating and then undervaluing technology has been around since Lady Lovelace first made that sage observation about

Babbages "analytical engine," and it can still lead to both disappointment and missed opportunity.

- This year Large-Scale Systems Directions will begin to focus on some of the considerations of residual cost while maintaining the familiar projections of residual values.

  - Chapter II of this report will present and analyze IBM's bid for faith in the large-scale systems area, and outline the potential alternatives. Potential areas of residual cost will be associated with those alternatives.

  - Chapter III will present recent announcements (including price changes), used market activity, and residual value forecasts. This report will provide a complete update of residual values for disk, tape, and printer systems, and critical updates of mainframes. The Mid-year Update, which will immediately follow this report, will provide a complete updating of IBM and software-compatible mainframes.

II IBM's LARGE-SCALE SYSTEMS DIRECTIONS

- In the first quarter of 1985, IBM announced both the extended capability models of the 3380 and Sierra (the IBM 3090 Processor Complex, Models 200 and 400). At the time, INPUT observed that IBM's direction for large-scale systems for the remainder of the 1980s was pretty well established with those two announcements. Our comments concerning those two announcements can best be summarized as follows:

  - Both the magnetic disk cost-per-bit and the processor price-performance were following highly predictable long-range trends and INPUT forecasts. (See Large-Scale Systems Directions: Disks, Tapes, and Printers, INPUT, 1985.)

  - Our specific comments concerning the 3090 were: ". . . there are no serious technological threats to competitors in the basic engines, but there is plenty of room for aggressive pricing as IBM sees fit."

- During the "slump" of 1985, IBM managed to grow enough to pass the $50 billion revenue mark and remain roughly on target toward becoming a $100 billion company by 1990, which is the fundamental goal of its corporate strategic direction. However, earnings growth was "disappointing" even though IBM was the most profitable private enterprise in the world, and its earnings of $6.6 billion was almost exactly equivalent to the revenues of its then nearest competitor in the computer industry--DEC.

- Faced with such disappointment, IBM has seen fit to be more aggressive in its pricing early in the 3090 product cycle. This confirms INPUT's opinion that the best thing that can happen for IBM's competitors is for IBM to be satisfied with its growth in both revenue and earnings; otherwise, the juggernaut will make vernier adjustments to its direction which will cause a great deal of turbulence for those operating on the fringes of IBM's direction. Large-scale compatible vendors (and leasing companies) are especially susceptible to impact from IBM's tactics. (There is a current fad which refers to practically everything as being of "strategic significance." It is important to distinguish between strategy and tactics; IBM cannot change strategies very easily, but has recently demonstrated remarkable tactical flexibility.)

- However, it is INPUT's opinion that IBM is aware that there is something more than price wrong in the large-scale systems market--there is a vague sense of unease about IBM's general direction (strategy). As complex computer/communications networks develop, the individual parts cannot be viewed as if they are isolated from each other; there are alternatives available and choices to be made. The direction in large-scale systems cannot be viewed as independent of what is happening (or not happening) with LANs, "departmental processors," or microprocessors.

A. IBM's ANNOUNCED DIRECTIONS

- IBM is sensitive to even the vaguest sense of unease among its customer base, and this is especially true among its large customers. The concern comes through in public meetings where IBM has been remarkably candid about its large-scale systems strategy while trying to inspire both users, computer services companies, and industry consultants to have confidence in its product offerings. The outline for presenting IBM's announced directions is taken directly from IBM's "Data Systems Roadshow" which was for large IBM customers, but some of the material included is from the IBM Computer

Services Conference (the two meetings were supplementary and complementary, but were not in conflict).

I. LARGE SYSTEMS TRENDS AND DIRECTIONS

- This session was intended as an overview and, in many ways, it was the most informative session because it gave insights into how IBM perceives large systems trends and directions. It was a view from the top of IBM's product strategy and how it was formed.

- Fundamental to IBM's planning in the large-scale systems area are the growth patterns it perceives among its large users. Exhibit II-1 plots projected growth from a 1985 base out to 1990.

  - Batch processing is believed to be growing between 20% and 30% per year.

  - Transaction processing has 40%-50% compound growth rate.

  - End user computing has 60%-70% compound growth rate.

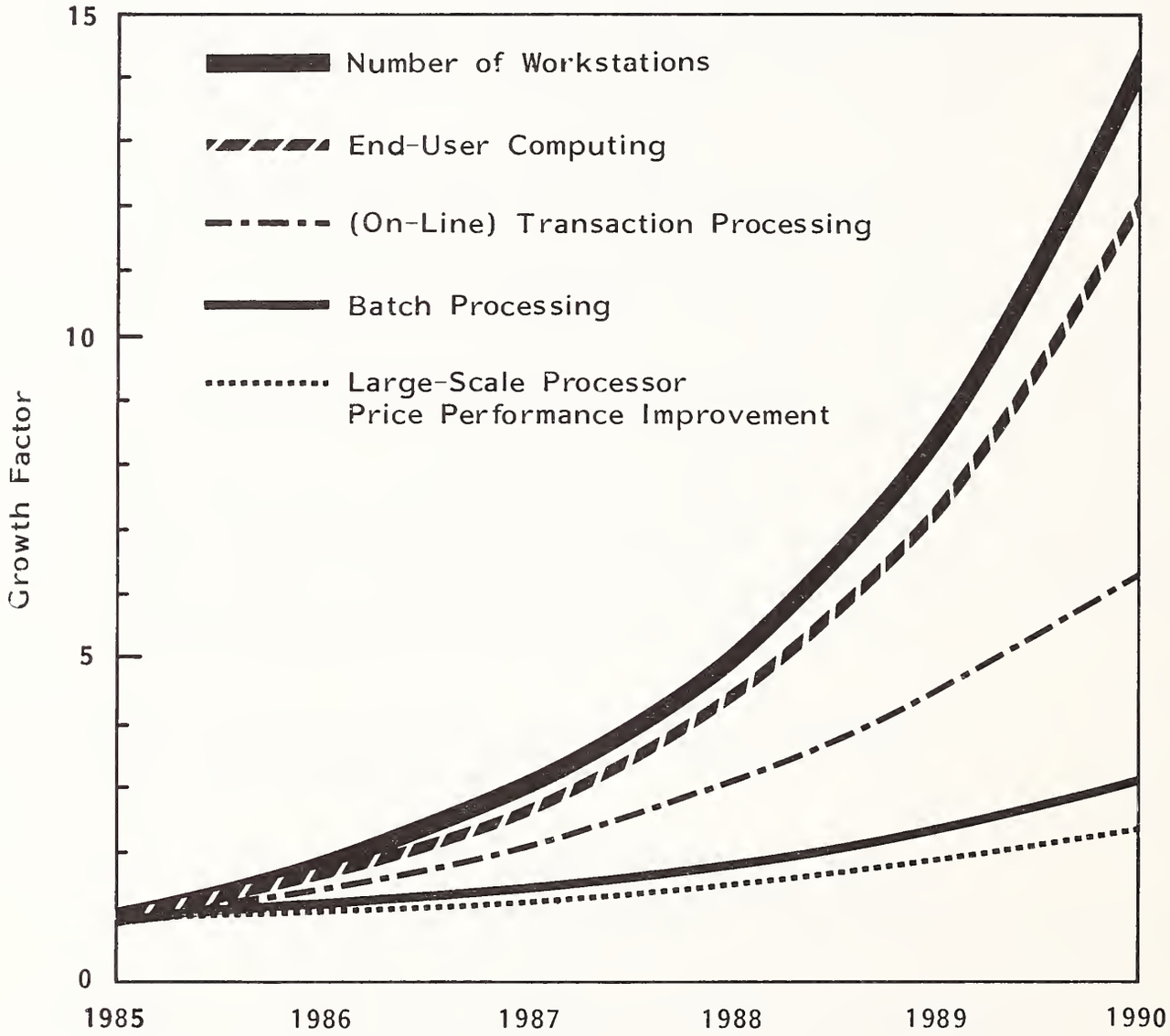
  - Workstations coming on-line are growing at 60%-80% compound growth rate.

