Large-Scale Systems Directions: Large IBM and Software-Compatible Mainframes

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LARGE-SCALE SYSTEMS DIRECTIONS: LARGE IBM AND SOFTWARE-COMPATIBLE MAINFRAMES

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ABSTRACT

This report addresses the broad issues that need to be understood when an institutional entity attempts to quantify or qualify the value of its data/information/knowledge systems. The way in which the data/information/knowledge are distributed and how they are used is central to the realization of that value. Before one "jumps on the band wagon" of new hardware/software technology, one must have a thorough comprehension of how that technology is going to be applied to benefit the productivity of the whole enterprise, including the human.

Residual values for selected large-scale IBM (including the 3090-400) and software-compatible mainframes are updated based on recent announcements and other factors affecting that value. Other manufacturers' response to the Sierra Series is also covered in the report.

This report contains 65 pages, including 35 exhibits.

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LARGE-SCALE SYSTEMS DIRECTIONS: LARGE IBM AND SOFTWARE-COMPATIBLE MAINFRAMES

CONTENTS

LARGE-SCALE SYSTEMS DIRECTIONS: LARGE IBM AND SOFTWARE-COMPATIBLE MAINFRAMES

EXHIBITS

I INTRODUCTION

- Since INPUT started the Large-Scale Systems Directions report series two years ago, we have concentrated on specific hardware and software technical directions which are important to users of large-scale IBM and compatible systems. Among the topics analyzed have been the following:

  - The demand for on-line storage, how is is being fueled by IBM's software strategy (especially the multiple DBMS environment which became apparent with the announcement of DB2 for mainframes), and the promise of optical memories providing some relief for the ever increasing costs of magnetic storage. (Large-Scale System Directions: Disk, Tape, and Printer Systems, INPUT, 1984.)

  - The central role of IBM systems software and SNA in establishing a new role for large host systems, and the possible limits of growth of these enormous "data base machines" which will force the distribution of processing and data to the distributed nodes in major networks. (Large-Scale Systems Directions: Mid-Year Update--1984, INPUT, 1984.)

  - The applicability of the concepts of General Systems Theory (progressive centralization, integration, differentiation, and mechanization) to mainframe and network architecture with the resulting necessary architectural differentiation of mainframe functions and mechanization of other functions using microprocessor technology. (Large-Scale

Systems Directions--Large IBM and Software-Compatible Mainframes, INPUT, 1984.)

- An historical review of hardware costs for both processors and storage, and IBM's announced projections of how it expects MIPS, system memory, and DASD to grow through the 1980s. (Large-Scale Systems Directions: Disks, Tapes, and Printers, INPUT, 1985.)

- An analysis of the IBM Sierra (3090 200/400) along with the apparent continued centralization of processing on mainframes with limited distribution to intelligent workstations (PC-based), and the obvious integration problems associated with both software (UNIX, for example) and hardware (mini- and micro-based office automation equipment)--both of which give a clear indication of IBM's general network directions for the remainder of the decade. (Large-Scale Systems Directions 1985--the title was truncated, Mid-Year Update should have been concatenated--INPUT, 1985.)

- The above issues will all have considerably more impact on the true value of existing and planned information systems than any considerations of residual values of hardware components (which are presented in Chapter III of this report, as is customary). In fact, this analysis reaches the rather heretical view that anticipated "residual expense" of systems may be a more important concern than hardware residual values.

II MAJOR ISSUES ASSOCIATED WITH LARGE-SCALE SYSTEMS

- As computer/communications networks of increasing complexity seem destined to continue to develop, it seems appropriate to stand back and take a look at the broader issues which are involved in determining the value of the hardware/software technology which is being applied and where it may be taking us. INPUT believes there are four major issues which must be faced, and these will be examined in Chapter II of this report. Briefly, they are:

    - The rather superficial understanding of data, information, and knowledge which underlies many of the systems being considered and/or installed.

    - The quality (and cost) ramifications of distributing data/information/knowledge over computer/communications networks.

    - The impact of computer/communications networks on white collar productivity (including productivity associated with systems development).

    - The increasingly dominant role being assumed by IBM in establishing standards, acceptance of new technology, and hardware/software product and systems development; and the increasing acceptance of this role by users and competitors.

