Large-Scale Systems Directions 1985

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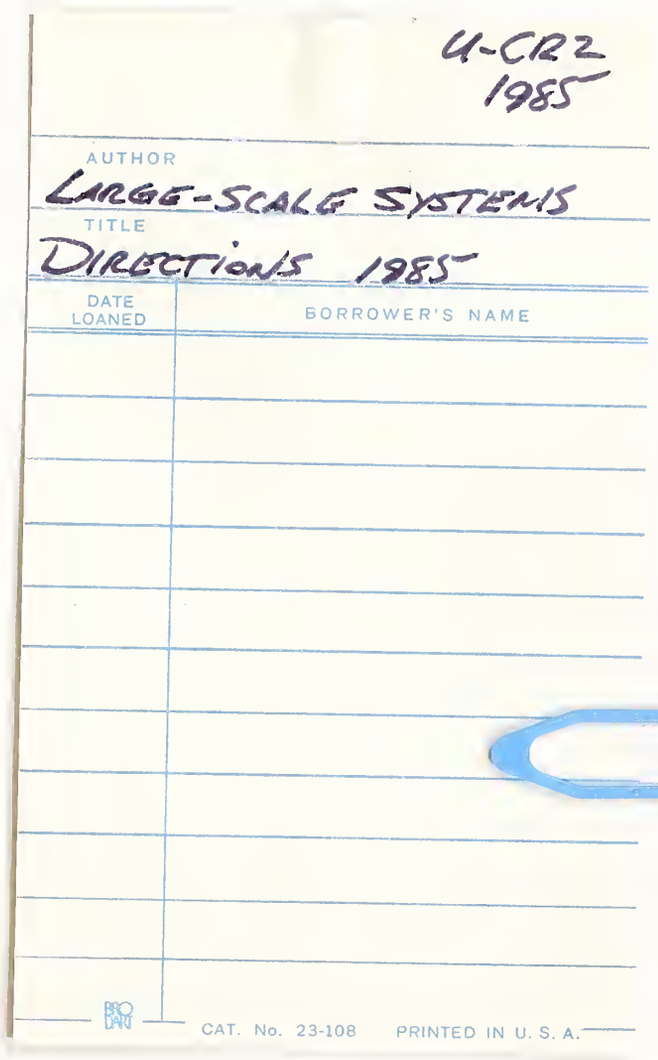
LARGE-SCALE SYSTEMS DIRECTIONS
1985



LARGE-SCALE SYSTEMS DIRECTIONS
1985

ABSTRACT

This Large-Scale Systems Directions report includes a general technical and strategic analysis of the IBM 3090 processors (Sierra) which were announced in the first quarter of this year. This mid-year update also contains charts of projected residual values of IBM and software compatible mainframes which reflect the used market impact of that announcement and the subsequent improved delivery schedules for the IBM 3090-200. In addition, projected residual values of IBM 3380 disk drives have been revised based on improved delivery schedules of the new extended capacity drives.

This report contains 73 pages, including 41 exhibits.

LARGE-SCALE SYSTEMS DIRECTIONS
1985

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LARGE-SCALE SYSTEMS DIRECTIONS
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EXHIBITS

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I INTRODUCTION

- INPUT has been forecasting detailed residual values for IBM software-compatible mainframes since 1977 and for selected peripheral products since 1979. The emphasis has always been on analysis and anticipation of significant product development and pricing strategies, rather than on the mere reporting of used-market values. This emphasis was formally recognized in 1984 with the incorporation of the residual value forecasts into the Large-Scale Systems Directions program.

- The first report of the 1985 program, Large-Scale Systems Directions: Disks, Tapes, and Printers, was published following a quarter of major IBM product announcements in the large-scale systems area. Both the 3380 extended capability and 3090 (Sierra) were announced, and INPUT analyzed IBM's large-scale systems strategy for the remainder of the 1980s in that report.

- The second quarter of 1985 has been noteworthy primarily because of IBM's announcements of lower than anticipated earnings, and its tactical adjustments to these results. One of these adjustments was the general lowering of prices after our residual forecasts had been completed, and another was improved delivery schedules on the 3380 extended capacity and 3090-200. Both of these adjustments have been incorporated in INPUT's residual value forecasts.

- Chapter II of this report contains a strategic analysis of the IBM 3090 Processor Complex within the perspective which INPUT has established in its

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Large-Scale Systems Directions program. While 3090 analysis in this report is self-contained, general familiarity with previous reports in the program is extremely helpful.

- Chapter III presents a set of updated residual value forecasts for the IBM and software-compatible mainframes which INPUT tracks. In addition, the residual value forecast for the current 3380 disk drive has been updated based on improved delivery schedules of the 3380 extended capability and recent price adjustments.

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II THE HIGH SIERRA

- On February 12, 1985, IBM announced "a number of significant enhancements for its large systems and interactive computing environments." Among those enhancements were two high-end processor models of the long awaited Sierra series. The immediate reaction among analysts and potential customers was, to put it mildly, restrained, and competitors had little difficulty with their own high-end processor announcements. It was obvious that IBM had selected the easier, softer way on the trail to the Summit (the long rumored follow-on series to Sierra).

- The more reasoned secondary reaction to the Sierra announcement has been as follows:

  - Analysts have started rationalizing their past published predictions on Sierra and adjusting their Summit predictions to reflect the February 12 announcements.

  - Most customers with purchased 308X series equipment installed have a warm, comfortable feeling now that IBM has "protected their investment."

  - The leading edge customers, who have rapidly expanding central data bases which are already pushing the processing power of their 3084 hosts, have the uneasy feeling that they have been selected to blaze some new trails through unexplored territory on the outer limits of SNA and distributed data bases.

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- INPUT believes the February 12 announcement provides a remarkably clear indication of IBM's large-scale systems strategic direction for the remainder of the 1980s. It is our opinion that this is a critical period during which the role of large-scale, general purpose processors will shift from being the driving force in the systems hierarchy to being the limiting force. This has been the theme of INPUT's Large-Scale Systems Directions reports for the last year, and Sierra appears to leave little room for miscalculations on either your part or on the part of IBM.

A. THE HARDWARE

1. GENERAL PRICE-PERFORMANCE CHARACTERISTICS

- Since IBM announced System/360 in 1964, the concept of a compatible line of general purpose mainframes which can be used for both commercial data processing and scientific/engineering computation has dominated IBM's larger processor strategy. This strategy has been substantially more effective in the commercial data processing market than it has among the scientific/engineering community, where the true cost of computation is more easily measurable and apparent. The rich instruction set necessary to support the IBM mainframe strategy has added cost and resulted in price-performance which is not competitive against minicomputers (or supercomputers) for heavy computation. The recent attention being given to reduced instruction set computers (RISC) is acknowledgement that being all things to all people can be expensive.

- Nevertheless, the improved price-performance of the high-end of the IBM general purpose processor line has been impressive, and the 3090 models 200 and 400 (Sierra) follow a relatively predictable pattern, as shown in Exhibit II-1.

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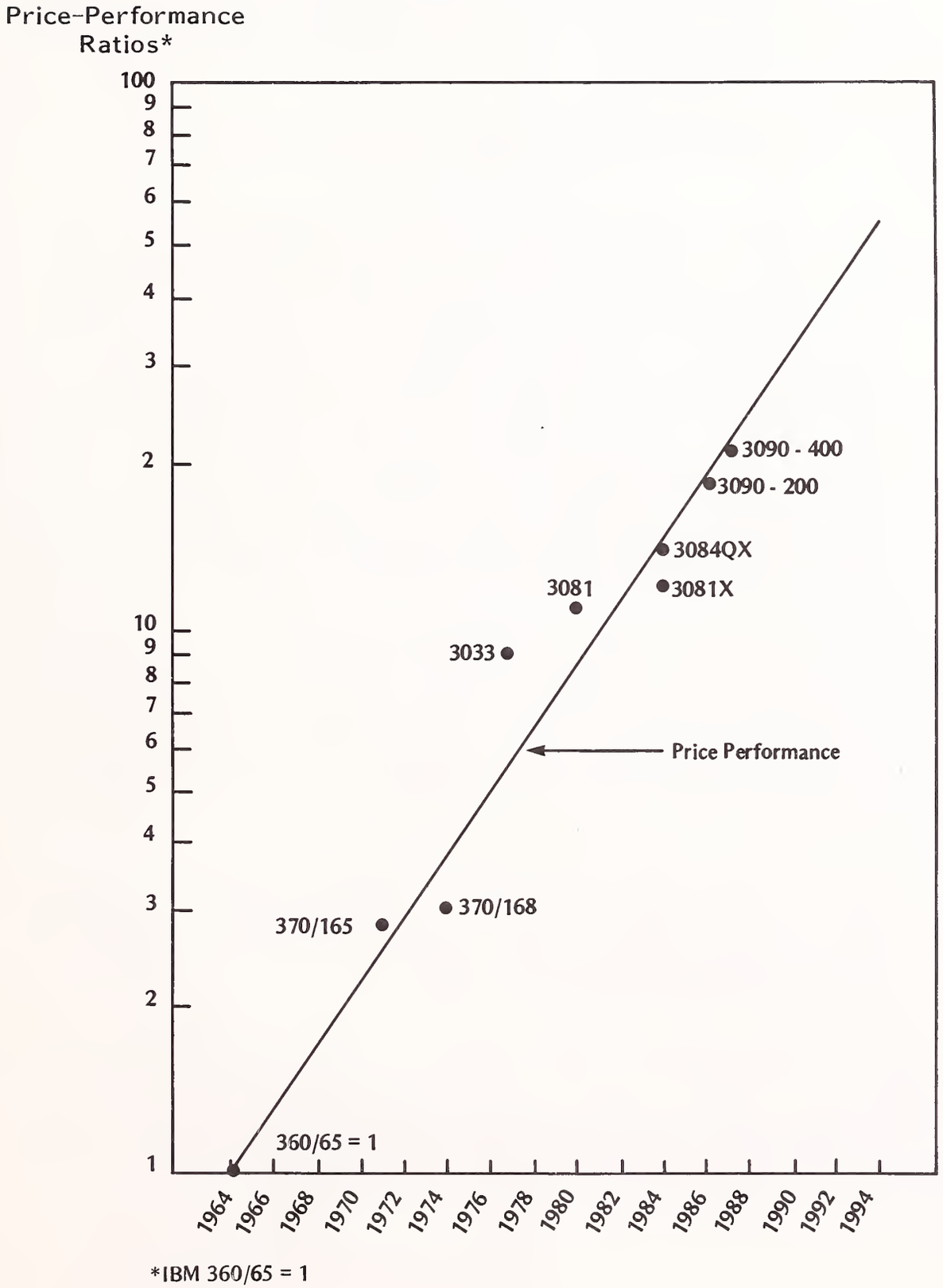
EXHIBIT II-1

PRICE-PERFORMANCE RATIOS OF IBM LARGE-SCALE MAINFRAMES

(1964 - Present)



*IBM 360/65 = 1

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- Only two major architectural changes have occurred in IBM large-scale mainframes since 1964:

  . The 370/168 added virtual storage capability in 1974, and the price-performance plotted from that point on assumes use of that facility.

  . The 3081 incorporated dyadic processors in 1980.

- The 3084QX and 3090-400 are plotted to demonstrate their price-performance as high end processors, but multiprocessing (MP) versions of high-end processors were available going back to the 360/65. However, the MP versions had lower price-performance than the uniprocessors they were based upon because they normally obtained less than 1.7 times the uniprocessor performance (with 1.5 times reported on some versions). The 3084QX has been reported to fall within the published range of 1.7 to 1.9 times the 3081, and it is assumed the 3090-400 will meet its published performance objectives.

- The IBM extended architecture (XA) has been hailed as a major architectural change by some of its developers, but there are also computer architects who consider it to be an "extended accommodation" of a fundamental 360 architectural weakness in terms of addressing capability.

- While the availability of expanded storage on the 3090 processors is being billed as a "new storage hierarchy," it is optional and does not represent a major architectural change.

- Internal processor performance is a function of architecture and technology, but pricing is a function of both cost and IBM business strategy. Plotting internal performance against price-performance gives some insight into IBM's past and current business strategy, as shown in Exhibit II-2.

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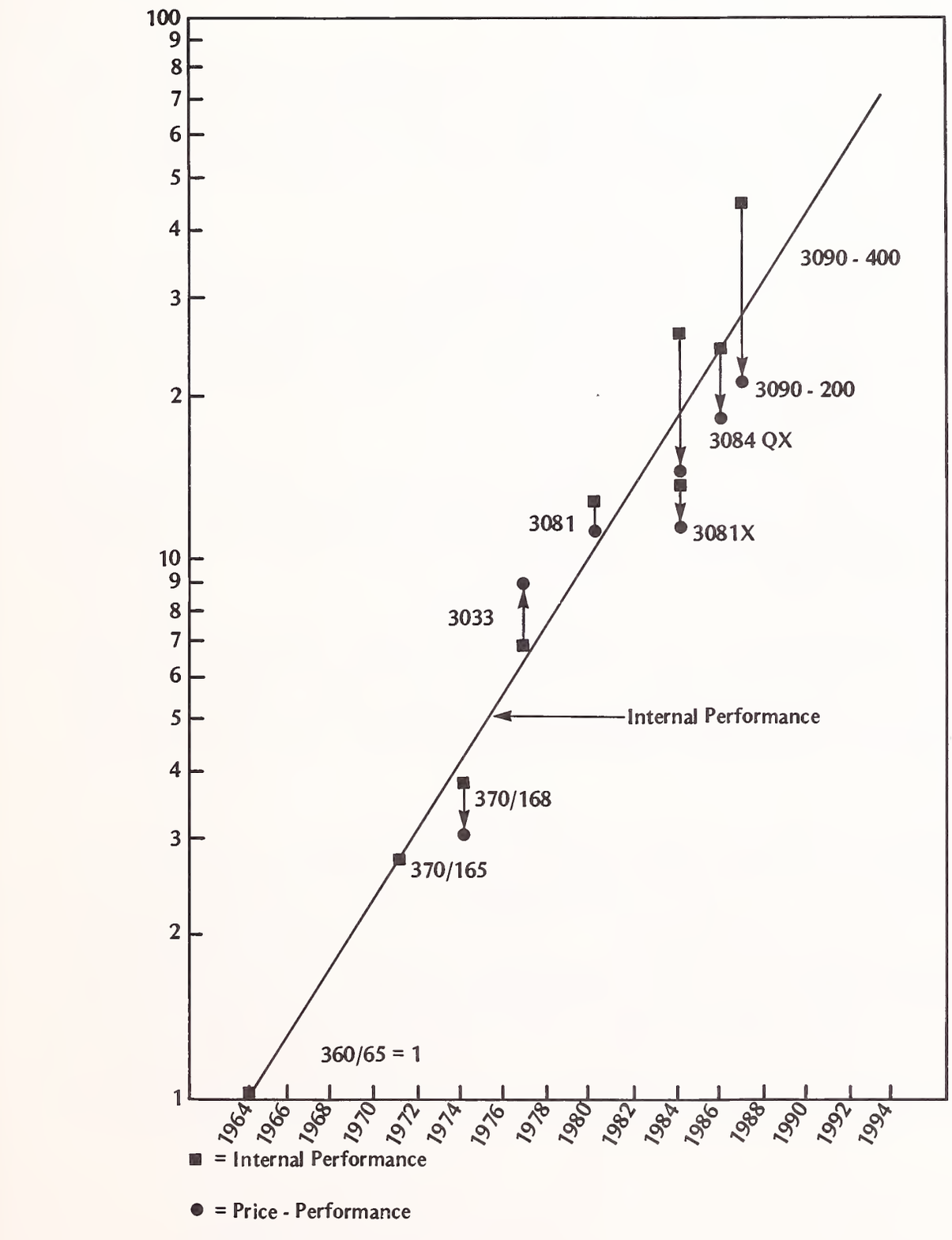
EXHIBIT II-2

INTERNAL PERFORMANCE RATIOS AND PRICE-PERFORMANCE

(1964 - Present)



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- As a general statement, it can be said that price-performance does not improve as rapidly as internal performance. However, the 370/165 did provide the full benefit of the improved internal performance, and the 3033 was obviously priced extremely aggressively. The reason in both cases was competitive.

  . The 370/165 was rushed to the marketplace before VS was available because large IBM users were running out of power on the 360/65 and competitive mainframe alternatives were available.

  . The 3033 was a reaction to Amdahl and the initial threat of plug-compatible mainframes. It had the unexpected effect of demonstrating to IBM that there is elasticity in the large mainframe market.

- The initial pricing of the 3090-200 is obviously high since the spread between performance and price-performance is greater than it was on the 3081 at the time of announcement.

- The 3084 and 3090-400 quadradic processor models demonstrate clearly that coupling processors in the traditional (MP) fashion increases internal performance substantially more than it does price-performance.

- The internal performance and price-performance on the 3090 are indicative of IBM's firm hold on the large-scale mainframe market. The challenge of the PCMs in the late 1970s has been met and the late 1980s belong to IBM. Exhibits II-1 and II-2 plot the 3090-200 and 3090-400 on their approximate availability dates of fourth quarter 1985 and second quarter 1987, respectively. The technology which will obviously be employed through the 1980's is proven Thermal Conductive Module (TCM) packaging and Emitter Coupled

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Logic (ECL) with highly overlapped design to achieve higher performance than in the past. In other words, 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.

2. PROCESSOR CHARACTERISTICS

- Exhibit II-3 summarizes the specific characteristics of the 3090 Processor Units, models 200 and 400, and the general characteristic shared by the 3090 Processor Complex. The specific characteristics of the two processor models are self-explanatory except for MIPS, which are merely extrapolations of IBM- announced performance improvement relative to the 3081KX. The more significant general characteristics of the 3090 Processor Complex require some comments and explanations.

  - The optional Expanded Storage is an electronics addition to the storage hierarchy which is designed to improve performance by reducing paging and swapping load to channel-attached paging devices. Data is not transfered directly from I/O devices to the expanded storage, but must pass through central storage under software control. Transfers between central storage and expanded storage are made by moving 4kb pages back and forth synchronously with processor operations.

    . Purchase price for 64 Mb is $475,000 and for 128 Mb is $830,000.

    . Expanded storage is the latest accommodation to I/O problems associated with paging and swapping which date back to early "thrashing problems."

    . The performance (and price-performance) ramifications will be discussed in a later section of this report.

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EXHIBIT II-3

SPECIFIC PROCESSOR UNIT CHARACTERISTICS
(IBM 3090, MODELS 200 AND 400)

3090 PROCESSOR UNIT	MIPS	PROCESSOR	CENTRAL STORAGE	EXPANDED STORAGE	CHANNELS
Model 200	29	Dyadic	64 Megabytes	128 Megabytes (64 Mb Increments)	32,40 or 48 Integrated Channels
Model 400	53	4-way	128 Megabytes	256 Megabytes (128 Mb Increments)	64,80 or 96 Integrated Channels

GENERAL IBM 3090 PROCESSOR COMPLEX CHARACTERISTICS

- 18.5 Nanosecond Cycle Time
- Supports Both System/370 and System/370 Extended Architecture
- Optional Expanded Storage
- Improved Performance for Preferred Mode Quests under VM/XA System Facility through the Start Interpretive Execution (SIE) Assist
- Improved Engineering/Scientific Performance
- A New Processor Controller
- Improved RAS Characteristics and Enhanced Remote Support

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- The SIE Assist is a capability which improves the performance of preferred-mode guest running under the VM/XA Systems Facility. Essentially it reduces the number of instructions VM executes in support of I/O instructions for dedicated devices attached to V=R (Virtual equals Real) guests.

  . With IBM's strategy of depending upon VM to run subordinant operating systems (such as UNIX), reduction of VM overhead (improved performance) is essential.

  . It becomes increasingly apparent that the demand for large memories is being fueled by the very systems which were originally designed to permit "large programs" to run in less real storage. V=R is the much "preferred mode" for operating systems guests running under VM.

  . The VM/XA Systems Facilities will be described under the software section of this report.

- The improved engineering/scientific performance of the 3090 processors is not reflected in either the MIP ratings or in the price-performance charts in the previous section. The significance of improved scientific engineering performance will be discussed in the performance section; it is accomplished through the following:

  . High speed multiply.

  . Faster floating-point add/subtract instructions.

  . Faster loop control execution time.

  . 64-bit wide data paths.

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- The 3092 Processor Controller has two processor elements which provide control and maintenance support for the rest of the 3090 Processor Complex (3090 Processor Unit, 3097 Power and Coolant Distribution Unit, and the 3092 Processor Controller itself). The normal mode is for one processor element to be active and the other available for backup. Essential data are recorded on required duplex 3370 disk drives and, in the event of failure (or malfunction) of the active processor or the DASD, the switchover of either processor or disk is expected to be accomplished without system interruption.

  . Additional equipment associated with the 3092 includes two 3180 Display Stations, access to a tape control unit and one IBM 3420 Magnetic Tape unit, and a 3864 modem.

  . It is obvious that the complexity of large systems requires a high degree of control sophistication, but the substitution of duplex 3370s for floppy disks for purposes of storing micro-code, diagnostics, and "vital operational data" indicates a processor controller with potential RAS problems of its own.

- RAS has been emphasized since the 370/65 was announced and each hardware iteration seems to make the same statements. The fully-duplexed Processor Controller and enhanced remote support from central maintenace facilities should help. The complexities of large hardware-software is certainly getting beyond the capabilities of the average field engineer. The technical limits of centralization of function will be discussed later in the report.

- Generally speaking, the hardware has been improved to enhance the performance of IBM-provided systems software. This is appropriate because that is where the most obvious performance problems have originated. However, there is no question that the 3090 has been directed specifically towards scientific/engineering applications where performance has traditionally been

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measured by sheer computational speed rather than by more "fuzzy" measures such as response time, turnaround, and throughput. It is an area where IBM has suffered numerous frustrations in the past.

3. PERFORMANCE CHARACTERISTICS

- Exhibit II-4 presents IBM's published performance information at the time of the February 12, 1985 large systems announcement. Having reviewed numerous IBM mainframe announcements over the years, INPUT believes that IBM has improved substantially in both the quality and quantity of published performance information. Performance measurement is complex and sensitive, and IBM is to be commended for its efforts in this regard. (The numbers in the exhibit are presented for comments only, and readers are referred to IBM announcement 185-014 for more detailed information concerning testing procedures.)

  - It should be pointed out that IBM has been very specific in stating that 3090-200 performance improvement is in throughput times for the 3081KX, and the 3090-400 performance improvement is in instruction rates times for the 3090-200. In other words, throughput rate improvement of the 3090-400 may not fall within the classic 1.7 to 1.9 times which are quoted for multiprocessing versions of basic uniprocessing and dyadic engines.