  - Against these growth rates, IBM large-scale price-performance is improving at 15%-20% per year.

- These growth rates are pretty much in line with the 10 times growth in installed processing power which IBM was projecting for 1990 one year ago. (See Large-Scale Systems Directions: Disks, Tapes, and Printers, INPUT, 1985.) The chart in Exhibit II-1 was plotted using the mid-point of the ranges IBM presented this year, and it is obvious that improved price-performance is not keeping up with increased use.

EXHIBIT II-1

PROJECTED LARGE-SCALE SYSTEMS CHARACTERISTICS, 1985-1990



- Faced with this view of customer growth, IBM emphasizes the following general characteristics of its Data Systems product offerings:

  - Announced products provide a base for future growth to meet customer demands.

  - Development and/or release of new technology, architecture, and performance improvement would be "very evolutionary."

  - Customers could anticipate "asset growth" of IBM high-end products because they are designed to be expandable in terms of:

    . Capacity.

    . Performance.

    . Function.

- In presenting technology, IBM emphasized the following:

  - One Megabyte chips would be available "soon."

  - Proven ECL logic and TCM packaging in the 3090 was state-of-the-art and protected the customers "assets."

  - The multiple chip module (MCM) packaging was the "best in the market" and has "extensive growth." The importance of packaging was stressed repeatedly.

  - An overview of significant features of the 3090 Processor Complex highlighted the following:

- The channels have a 50 MIP RISC in them. (It is hardly news that channels are reduced instruction set computers, they always have been, but IBM has mentioned such MIP ratings recently in a rather disparaging manner designed to point up the obvious inadequacy of this measure in today's environment with such statements as: MIPS means "miscellaneous indicator of performance per second" - it is a point well made.)

- Virtual storage of two gigabytes.

- Expanded storage is an important consideration as far as growth was concerned. (During the question and answer period, a simple "Yes" was the answer to the question concerning whether Expanded Storage would be supported in ways other than for paging.)

- The processor controller and RAS (reliability, availability, and serviceability) are becoming an increasingly complex and important part of the processor complex. (Every IBM announcement since System/360 has emphasized RAS, and there is no question that the original hardware/software combination was not specifically designed to support non-stop operation which is becoming increasingly important in today's environment.)

- The 3090 processor has been rated the fastest scalar processor by an independent testing facility, and combined with the vector processor, this gives customers assurance that the processing power for advanced applications will be available.

- As far as DASD is concerned, the 3380 extended capacity was presented as the natural companion to the 3090 Processor Complex, and it was pointed out that IBM is the recognized and established leader in large-scale magnetic storage devices.

- Major architectural changes were stated to run in 10-year cycles, and it was pointed out that full software implementation of necessity lagged hardware. The following examples were given:

  - The System/360 architecture became available in 1964, and software (OS/360) was not available until 1966 (and even that may have been stretching it a bit).

  - The System/370 (VS) architecture was available in 1972 and software (MVS) did not become available until 1975.

  - The XA architecture was available in 1982 but software was not available until 1984-1985.

  - At this point, customers were not left to draw their own conclusions. The statement was made that XA was the architecture which would extend into the 1990s and that users could plan on that.

- What users could expect over the next several years with this architecture would be the following:

  - Two gigabytes of real storage would become available and virtual could literally equal real.

  - Up to 256 channels would become available (compared to 96 on the 3090 Model 400).

  - Data streaming would be extended beyond 400 feet.

  - Three meg. channels could be expected to go to: "6 to 10 to 20 meg. over the next several years."

- The "code to support 16-way processors was available now," but there would be a slow move from 4-way to "N-way".

- The links for connecting multi-systems would be fiber optics.

- "Software manufacturing" in terms of custom built installation and product delivery offerings would be extended to VM "shortly."

- By 1990 customers were told that they could expect to see the following observable benefits in large-scale installations compared to today:

  - While transaction size (in terms of number of lines of code) will go up to 1 million from 250k, response time will go down to less than 0 .5 seconds (from 1 second).

  - System availability will improve to "99.9%+" from the current 99.0% to 99.3%.

  - Recovery will be automatic as opposed to having to IPL.

  - Average outage will decrease from 1 hour to 15 seconds.

  - The operation of the large sites will go from requiring operators to being "automated."

  - Installability of new hardware/software systems will decrease to 2 to 4 hours from the current 8 to 10 hours.

- In addition to the question concerning the potential uses of expanded storage, which was mentioned earlier, an attendee asked about IBM's position on UNIX. The reply was refreshingly candid.

  - UNIX was stated to be "very troublesome" to the IBM company.

- As an example, it was stated that UNIX was in just about the "same place VM was 8 to 10 years ago" in terms of how IBM was viewing it.

- While UNIX got off to "several false starts," it was now a fast growing market. The question from IBM's perspective was how to afford UNIX development, and the point was made that it was difficult to "get outside parties involved in the development philosophy."

- And, finally, it was stated that it would be "some time" before IBM established any clear UNIX direction.

- IBM's presentation on large systems trends and directions was forthright and professional. Essentially, it explained that IBM's announced large-scale hardware/software was relatively early in its life-cycle, the hardware had significant potential for growth, the software had not yet fully supported the potential of the hardware, and there were not going to be any real surprises (either good or bad). Customers ordering and installing now could rest assured that they were investing in a quality product which would support the growth IBM perceived in the marketplace out to 1990 and beyond. The presentations which followed amplified the statements in the overview and had a more aggressive sales quality to them.

2. 3090 PRODUCT EXCELLENCE

- This session started with a general statement of plant capacity which got somewhat confused in the translation of acres into millions of square feet (the problem was probably in converting square yards to square feet), but it isn't really too important; IBM has invested in enormous capacity to meet the anticipated demands for 3090s (and associated magnetic disk systems). If even a small percentage of IBM customers decide on alternate sources to supply their large-scale systems needs, it is doubtful that IBM's competitors (such as NAS and Amdahl) could increase production rapidly enough to take advantage of the windfall.

- The speaker stated a three to five year lead in technology and packaging (MCM) was probably going to be stretched to eight to nine years, and that IBM was going to continue to build water-cooled processors at the high end. He stated water has always been more effective than air, and the whole argument was just a marketing ploy anyhow. The specific advice was: "invest in water cooling, its going to be around for 15 years."

- It was stated that the 3090 was IBM's mainframe out to 1990 and that with the requirement for raw processing power increasing by 50% per year (and the speaker stated he knew of many large accounts where demand was growing more rapidly), it could not be satisfied through processor technology which was only providing improvement at 20% per year. Therefore, the answer had to be multiprocessors (2x, 4x and beyond), and a single system (processor complex) would provide 2,000 MIPS (referred to as 2 BIPS in another IBM presentation) by 1990. This 2 BIP figure obviously includes processors embedded within the system, and it was stated that XA supports eight levels of processors under the covers. (It is obvious that IBM will not allow MIPS of the primary engines to be used as a measure of processing power; perhaps they will revive the MACHAN analysis and Gibson mix--anything might be an improvement over the figures in the trade press.)

- It was then pointed out that the 308X series provided 14 different models with a 1,000% performance range (10x) from bottom to top and supported XA at all levels. That strategy has not changed for the 3090, and general performance improvements such as the SIE instruction (start interpretive execution) and the improved sort would assure that performance on the low end of the line could fully support an XA environment. (It was pointed out that the 4381 was specifically included in IBM's definition of large-scale and was designed to operate in the XA environment.)

- The specific point was made that there were no restrictions on what machine was being interpreted using VM and the SIE instruction. This supports once

again INPUT's contention that VM is being positioned by IBM as a tool for integration of, not only software, but hardware systems. The full implications of this are enormous in terms of both systems and network structuring.