A. THE ISSUES DEFINED

1. DATA/INFORMATION/KNOWLEDGE IMPACTS

- Large-scale systems have been described by INPUT as tending to become "enormous data base machines." The routine tasks of automating factories and offices (in other words, the systems in support of day-to-day operations) are more effectively and efficiently performed by distributed mini- or micro-based systems. The big host engines are being used to pull together the data necessary to "run the business more effectively." Essentially, this nets down to accounting and statistical data to provide management information for planning, control, and decisionmaking.

- We have all been informed that corporate data bases (once built) have value, and it has even been suggested that the development effort of building them should be capitalized. Information has been classified as a corporate asset (at least by vendors), and books describing the rapidly approaching "information age" have become best sellers. And now the knowledge in the graying heads of decisionmakers (or professionals) is deemed to have residual value worth capturing and recycling in "knowledge bases." However, there is a major issue of understanding what all of this talk about data/information/knowledge really means.

- Not only do most information systems personnel (both vendors and users) have limited understanding of what data, information, and knowledge are, but it is only necessary to browse through the literature of "information science" to understand that dictionary definitions will not suffice. While some of the difficulty can be attributed to "semantic quirks," there are profound conclusions which can (and must) be reached concerning the distribution and flow of data/information/knowledge over computer/communications networks once the operators at the workstations are included in the analysis (as they must be).

- Despite all of the glib pronouncements about the value of data/information/knowledge, there is currently no way to place a value upon it. This is because value is tied to quality and not quantity: more gigabytes of data do not necessarily add value; more tons of paper do not necessarily contain more information; and, contrary to popular opinion, two or even 100 heads do not necessarily contain more knowledge than one.

- Assuming we are on an irreversible course toward the "information age," there is no assurance that the systems to support this new era can be built. Certainly the past track record has not been anything to inspire confidence in the future--we are still talking about doing the things which were being promised 20-25 years ago. The primary reason (or excuse) remains the same--the program will work if the data are good and available, and the information system will work if the users can decide what information they need. Expert systems will inevitably reach a similar stonewall relative to knowledge and intuition.

- Finally, even if we built the necessary systems and entered into the "information age," what will be the impact on business, the economy, and the general commonwealth?

2. NETWORK DISTRIBUTION OF DATA/INFORMATION/KNOWLEDGE

- INPUT first described a "proper hierarchical network" 10 years ago, and the Large-Scale Systems Directions report series has analyzed the development of such networks (see Chapter I of this report). The following supplementary comments will highlight the reasons distribution of data/information/knowledge remains a major issue.

- The stated goal of computer/communications network architecture is to permit the user at the workstation to have transparent access to the processing power, data, information, and (eventually) knowledge connected to the network. Therefore, the proper hierarchical network must be extended to include human beings at their point of interface with the network (see Exhibit II-1). It then becomes apparent that what we are dealing with is one big system and it really does not make sense to talk about mainframes, office automation, and personal computers--it is the direction that network architecture will take which will dictate the proper role of the parts.

- The primary distribution of data/information/knowledge over the network then falls quite conveniently into the proper hierarchy:

  - Most data reside, and are processed, on mainframes (forget about more MIPS being installed on PCs--substantially less than 1% of their time is spent processing data).

  - Minicomputers (departmental processors) are the engines of office automation where most information is generated, stored, and handled.

  - The intelligent workstation (personal computer) is where both data and information interface with knowledge (the human user).

  - Dumb terminals remain dumb in the sense that they perform specific functions (as opposed to being user programmable), but may be more expensive than their intelligent relatives at Level III (an ATM is a good example). The trend toward dumb terminals attached to intelligent workstations is immaterial from the operator's point of view. It remains the point of interface with all the processing power, data, and information on the network.

  - Mobile terminals (not normally shown on exhibits depicting the proper network, but predicted in the 1976 report) are becoming increasingly practical because of rapid microprocessor and storage developments combined with improved communications networks such as cellular radio. Once again, as soon as the terminal is connected to the network,

EXHIBIT II-1

THE PROPER HIERARCHICAL NETWORK*
(Extended to Include Humans)

Level	($ Thousands)	Hardware Class			Data, Information, Knowledge Distribution
I	> 4,000	Very Large Mainframes			Primarily Data
II	< 200	Minicomputers			Primarily Information
III	< 10	Intelligent Workstations		Knowledge	Limited Data & Information
IV	Varies	Dumb Terminals Levels I & II		Knowledge	Input & Output
V	< 10	Mobile Terminals		Knowledge	Limited Data & Information

*For Summary of Functions at Various Levels, See Exhibit II-6, Large-Scale Systems Directions, 1985 (last report).

whether from a car, boat, or airplane, large systems capability becomes available.