  - The confusion concerning MIPS and throughput rates becomes compounded as MIPS rates are usually published in the trade press immediately following IBM announcements. In this case, the fundamental relationship (between the 3090-200 and 3081KX) established by IBM was the "internal throughput ratio," which will not necessarily translate into increased MIPS. Past errors in this type of estimating leads to distorted numbers being brandished about.

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EXHIBIT II-4

PERFORMANCE CHARACTERISTICS
(IBM 3090 - 200 and 400 AT ANNOUNCEMENT)

IBM 3090 PROCESSOR MODEL	COMMERCIAL	ENGINEERING SCIENTIFIC	3090-200 PERFORMANCE IMPROVEMENT WITH EXPANDED STORAGE
3090-200	1.7 to 1.9 Times 3081KX Throughput	1.9 to 2.9 Times 308KX Throughput	MVS/XA TSO & TSO Batch Paging - 70-80% Average Response Time - 5-25% Trivial Response Time - 20-45% "Some Throughput Benefits" IMS Paging "Up to 100% Reduction with Virtual Fatch" Response Time - 0-30% (15% Average) "Some Throughput Benefit" VM SIO Rates to Paging DASD 78-90% Trivial Response Time - 20-52% Average Response Time - 6-21%
	MVS/XA Batch - 1.9 Interactive TSO - 1.7 IMS - 1.7 CICS - 1.7 VM/SP CMS - 1.8 370 Mode (MVS) Commercial 1.5-1.8	MVS/XA Program Development - 1.9 Data Development - 2.1 Production Job Set - 2.3-2.9 370 Mode (MVS) Program and Data Development - 1.9-2.1	
3090-400	1.7 to 1.9 Times 3090-200 Instruction Rate	1.7 to 1.9 Times 3090-200 Instruction Rate	

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- MIPS as a measure suffers from the fact that individual instructions vary substantially in their execution rates. For example, the range can be as high as 30-1 for specific implementations of the IBM 360/370 instruction set. Also, the relative performance of individual instruction varies from processor to processor; for example:

  . INPUT did benchmarks to determine Amdahl's early performance claims of the Amdahl V/6 against the IBM 370/168, and concluded that they were essentially correct.

  . An instruction-by-instruction analysis revealed that the IBM 370/168 had an extremely fast execute (EX) instruction and Amdahl's was relatively slow.

  . How important is one instruction?

  . Amdahl discovered it was quite important because extensive use is made of EX in IBM systems software, and an engineering change was later made to improve Amdahl performance of that specific instruction.

- Throughput, as a measure, suffers because of the nature of the benchmarks and the environment in which they are being run. IBM has been careful to qualify all performance estimates by stating that ratios will vary substantially depending upon customer application set and operating environment.

- Response time and paging rates may be improved substantially without noticeable improvement in throughput, and relative response time can be meaningless depending upon how bad (or good) it was to begin with.

- Therefore, it would seem important to understand more clearly what "some throughput improvement" means before spending $830,000 for

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128 Mb of expanded storage (which is what the 3090-200 with expanded storage promises).

- When addressing the engineering/scientific community, IBM is aware that MIPS and throughput improvement are not sufficient to satisfy the potential customers. A separate Engineering/Scientific Large-Systems Perspective document (Announcement 185-018) is available which is more specific in terms of the engineering/scientific performance which can be expected. The more detailed analysis supports the IBM claims of a 1.9 to 2.9 times internal throughput ratio improvement between the 3081KX and the 3090-200 when running a standard scientific job set.

  - While IBM cites an independent performance evaluation service which states its 3090 processors are the fastest scalar processors (measured by megaflop ratings), they still cannot compete with announced vector and array processors for sheer number crunching on a wide variety of scientific and engineering problems.

  - However, the 3090 models 200 and 400 do represent a doubling of price-performance over the 3081KX and 3084QX for engineering/scientific work, and it is obvious that IBM is attempting to attract workload from:

    . Those who do not have sufficient workload to warrant a supercomputer.

    . Those currently using minicomputers.

- Software has been the key to IBM's managing the greater than 20-fold increase in large-scale price-performance over the last 20 years (as depicted in Exhibit II-1). No matter how much internal performance and price-performance improve, customers are expected to upgrade and spend more money. The software announcements associated with the February 12

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announcement indicate that IBM may still be intent on being sure processing load continues to climb faster than any improvements in performance and price-performance. (This will be discussed under the section on software.

4. THE 3044 FIBER OPTIC CHANNEL EXTENDER LINK

- One reason for having more powerful processors is to support larger data bases and more direct access storage (see Large-Scale Systems Directions--Disks, Tapes and Printers, 1985). However, DASD is growing so rapidly there are physical space problems around the mainframe.

- The 3044 Fiber Optic channel extender link will permit attaching low to medium speed (up to 1.25 megabytes/second) I/O control units, switching units, and channel-to-channel interfaces to byte and block multiplexor channels at distances of up to 2 KM. The "freed-up" space close to the mainframe can thus be used for higher speed I/O devices, and the response time for "remote" users will be "near local."

- Some customers at the IBM announcement seemed to feel the 3044 was the most exciting part of the entire announcement (probably those who felt they might have to construct a new building because of space problems), and the channel extender does have tactical significance in IBM's continuing battle against minicomputers by permitting users to have high speed access to UNIX on IBM mainframes.

B. SUPPORTING SOFTWARE

- The primary software enhancements announced along with the 3090 processors were the Extended Recovery Facilities (XRF), the VM/XA Systems Facility, and IX 370 (which is IBM's implementation of UNIX). These three enhancements are significant indicators of IBM's large-scale systems software directions.

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- The Extended Recovery Facility (XRF) is an MVS/XA, SNA, and IMS/VS enhancement which "increases the availability of IMS transaction processing applications as seen by the end user with XRF-support terminals." MVS/XA, SNA, and IMS are the mainstream software systems supporting IBM's highly centralized data base strategy which consumes so much of the processing power of large-scale processors. The XRF announcement is sufficiently vague about performance impact so as to be disquieting. For example:

  . "Availability is improved by using additional resources to lessen the impact of certain events that disrupt service to the end user."

  . "Allows an installation to define an XRF environment by establishing an active subsystem environment and an alternate subsystem environment."

  . "The system resource manager (SRM) component of MVS/SP 2.1.3. Availability Enhancement has been enhanced to accelerate the acceptance of the new workload on the alternate system at takeover, based on installation performance parameters."

  . "The virtual storage requirements for this enhancement will be available prior to general availability."

  . "Performance information for the MVS/SP 2.1.3 Availability Enhancement will be available prior to general availability."

  . In other words, the cost for high systems availability has not yet been specified. It is likely to consume significant processing resources when XRF becomes available in the third quarter of 1986.

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- The VM/XA Systems Facilites is billed as a "strategic new VM product for the XA environment," and INPUT agrees that VM is key to the operating systems environment which is emerging. (See Market Impacts of IBM Software Strategies, INPUT 1984.) The improved performance through support of the Start Interpretive Execution (SIE) assist is of primary interest in this report, and IBM performance enhancement for V=R preferred guests was announced as follows:

  . ". . . MVS/XA achieved an internal throughput rate of 90-92%."

  . "MVS/370 . . . achieved an internal throughput rate of 86-88%."

  . "This represents an internal throughput rate improvement of up to 14% over that attainable on the VM/XA Migration Aid for the same workload."

  . Despite the improvement, merely running a single preferred guest reduces throughput by 10%, which means that in shifting to VM/XA-MVS/XA when going from the 3081KX to the 3090-200, throughput improvement will be reduced to 1.5 to 1.7 (from 1.7 to 1.9).

- INPUT predicted that IBM would provide UNIX for those who wanted it, and we also predicted it would be provided under VM (Market Impact of IBM Software Strategies, INPUT, 1984). However, we certainly did not anticipate all of the finer ramifications of IX/370, much less the strategic significance from IBM's point of view. If the product manager (and development team) for IX/370 doesn't get an outstanding contribution award from IBM, there is no justice. Consider the following:

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- IX/370 is based on UNIX System V, but IBM has made significant extensions to the system--in other words, IBM is going to set the UNIX standard and force AT&T Bell Laboratories to dance to its tune.

- By subordinating IX/370 to VM it is possible to run multiple IX/370 systems either as separate virtual machines or running several images of IX/370 in a single virtual machine.

- By using the connect command (developed for IBM by Interactive Systems Coporation), it is possible to do concurrent work on two IX systems, such as PC/IX and IX/370, by allowing one system to act as a terminal and active system simultaneously.

- An IBM Series/1 is required to support the IX/370 ASCII Control Feature. One or more Series/1s can be connected to each IX/370 virtual machine, but virtual machines cannot share a Series/1.

- Pricing of IX/370 is based on the maximum number of currently signed-on users (CSTVs), and the one-time charge ranges from $10,000 (for 16 CSTVs or less) up to $75,000 (for 65 plus CSTVs).

- As far as performance is concerned, IBM warns users to wait for enhanced VM support before installing IX/370, and to avoid applications and editors which interpret individual characters. When IBM issues performance warnings, everyone should listen.

- Essentially, IX/370 provides a powerful potential weapon to be used against AT&T and minicomputer competitors. It is ironic that the weapon was seized from AT&T and that IBM is employing its own minicomputer (Series/1) as a terminal controller in the battles.

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- Other software enhancements included in the IBM large systems announcement are as follows:

  - A VS FORTRAN Program Multitasking Facility permits a single FORTRAN application to "simultaneously use all of the engines of a multi-engine processor" resulting in improved turnaround and throughput for "large, processor-bound jobs."

  - A new release of IBM/VS Version 2 which supports XRF and provides higher application program data availability and improved data sharing.

  - New releases of MVS/XA which provide support for XRF, improved RAS, and enhancements to JES-2 and JES-3.

  - VM/Entry which is a "lower-priced VM alternative for small and intermediate customers" and is in keeping with IBM's VM-oriented strategy.

C. STRATEGIC DIRECTIONS

1. THE LARGE HOST SOFTWARE ENVIRONMENT

- Exhibit II-5 presents a general schematic of the emerging large IBM host software environment. The primary emphasis remains upon highly centralized host control.

- The emphasis upon VM as a tool for integrating diverse operating environments was inevitable, and it was a wise choice. Originally designed to integrate various operating systems running on virtual machines so that systems programmers could each have their own versions on a central development system, VM is now being employed for multiple purposes.

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EXHIBIT II-5

THE HOST SOFTWARE ENVIRONMENT

Centralization on Large Mainframes

<table>
<tr><td colspan="4">VM/XA</td></tr>
<tr><td colspan="4">Integration of
1. Commercial and Engineering/Scientific
2. Interactive and Batch
3. Operating Systems</td></tr>
<tr><td colspan="3">MVS/XA</td><td>Commercial
CMS</td></tr>
<tr><td colspan="3">1. Data Base Systems Integration
2. Batch Scheduling and Control
3. "Distributed" Data Base Management
a. Synchronization and Integration
b. Security
c. Extracts, File Sharing
d. Back-up and Archival
4. TSO (Interactive)</td><td>1. Interactive
2. Program Development</td></tr>
<tr><td colspan="3">DIFFERENTIATION OF DBMS</td><td>IX/370</td></tr>
<tr><td>IMS</td><td>DB2</td><td>Other</td><td>Engineering/
Scientific</td></tr>
<tr><td>1. Transaction Processing
2. Operational Data Bases</td><td>1. Queries
2. Ad Hoc Reporting
3. Planning Data Bases
4. Relational</td><td>1. Sequential
2. VSAM
3. BDAM
4. "Image Bases"</td><td>1. Interactive
2. Program Development
3. Integration and Replacement of Minicomputers</td></tr>
</table>

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- Migration from one operating system to another (such as MVS/370 to MVS/XA).

- Integration of the big commercial "data base machine" (MVS/XA) with engineering/scientific processing (IX/370).

- Defining and integrating batch and interactive processing where MVS/XA is recognized as having evolved out of the batch-oriented operating systems for System/360 and both CMS and UNIX (IX/370) started with an interactive orientation.

- The role of MVS/XA as a big data base machine has been detailed in INPUT's past Large-Scale Systems Directions reports. It is important to recognize that MVS/XA not only serves as an integration tool but also facilitates differentiation.

  - The batch scheduling role of MVS/XA (or any such operating system) permits the integration (and balancing) of commercial work (with heavy I/O requirements) with engineering/scientific work (with heavy computational requirements). Regardless of past difficulties, IBM has had more experience than any other vendor with the mixed batch environment, and that is where the big central data base machines are headed. Complex algorithms are required for analysis of large data bases (even for data reduction) and processing power is definitely a requirement as knowledge bases are developed.

  - The integration of data base systems and data models became an obvious IBM strategy at the time DB2 for mainframes was announced (cite UCLS-2). As pointed out in the last Large-Scale Systems Directions report: When data bases grow in size, processing requirements to avoid chaos increase even more rapidly and major problems begin to surface.

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  - Data base synchronization and integrity.

  - Security and privacy.

  - Complex file sharing.

  - Back-up and archiving.

- Centralization and integration are of fundamental importance in such an environment and MVS/XA is IBM's preferred vehicle for those purposes. However, performance is going to require the distribution of data bases. This distribution may be either through distribution to lower levels in the SNA hierarchy or by distribution to host back-end processors (intelligent controllers or back-end data base machines). Such distribution results in centrally controlled differentiation of data bases used for specialized purposes.

- Under MVS/XA, IBM has already established a rough differentiation between its two main DBMS offerings. IMS has been designated as the primary DBMS for transaction processing against large operational data bases, and DB2 has been recommended for use in planning systems where the flexibility and ease of use associated with the relational data model make it suitable for queries and ad hoc reporting. Additional differentiation will be necessary for the following:

  - On-line electronic filing of documents on optical disks has already led one vendor (File Net) to refer to "image-base management," and the problems of handling images do not lend themselves to conventional data management systems.

  - The developers of expert systems and/or knowledge bases require fine differentiation of data and information handling due to the integration of decision and inference rules (programs) with knowledge (including data and information).

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- VM/CMS was developed outside of the IBM mainstream, but it was designed for an interactive environment and managed to survive the internal wars for decades. Along with TSO (not shown, but buried under MVS), it will remain an IBM preferred solution for interactive computing and program development in the commercial environment.

- However, for those who want it (particularly in the engineering/scientific communities), UNIX is now available in the form of IX/370. While we have all heard so much about UNIX extending from desk top to mainframe and its wonderful portability, be reminded that attempts to make UNIX a full-function operating system with "MVS-type" capability will only ruin it. IBM has selected a more pragmatic approach--it will use IX/370 in another attempt to stamp out those pesky minicomputers.

2. IBM's DISTRIBUTED PROCESSING STRATEGY AND UNIX

- INPUT has argued that IBM's SNA-oriented, distributed data processing strategy will result in mainframes being used as enormous central data base machines which may exceed the processing power of the engines available to drive them. The announcement of the IBM 3090 has done nothing to allay that fear, but at the risk of appearing to be alarmists, we will only mention briefly that data and information entropy appear to be real problems of a non-trivial nature.

- IBM is either unaware of these problems, ignoring them, or has a solution of which the rest of us are unaware. It is INPUT's opinion that it is probably a combination of all three, but the general tenor of the large-scale systems enhancement announcement and the probable tactical approach to attracting engineering/scientific (and other minicomputer) workload to larger hosts would only seem to exacerbate any performance problems which do exist.

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- For a number of years, INPUT has propounded a "proper" hierarchical network, with processing distributed to economically appropriate levels. Periodically, we have published IBM's alternative solutions. A functional summary of some of the hierarchies is included in Exhibit II-6.

  - With minor modifications, the proper network of 1971 remains proper today.

  - SNA, when it was announced in 1974, retained virtually all processing at the large central mainframe. This heavy host orientation remains to this day.

  - Over the years, Level II minicomputers have gained increased acceptance for distributed processing, and SNA has been designed quite specifically to exclude them from their proper place in the hierarchy.

  - In 1983, IBM announced a variety of alternatives to minicomputers. (See Residual Value Forecasts for Large-Scale Systems, December 1983.)

    . The 4361 and 4381 with improved processing power (especially for engineering/scientific processing) and price-performance.

    . The XT370, 3270PC, and improved 8100s all providing improved processing capability.

  - However, the burden of IBM systems software remained, and UNIX on minicomputers was being actively promoted as being portable for micro to mainframe. The 4361 which was specifically targeted against minicomputers being used for engineering/scientific processing was at a distinct disadvantage.

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EXHIBIT II-6

PROCESSING HIERARCHIES (FUNCTIONS)

LEVEL	INPUT PROPER HIERARCHY (1971)	ORIGINAL SNA (1974)	IBM HIERARCHY (1983)
	LARGE MAINFRAME	LARGE MAINFRAME	LARGE MAINFRAME
	1. Heavy Computation 2. Transaction Processing (Large Data Bases) 3. RJE Replacement of Standalone Batch	1. Heavy Computation 2. Transaction Processing (A1 Data Bases) 3. Timesharing 4. Program Development and Maintenance 5. Collection and Editing of Data 6. Network Control	1. Heavy Computation 2. Transaction Process (Control Data Bases) 3. Timesharing 4. Program Development and Maintenance 5. Network Control
II	MINICOMPUTERS	3705 CONTROLLER	3725 CONTROLLER
	1. Network Control 2. Scientific Timesharing 3. Program Development and Maintenance 4. Simple Transactions Processing	1.Some Network Control	1. Some Network Control MIDRANGE 43XX 2. Local DBMS 3. Replacement of Minicomputers
III	INTELLIGENT TERMINALS	3790 CONTROLLER	SERIES 1, 8100's AND PC-ORIENTED INTELLIGENT WORKSTATIONS
	1. Collection, Editing, and Display of Data 2. Terminal Control	1. Terminal Control	1. Transaction Processing Personal Data Bases 2. Some Program Development 3. Collection, Editing, and Display of Data 4. Terminal Control
IV	TERMINALS	TERMINALS	TERMINALS
	1. Data Entry and Display 2. Sensing and Control Devices	1. Data Entry and Display 2. Sensing and Control Devices	1. Data Entry and Display 2. Sensing and Control Devices

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- The large-scale systems announcement of IX/370 and the IBM 3044 Fiber Optic Channel Extender Link offers yet another alternative to Level II minicomputers. It is INPUT's opinion that replacement of minicomputers running UNIX will be recommended as cost justification for upgrading large host systems. It is a natural follow-on to the old strategy of using outside timesharing expenses to upgrade to a System 370 using TSO. However, this time it is even more appealing (see Exhibit II-7). The scenario goes something like this:

  - The central I/S facility with a large IBM mainframe, and VM and IX/370 installed, can now "reach out and touch someone," and that someone is the user department with a minicomputer running UNIX. If the minicomputer is located within a mile (2 Km or 6,600 feet), it is possible to touch them directly with the IBM 3044; otherwise, a communications carrier may be required.

  - The argument goes something like this:

    . The user currently is spending (or intends to spend) X number of dollars on a big minicomputer.

    . They can have "unlimited" processing power at a cheaper cost (they only pay for what they use) by using IX/370 on a mainframe.

    . The Y dollars saved can be used to finance an upgrade from the current 3081KX to the 3090-200, or from the 3084QX to the 3090-400 when it becomes available.

  - For those users who like to think they have control over their own hardware, the "virtual distributed processing" systems is an ideal solution.

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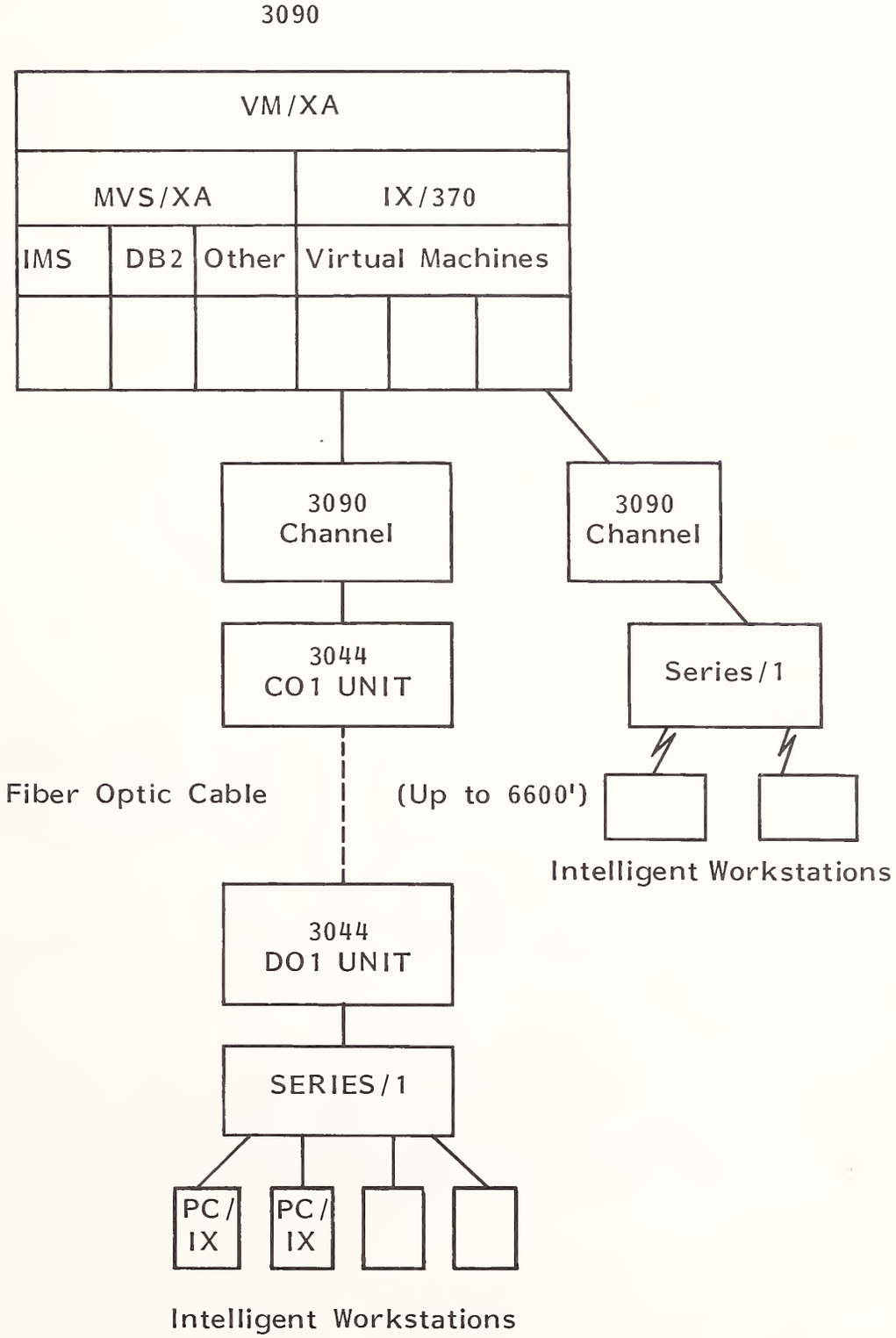
EXHIBIT II-7

VIRTUAL DISTRIBUTED PROCESSING



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- First of all, they will have their own minicomputer installed (the Series/I necessary to support ASCII terminals).