- Again stressing "evolution rather than revolution," it was stated that it would really be a "revolution without impact," and the strategy was designed to protect the users' software investments. In that regard, the 3090 must bridge the next generation, and it was predicted that it would be around in bi-modal form in the mid-1990s.

- Special attention was directed to Expanded Storage because there had been a "lot of misunderstanding" about it. The obvious advantages of price ($4,000 per meg. cheaper than main storage), comparable performance (to main storage), availability (single and double bit memory correction), and growth potential were all mentioned. It was stated that the addressing permitted up to 16 trillion bytes to be addressed (in 4k pages), and potential users were advised to view Expanded Memory as a "new level" rather than an extension. For those with long memories of IBM's past introductions of new levels of memory, it is probable that LCS (large core storage) and the Data Cell must have come to mind. However, if IBM is concerned about misunderstanding they certainly have not seen fit to clarify how Expanded Storage may be supported in the future--there are some intriguing possibilities.

- In closing the session, "horizontal growth" with multiple processors and the 3044 Channel Extender was emphasized, and it was predicted that customers would see doubling of the 3090-400 soon. (This prediction seems at conflict with the first presentation which was more cautious about growth from 4-way, but it was stated that code to support 16-way was already available.)

3. 4381 DIRECTIONS (DISTRIBUTED)

- This session reminded us of old conflicts within IBM going back to the time before the 43xx and 8100 were announced and were still being referred to as

the "E-Series" and "Orbit." (INPUT has tracked this conflict with good results going back to Impact of the 8100 which was published in March 1979 and predicted that the 8100 was not an appropriate engine for distributed processing except as a cluster controller.)

- The presentation started with some rather candid appraisals of IBMs efforts in "Distributed Departmental Systems" and the misconceptions among IBM customers about how mainframes fit into that strategy.

  - First of all, it was stated that customers did not believe the Data Systems Division was involved with distributed departmental systems because it was responsible for large systems.

  - The 8100 was not viewed as a departmental system.

  - The System/36 was not viewed as a departmental system because it did not have an appropriate operating system.

  - It was then concluded that there had been misconceptions about the 43xx since the time of its announcement. Among these misconceptions were the following:

    . The 4300 was announced as a standalone. (In fact, IBM did downplay the fact that a substantial effort--the Hydra project--viewed the 4300 as the engine for distributed processing. This was done because the 8100 was announced at the same time as IBM's answer to distributed processing.)

    . Another problem was stated to be that people thought 4300s run DOS, and at this point the presenter tossed out a side comment: "DOS is not dead, it is alive and well - on PCs."

    . Then people thought 4300s were only capable of running VSE/SP.

- Then several case studies were presented which demonstrated that 4341s could grow to 4381s (and 308Xs) operating under MVS and/or VM as distributed processors tied into larger hosts. This version of distributed processing was purported to have the following attributes:

  - The remote nodes could operate without systems programmers, applications programmers, or operators.

  - All program distribution and problem determination could be exercized from the host. (Much of the software being used goes back to the Hydra project and has been around as long as the 4300 series; for example, the Remote Operator Console Facility.)

  - Most transactions are handled at the node with consistent response time, and orderly growth was possible as the load at the remotes grew.

- The advantages of centralized DP were mentioned (economy of scale, use of equipment and staff, corporate direction, standards and management of corporate data) along with other "considerations" such as: central CPU dependence, remote needs for responsiveness and involvement in the development process, and communications costs. These other considerations were "driving companies to distributed data processing" and there was an "end-user revolution."

- Essentially, the message was the "orderly distribution of processing" which INPUT has advocated for the last 10 years. The challenge to corporate IS was to recognize that its role was changing from implementors to consultants who should endeavor to:

  - Enhance, not impede, end-user efforts which result from the "work-station explosion."

- Control the costs of distributed processing by planning end-user computing and the data processing requirements of subordinate organizations (departments, divisions, or companies).

- Establish standards which assure hardware/software compatibility and the ability to exchange data and information conveniently.

- Link end users to hosts where they can be given more function in a "managed" environment.

- The arguments for highly centralized control in an environment characterized by distributed systems development (DSD) are compelling regardless of how self-serving they may seem. The code name of Hydra, which was used nearly 10 years ago, is highly appropriate and, while the primary threat to large-scale systems at that time was minicomputers and the primary threat now is microprocessors with what used to be considered mainframe performance, the distribution of processing using mainframes resembles the hydra--cut back one large host mainframe by distributing processing and grow several to replace it.

4. MVS/VM SOFTWARE DIRECTIONS

- During the presentation on "Large Systems Trends and Directions," the primary and secondary systems software support for large systems was summarized briefly, as depicted in Exhibit II-2. The "MVS/VM Software Directions" session stated IBM's obvious intentions in the operating systems area.

  - XA is the base for IBM's direction, and MVS/XA is the "enabling" architecture. The key considerations are:

    . High capacity.

    . Systems management.

EXHIBIT II-2

SYSTEMS SOFTWARE SUPPORT - LARGE-SCALE SYSTEMS

Primary Support

MVS/XA	JES 2	VM/XA SF	TPF
MVS/370	JES 3	VM/SP HPO	DOS/VSE
XRF	TSO/E		

Secondary Support - Systems Management

3814 Switching Management

3088 Multi-System Channel Connection

3044 Fiber Optic Channel Extender

Systems Management Software

- High availability.

- End-user interactive (although it was qualified by stating that it was not designed to support "graphics systems programmers hitting a bunch of function keys").

- VM/XA SF and VM/SP HPO were stated to be the strategy for supporting high performance of preferred guests and interactive computing.

- The VM/XA System Facility SIE Assist was specifically mentioned as being an architectural interface for virtual machine execution and providing substantially improved performance for preferred guests operating in a V = R mode. This has obvious ramifications in attempting to attract various production operating environments to the large central mainframes on a continuing basis as opposed to VM being used primarily as a migration aid. IBM knows from past experience with emulators that residues of applications remain for years as users update to new hardware and operating environments. It is INPUT's belief that VM will be the tool of both horizontal and vertical integration for IBM.

  - Horizontal integration provides for the "wave-like" integration of various IBM operating systems over time and across more rapidly changing hardware architectures. It is not unlikely that there will be residues of all of the primary operating environments in Exhibit II-2 running as virtual machines in 1995 along with XA's successor.

  - Vertical integration of smaller IBM and competitive systems onto large IBM systems under VM is not only possible, but inevitable. The point that SIE is not restricted in terms of the machines being interpreted is extremely significant in terms of large systems strategy. Only ever larger systems can be expected to absorb a high percentage of today's hardware/software systems and still run what is coming tomorrow.

- Based on IBM's experience, old operating systems never die---they just live to haunt you. (Even their own DOS is a good example.) However, VM has finally been recognized as a tool, not only to accommodate those old systems, but to reach out and absorb any competitive systems. (IX/370 is a good example of that.)

- Combined with IBM's multi-operating systems strategy is a companion DBMS strategy which emphasizes both IMS and DB2. At the IBM Computer Services Conference, IBM made the following points concerning DBMS:

  - No single DBMS can satisfy user needs.

  - The emphasis for IMS development will be on high availability and high performance. The issues of manageability, capacity, and cost per transaction as data bases increase substantially in size during the late 1980s is of paramount importance, and IBM is aiming at substantial performance improvement for IMS to accommodate the larger transaction sizes and improved response times mentioned earlier.

  - DB2 on the other hand is aimed at flexibility and high functionality, with the main priority being referential integrity (perhaps along with belaboring competitors who have "relational-like" systems). It was specifically stated that distributed data will be based on the relational model (an opinion expressed by INPUT since IBM announced DB2), and that the objective was to improve DB2 performance to the point where it is equivalent to IMS without Fast Path (approximately 40 transactions per second).