- Communications alternatives, both in technology and services, have proliferated more rapidly than has technology on the computer side.

  - Competition between carriers of all kinds may be confusing, but it is certainly providing alternatives. Bypass microwave networks and satellite "teleports" are coming into being, with the result that cost effective alternatives for both international and local distribution are becoming available.

  - Integrated digital systems networks (IDSNs) are being planned for the immediate future, antennas are becoming cheap enough for even the smallest company to afford, and technology is now being developed which will turn a conventional TV antenna into a two-way station for interactive access to the spectrum between over-the-air TV channels.

  - Geography is becoming less important in terms of space, time, and cost. The major issue involved for computer/communications networks is how the two technologies will merge. Standards are the key to this determination. Traditionally, computer systems and communications organizations do not communicate very well—each considers the other to be an extension of itself.

- At the time the distributed network was first described by INPUT, it was also recommended that all processing and data first be centralized and then distributed in an "orderly" basis. (That is why replacement of standalone systems was, and remains, an important function of very large mainframes.) Unfortunately, productivity problems associated the systems development process combined with the rapid development of microprocessor technology in the form of personal computers has resulted in the distribution of computer power to the users being far from orderly.

- In fact, the distribution of data, information, and knowledge over the computer/communications network has been chaotic, and the result has been the potential for every employee to have a standalone system waiting to be tied into the network. Data/information/knowledge have been, and continue to be, distributed without regard for how control can be exercized. It is difficult to exaggerate the potential danger of this situation to general corporate well being.

- Concurrent with this dangerous situation, computer/communications technology continues to advance more rapidly than can be comprehended, much less be put to intelligent use. When the original network was described by INPUT, it was stated that emphasis on processors was misplaced since it would soon be possible for every employee to have more than enough processing power at the desk top. Not only has this occurred, but it is now safe to say that with the development of optical memories it will soon be possible for each employee to have a significant portion of the entire corporate data/information base not only at their desk top but in their briefcase. And when knowledge-based systems are developed, they can also be easily distributed and transported.

- There has been entirely too much attention given to new hardware technology (combined with a pathological compulsion to apply it) and entirely too little attention given to the intelligent application of this technology.

3. PRODUCTIVITY IMPROVEMENT

- The cost justification for data/information/knowledge based systems is to improve white collar productivity, and it is acknowledged that the key white collar area which needs improvement is in the systems development process itself--otherwise the systems to improve the productivity of other workers will not be developed. Over the years, INPUT has conducted substantial research on productivity in the systems development process, and in 1984 it was determined that the predominant trend was toward distributed systems development (DSD).

- Distributed systems development (DSD) is manifested in the following current trends.

  - The use of personal computers to complement and/or supplement services (or lack thereof) from the IS department.

  - The strong and natural desire to connect these personal computers to mainframe data bases so that end users can have access to corporate data.

  - The promotion of Information Centers to improve the responsiveness of the IS department in developing new systems or modifying old ones.

  - The use of productivity tools, such as 4GLs, to prototype applications and show immediate results.

- While recognizing that the intelligent application of any of these approaches may achieve significant improvements in productivity, it is necessary to recognize that there are inevitable conflicts in the DSD environment. To mention a few:

  - Top-down systems design does not necessarily interface smoothly with bottoms-up applications development--in fact, prototyping is being referred to as "premature and eternal systems development" by some IS departments.

  - Access to corporate data creates security problems and security requirements can restrict access--there is a problem both ways.

- As systems development tools become more integrated from micro-to-mainframe, there is increased functional capability (and complexity), and this is not necessarily compatible with the user friendliness which encouraged the use of personal computers to begin with--quite the contrary.

- The problems of data base integrity and synchronization increase exponentially as data bases are distributed to Information Centers and intelligent workstations. These problems do not have a ready solution.