- In addition, they can have their own dedicated virtual machine running IX/370, tailored to their own requirements (number of current on-line users).

- Then the individual user can run PC/IX and IX/370 simultaneously.

- It appears to be the best of all possible worlds for both IS management and the end users, and technically it makes some sense. There are only two problems:

  - What will the true cost be?

  - Can the big general-purpose engines drive the IBM systems software being heaped upon them?

3. INPUT'S CONCLUSIONS

- INPUT does not believe that large central processors of general purpose architecture and rich instruction sets can ever be as cost effective as more specialized processors--whether they be minicomputers, supercomputers, back-end data base machines, RISC's, or microprocessors. Differentiation and mechanization of processing is inevitable; in other words, both architectural and geographic distribution of processing is going to be required.

- INPUT continues to believe that there is high potential for unpleasant performance surprises in the large host environment depicted in Exhibit II-5, and that distribution of large central data bases will be required in order to solve the potential problems of data and information entropy.

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- IBM's current software strategy of centralization and integration may exceed the power of the host processors, forcing some type of data base distribution. Solution of the problems associated with distributed data bases will require customer and other vendor involvement.

- There are currently unsolved technical problems associated with distributed data bases which do not lend themselves to simple general purpose solutions. IBM is aware of the problems and can make a good argument that central control of data bases is more important than it has ever been. (In other words, the SNA emphasis upon centralization can be justified.)

- IBM is confronted with integration problems in both software (UNIX, for example) and hardware (mini- and micro-based office automating equipment) which are unprecedented because of technological advances, and they must retain their current strategic direction.

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III RESIDUAL VALUE FORECASTS

A. LARGE-SCALE SYSTEMS ANNOUNCEMENTS

- After the major product announcements by IBM in the first quarter of 1985, and customary reactions by competitors, which were reported in Large-Scale Systems Directions: Disks, Tapes, and Printers earlier this year, it is not surprising that there have not been any major large-scale systems product announcements during the second quarter. However, the impact of the earlier product announcements was obviously not foreseen even by IBM which is in the best position to forecast such an impact.

- The major industry announcements during the second quarter involved IBM's financial results, specifically:

  - IBM's first quarter net income fell 18% to $986 million on revenue which was comparable to that in 1984 ($9.77 billion).

  - On June 12, 1985, IBM announced that it is unlikely to post "solid growth" in revenue and profit for the year and, in fact, would have to have an especially strong fourth quarter to show any profit increase at all, despite projected total revenue of over $50 billion (up from $45.9 billion).

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- Then, in July, it was announced that second quarter earnings dropped 13% to $1.41 billion on revenue of $11.43 billion (up 2.1%).

- IBM demonstrated that its computerized administrative systems permit it to have great flexibility in its response to deviations from its plan. INPUT has previously commented on IBM's ability to adjust prices, and on June 18, 1985, IBM reduced prices on a broad range of computer systems.

  - The reductions ranged from 4.1% (3083, CX8) to 8.6% (3083, EX8) on the processor models covered in this report, and covered processors from the 4361 through the 3084.

  - These reductions represent an effort by IBM to stimulate sales of the 308XX systems which are highly profitable for IBM even at the reduced prices.

  - In addition, IBM has announced improved delivery schedules (September/October 1985) for both the 3380 extended capacity disk systems and 3090 model 200 processors which were announced in the first quarter.

- These changes are reflected in the residual value forecasts contained in this report.

B. USED MARKET ACTIVITY

- In announcing IBM's revised 1985 financial results, it was stated that orders for "office, computer, and accounting equipment" plunged 30% from March to April. It is INPUT's opinion that this is more a result of IBM's first quarter product announcements than the general economic situation.

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- Large users recognized that substantial investment in new large-scale processors and disk storage systems would be required over the next two years.

- The obvious pressure on mid-range minicomputers from IBM's strategy (including the UNIX announcements) as described in Chapter II of this report, created even more uncertainty concerning distributed processing. The major questions of departmental processors, local area networks, and micro-mainframe links remain unanswered.

- INPUT has often stated that uncertainty in the marketplace benefits only IBM, but assuming customers are willing to accept IBM's large host strategy (and we feel they are), the question of how processing will eventually be distributed from these hosts is entirely unclear. Even within the IBM product line there is confusion. What systems should be tied into a large host data base machine--a 43XX, System 36, System 38, 8100, Series I (or successor), PC AT (or successor), PC-based intelligent workstation, or all of the above? Customers just don't know what to do about a large array of products between large mainframes and PCs.

- Combine this with the uncertainty surrounding the 308XX models below the 3084QX, and it is understandable that customers are "sitting tight." It is little wonder that IBM order rates for existing mainframe and intermediate-size computers is lagging.

- And if IBM is suffering from the confusion in the processing hierarchy, competitors are in real trouble.

- Despite the problems outlined above, or perhaps because of them, used market prices for the processors covered in this report held up quite well until June, when there was a noticeble softening in the 3083 E and Bs.

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- It is INPUT's opinion that IBM is correct in downplaying the possiblility that there is any fundamental change in the computer industry's long-term outlook. We also believe that IBM can and will do more to get the industry back on a "proper" growth curve than any external factors, including fluctuations in the economy. In other words, INPUT believes there is potential for growth in the industry independent of normal cycles in the economy, and we believe the industry depends upon IBM for growth rather than vice versa.

- To ignore IBM's dominant role in all aspects of the computer industry (including residual values in the used market) is to be naive, to anoint IBM with infallability or altruism is dangerous, and to recognize IBM as a significant factor in the national economy is necessary. To be quite blunt, both the health of the computer industry and that of the American economy are heavily dependent upon IBM's success or failure.

- The purpose of Large-Scale Systems Directions program is to provide insight into major technological trends and IBM's strategy so that investment in computer systems will be reasonably well protected. As a direct result of these analyses, it is hoped that user investments will give some direction to IBM, and competitors will find windows of opportunity which are complementary and supplementary to IBM's strategy.

C. PROJECTED USED MARKET PRICES AND RESIDUAL VALUES

- Exhibit III-1 presents actual and short-term used market values for selected IBM mainframes.

- Exhibits III-2 and III-3 present projected used market retail values in dollars and projected residual values as a percent of vendor list price for selected IBM and software compatible mainframes.

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EXHIBIT III-1

ACTUAL AND SHORT-TERM USED MARKET RETAIL PRICES
(SELECTED IBM MAINFRAMES)

MODEL	USED MARKET RETAIL VALUE (Percent of IBM List Price at that Date)							
	1984				1985			
	JAN.	APR.	JUL.	OCT.	JAN.	APR.	JUL.*	OCT.*
4331-J02	67%	60%	54%	50%	45%	42%	36%	34%
4341-L02	58	54	43	21	20	16	19	15
4361-OK4			85	82	77	70	73	70
4381-OM2					90	86	85	78
3083-CX								
3083-E8				70	63	62	55	51
3083-EX8								
3083-B16	90	82	80	74	68	60	58	52
3083-BX16								
3083-J32					70	64	60	54
3081-G16	80	80	78	77	68	66	65	60
3081GX16								
3081-K24	85	85	83	80	75	72	67	63
3081-KX24								
3084-Q64					78	70	68	65
3084-QX64								
3090-200								

The values shown are used market retail values as a percent of IBM list price. At any given time, Three price levels exist: Retail Price, Dealer Price, Wholesale Price.

* Projected

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EXHIBIT III-2

PROJECTED USED MARKET RETAIL VALUES

VENDOR	PROCESSOR MODEL	CURRENT LIST 6/85	PROJECTED USED MARKET RETAIL VALUE AT JANUARY 1 OF: 1986	1987	1988	1989	1990
IBM	4331-J02	$ 45,220	$ 13,566	$ 10,401	$ 5,426	$ 3,165	$ 1,809
	4341-L02	312,000	37,440	28,080	21,840	9,360	3,120
	4361-0K4	126,900	82,485	64,719	50,760	13,959	6,345
	4381-0M2	500,000	360,000	290,000	225,000	80,000	40,000
	3083-CX8	705,000	366,600	211,500	84,600	35,250	14,000
	3083-EX8	695,000	382,250	229,350	104,250	41,700	13,900
	3083-BX16	1,255,000	627,500	451,800	238,450	100,400	37,650
	3083-JX32	1,850,000	962,000	740,000	388,500	185,000	55,500
	3081-GX16	2,190,000	1,204,500	876,000	438,000	262,800	109,500
	3081-KX24	3,010,000	1,926,400	1,354,500	722,400	451,500	210,700
	3084-QX64	5,220,000	3,654,000	2,871,000	2,349,000	1,305,000	626,400
	3090-200	4,860,000	4,860,000	3,985,200	3,159,000	2,138,400	1,215,000
AMDAHL	5840-16	$1,550,000	$ 868,000	$ 496,000	$ 217,000	$ 77,500	$ 31,000
	5850-24	1,950,000	1,170,000	760,500	351,000	156,000	39,000
	5860-24	2,380,000	1,618,400	999,600	476,000	238,000	71,400
	5868-32	3,410,000	2,387,000	1,500,400	750,200	375,100	102,300
	5870-32	3,470,000	2,429,000	1,665,600	902,200	451,100	208,200
	5880-64	4,590,000	3,304,800	2,295,000	1,285,200	826,200	413,100
NAS*	AS/6630	$ 341,500	$ 119,525	$ 61,470	$ 27,320	$ 17,075	$ 6,830
	AS/6660	475,000	266,000	166,250	104,500	71,250	33,250
	AS/8023-8	699,000	363,480	230,670	83,880	41,940	13,980
	AS/843-8	1,067,000	586,850	373,450	160,050	85,360	42,680
	AS/8053-8	1,492,000	850,440	537,120	238,720	134,280	74,600
	AS/8063-8	1,905,000	1,200,150	742,950	323,850	209,550	133,350
	AS/8083-1	3,046,000	2,040,820	1,309,780	609,200	426,440	243,680
	AS/9040-8	1,492,000	298,400	134,280	74,600	29,840	14,920
	AS/9050-8	1,909,000	477,250	229,080	133,630	76,360	38,180
	AS/9060-1	2,280,000	684,000	410,400	228,000	136,800	91,200
	AS/9070-1	3,221,000	1,352,820	773,040	483,150	257,680	193,260
	AS/9080-1	4,112,000	1,932,640	1,233,600	740,160	411,200	287,840
	AS/9140-1	1,887,000	1,887,000	1,320,900	792,540	339,660	169,830
	AS/9150-1	2,304,000	2,304,000	1,658,880	1,059,840	552,960	230,400
	AS/9160-1	2,580,000	2,580,000	1,960,800	1,264,200	722,400	309,600
	AS/9170-1	3,821,000	3,821,000	3,018,590	2,063,340	1,337,350	649,570
	AS/9180-1	4,712,000	4,712,000	3,910,960	2,827,200	1,884,800	942,400

*National Advanced Systems (NAS) does not quote processor prices separately; list price on this schedule includes power distribution controller and console, where appropriate.

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EXHIBIT III-3

PROJECTED RESIDUAL VALUES
(AS A PERCENT OF VENDOR LIST PRICE)

VENDOR	PROCESSOR MODEL	CURRENT LIST 6/85	PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE VALUE AT JANUARY 1 OF:				
			1986	1987	1988	1989	1990
IBM	4331-J02	$ 45,220	30%	23%	12%	7%	4%
	4341-L02	312,000	12	9	7	3	1
	4361-0K4	126,900	65	51	40	11	5
	4381-0M2	500,000	72	58	45	16	8
	3083-CX8	705,000	52	30	12	5	2
	3083-EX8	695,000	55	33	15	6	2
	3083-BX16	$1,255,000	50	36	19	8	3
	3083-JX32	1,850,000	52	40	21	10	3
	3081-GX16	2,190,000	55	40	20	12	5
	3081-KX24	3,010,000	64	45	24	15	7
	3084-QX64	5,220,000	70	55	45	25	12
	3090-200	4,860,000	100	82	65	44	25
AMDAHL	5840-16	$1,550,000	56%	32%	14%	5%	2%
	5850-24	1,950,000	60	39	18	8	2
	5860-24	2,380,000	68	42	20	10	3
	5868-32	3,410,000	70	44	22	11	3
	5870-32	3,470,000	70	48	26	13	6
	5880-64	4,590,000	72	50	28	18	9
NAS*	AS/6630	$ 341,500	35%	18%	8%	5%	2%
	AS/6660	475,000	56	35	22	15	7
	AS/8023-8	699,000	52	33	12	6	2
	AS/8043-8	1,067,000	55	35	15	8	4
	AS/8053-8	1,492,000	57	36	16	9	5
	AS/8063-8	1,905,000	63	39	17	11	7
	AS/8083-16	3,046,000	67	43	20	14	8
	AS/9040-8	1,492,000	20	9	5	2	1
	AS/9050-8	1,909,000	25	12	7	4	2
	AS/9060-16	2,280,000	30	18	10	6	4
	AS/9070-16	3,221,000	42	24	15	8	6
	AS/9080-16	4,112,000	47	30	18	10	7
	AS/9140-16	1,887,000	100	70	42	18	9
	AS/9150-16	2,304,000	100	72	46	24	10
	AS/9160-16	2,580,000	100	76	49	28	12
	AS/9170-16	3,821,000	100	79	54	35	17
	AS/9180-16	4,712,000	100	83	60	40	20

*National Advanced Systems (NAS) does not quote processor prices separately; list price on this schedule includes power distribution controller and console, where appropriate.

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- Exhibits III-4 and III-5 present projected used market retail values in dollars and projected residual values as a percent of vendor list price for selected disk, tape, and printer products. These projections represent an adjustment to previously projected values of 3380 disk products based on the recently announced earlier delivery of the new 3380 extended capacity models.

- Exhibits III-6 through III-33 graph projected residual values for IBM and software compatible mainframes for the period from 1986 through 1990.

  - Exhibits III-6 through III-17 are for IBM processors.

  - Exhibits III-18 through III-22 are for Amdahl processors.

  - Exhibits III-23 through III-33 are for NAS processors.

- Exhibit III-34 graphs the new projected residual values for the current IBM 3380 disk drive.

- The factors affecting residual value forecasts are contained in Appendix A of this report.

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EXHIBIT III-4

PROJECTED USED MARKET VALUE
(IBM DISK, TAPE, AND PRINTER SYSTEMS)

EQUIPMENT TYPE	MODEL NUMBER	CURRENT LIST 6/85	PROJECTED USED MARKET RETAIL VALUE AT JANUARY 1 OF:				
			1986	1987	1988	1989	1990
Disk	3350-A02	$ 32,030	$ 1,602	$ 961	$ 641	$ 320	$ 0
	3350-B02	25,360	1,014	761	507	254	0
	3380-AA4	88,780	50,605	38,175	23,083	14,205	6,215
	3380-B04	64,440	38,020	28,998	18,688	11,599	5,155
Tape	342-003	$ 15,635	$ 469	$ 313	$ 313	$ 156	$ 0
	342-005	19,705	2,365	1,379	788	394	197
	3420-007	21,625	5,406	3,460	2,163	1,298	649
	3420-004	17,545	6,316	3,860	2,456	1,755	877
	3420-006	20,125	11,673	8,453	5,031	3,623	2,013
	3420-008	22,085	18,772	15,018	9,938	6,626	2,650
Printer	1403-N01	$ 40,040	$ 400	$ 0	$ 0	$ 0	$ 0
	3211-001	40,080	6,012	4,008	2,405	1,202	401
	3800-001	315,000	113,400	78,750	50,400	22,050	15,750
	3800-003	315,000	173,250	132,300	88,200	47,250	25,200

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EXHIBIT III-5

LIST PRICE VERSUS PROJECTED RESIDUAL VALUE (IBM DISK, TAPE, AND PRINTER PRODUCTS)

EQUIPMENT TYPE	MODEL NUMBER	CURRENT LIST 6/85	PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE VALUE AT JANUARY 1 OF:				
			1986	1987	1988	1989	1990
Disk	3350-A02	$ 32,030	5%	3%	2%	1%	–
	3350-B02	25,360	4	3	2	1	–
	3380-AA4	88,780	57	43	26	16	7%
	3380-B04	64,440	59	45	29	18	8
Tape	3420-003	$ 15,635	3%	2%	2%	1%	–
	3420-005	19,705	12	7	4	2	1%
	3420-007	21,625	25	16	10	6	3
	3420-004	17,545	36	22	14	10	5
	3420-006	20,125	58	42	25	18	10
	3420-008	22,085	85	68	45	30	12
Printer	1403-N01	$ 40,040	1%	–	–	–	–
	3211-001	40,080	15	10%	6%	3%	1%
	3800-001	315,000	36	25	16	7	5
	3800-003	315,000	55	42	28	15	8

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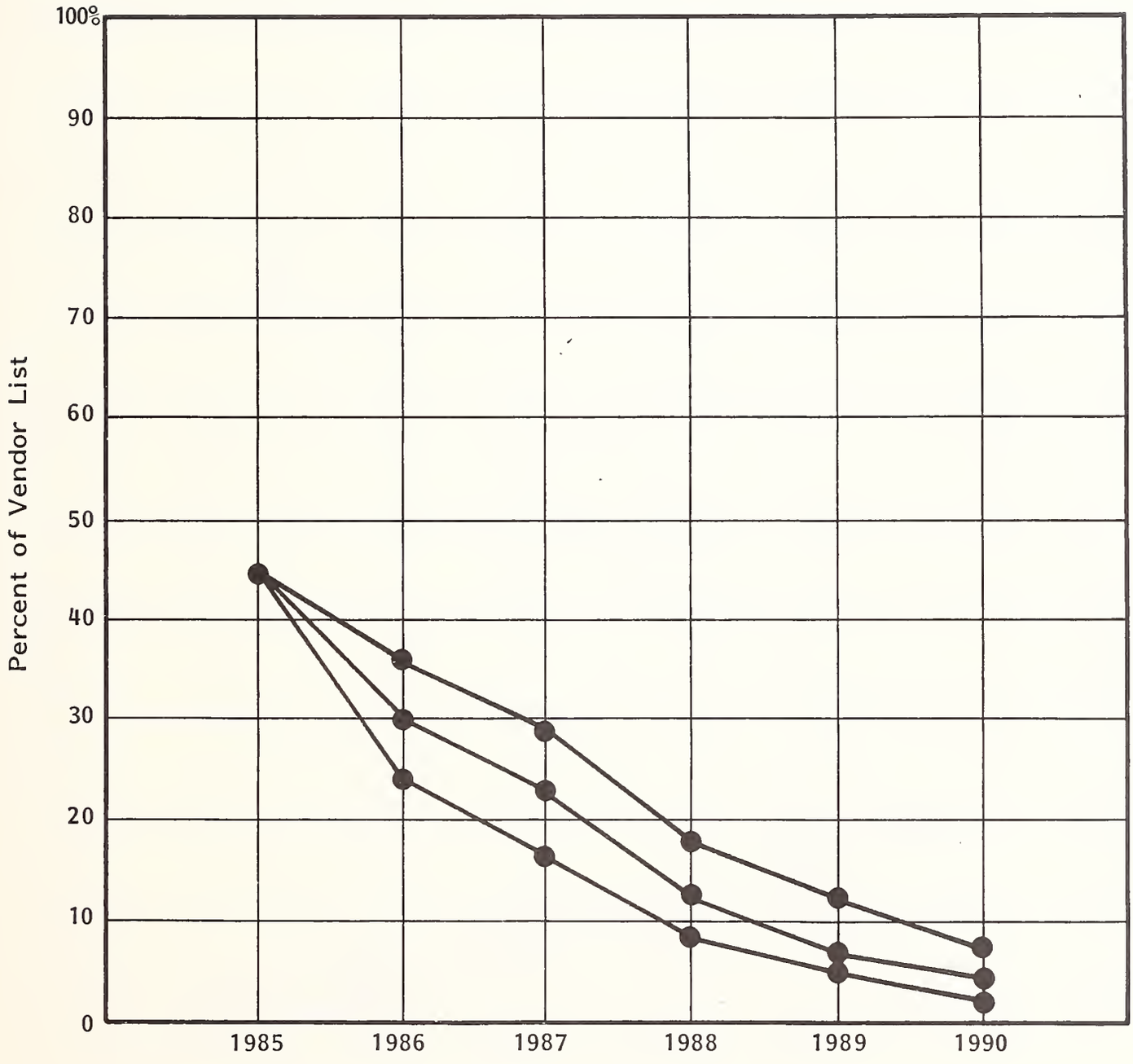
EXHIBIT III-6

RESIDUAL VALUE FORECAST FOR
IBM 4331 - JO2 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	45%	36%	29%	18%	12%	7%
Expected	45	30	23	12	7	4
Medium	45	24	16	8	5	2