  - It was also pointed out that, while TPF will continue to be enhanced, eventually IMS Fast Path is expected to improve to the point where TPF can be replaced.

- One statement by IBM should be soberly considered--it was that IBM looks on a data base decision as a "30 year decision."

5. STORAGE SUBSYSTEMS

- INPUT has pointed out that IBM is heavily dependent upon increased sales of magnetic disk storage systems to meet its business objectives during the late 1980s. The presentation on storage subsystems was prefaced with the statement that for the first time revenue from disk storage had exceeded that from processors, channels, and all other I/O equipment combined. (INPUT had projected that this would happen before 1990 even excluding the cost of disk controllers, but this came as something of a surprise.)

- IBM's primary interest at this time is to promote the 3380E based on growth of DASD per system and performance objectives in terms of improved response time despite increased transaction size. The ability of the 3380E to handle larger data bases, with increased transaction sizes, and still improve response time is heavily dependent upon:

  - Effective use of the storage hierarchy of cache memory within the 3380 controllers and expanded memory on the large processors.

  - Storage management software.

- It was stated that IBM's DF (data facility) products including ISMF (Interactive Storage Management Facility) consist of 1.3 million lines of code and MVS itself consists of 1.6 million. The implication is obvious, IBM is investing an enormous amount of resources in improving DASD management (at one meeting, it was stated that IBM had a development staff of 300 people working in this area), and it is felt that these facilities will actually lead to faster growth in DASD use (sales).

- It was pointed out that the improvements in DF Sort would be significant for users because large commercial installations devoted between 15% and 30% of their CPU cycles and I/O activity to sorting. This becomes significant when you consider the following:

  - Over 20 years ago, large IBM installations (7070/74, 7080, 7090/94) doing commercial work spent between 20% and 25% of their operational hours sorting. (This was discovered in an IBM study of over 250 large IBM installations which was conducted prior to the time System/360 was announced, and the average times reported were 23% for the 7070/74, 22% for the 7080, and 21% for the 7090/94.)

  - In the early 1960s installations were operating in a serial batch environment without the benefit of DASD, multi-programming, or data base management systems. These advances in storage hardware, process management (operating systems), and data management concepts (models) were supposed to decrease the amount of systems resources devoted to sequencing transactions for running against "master files" which frequently overlapped primarily because of different sort keys and sequences.

  - The fact that these early wall clock measurements of time, devoted to sorting, averaged in the center of the range being reported today, would indicate that not much progress has been made in eliminating sorting. In fact, there are indications that sorting as a percentage of the systems productive resource has probably increased substantially. Consider the following:

    . Not only has sorting resisted the efforts of the primary environmental changes (DASD, operating systems, and DBMSs) of the last two decades, but there have been significant improvements in channels and controllers for I/O.

- . Sorting algorithms have been improved substantially since the early sort packages which were being used in the early 1960s.

- . Today's operating environment is substantially more complex (for example interactive terminals) and yet sorting continues to absorb a comparable portion of the total systems capacity; therefore, the ratio of sort to problem program (production) must be much higher.

- There are several reasons this apparent phenomenon is of more than idle interest and warrants analysis:

  - . INPUT has projected that large host systems are becoming large "data base machines," and it is probable that such systems will become more, rather than less, batch oriented as data bases are distributed.

  - . The relational model, which will come into increasing use on large host systems, specifically excludes sequential (ordered) files (tables), and this will unquestionably play hob with all that sorting which is going on in the rest of the system (basically tending to increase it even more).

  - . Combining very large files, virtual storage, and sorting can have disastrous performance impacts, and that pretty much describes the current and projected large host environment.

- In terms of technology, IBM has a tremendous investment in, and dependence on, magnetic disk storage. It was stated that cost was coming down by 17% per year, and that a megabyte of storage costing $300 in 1973 (3330) costs $30 today (3380E) and will cost $3 in 1997, and that magnetic DASD would be around for the "next 20 years."

- INPUT's first Large-Scale Systems Directions in 1984 presented the potential impact of optical memories on large-scale, magnetic disk systems. IBM's attitude about optical memories today can be best summarized by the following statements:

  - IBM always publically stated that they are working on optical memories in Tuscon. This makes it clear that IBM is aware of the technology and has continued work despite their abortive attempt at an optical disk joint venture with MCA (DiscoVision). The announcement that they are "working on it" also lends additional credence to their observations about the future of optical memories.

  - At the Systems Development Roadshow, an IBM representative (after stating they were working on optical memories in Tuscon) said it was his opinion that they would appear at the low end of the line first. This would seem to be a fair statement because IBM will probably announce a CD ROM-type product for PCs before the year is out, and such technology would certainly be highly appropriate for program and documentation distribution for IBM systems (IBM is one of the biggest publishing firms in the world) and for education in the use of those systems.

  - At the IBM briefing for the computer services industry, another representative of IBM stated (after saying they handled optical storage systems out of Tuscon) that they considered optical storage systems as "very effective for mass storage replacing microfilm and for image processing." This is obviously getting a lot closer to large-scale information storage, but it makes no mention of encoded data. By ommission this implies that IBM does not yet believe (or support) optical memories are appropriate for archival storage of encoded data (back up of magnetic disk storage). This is not surprising since both presentations included a discussion of the 3480 tape cartridge as a labor saving device, stressed its reliability, and stated there were over 1,000 potential customers for the 3480 in the U.S.

B. ANALYSIS OF IBM's ANNOUNCED STRATEGY

- There are few surprises in IBM's announced strategy. Essentially IBM is now saying what INPUT has been saying in Large-Scale Systems Directions for the last two years (and in other reports for a much longer period of time). Essentially, this strategy relies on:

  - Keeping as much processing as possible on large central host processors.

  - Large central data bases to insure revenue growth from magnetic disk storage, which in turn requires ever larger processors.

  - Systems software (SNA, operating systems, and DBMSs) for account control and as the ultimate competitive weapon at all levels in the network hierarchy.

  - Evolution rather than revolution in all of the above.

  - The promotion of the concept of the "information age"--the premise that information in, and of, itself has value and that this value can, in some way, be positively correlated with volume and speed of distribution.

- While all of the basic elements of this strategy can be subject to both technical and philosophical debate, we have reached a point where the technical portion of IBM's strategy makes a lot of sense. This is true for the following reasons:

  - The trends toward end-user developed systems and the distribution of substantial data bases to the desk top are fraught with problems of data and information quality which have potential for severe adverse impact on institutional performance.

- Centralized control of data and information quality are essential, and it is desirable to proceed slowly in the distribution of data from mainframes until those quality problems are understood. Evolution rather than revolution is advisable in an environment which INPUT has referred to as Distributed Systems Development (DSD).

- Therefore, it is probable that IBM will not be forced from its large-scale strategy during the remainder of the 1980s. This means that IBM's announced large-scale systems strategy will prove to be substantially correct, and customers can invest in announced products with some assurance that they will not be prematurely made obsolete. In other words, IBM will roughly meet its business objectives and not have to do anything drastic between now and 1990.

- However, the fact that IBM meets its objectives, and even has a certain amount of "right" on its side, does not mean that there are not severe potential impacts for those who blindly follow IBM during this period. Grace Hopper felt IBM was "building dinosaurs" 10 years ago and those dinosaurs have continued to grow; but it is wise to remember that while dinosaurs evolved slowly they died rapidly.

C. POTENTIAL RESIDUAL COST EXPOSURES

- The success of IBM's large-scale systems strategy may indeed protect the residual value of mainframes in the conventional sense, but this does not mean that there are not more important cost exposures inherent in adopting this strategy. Perhaps the best indication of the importance of today's decisions was the statement by IBM that data base decisions are viewed as "30-year decisions." The computer/communications networks built around large central data bases are going to be all but impossible to replace and difficult to

modify. This means you may be stuck with them regardless of how effective they turn out to be.

- Specifically, INPUT's concerns have centered on the following considerations:

  - While large-scale price-performance may be improving more rapidly than microprocessor price-performance (another point which was made by IBM), that does not mean that much of the processing now being done on large mainframes could not be more effectively done on minicomputers and/or microprocessors. To the degree that such processing is "trapped" on large mainframes, it becomes a residual cost.

  - Given the tremendous overhead of the systems software (operating systems and DBMSs) on large mainframes, will the large mainframes be able to serve as "large host data base machines" and service the demands for extracts from these data bases? Establishing networks which assume such central focus will result in residual costs, of not only the large central hosts, but the communications network. A substantial portion of these costs will continue regardless of how infrequently these large central data bases are accessed.

  - INPUT has described the problem of potential data base entropy associated with large data bases (and especially the relational model) in numerous reports including Large-Scale Systems Directions: Disks, Tapes, and Printers, 1985. The sort phenomenon identified in this report is probably the direct result of increased entropy as data bases increase in size. The use of the relational model for the distribution of data bases (regardless of its technical merit) has substantial and unpredicatable residual cost in the highly centralized environment inherent in IBM's strategy. The increase in sorting is simply the manifestation of the increased energy required to maintain order in a complex environment.

- IBM's horizontal growth of multiple processors, multiple operating systems, and multiple data models presenting a single systems view is going to establish a level of internal complexity (and cost) which will remain well beyond the 30-year period of the data base decision. The residual cost associated with supporting this complexity will remain even after the network architecture has been substantially modified.

- As large data bases on magnetic disk storage continue to grow, the redesign of applications systems using those data bases become increasingly difficult (if not impossible). Therefore, the conversion of applications systems to take advantage of optical disk technology (which is coming more rapidly than IBM is willing to admit) will require enormous lead times, and having magnetic disk storage installed past the early 1990s will represent a substantial residual cost.

- Contrasted with the exposures associated with following IBM's strategy are the potential exposures of not following IBM's strategy. For those who proceed more rapidly with distributed processing and office systems, there is the probability that IBM may effectively obsolete all installed equipment (including its own) once they get their office systems act together in the early 1990s. The evolution will become a revolution at the point where IBM becomes convinced it cannot grow from $100 billion to $200 billions by primarily relying upon its mainframe-oriented strategy. The residual costs of proceeding too rapidly may result in some substantial write-offs of office equipment.

- Even more important, the uncontrolled distribution of data and systems development activities (in the name of productivity improvement) may result in the proliferation of low quality information with catastrophic impacts on institutional performance (the decision-making process).

- Last, but not least, is the possibility that it will be discovered that a small amount of high quality data and information (combined with a little knowledge) is infinitely more valuable than hundreds of gigabytes of relatively raw data which must be massaged through the big central systems in order to extract the few nuggets of worthwhile information needed to run the specific enterprise. The megamyths of the information age may not stand up under the weight of their own product, much less careful systems analysis or knowledgable executive scrutiny.

- Large-scale systems are on a rapidly escalating path toward complexity which may already be beyond the point of no return. However, careful consideration of the residual costs of such systems is essential and INPUT will attempt to identify major areas for consideration as we continue to project the residual value of such systems over their life cycle.

III RESIDUAL VALUE FORECASTS

A. ANNOUNCEMENTS

1. IBM

- In February, approximately one year after the announcement of Sierra, IBM made the following large-scale processor announcements:

  - The 3090 models 150 and 180 were announced, with the Model 180 stated to be "approximately 1.7 to 2.1 times the instruction execution rate (IER) ratio of the IBM 3083-JX and expected to be approximately 1.4 - 1.6 times the IER ratio of the 3090 Model 150 (executing under MVS/XA)." While that may seem confusing, the IBM product announcement did provide good relative performance analysis against existing IBM systems based on various types of work loads (commercial and scientific) and, as pointed out in the previous section of this report, IBM seems intent on exposing MIPS as an inadequate measure of performance. (However, for those not interested in analyzing IBM's performance information, the Model 150 is estimated to be between 9.2 and 10.9 MIPS and the Model 180 between 14.2 and 17.6 MIPS.)

  - Four new models of the 4381 series were announced with performance being specified as ratios of internal throughput rates (ITR) relative to the previously available 4381 Model Group 2 (the 4381 Models 1, 2,

and 3 were withdrawn from marketing). The performance information contained in the announcement was broken down into ITR ratios for commercial batch, engineering/scientific batch, interactive + batch, interactive, and on-line (IMS and CICS) by operating system. Once again, for those who want a quick and dirty performance estimate for the new processors, the MIPS ratings are as follows:

- 4381 Model 11 - 1.4 MIPS.
- 4381 Model 12 - 2.8 MIPS.
- 4381 Model 13 - 3.5 MIPS.
- 4381 Model 14 - 6.0 MIPS.

- Related processor announcements were as follows:
  - The four-processor 3090 Model 400 was announced as a system rather than as an upgrade to the Model 200.
  - Expanded memory capacity on both the Model 200 and Model 400 was doubled--up to 256Mb on the Model 200 and up to 512Mb on the Model 400.
  - A cheaper version of the 3097 Power and Coolant Distribution Unit for the 3090 was announced--the Model 2 at $111,000.
  - Maintenance costs on the new 4381 models are between 16% and 20% lower than on existing 43XX systems.
  - The 4341 product line was withdrawn from marketing.

- . Attractive upgrade prices for existing 43XX technology to newer, bigger models of the 4381 series were made available.

- The following pricing adjustments were also made:

  - . Purchase prices of selected 308X models were reduced from 3%-24%.

  - . Memory prices on the 308X were reduced by 20%.

  - . Upgrades within the 308X series were reduced by as much as 40%.

  - . And, last but not least, purchase prices of the 3090 Models 200 and 400 processors were reduced by an average of 10%. (While much has been made about this early price adjustment to Sierra, INPUT believes the possibility of an early price adjustment was probably built into the IBM plan because of the long delivery schedules in the initial announcement--the increased flexibility of IBM's product announcement and pricing strategies cannot be overemphasized in terms of potential impact on the market and residual values.)

- IBM also announced the Model 3422 model of the reel-to-reel tape drives which eliminates the need for the 3803 controller, and more recently, the long-awaited automatic loader for the 3480 cartridge tape system.

- IBM's emphasis on magnetic disk storage, and specifically the "E models", has been pointedly enhanced by a recent announcement that the single density 3380s will not be marketed after September of this year. (Rumors of another doubling of density on the 3380 also abound.)

- An area where rumors do not abound is in the area of large-scale printer systems where the venerable 3800 printer seems destined to go on forever. With so much excitement about laser printers and desktop publishing, it is possible that the age of distributed printing may truly be arriving.

2. OTHER ANNOUNCEMENTS

- Reviewing the first five months of this year for large-scale, IBM-compatible product announcements creates an eerie sense that IBM alone is battling the "slump." Both NAS and Amdahl have been relatively quiet, with only the following announcements:

  - Amdahl announced double capacity on its 6380 disk drives.

  - NAS announced a "12.5% improvement in internal throughput" for its low end AS/8000 series processors (8023, 8043, and 8053) in January prior to IBM's processor announcements in February. This improvement was gained by cutting the cycle time from 40 to 35 nsec on those processors, and NAS has not seen fit to respond to IBM's announcements with any price adjustments.

  - NAS also announced new models of its 7380 single-density disk drives which can be field-upgraded to double-density. It was stated that, while the double-density models had been announced a year ago it appeared that customers wanted the single-density drives which could be upgraded. Also instituted was a "Gigabyte Discount Program" which ties discounts to the total storage capacity ordered (as opposed to specific models).