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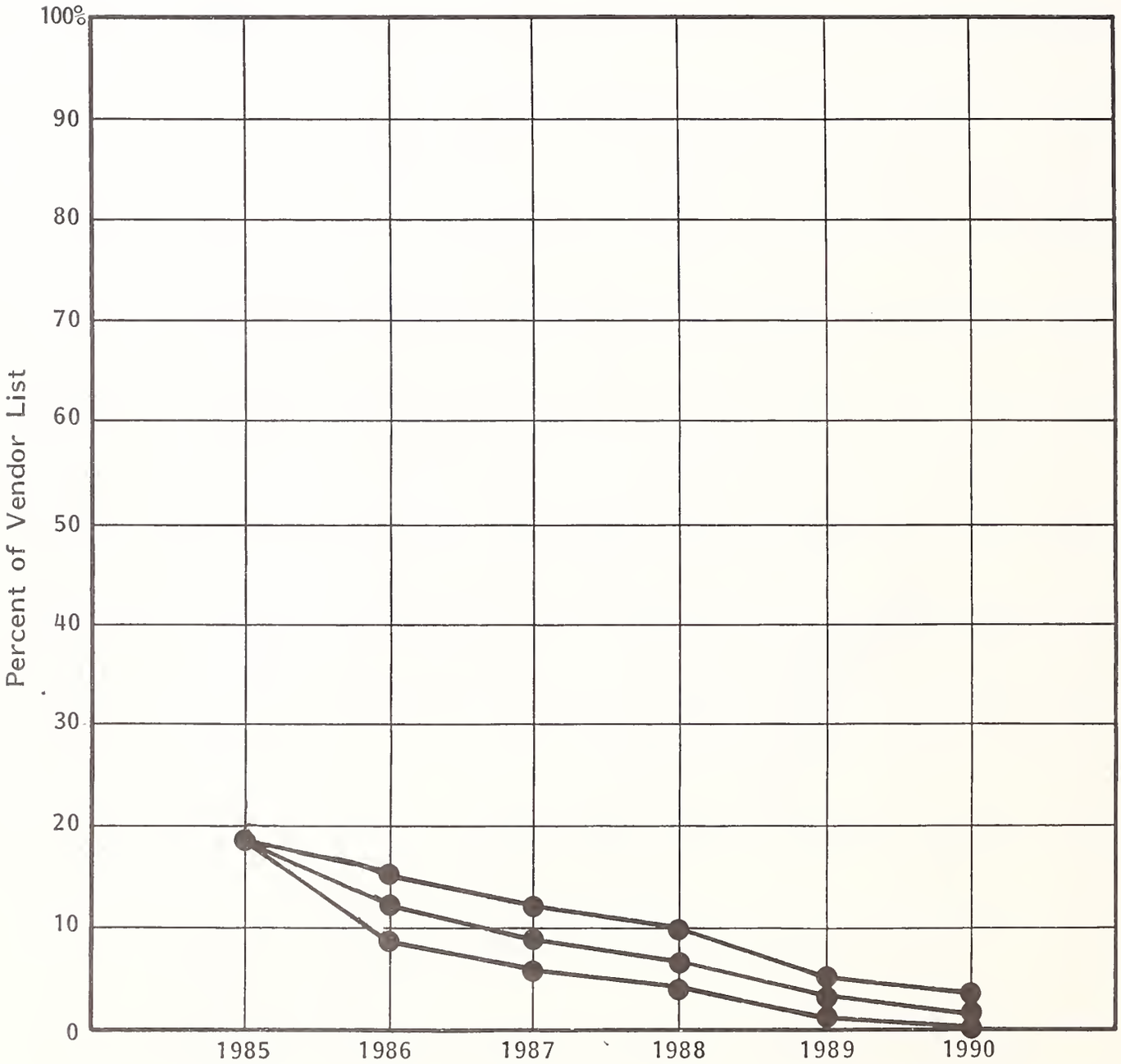
EXHIBIT III-7

RESIDUAL VALUE FORECAST FOR
IBM 4341 - LO2 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	18%	15%	12%	10%	5%	3%
Expected	18	12	9	7	3	1
Medium	18	9	6	4	1	0

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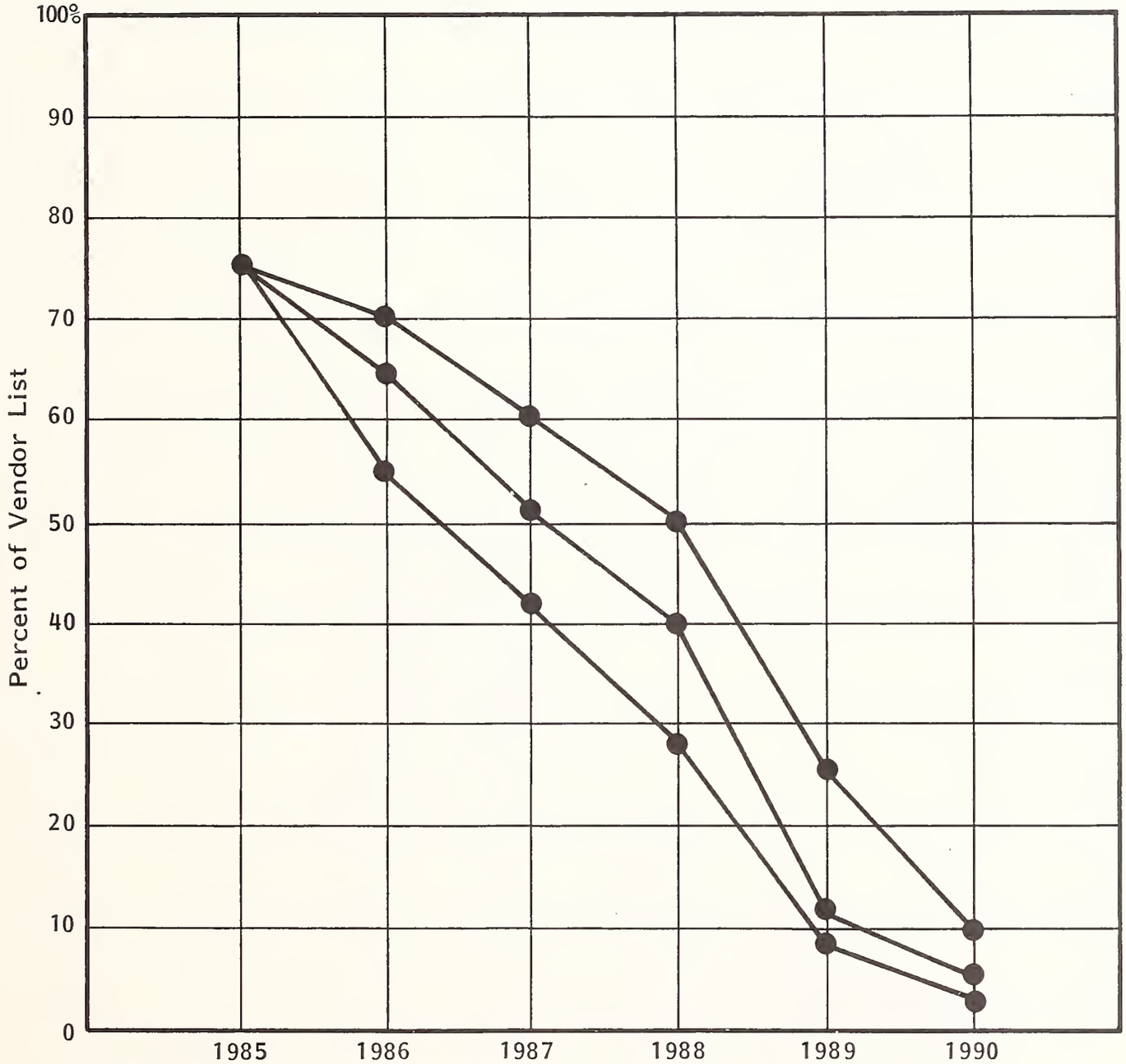
EXHIBIT III-8

RESIDUAL VALUE FORECAST FOR
IBM 4361 - KO4 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	77%	70%	60%	50%	25%	10%
Expected	77	65	51	40	11	5
Medium	77	55	42	28	8	3

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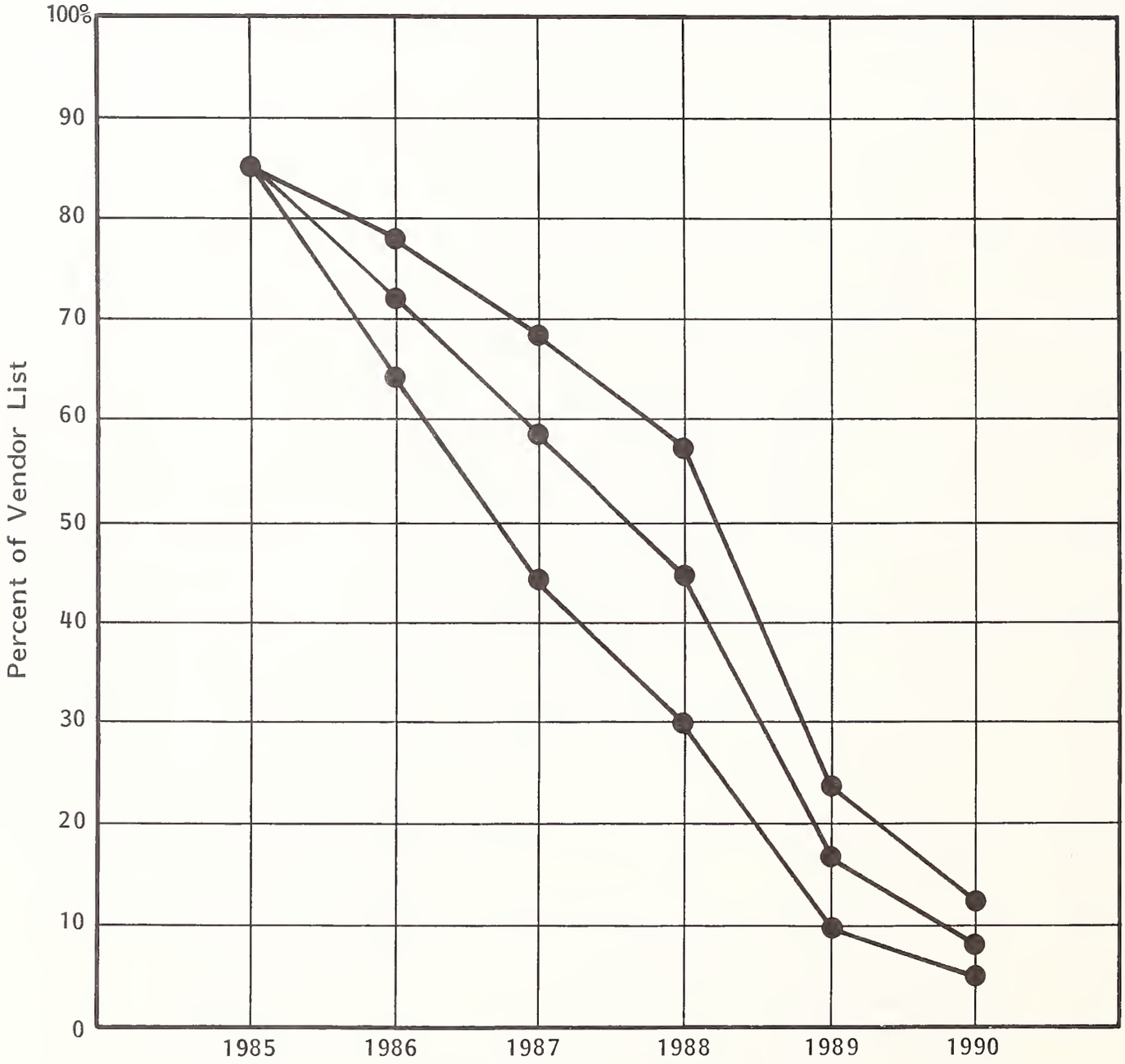
EXHIBIT III-9

RESIDUAL VALUE FORECAST FOR
IBM 4381 - OM2 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	85%	78%	68%	57%	23%	12%
Expected	85	72	58	45	16	8
Medium	85	64	44	30	10	5

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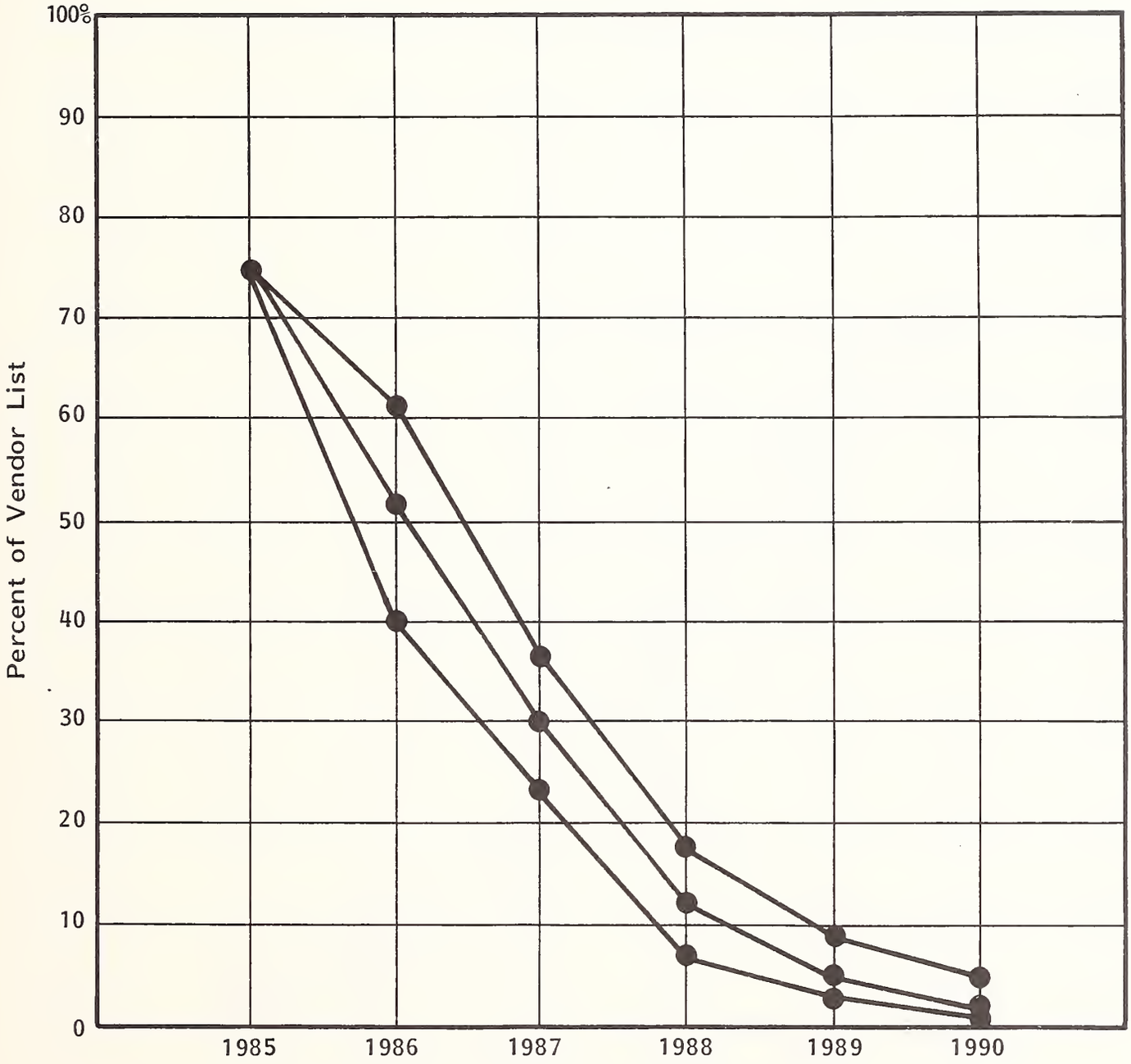
EXHIBIT III-10

RESIDUAL VALUE FORECAST FOR
IBM 3083CX8 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	75%	61%	36%	18%	9%	5%
Expected	75	52	30	12	5	2
Medium	75	40	23	7	3	1

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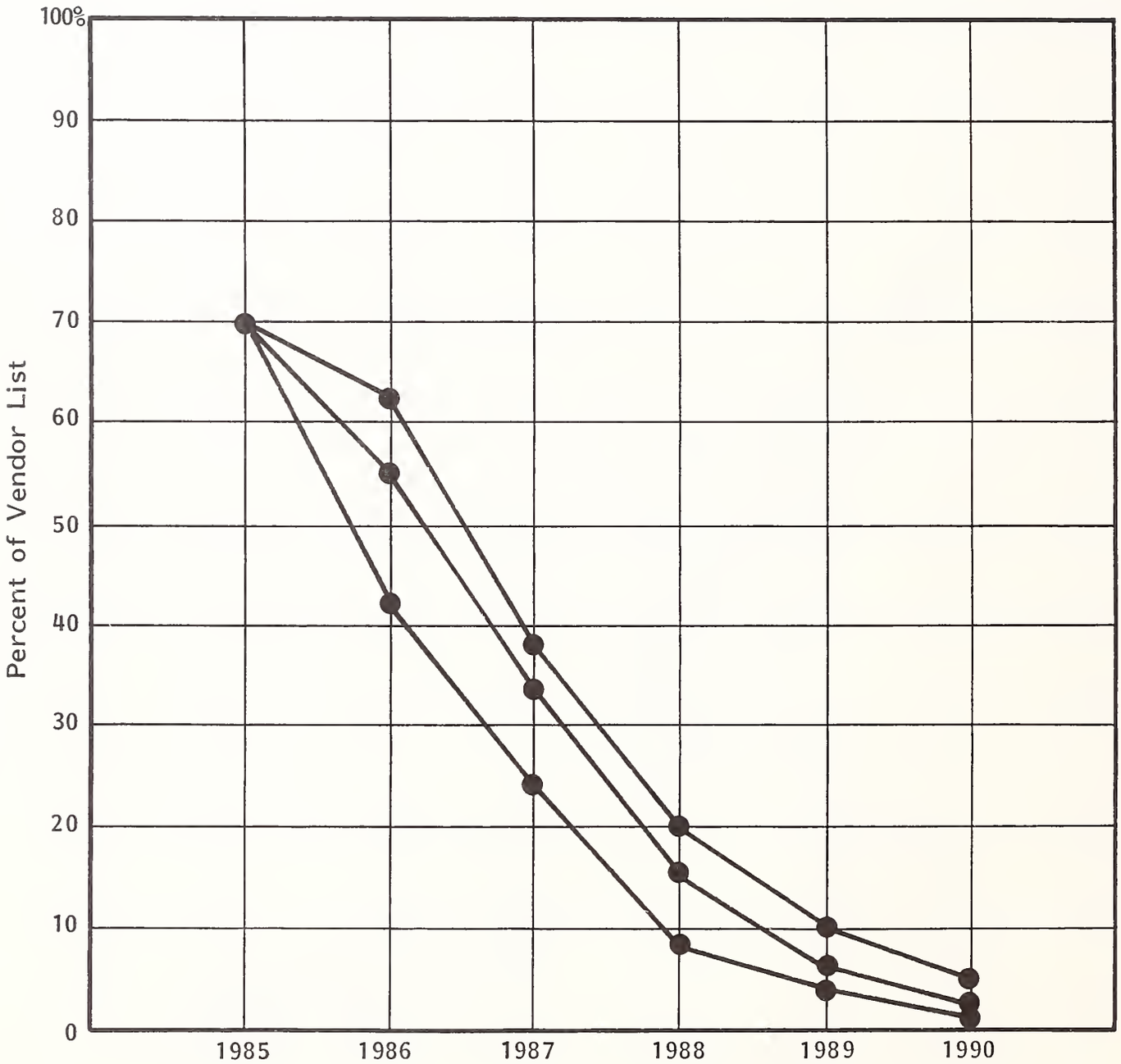
EXHIBIT III-11

RESIDUAL VALUE FORECAST FOR
IBM 3083EX8 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	70%	62%	38%	20%	10%	5%
Expected	70	55	33	15	6	2
Medium	70	42	24	8	4	1

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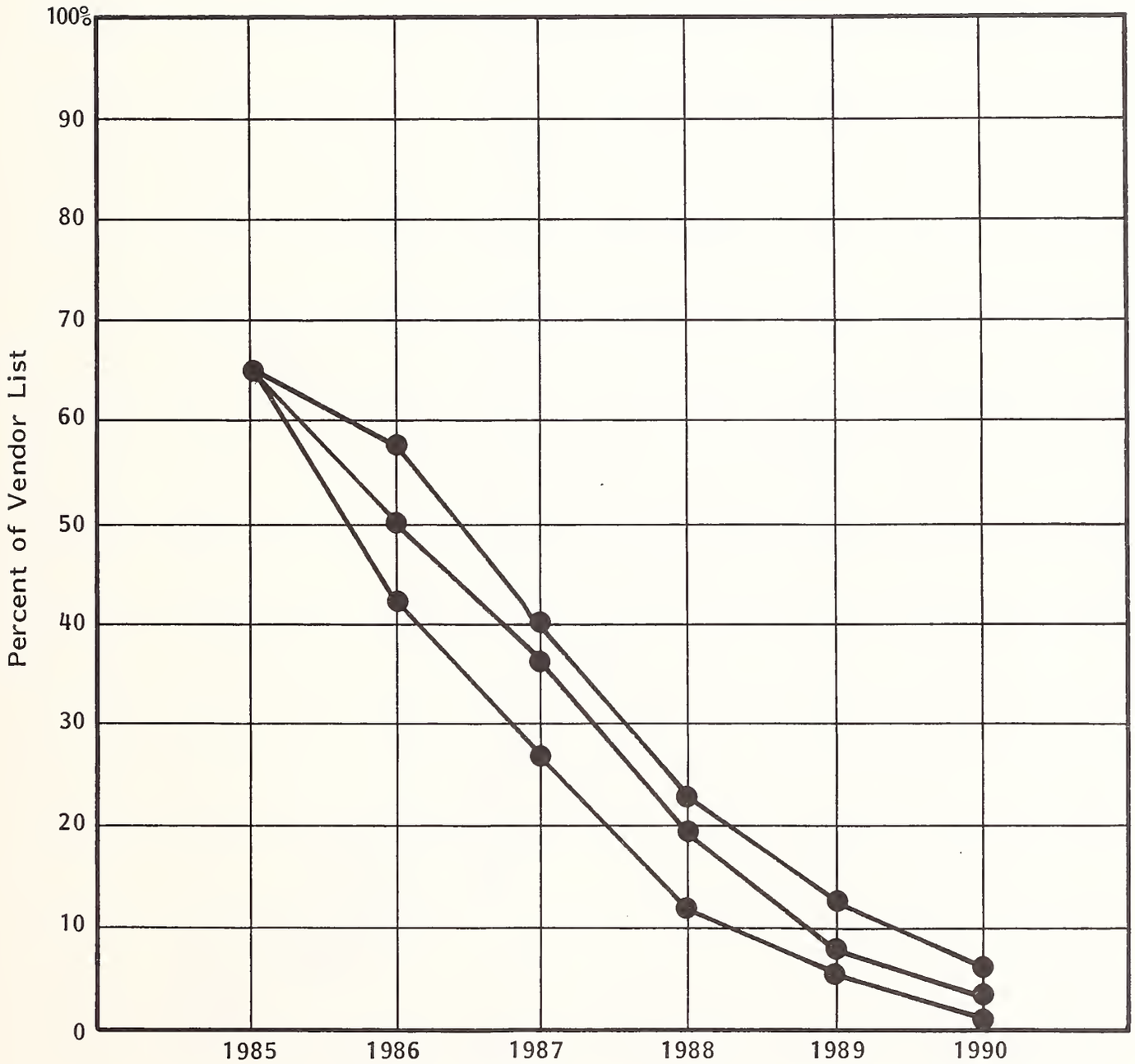
EXHIBIT III-12