- It is difficult to know whether the relative quiet on the part of IBM's large-scale competitors is because their initial responses to IBM's major announcements of 1985 (Sierra and the 3380 E models) were satisfactory and anticipated what has happened so far this year, or whether it is just a case of not

wanting to antagonize IBM while it is attempting to get its large-scale juggernaught back on track. However, it is INPUT's opinion that both NAS and Amdahl are currently operating against 1986 business plans which are reasonably free of impact from IBM's latest announcements and price adjustments.

B. USED COMPUTER MARKET ACTIVITY

- Exhibit III-1 presents List versus secondary market price for selected vendor equipment which has traded in the used market. At any given time, there are three price levels in the secondary market:

  - Retail price which is the amount an end user would pay for the equipment.

  - Dealer price which is the amount a dealer would pay another dealer to acquire equipment to complete a contracted sales obligation.

  - Wholesale price which is the amount a dealer would pay to acquire equipment for resale.

  - The dollar spread between levels is a function of the total value of the transaction. For large processors the wholesale price will typically be 80%-95% and for peripheral equipment 70%-90% of the retail price.

- The retail and wholesale prices are listed for equipment where there is an active used market. Where there is not an established used market for specific equipment that is so noted. The fact that no used market activity has been recorded does not preclude spot transactions which may occur. Generally speaking the following observations can be made:

EXHIBIT III-1

LIST VERSUS SECONDARY MARKET PRICE FOR SELECTED VENDOR EQUIPMENT

VENDOR	PRODUCT MODEL	VENDOR LIST PRICE MAY 1986	SECONDARY MARKET ($) RETAIL	SECONDARY MARKET ($) WHOLESALE
IBM	Processors:			
	3083CX8	$802,731	--	--
	3083-E8	1,157,731	150,000	115,000
	3083-EX8	852,731	175,000	140,000
	3083-B16	2,032,731	505,000	455,000
	3083-BX16	1,337,731	530,000	480,000
	3083-J16	2,527,731	645,000	585,000
	3083-JX16	1,587,731	675,000	615,000
	3081-D16	2,437,731	760,000	700,000
	3081-G16	3,082,731	900,000	840,000
	3081-GX16	2,052,731	940,000	880,000
	3081-K32	4,032,731	1,250,000	1,175,000
	3081-KX32	2,777,731	1,295,000	1,220,000
	3084-Q64	7,010,462	2,540,000	2,465,000
	3084-QX64	5,060,462	2,675,000	2,550,000
	3090-150	1,707,810	--	--
	3090-180	2,607,810	--	--
	3090-200	4,508,900	--	--
	3090-400	8,515,785	--	--
	DASD:			
	3350-A02	32,030	1,000	500
	3350-B02	25,360	800	300
	3370-A1	35,480	14,800	12,800
	3370-A2	35,480	29,500	27,500
	3370-A11	35,480	17,000	15,000
	3370-A12	35,480	29,500	27,500
	3370-B1	26,600	14,200	12,200
	3370-B2	26,600	22,800	20,800
	3370-B11	26,600	15,000	13,000
	3370-B12	26,600	23,700	21,700
	3375-A1	38,040	12,000	10,000
	3375-B1	28,770	10,500	8,500
	3380-A4	77,680	33,500	31,500
	3380-AA4	88,780	47,100	45,100
	3380-AD4	88,780	--	--
	3380-AE4	122,480	--	--
	3380-B4	64,440	46,700	44,700
	3380-BD4	64,440	--	--
	3380-BE4	98,140	--	--

-- = No secondary (used) market activity.

Continued

LIST VERSUS SECONDARY MARKET PRICE FOR SELECTED VENDOR EQUIPMENT

VENDOR	PRODUCT MODEL	VENDOR LIST PRICE MAY 1986	SECONDARY MARKET ($) RETAIL	SECONDARY MARKET ($) WHOLESALE
IBM	Tape:			
	3420-003	14,800	500	300
	3420-004	17,545	3,900	2,900
	3420-005	19,705	750	500
	3420-006	20,125	5,000	4,000
	3420-007	21,625	2,500	1,500
	3420-008	22,085	7,300	6,300
	3422-A1	36,800	--	--
	3422-B1	17,900	--	--
	3480-A22	65,430	--	--
	3480-B22	43,120	--	--
	Printers:			
	3203-5	33,875	2,600	1,700
	3211-001	57,765	1,500	800
	3800-001	215,000	80,000	65,000
	3800-003	$330,750	$235,000	$215,000
AMDAHL	Processors:			
	5840-16	1,270,000	635,000	585,000
	5850-16	1,450,000	730,000	670,000
	5860-16	1,630,000	825,000	750,000
	5867-24	2,390,000	--	--
	5868-32	2,850,000	--	--
	5870-32	2,770,000	--	--
	5880-64	4,036,000	--	--
	5890-200	3,825,000	--	--
	5890-300	4,500,000	--	--
	5890-600	8,500,000	--	--
	DASD:			
	6280-AA4	41,900	21,000	21,000
	6280-B4	30,420	15,000	15,000
	6380-AA4	71,200	--	--
	6380-B4	48,700	--	--
	6380-M4	38,950	--	--

-- = No secondary (used) market activity.

Continued

LIST VERSUS SECONDARY MARKET PRICE FOR SELECTED VENDOR EQUIPMENT

VENDOR	PRODUCT MODEL	VENDOR LIST PRICE MAY 1986	SECONDARY MARKET ($) RETAIL	SECONDARY MARKET ($) WHOLESALE
NAS	Processors:			
	8023-16	475,500	--	--
	8043-16	698,300	--	--
	8053-16	939,500	--	--
	8063-16	1,104,600	--	--
	8083-32	2,271,900	--	--
	9040-16	1,620,000	--	--
	9050-16	2,012,000	--	--
	9060-16	2,156,000	--	--
	9070-32	3,041,000	--	--
	9080-32	3,878,000	--	--
	9140-16	1,920,000	--	--
	9150-16	2,312,000	--	--
	9160-16	2,456,000	--	--
	9170-32	3,641,000	--	--
	9180-32	4,478,000	--	--
			--	--
	AS/XL-60	4,356,605	--	--
	AS/XL-80	7,227,410	--	--
	DASD:			
	7380-AD4	84,350	--	--
	7380-AE	116,355	--	--
	7380-BD4	61,225	--	--
	7380-BE	93,235	--	--
	Tape:			
	7420-88	25,000	--	--

-- = No secondary (used) market activity.

- There is little demand for the 3083 which is being effectively squeezed from both sides by recent IBM announcements.

- There continues to be some activity for the 3081 and 3084 but very little supply at this point in time.

- There has been very little activity in the 4381 used market but this will probably pick up.

- The activity for 3380 single density drives has been brisk and probably will remain so considering IBM's recent announcement.

- While there is an active used market for some Amdahl processors and DASD, an active used market for NAS equipment has not yet developed.

- The current actual and short-term projected secondary market retail price for selected IBM equipment is presented in Exhibit III-2.

C. PROJECTED USED COMPUTER MARKET PRICES AND RESIDUAL VALUES

- Exhibits III-3 and III-4 present the 1987-1991 projected residual values as a percent of vendor list price and projected used market retail values based on those residual values.

- Exhibit III-5 presents the range of anticipated values for selected IBM processors (those primarily effected by IBM announcements since the last report Large-Scale Systems Directions: Large IBM and Software-Compatible Mainframes, INPUT, 1985) and peripheral systems for the 1987 to 1991 timeframe.

EXHIBIT III-2

ACTUAL AND PROJECTED SECONDARY MARKET RETAIL PRICE FOR SELECTED IBM EQUIPMENT

EQUIPMENT TYPE	MODEL NUMBER	CURRENT LIST PRICE MAY 1986	ACTUAL 1985 JANUARY	ACTUAL 1985 APRIL	ACTUAL 1985 JULY	ACTUAL 1985 OCTOBER	ACTUAL 1986 JANUARY	ACTUAL 1986 APRIL	PROJECTED 1986 JULY	PROJECTED 1986 OCTOBER
Processors	3083-CX	$802,731	--	--	--	--	--	--	--	--
	3083-E8	1,157,731	752,525	725,000	540,000	460,000	430,000	220,000	150,000	125,000
	3083-EX8	852,731	--	958,414	893,414	893,414	475,000	250,000	175,000	145,000
	3083-B16	2,032,731	1,376,414	1,225,000	1,030,000	875,000	775,000	500,000	425,000	375,000
	3083-BX16	1,337,731	--	1,683,414	1,583,414	1,583,414	875,000	525,000	450,000	390,000
	3083-J16	2,527,731	1,905,500	1,650,000	1,450,000	1,100,000	950,000	700,000	650,000	530,000
	3083-JX16	1,587,731	--	2,103,414	1,978,414	1,978,414	1,100,000	750,000	675,000	550,000
Disk	3370-A1	35,480	18,800	20,000	19,000	19,000	19,500	17,000	14,800	12,500
	3370-A12	35,480	--	--	--	35,000	33,700	31,600	29,000	27,500
	3370-B1	26,600	17,500	19,500	19,000	18,500	17,500	15,000	14,200	11,750
	3370-B12	26,600	--	--	--	26,300	25,250	23,700	21,000	20,000
	3375-A1	38,040	27,500	27,400	27,000	23,500	19,000	16,000	13,000	11,500
	3375-B1	28,770	20,700	20,700	20,000	19,000	15,500	12,000	10,000	9,000
	3380-A4	77,680	74,000	68,350	46,600	42,000	35,000	40,000	43,000	45,000
	3380-AD4	88,780	--	--	--	--	--	--	--	70,000
	3380-AE4	122,480	--	--	--	--	--	--	--	--
	3380-B4	64,440	62,500	59,000	42,000	41,000	45,000	44,500	46,700	48,000
	3380-BD4	64,440	--	--	--	--	--	--	--	56,000
	3380-BE4	98,140	--	--	--	--	--	--	--	--
Tape	3420-004	17,545	8,500	6,500	4,500	5,000	5,000	4,500	3,900	3,000
	3420-006	20,125	14,000	12,000	7,800	6,500	6,500	5,500	5,000	4,000
	3420-008	22,085	20,500	18,000	13,000	9,500	10,000	8,000	7,250	6,500
	3422-A1	36,800	--	--	--	--	--	--	--	33,120
	3422-B1	17,900	--	--	--	--	--	--	--	16,110
	3480-A22	65,430	--	--	--	--	--	--	--	52,344
	3480-B22	43,120	--	--	--	--	--	--	--	34,496
Printer	3203-5	33,875	24,000	20,000	19,500	16,000	7,500	4,500	3,000	2,500
	3211-001	57,765	12,000	9,000	5,000	2,500	2,000	1,000	750	500
	3800-001	215,000	170,600		140,000	140,000	125,000	110,000	110,000	105,000
	3800-003	330,750	295,000		285,000	285,000	275,000	250,000	250,000	240,000

EXHIBIT III-3

PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE

VENDOR	PROCESSOR MODEL	CURRENT LIST PRICE	PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE VALUE AT JAN. 1 OF: 1987	1988	1989	1990	1991
IBM	4331-J2	$44,436	14%	8%	5%	3%	2%
	4341-L1	202,231	4%	2%	1%	1%	--
	4341-L12	334,531	7%	4%	2%	1%	1%
	4361-K3	59,231	34%	18%	10%	4%	2%
	4361-K5	171,931	28%	15%	8%	3%	1%
	4381-L2	462,731	60%	51%	38%	21%	9%
	4381-M3	778,231	62%	54%	40%	25%	10%
	4381-L11	187,731	90%	80%	66%	38%	21%
	4381-M12	332,731	88%	77%	63%	35%	17%
	4381-13	442,731	85%	73%	58%	31%	14%
	4381-14	740,462	82%	70%	55%	27%	11%
	3083-CX	802,731	15%	8%	3%	1%	1%
	3083-EX	852,731	13%	6%	2%	1%	1%
	3083-BX	1,337,731	25%	14%	6%	3%	2%
	3083-JX	1,587,731	30%	16%	9%	4%	3%
Disk	3350-A02	$32,030	2%	1%	--	--	--
	3350-B02	25,360	2%	1%	--	--	--
	3370-A1	35,480	38%	18%	8%	5%	2%
	3370-A2	35,480	78%	54%	22%	15%	7%
	3370-B1	26,600	44%	23%	11%	7%	3%
	3370-B2	26,600	81%	56%	25%	17%	10%
	3375-A1	38,040	24%	11%	5%	3%	2%
	3375-B1	28,770	27%	13%	6%	4%	3%
	3380-AA4	88,780	38%	17%	8%	4%	2%
	3380-B04	64,440	42%	20%	10%	5%	3%
	3380-AD4	88,780	90%	52%	28%	10%	6%
	3380-BD4	64,440	90%	55%	30%	12%	7%
	3380-AE4	122,480	93%	64%	36%	18%	11%
	3380-BE4	98,140	93%	68%	39%	24%	15%
Tape	3420-004	17,545	14%	6%	3%	2%	1%
	3420-005	18,870	2%	1%	--	--	--
	3420-006	20,125	18%	10%	5%	3%	2%
	3420-007	21,625	8%	5%	2%	1%	--
	3420-008	22,085	22%	13%	7%	4%	3%
	3422-A1	36,800	103%	85%	73%	58%	40%
	3422-B1	17,900	103%	88%	75%	62%	45%
	3480-A22	65,430	88%	80%	72%	60%	44%
	3480-B22	43,120	88%	82%	75%	63%	46%
Printer	3203-5	33,875	6%	3%	2%	1%	1%
	3800-001	215,000	30%	22%	15%	10%	7%
	3800-003	330,750	65%	57%	50%	43%	35%

EXHIBIT III-4

PROJECTED USED MARKET RETAIL VALUE

VENDOR	PROCESSOR MODEL	CURRENT LIST PRICE	PROJECTED USED MARKET RETAIL VALUE AT JAN. 1 OF: 1987	1988	1989	1990	1991
IBM	4331-J2	$44,436	$6221	$3555	$2222	$1333	$889
	4341-L1	202,231	8089	4045	2022	2022	0
	4341-L12	334,531	23417	13381	6691	3345	3345
	4361-K3	59,231	20139	10662	5923	2369	1185
	4361-K5	171,931	48141	25790	13754	5158	1719
	4381-L2	462,731	277639	235993	175838	97174	41646
	4381-M3	778,231	482503	420245	311292	194558	77823
	4381-L11	187,731	168958	150185	123902	71338	39424
	4381-M12	332,731	292803	256203	209621	116456	56564
	4381-13	442,731	376321	323194	256784	137247	61982
	4381-14	740,462	607179	425025	233764	63116	6943
	3083-CX	802,731	120410	64218	24082	8027	8027
	3083-EX	852,731	110855	51164	17055	8527	8527
	3083-BX	1,337,731	334433	187282	80264	40132	26755
	3083-JX	1,587,731	476319	254037	142896	63509	47632
Disk	3350-A02	32,030	$641	$320	$0	$0	$0
	3350-B02	25,360	507	254	0	0	0
	3370-A1	35,480	13,482	6,386	2,838	1,774	710
	3370-A2	35,480	27,674	19,159	7,806	5,322	2,484
	3370-B1	26,600	11,704	6,118	2,926	1,862	798
	3370-B2	26,600	21,546	14,896	6,650	4,522	2,660
	3375-A1	38,040	9,130	4,184	1,902	1,141	761
	3375-B1	28,770	7,768	3,740	1,726	1,151	863
	3380-AA4	88,780	33,736	15,093	7,102	3,551	1,776
	3380-B04	64,440	27,065	12,888	6,444	3,222	1,933
	3380-AD4	88,780	79,902	46,166	24,858	8,878	5,327
	3380-BD4	64,440	57,996	35,442	19,332	7,733	4,511
	3380-AE4	122,480	113,906	78,387	44,093	22,046	13,473
	3380-BE4	98,140	91,270	66,735	38,275	23,554	14,721
Tape	3420-004	17,545	2,456	1,053	526	351	175
	3420-005	18,870	377	189	0	0	0
	3420-006	20,125	3,623	2,013	1,006	604	403
	3420-007	21,625	1,730	1,081	433	216	0
	3420-008	22,085	4,859	2,871	1,546	883	663
	3422-A1	36,800	37,904	31,280	26,864	21,344	14,720
	3422-B1	17,900	18,437	15,752	13,425	11,098	8,055
	3480-A22	65,430	57,578	52,344	47,110	39,258	28,789
	3480-B22	43,120	37,946	35,358	32,340	27,166	19,835
Printer	3203-5	33,875	2,033	1,016	678	339	339
	3800-001	215,000	64,500	47,300	32,250	21,500	15,050
	3800-003	330,750	214,988	188,528	165,375	142,223	115,763