RESIDUAL VALUE FORECAST FOR
IBM 3083BX16 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	65%	58%	40%	22%	12%	6%
Expected	65	50	36	19	8	3
Medium	65	42	27	11	6	1

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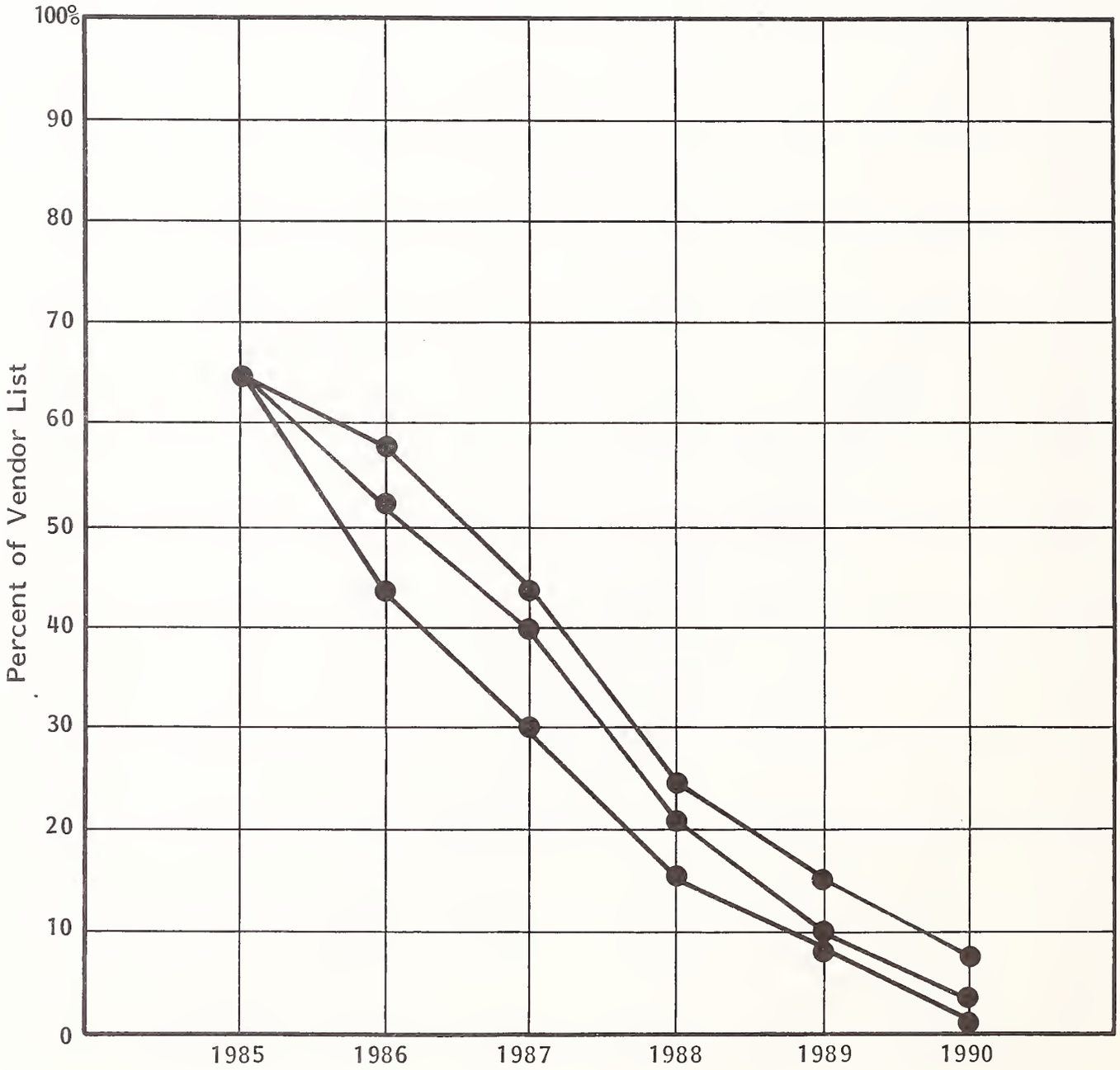
EXHIBIT III-13

RESIDUAL VALUE FORECAST FOR
IBM 3083JX32 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	65%	58%	43%	25%	15%	7%
Expected	65	52	40	21	10	3
Medium	65	43	30	15	8	1

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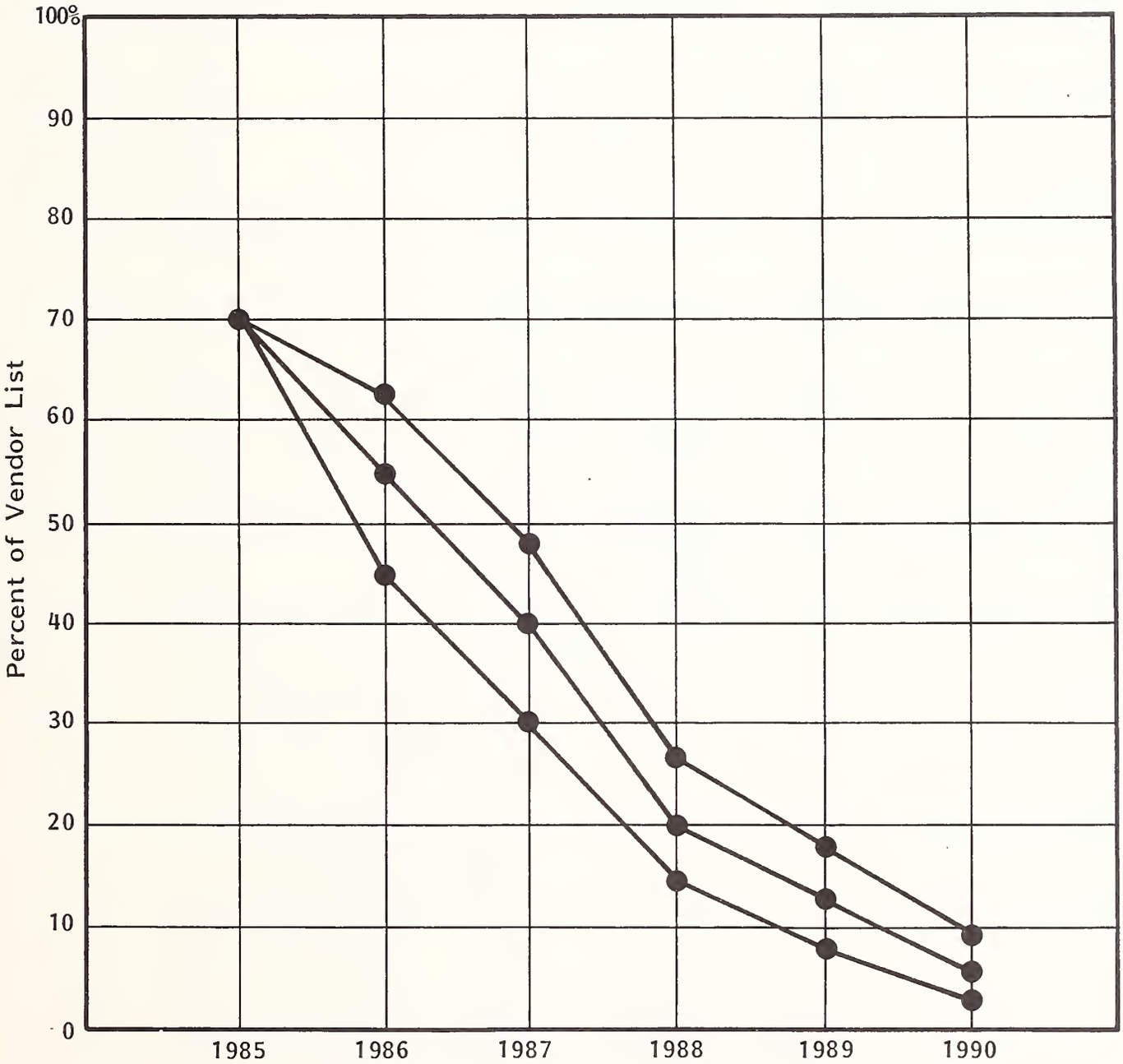
EXHIBIT III-14

RESIDUAL VALUE FORECAST FOR
IBM 3081GX16 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	70%	62%	48%	26%	17%	9%
Expected	70	55	40	20	12	5
Medium	70	45	30	14	7	3

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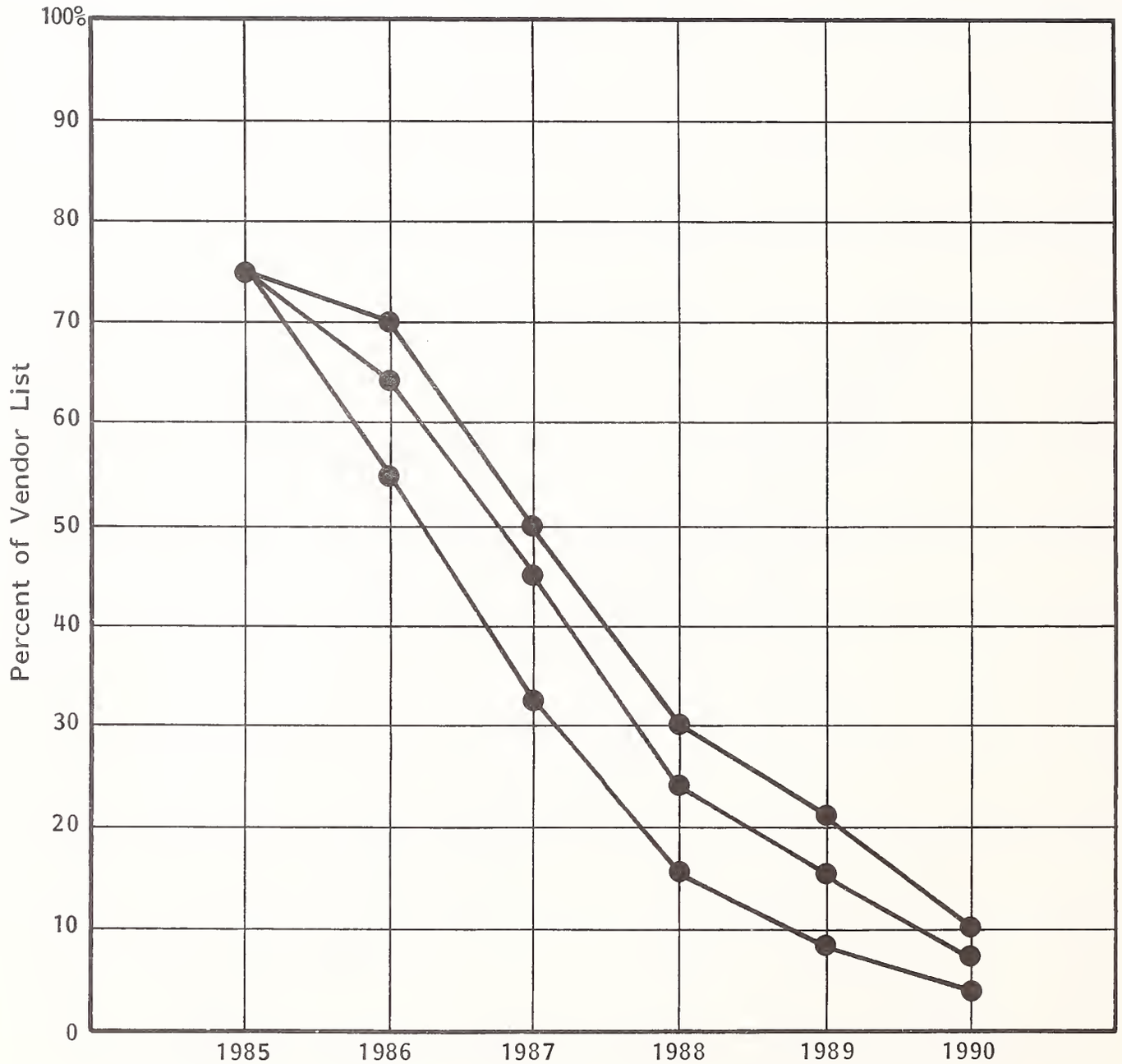
EXHIBIT III-15

RESIDUAL VALUE FORECAST FOR
IBM 3081KX24 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	75%	70%	50%	30%	21%	10%
Expected	75	64	45	24	15	7
Medium	75	55	32	15	8	4

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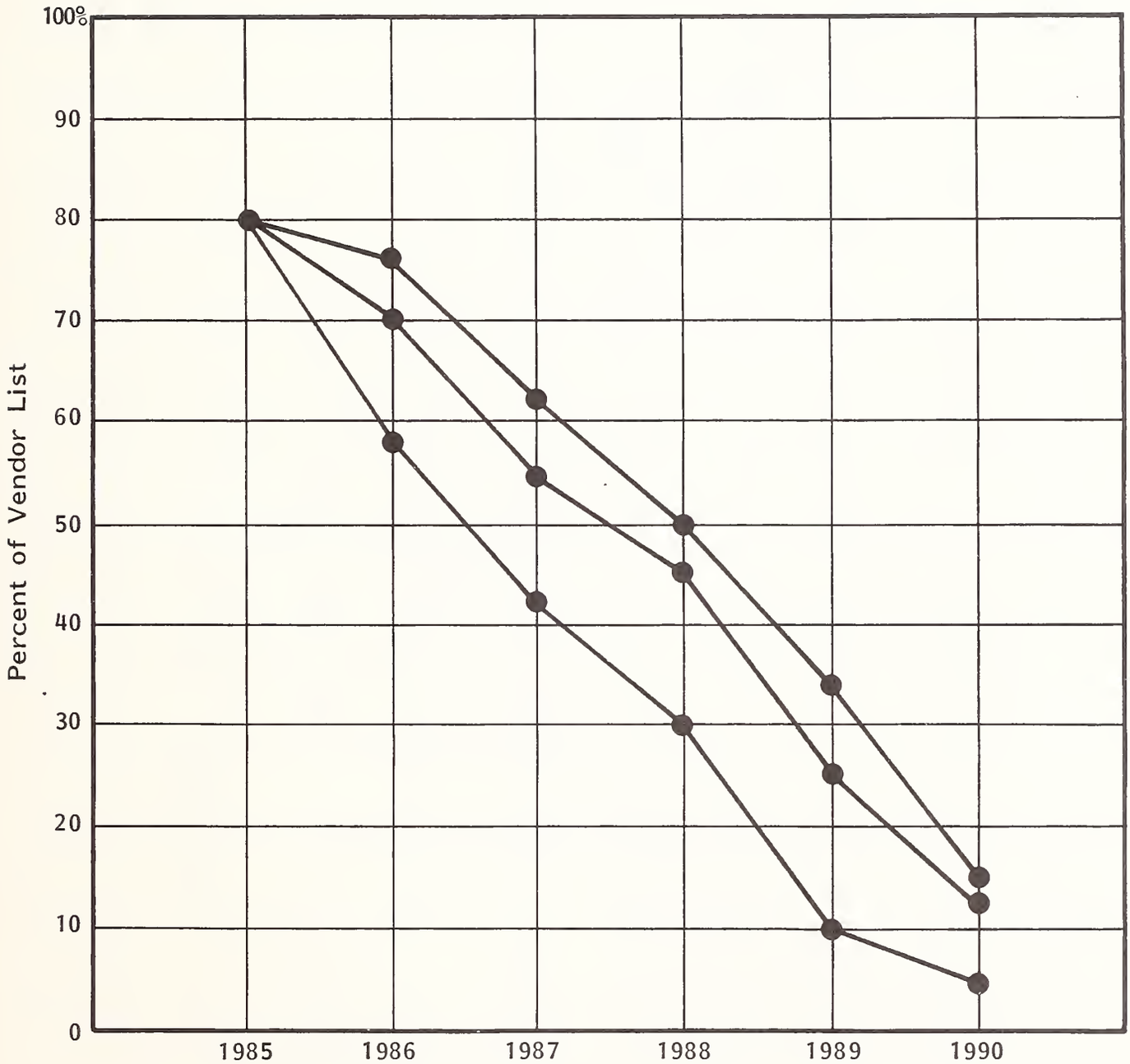
EXHIBIT III-16

RESIDUAL VALUE FORECAST FOR
IBM 3081QX64 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	80%	76%	62%	50%	33%	15%
Expected	80	70	55	45	25	12
Medium	80	58	42	30	10	5

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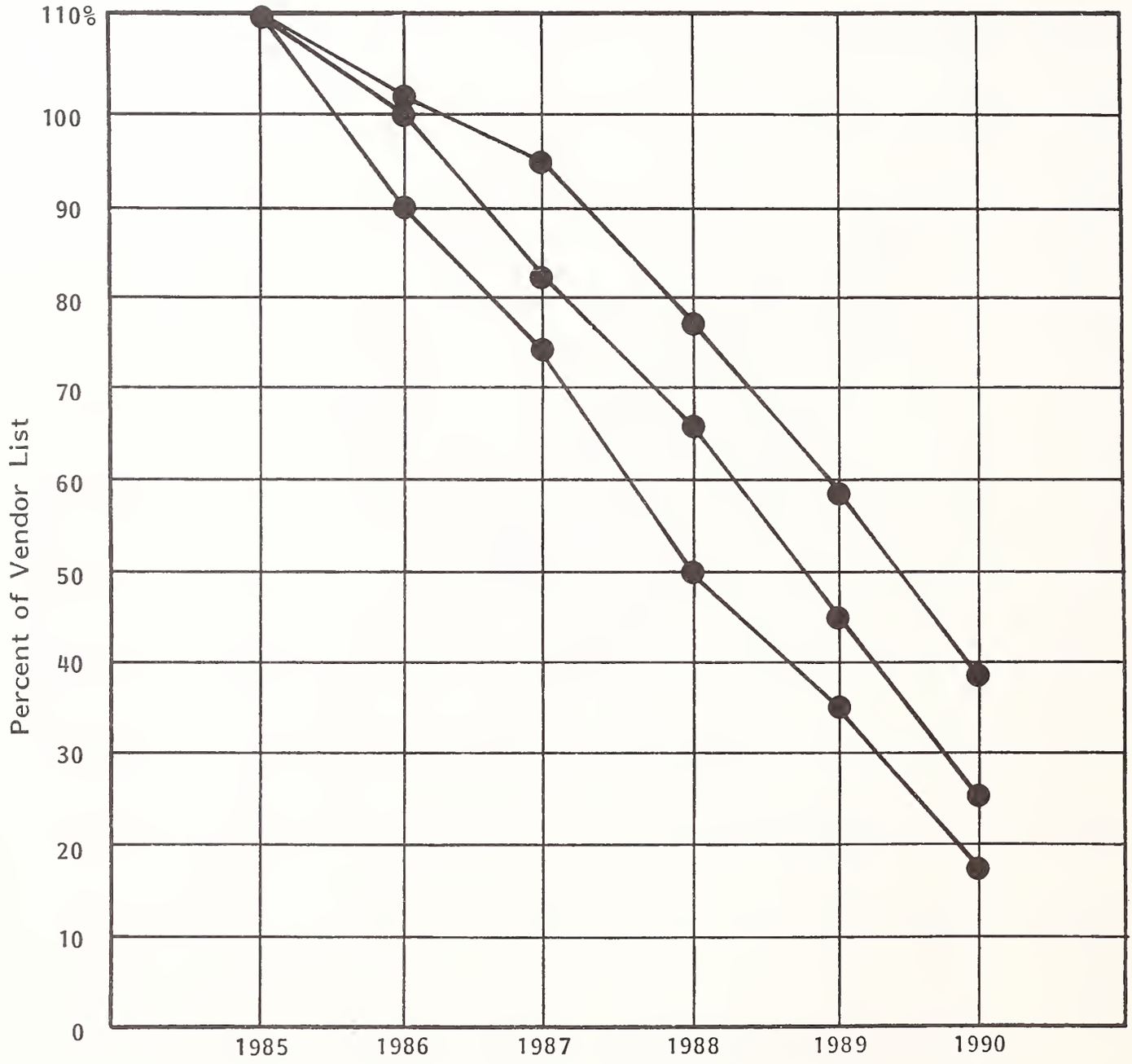
EXHIBIT III-17

RESIDUAL VALUE FORECAST FOR
IBM 3090-200 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	110%	102%	95%	77%	58%	38%
Expected	110	100	82	65	44	25
Medium	110	90	74	50	35	17