EXHIBIT III-5

RANGE OF PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE

VENDOR	PROCESSOR MODEL		1987	1988	1989	1990	1991
IBM	4331-J2	High	17%	11%	8%	5%	4%
		Expected	14%	8%	5%	3%	2%
		Low	8%	3%	2%	1%	--
	4341-L1	High	7%	4%	3%	3%	1%
		Expected	4%	2%	1%	1%	--
		Low	2%	1%	--	--	--
	4341-L12	High	10%	7%	4%	2%	2%
		Expected	7%	4%	2%	1%	1%
		Low	4%	2%	--	--	--
	4361-K3	High	39%	24%	15%	10%	7%
		Expected	34%	18%	10%	4%	2%
		Low	25%	12%	6%	2%	--
	4361-K5	High	32%	20%	12%	7%	4%
		Expected	28%	15%	8%	3%	1%
		Low	22%	10%	3%	1%	--
	4381-L2	High	66%	60%	45%	30%	15%
		Expected	60%	51%	38%	21%	9%
		Low	56%	40%	25%	14%	4%
	4381-M3	High	67%	62%	48%	31%	15%
		Expected	62%	54%	40%	25%	10%
		Low	54%	42%	26%	15%	5%
	4381-L11	High	93%	85%	72%	50%	27%
		Expected	90%	80%	66%	38%	20%
		Low	85%	68%	48%	18%	6%
	4381-M12	High	92%	84%	70%	48%	23%
		Expected	88%	77%	63%	35%	18%
		Low	82%	65%	45%	15%	4%
	4381-13	High	90%	80%	66%	45%	20%
		Expected	85%	73%	60%	31%	15%
		Low	80%	63%	41%	12%	3%
	4381-14	High	85%	77%	63%	42%	18%
		Expected	82%	70%	55%	27%	11%
		Low	77%	58%	35%	8%	2%
	3083-CX	High	18%	12%	8%	5%	3%
		Expected	15%	8%	3%	1%	1%
		Low	7%	3%	1%	--	--
	3083-EX	High	15%	10%	7%	4%	3%
		Expected	13%	6%	2%	1%	1%
		Low	6%	3%	1%	--	--
	3083-BX	High	28%	18%	12%	7%	4%
		Expected	25%	14%	6%	3%	2%
		Low	15%	5%	2%	1%	--
	3083-JX	High	35%	20%	14%	9%	5%
		Expected	30%	16%	9%	4%	3%
		Low	18%	8%	4%	2%	1%

EXHIBIT III-5 (Cont.)

RANGE OF PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE

EQUIPMENT TYPE	MODEL NUMBER		1987	1988	1989	1990	1991
Disk	3350-A02	High	4%	2%	1%	--	--
		Expected	2%	1%	--	--	--
		Low	1%	--	--	--	--
	3350-B02	High	4%	2%	1%	--	--
		Expected	2%	1%	--	--	--
		Low	1%	--	--	--	--
	3370-A1	High	43%	28%	15%	10%	6%
		Expected	38%	18%	8%	5%	2%
		Low	35%	10%	5%	2%	--
	3370-A2	High	82%	60%	30%	22%	15%
		Expected	78%	54%	22%	15%	7%
		Low	70%	45%	15%	8%	3%
	3370-B1	High	48%	30%	17%	12%	7%
		Expected	44%	23%	11%	7%	3%
		Low	38%	12%	5%	2%	--
	3370-B2	High	85%	63%	35%	25%	17%
		Expected	81%	56%	25%	17%	10%
		Low	74%	48%	16%	10%	5%
	3375-A1	High	28%	16%	10%	8%	5%
		Expected	24%	11%	5%	3%	2%
		Low	20%	5%	2%	1%	--
	3375-B1	High	30%	19%	12%	10%	7%
		Expected	27%	13%	6%	4%	3%
		Low	21%	8%	4%	2%	--
	3380-AA4	High	43%	25%	15%	9%	6%
		Expected	38%	17%	8%	4%	2%
		Low	35%	11%	3%	1%	--
	3380-B04	High	45%	30%	18%	13%	8%
		Expected	42%	20%	10%	5%	3%
		Low	37%	14%	5%	2%	--
	3380-AD4	High	92%	62%	40%	18%	11%
		Expected	90%	52%	28%	10%	6%
		Low	87%	40%	15%	6%	2%
	3380-BD4	High	93%	66%	45%	20%	12%
		Expected	90%	55%	30%	12%	7%
		Low	88%	42%	19%	6%	3%
	3380-AE4	High	95%	73%	50%	27%	16%
		Expected	93%	64%	36%	18%	11%
		Low	88%	45%	25%	10%	4%
	3380-BE4	High	95%	80%	55%	30%	19%
		Expected	93%	68%	39%	24%	15%
		Low	89%	48%	28%	12%	7%

RANGE OF PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE

EQUIPMENT TYPE	MODEL NUMBER		1987	1988	1989	1990	1991
Tape	3420-004	High	16%	9%	6%	4%	2%
		Expected	14%	6%	3%	2%	1%
		Low	10%	3%	1%	--	--
	3420-005	High	5%	3%	2%	1%	1%
		Expected	2%	1%	--	--	--
		Low	1%	--	--	--	--
	3420-006	High	22%	14%	8%	5%	3%
		Expected	18%	10%	5%	3%	2%
		Low	15%	6%	3%	1%	--
	3420-007	High	10%	7%	5%	3%	1%
		Expected	8%	5%	2%	1%	--
		Low	5%	3%	1%	--	--
	3420-008	High	25%	17%	12%	7%	5%
		Expected	22%	13%	7%	4%	3%
		Low	19%	8%	3%	1%	--
	3422-A1	High	110%	90%	80%	65%	48%
		Expected	103%	85%	73%	58%	40%
		Low	90%	77%	60%	45%	20%
	3422-B1	High	110%	92%	83%	70%	55%
		Expected	103%	88%	75%	62%	45%
		Low	93%	80%	65%	50%	26%
	3480-A22	High	90%	85%	78%	65%	50%
		Expected	88%	80%	72%	60%	44%
		Low	80%	70%	60%	45%	25%
	3480-B22	High	92%	88%	81%	68%	55%
		Expected	88%	82%	75%	63%	46%
		Low	83%	72%	64%	50%	30%
Printer	3203-5	High	8%	5%	4%	3%	2%
		Expected	6%	3%	2%	1%	1%
		Low	4%	2%	1%	--	--
	3800-001	High	36%	30%	24%	18%	12%
		Expected	30%	22%	15%	10%	7%
		Low	25%	15%	8%	3%	1%
	3800-003	High	68%	63%	55%	48%	41%
		Expected	65%	57%	50%	43%	35%
		Low	58%	48%	35%	20%	8%

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