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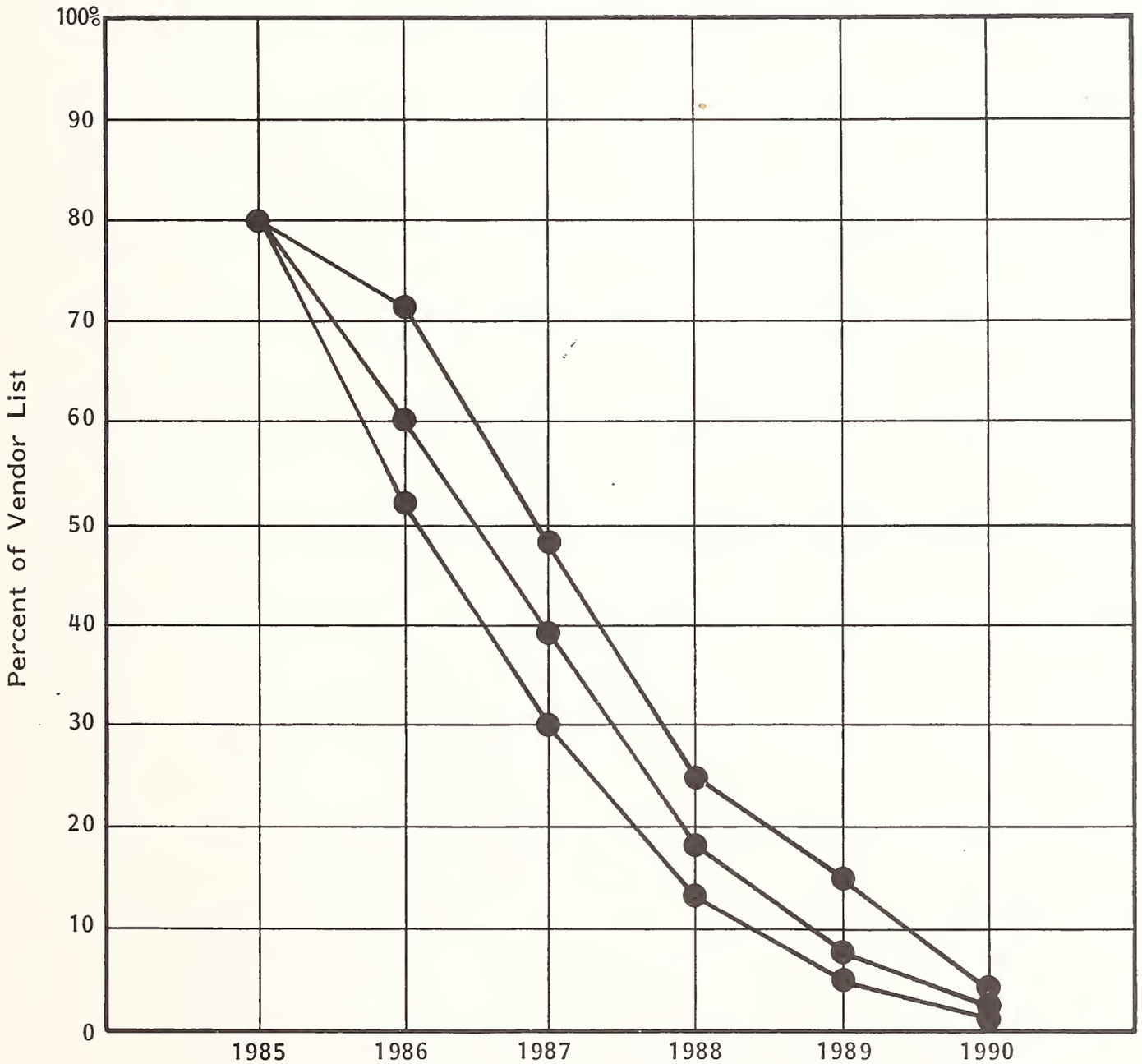
EXHIBIT III-18

RESIDUAL VALUE FORECAST FOR
AMDAHL 5850-24 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	80%	71%	48%	25%	15%	4%
Expected	80	60	39	18	8	2
Medium	80	52	30	13	5	1

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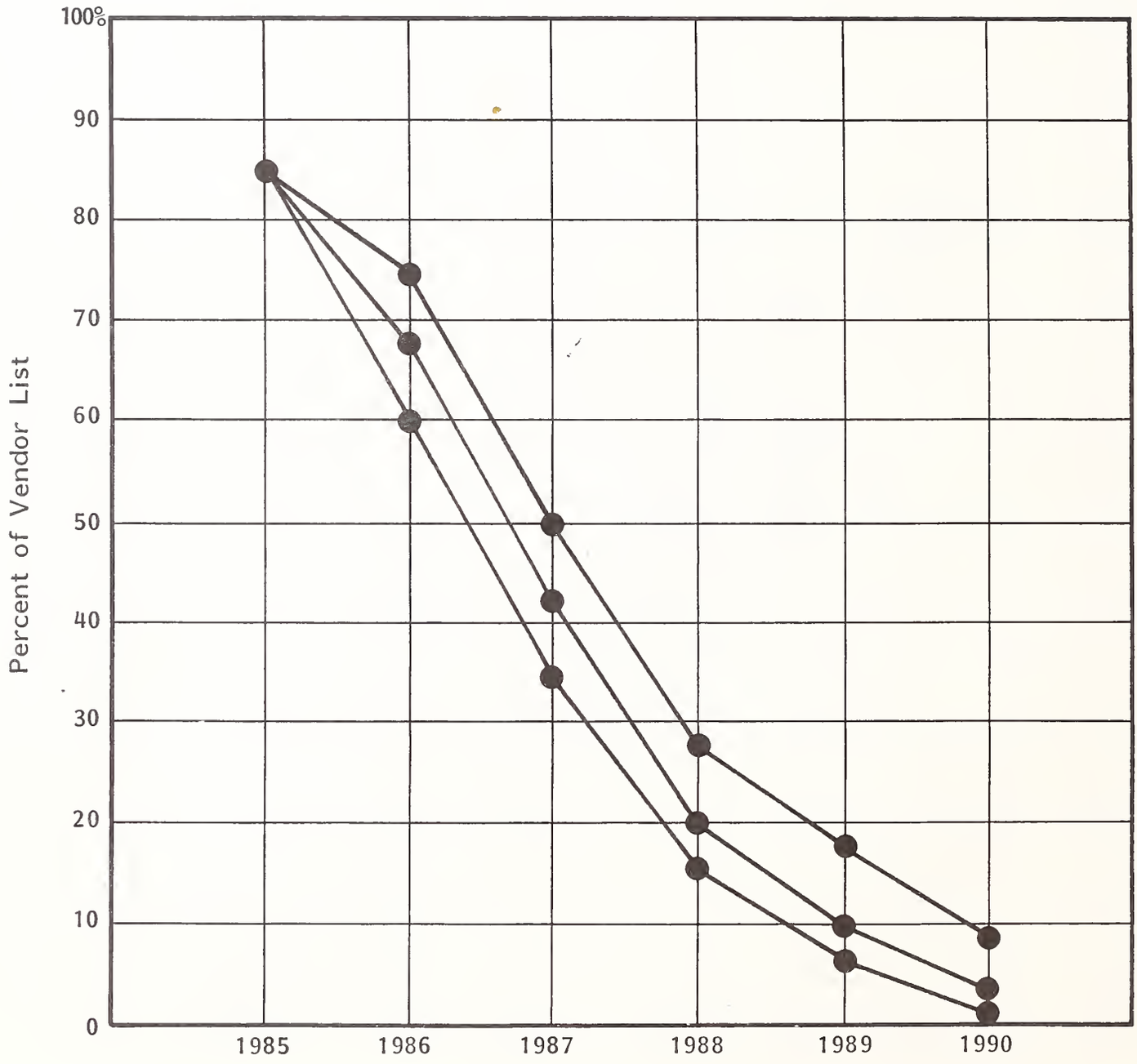
EXHIBIT III-19

RESIDUAL VALUE FORECAST FOR
AMDAHL 5860-24 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	85%	75%	50%	28%	17%	8%
Expected	85	68	42	20	10	3
Medium	85	60	34	15	6	1

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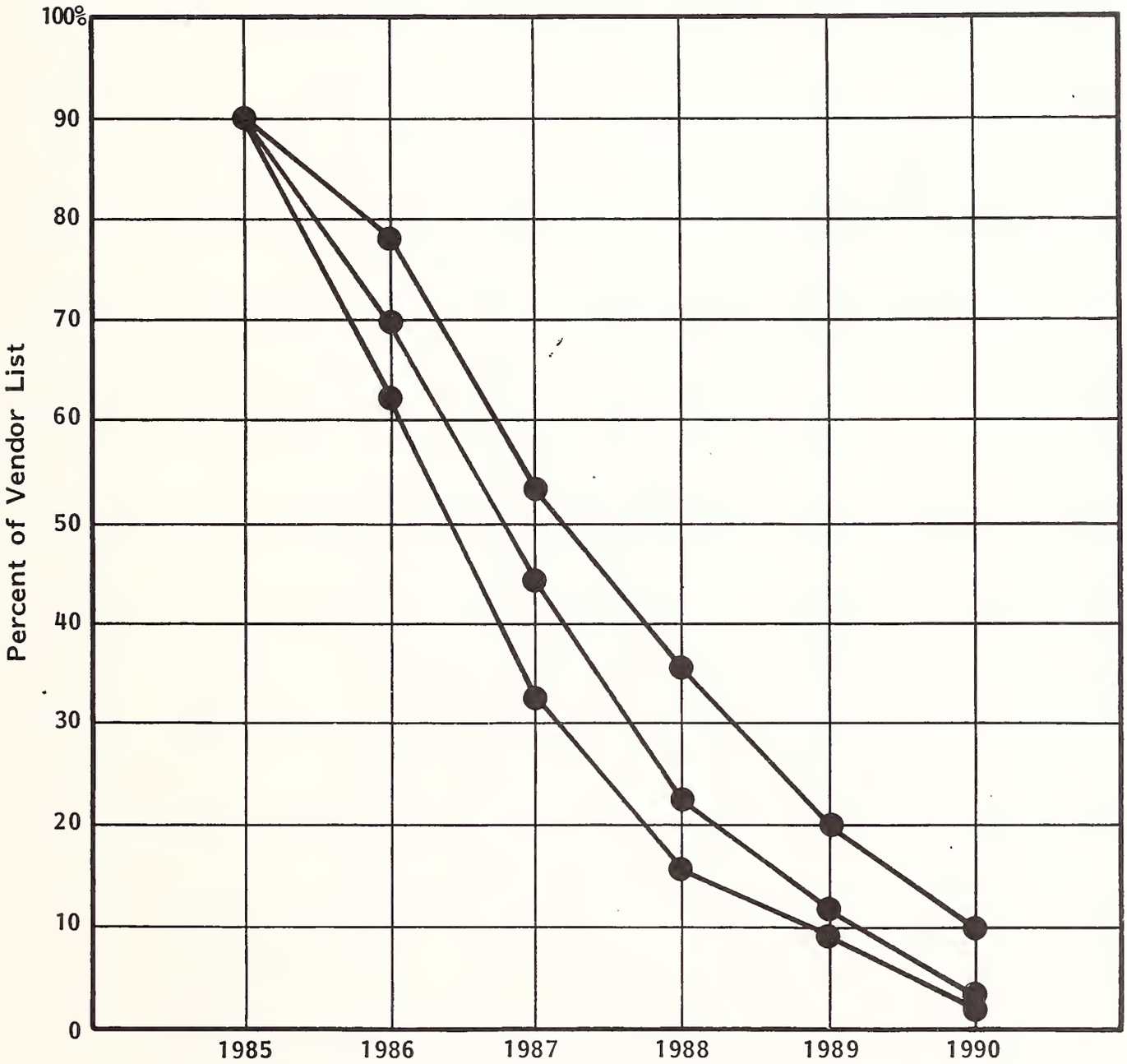
EXHIBIT III-20

RESIDUAL VALUE FORECAST FOR
AMDAHL 5868-32 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	90%	77%	53%	35%	20%	10%
Expected	90	70	44	22	11	3
Medium	90	62	32	15	9	2

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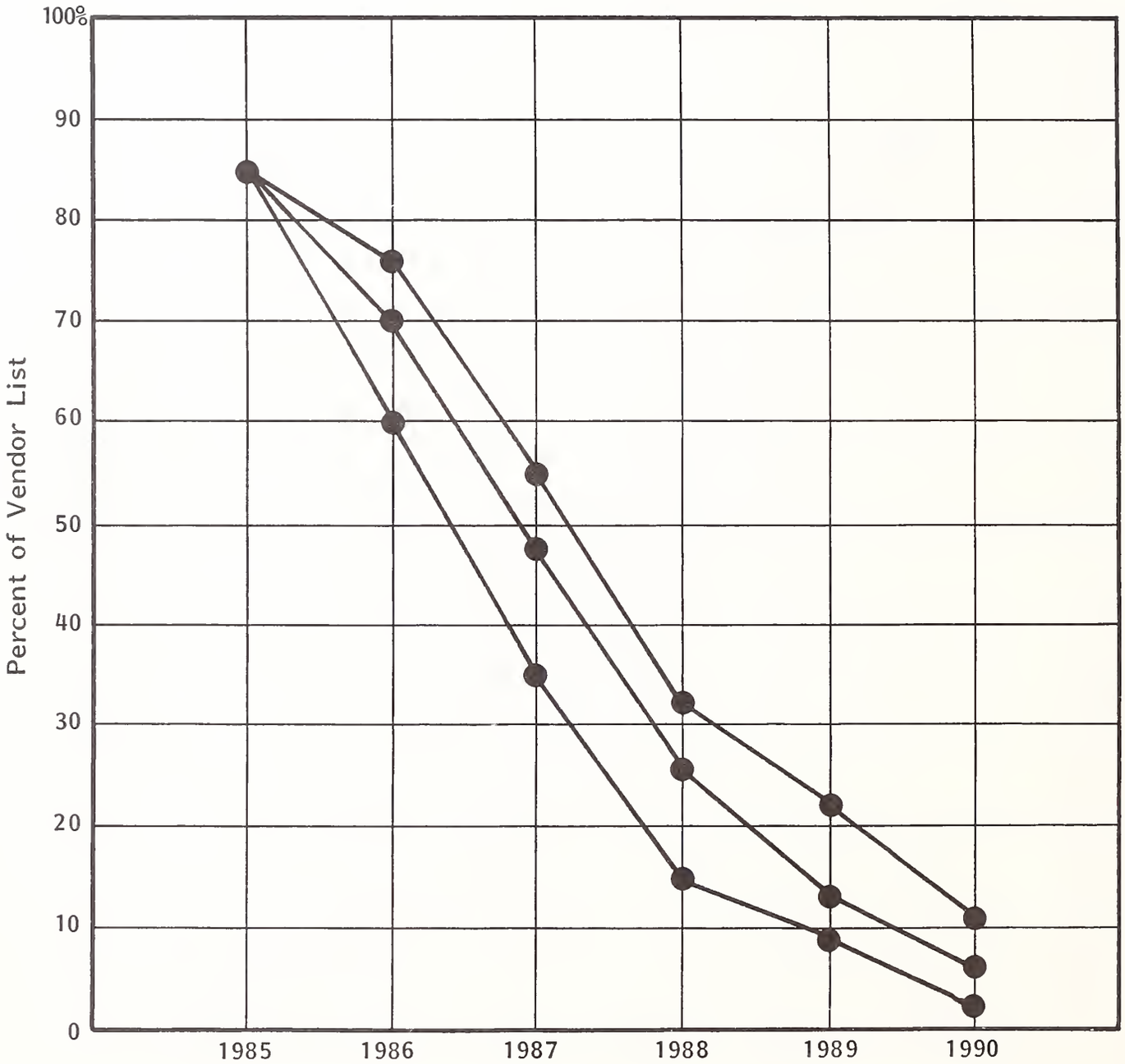
EXHIBIT III-21

RESIDUAL VALUE FORECAST FOR
AMDAHL 5870-32 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	85%	76%	55%	32%	22%	11%
Expected	85	70	48	26	13	6
Medium	85	60	35	15	9	2

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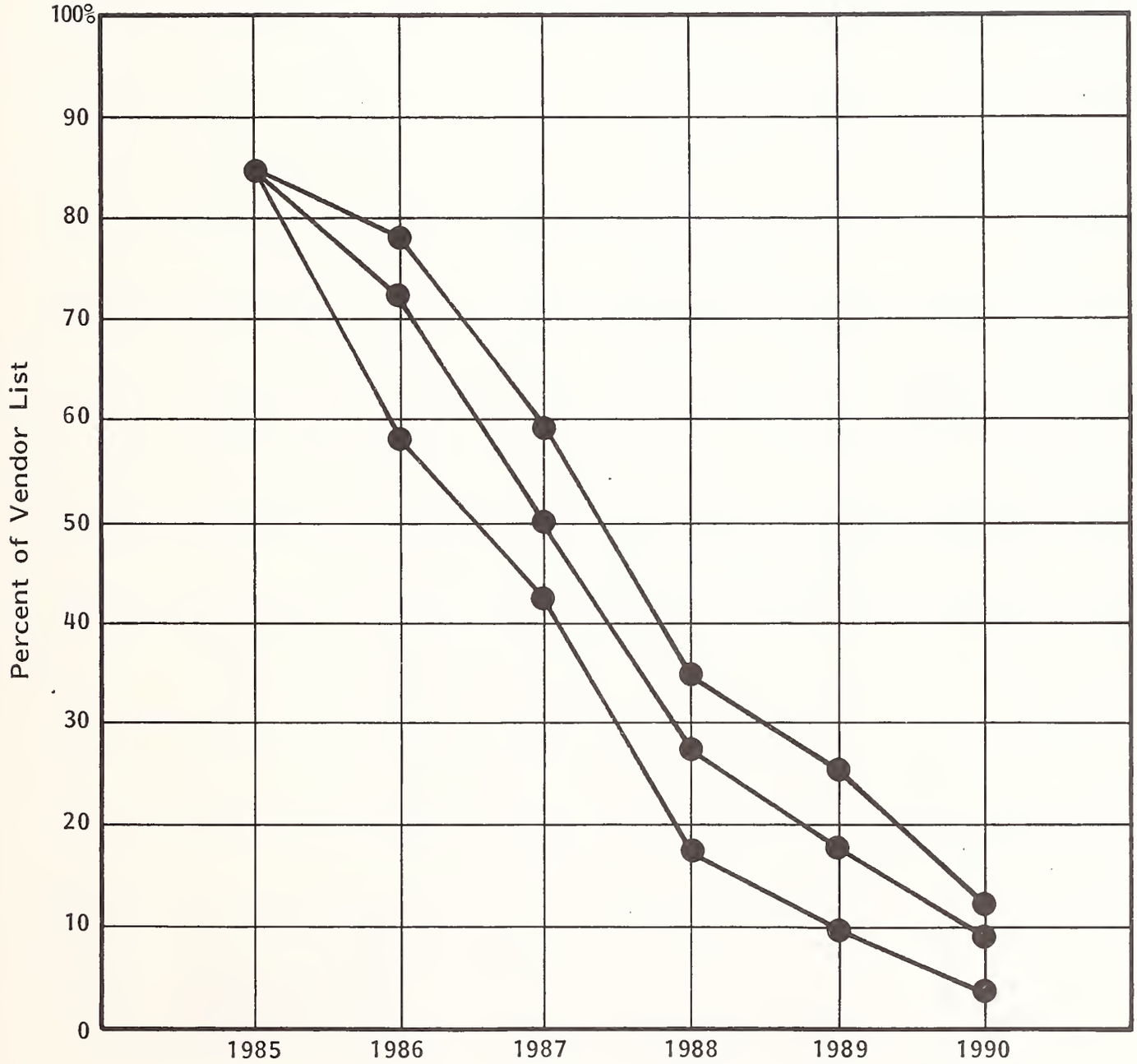
EXHIBIT III-22

RESIDUAL VALUE FORECAST FOR
AMDAHL 5880-48 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	85%	78%	59%	35%	25%	12%
Expected	85	72	50	28	18	9
Medium	85	58	42	18	10	4

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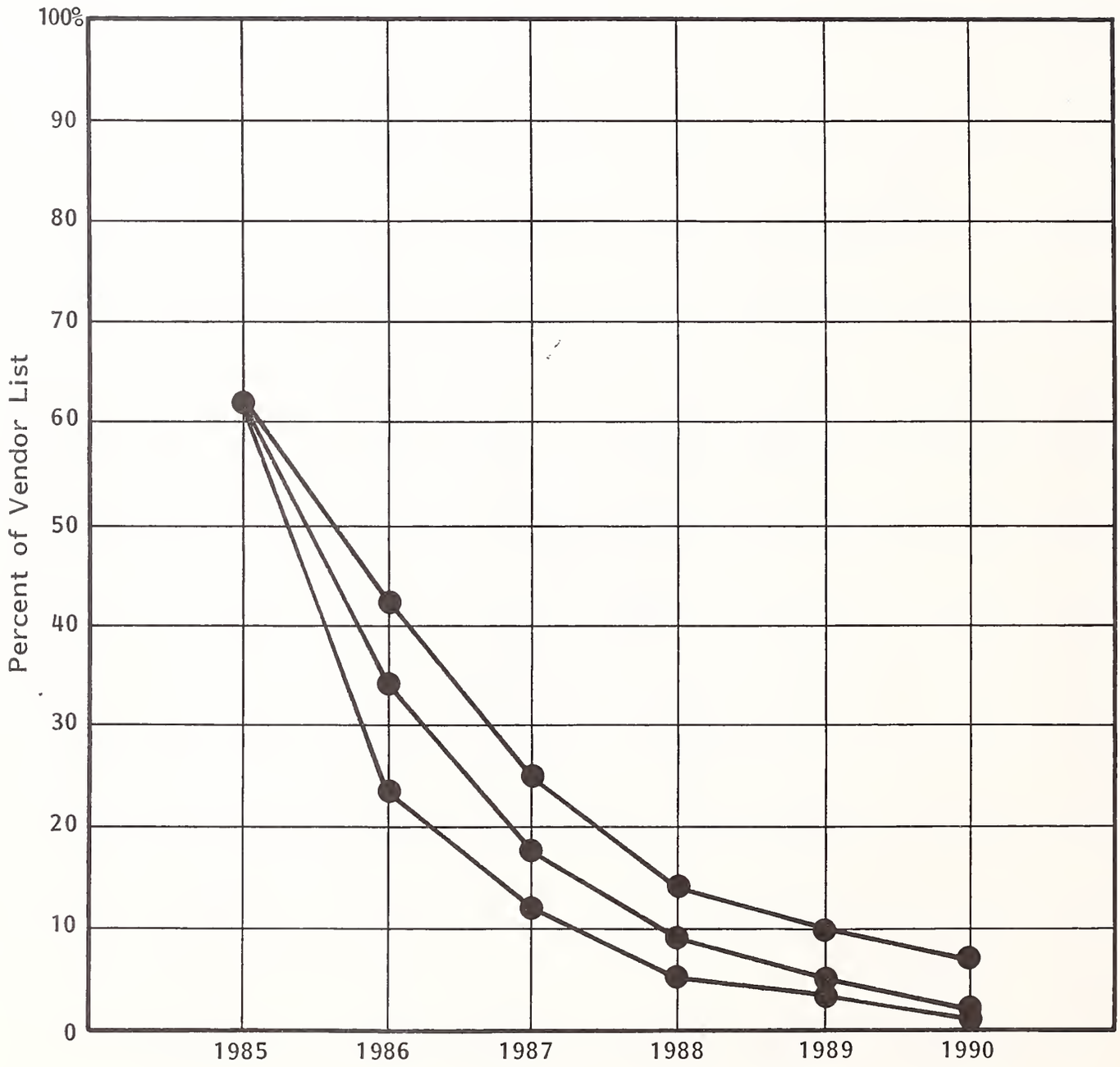
EXHIBIT III-23

RESIDUAL VALUE FORECAST FOR
NAS AS/6630 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	62%	42%	25%	14%	10%	6%
Expected	62	35	18	8	5	2
Medium	62	23	12	5	3	1

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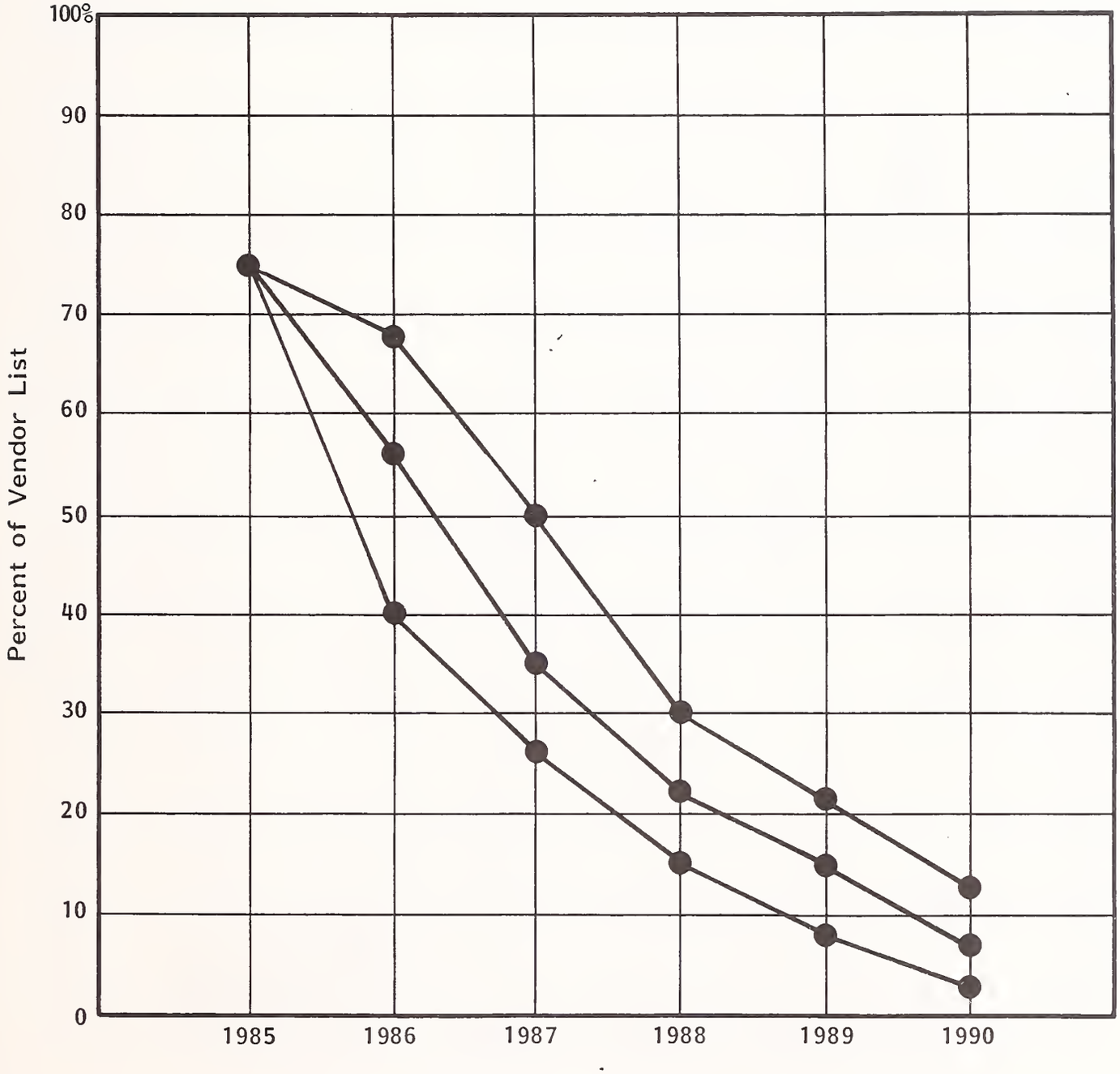
EXHIBIT III-24

RESIDUAL VALUE FORECAST FOR NAS AS/6660 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	75%	68%	50%	30%	21%	12%
Expected	75	56	35	22	15	7
Medium	75	40	26	15	8	3

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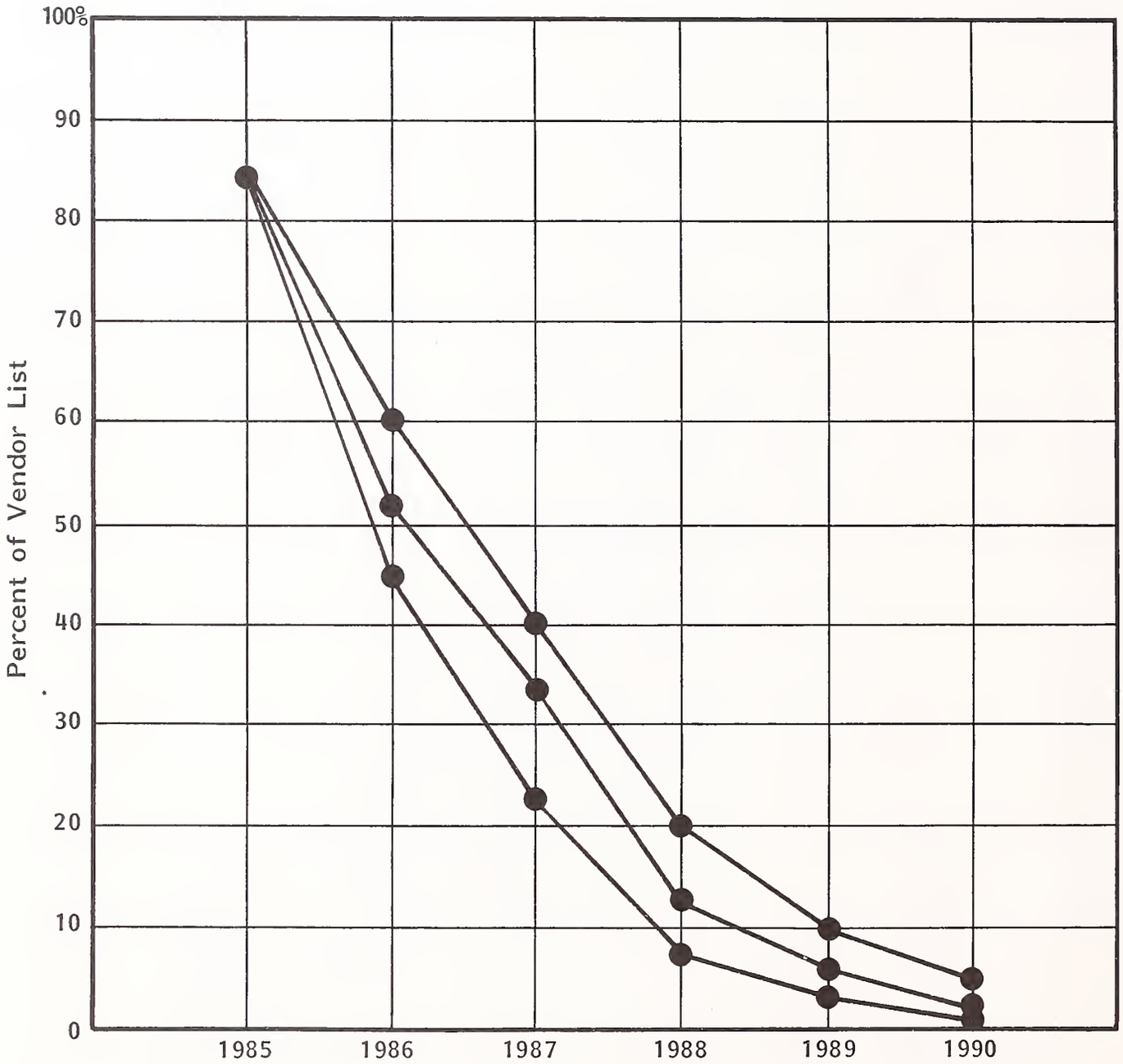
EXHIBIT III-25

RESIDUAL VALUE FORECAST FOR
NAS AS/8023 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	85%	60%	40%	20%	10%	5%
Expected	85	52	33	12	6	2
Medium	85	45	22	8	3	1

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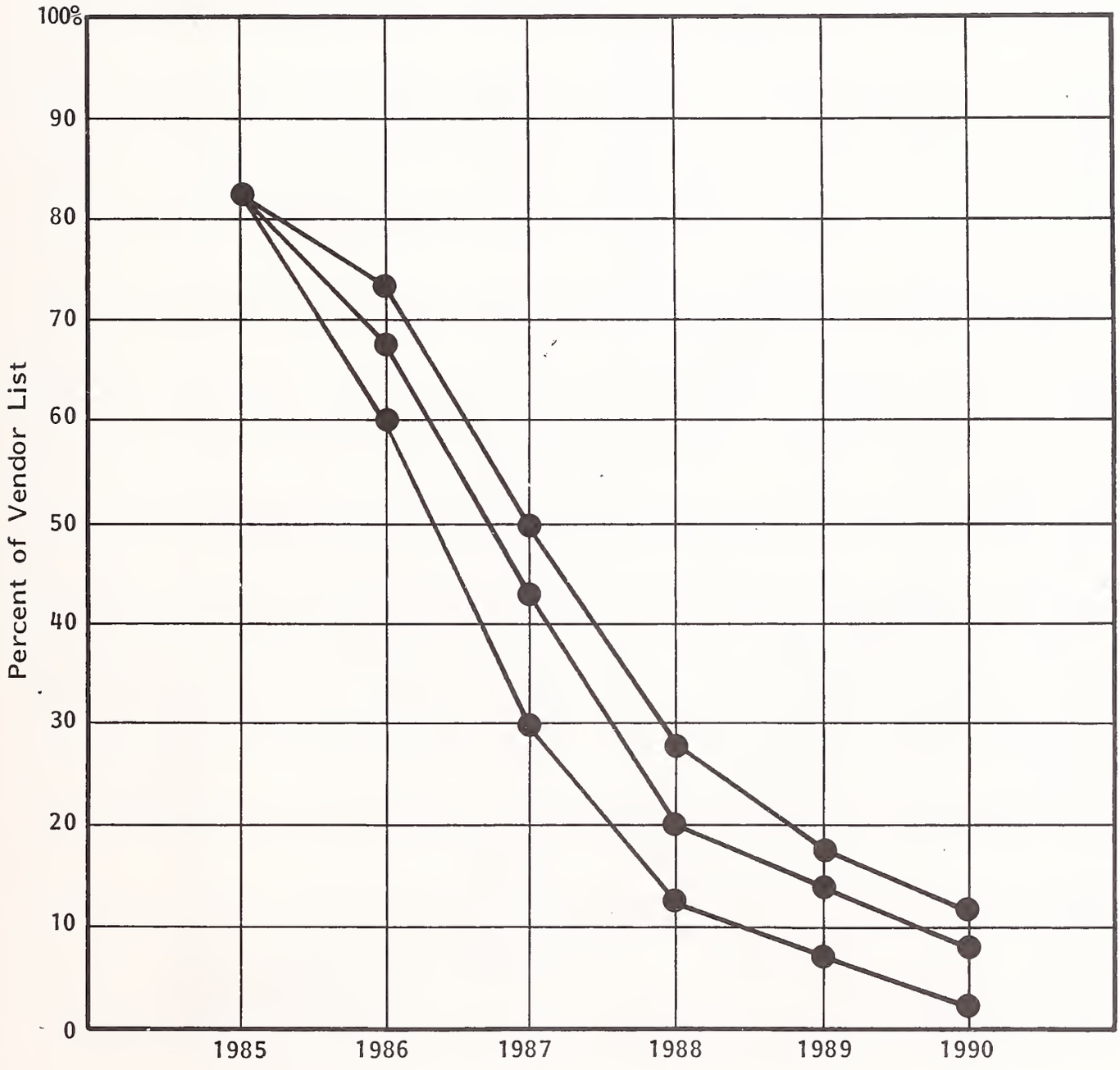
EXHIBIT III-26

RESIDUAL VALUE FORECAST FOR
NAS AS/8083 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	82%	73%	50%	28%	18%	11%
Expected	82	67	43	20	14	8
Medium	82	60	30	12	7	2

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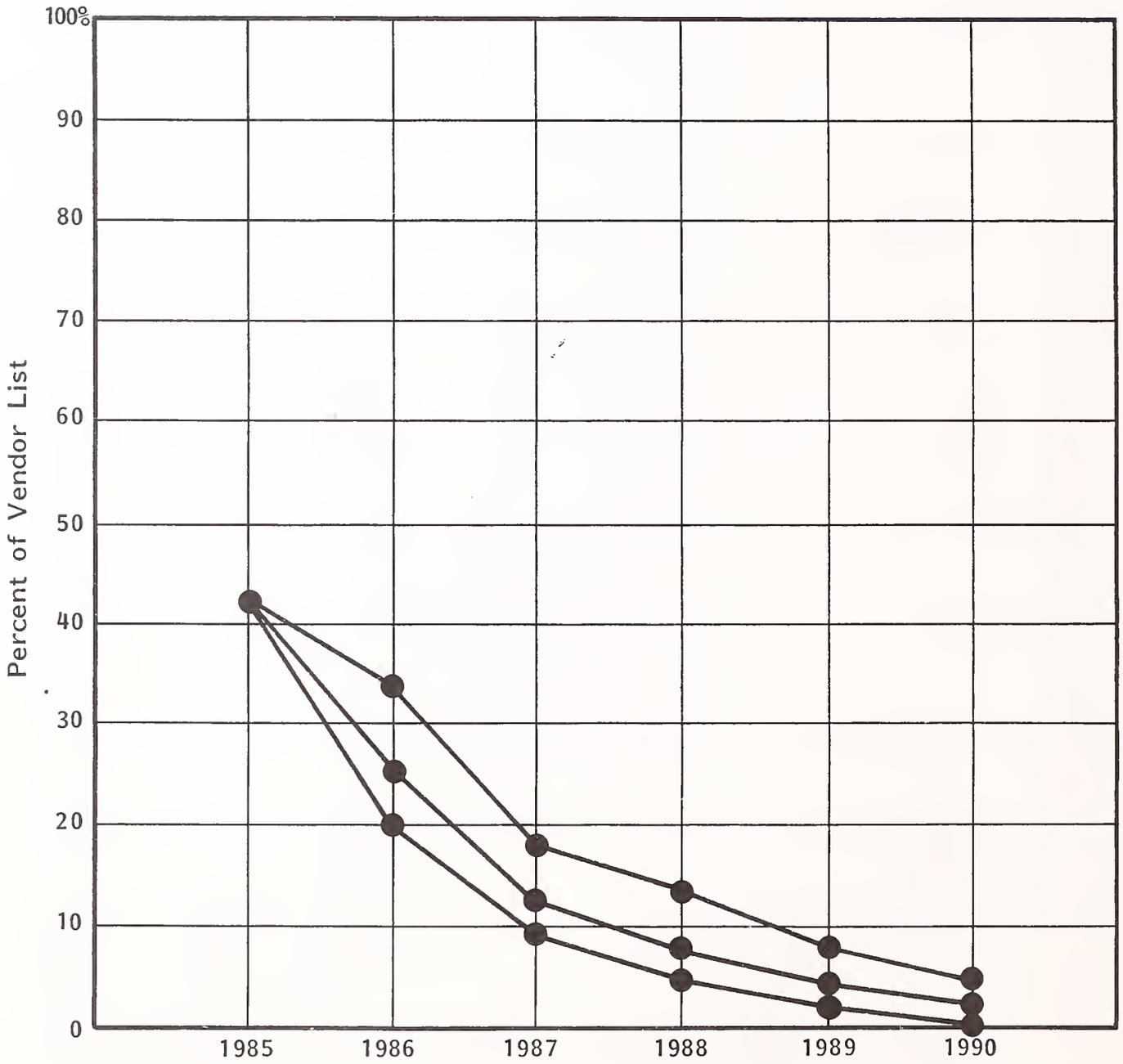
EXHIBIT III-27

RESIDUAL VALUE FORECAST FOR
NAS AS/9050 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	42%	33%	18%	13%	7%	4%
Expected	42	25	12	7	4	2
Medium	42	20	9	4	2	0

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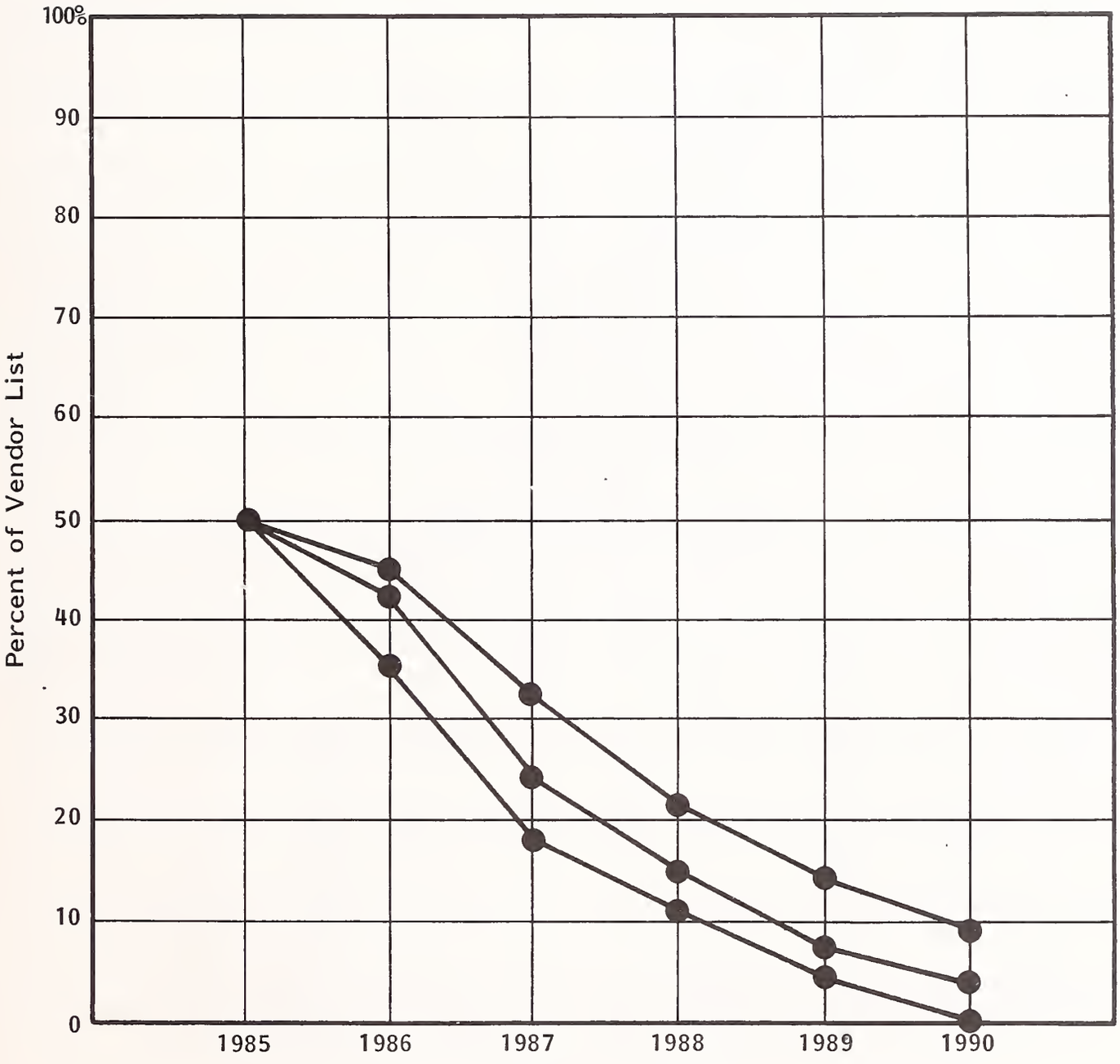
EXHIBIT III-28

RESIDUAL VALUE FORECAST FOR
NAS AS/9070 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	50%	45%	32%	21%	14%	9%
Expected	50	42	24	15	8	4
Medium	50	35	18	11	5	0

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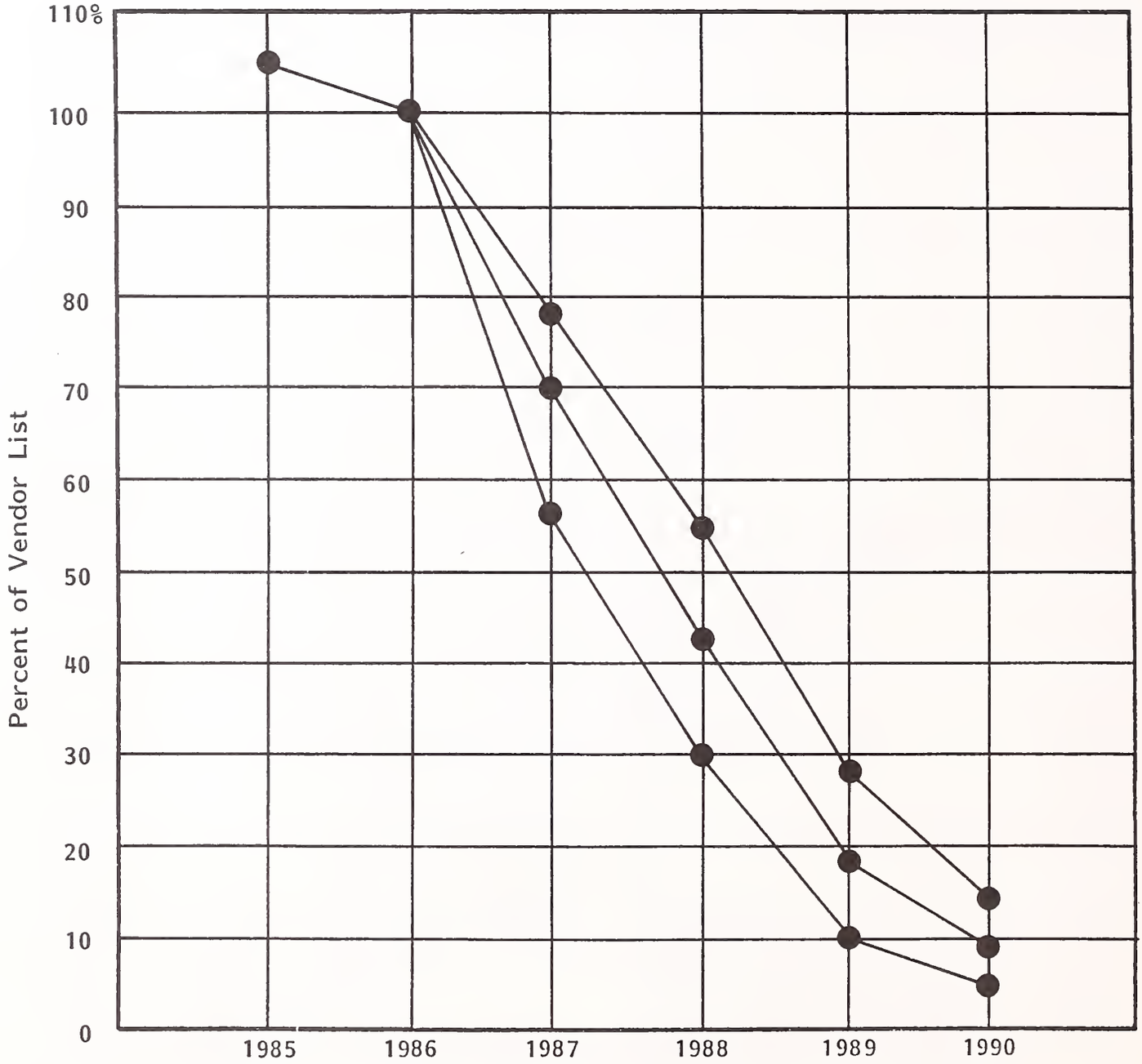
EXHIBIT III-29

RESIDUAL VALUE FORECAST FOR
NAS AS/9140 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	105%	100%	77%	55%	28%	14%
Expected	105	100	70	42	18	9
Medium	105	100	56	30	10	5

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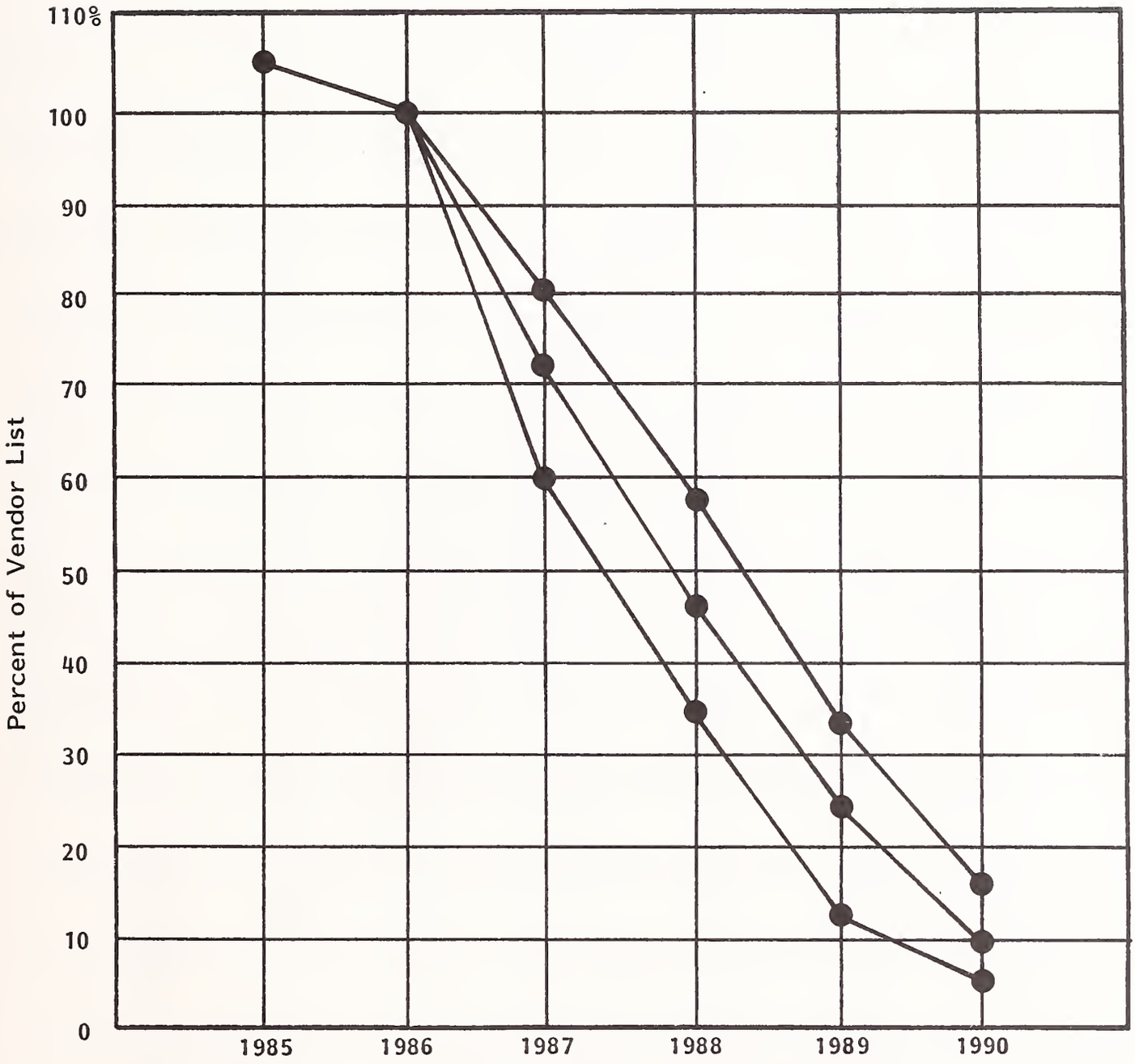
EXHIBIT III-30

RESIDUAL VALUE FORECAST FOR

NAS AS/9150 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	105%	100%	80%	58%	33%	16%
Expected	105	100	72	46	24	10
Medium	105	100	60	35	12	6

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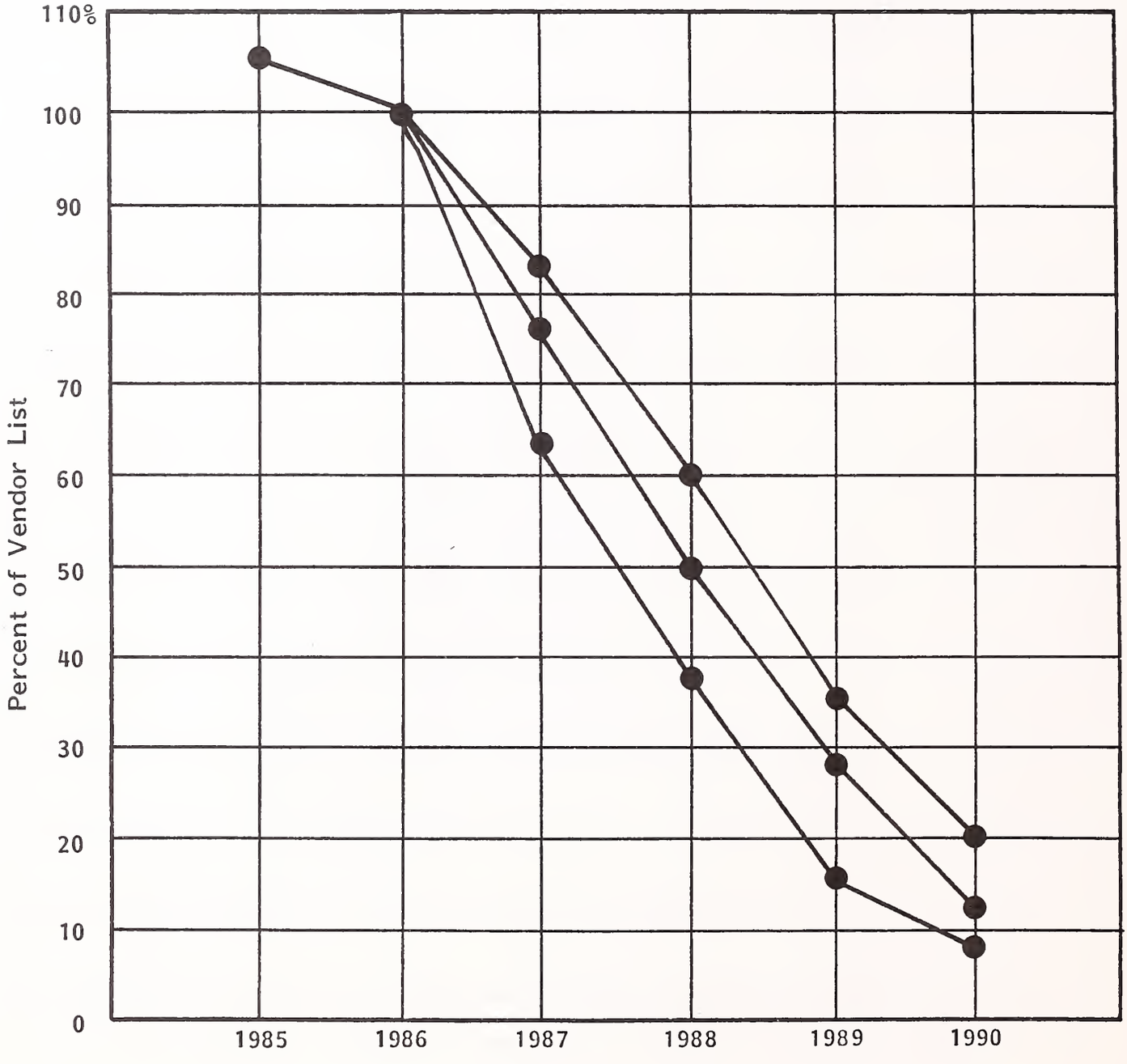
EXHIBIT III-31

RESIDUAL VALUE FORECAST FOR
NAS AS/9160 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	105%	100%	82%	60%	35%	20%
Expected	105	100	76	49	28	12
Medium	105	100	63	37	15	8

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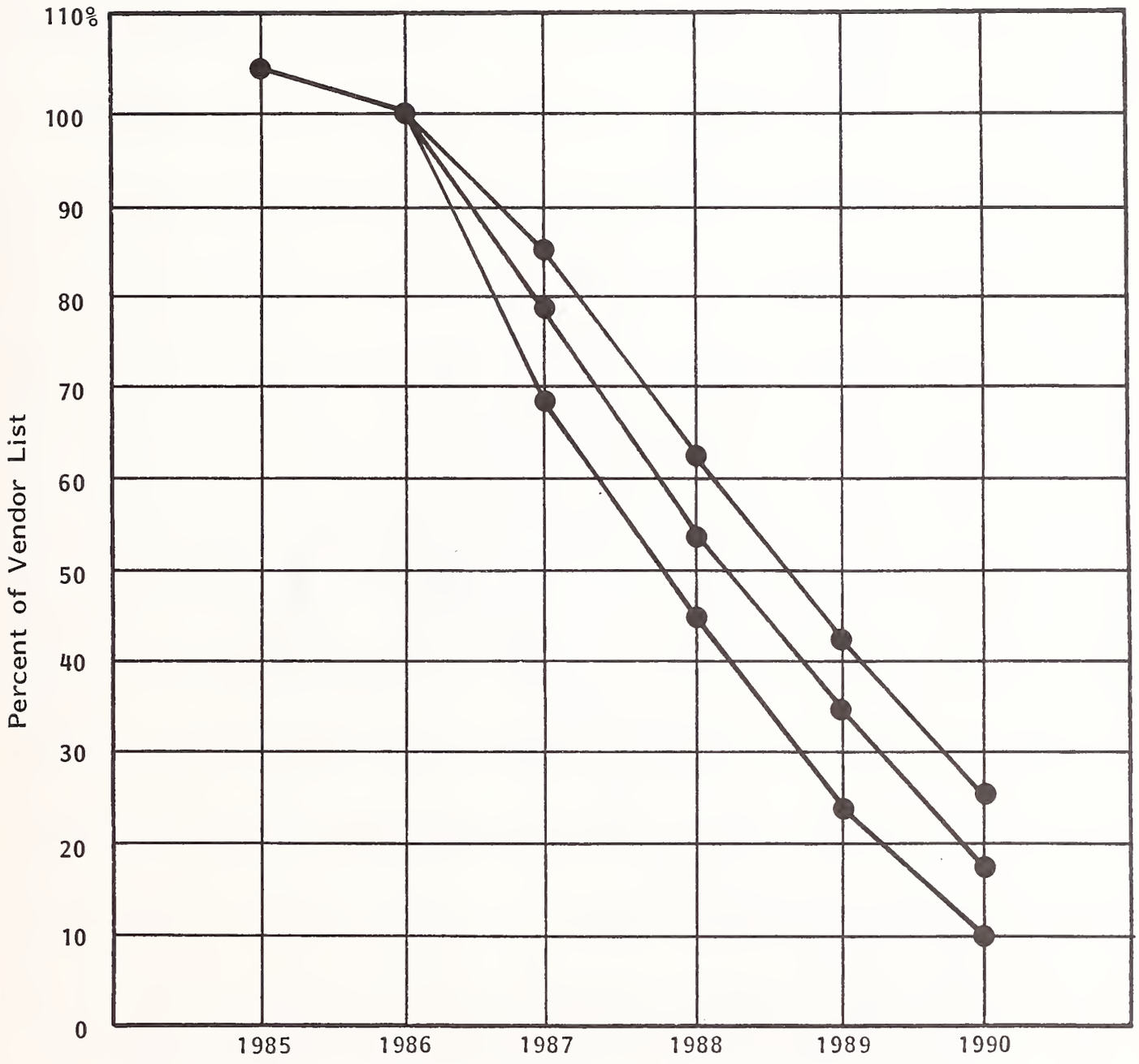
EXHIBIT III-32

RESIDUAL VALUE FORECAST FOR
NAS AS/9170 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	105%	100%	85%	62%	43%	25%
Expected	105	100	79	54	35	17
Medium	105	100	68	45	24	10

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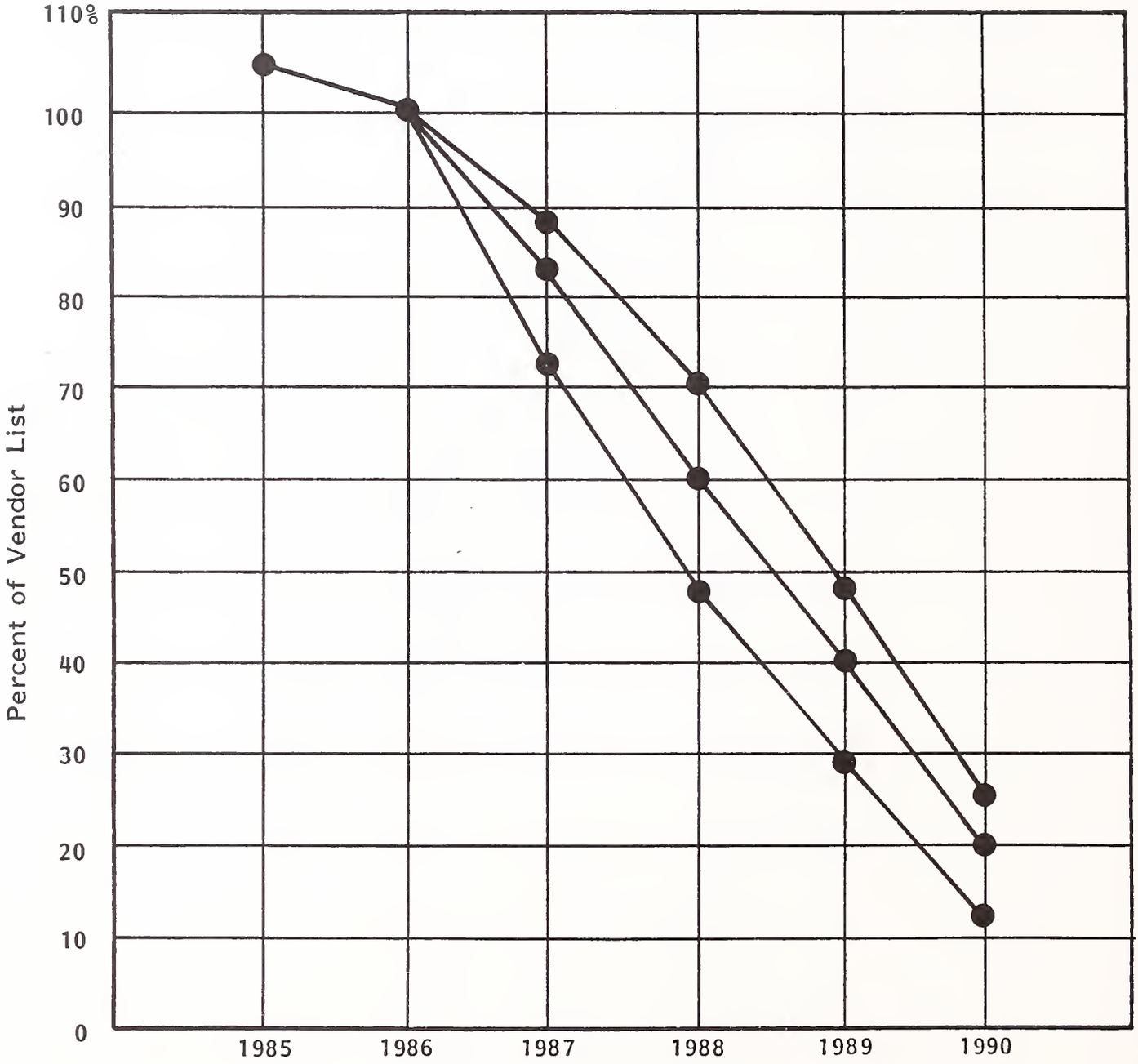
EXHIBIT III-33

RESIDUAL VALUE FORECAST FOR
NAS AS/9180 PROCESSOR



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	105%	100%	88%	70%	48%	25%
Expected	105	100	83	60	40	20
Medium	105	100	72	48	29	12

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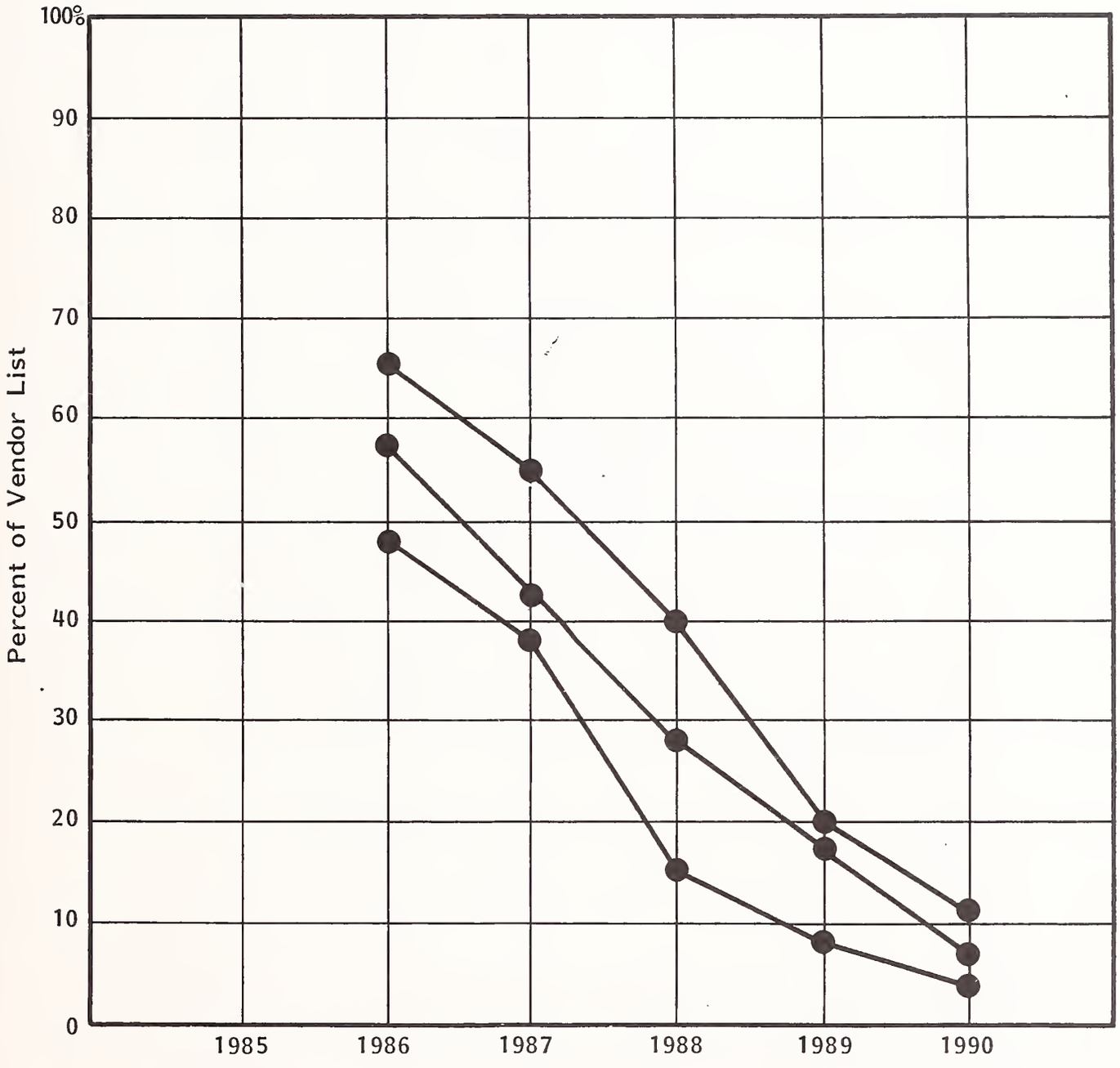
EXHIBIT III-34

PROJECTED RESIDUAL VALUES FOR THE
IBM 3380 DISK DRIVE



PROJECTED VALUES RANGE	1985	1986	1987	1988	1989	1990
High	0%	65%	55%	40%	20%	11%
Expected	0	58	42	27	18	7
Medium	0	48	37	15	8	4

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APPENDIX

FACTORS AFFECTING COMPUTER EQUIPMENT RESIDUAL VALUES

- IBM practices and policies
  - New product announcements
    - Price/performance ratios relative to existing products.
    - Ease of conversions, transitions, and lead time in obtaining new products.
    - Ease of installation and maintenance.
    - Effect on perceptions about IBM's technical direction.
  - Pricing policies
    - Price increases or decreases on existing products.
    - Rental versus purchase break-even ratios.
    - Lease plans and penalty provisions for lease termination.
    - Purchase option accruals.
  - Maintenance policies
    - Availability and cost.
    - Attitude toward other vendor modifications to IBM equipment.
- Alternative equipment services
  - Price/performance of plug- (software-) compatible alternatives.
  - Third-party leasing options.
- Other variables
  - Environmental support considerations, e.g., electrical power consumption, air conditioning needs, space requirements.
  - Tax considerations, e.g., income tax incentives such as investment tax credit and accelerated depreciation, and also property taxation rates.
  - General economic conditions, e.g., cost and availability of capital and overall demand for computing capacity.

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