- While the purchase of personal computers (and the implementation of distributed processing) has frequently been justified on the basis of offloading mainframes and providing a more cost effective information systems solution, there is no indication of the predicted decrease in demand for mainframe processing power--in fact, micros linked to mainframes seem to create processing demands which threaten to overburden host mainframes further.

- Add to all of this the problem of conflicting reports generated from competing systems (or those in different stages of evolution), and it becomes apparent that volume of information does not correlate very well with quality (true information content), and it drives both internal and external auditors crazy.

• In fact, it becomes apparent that the very productivity tools which drive the DSD environment may be counterproductive when they are evaluated against anything other than the ability to "get results." The recent highly publicized case of using a 4GL to develop an unworkable system for motor vehicle registration in New Jersey is a good example--it is not productive to get a system "up and running" if it is of such poor quality that it must be done over.

• In the current DSD environment, it is especially important to measure productivity improvement based on performance at the following levels:

- Hardware/Software performance has been deemed as being relatively unimportant because: "Hardware costs are coming down and people costs are going up." While this is an understandable argument from both hardware vendors and users to justify the latest technology, it is also true that substantial investments have been made in new technology which has not provided promised benefits in terms of either decreased costs or improved business planning. And, the number of applications systems which require additional, unanticipated hardware to achieve minimally acceptable performance is legend but seldom measured.

- Human/Computer Dyad performance refers to the relative effectiveness of an individual using computer/communications technology, and while such performance is relatively easy to measure, the validity of many measurements is highly questionable. For example, getting out bigger documents faster does not address the value of the information being generated, and the measurements are frequently flawed in terms of ignoring hidden costs such as professionals' time spent performing clerical functions at the expense of professional duties.

- Work Unit Networks represent various organizational entities such as departments or project teams and their relative effectiveness before and after automation (or whatever we want to call it). Work unit networks are characterized by being communications oriented, and the measurement problems associated with paper volume versus information content become even more complicated. Unnecessary communications between, or among, network nodes can adversally impact work unit performance while appearing to enhance the performance of all human/computer dyads.

  . There is a significant difference between being busy and being productive in the office, and little attention has been given to anything other than word processing and routine calculations (such as spreadsheets) in measuring white collar productivity.

- There is also another important consideration and that is that work networks do not have to be local or constrained by physical buildings or geography, and this has great significance in terms of both organization and span of control.

- Institutional performance is by far the most important and the most difficult to analyze in terms of the contribution of computer/communications systems. Despite all of the talk about decision support, it is doubtful that anything other than routine accounting reports contribute very much to the decisionmaking process. Therefore, the correlation between decisionmaking and institution performance must be established, and this is seldom done objectively. Management is all too ready to accept credit for outstanding institutional performance and blame "bad" data and information for the failures. Surprisingly, this rarely turns out to be the case. Given the same data/information, some executives will succeed and others will fail--executives have some right to take credit for success. However, even the best executives can be misled by faulty or conflicting information.

4. THE ROLE OF IBM

- The Large-Scale Systems Directions series of reports has, of necessity, recognized the dominant role of IBM in large-scale systems directions and in the determination of residual values for such equipment. IBM has established a position of dominance which permits it to control the release and/or acceptance of new technology. To the degree that it dominates and exercises this control, IBM lends an element of stability to the advance of technology which is not recognized in the marketplace or by its competitors because of the constant state of confusion surrounding specific product announcements.

- INPUT reviewed historical trends of both large-scale mainframes and direct access storage devices in Large-Scale Systems Directions: Disks, Tapes, and Printers published earlier this year. It was pointed out that INPUT forecasts made nearly 10 years ago were quite accurate in terms of projected price/performance improvement precisely because we recognized IBM's position of leadership in establishing the pricing "umbrella" for large-scale systems.

  - The point is that IBM will be quite orderly and predictable in its technology releases as long as it can meet its business objectives--which are also orderly and predictable. However, IBM has demonstrated a remarkable ability to respond to perceived competitive threats especially since it was forced to shorten product cycles in response to rapidly changing microprocessor technology.

- The instruments of IBM control are systems software and its Systems Network Architecture (SNA). And regardless of how much they have been maligned, both in the industry and within IBM, IBM operating systems (from OS to VS to MVS to MVS/XA, and now VM) have sold more iron (directly and indirectly) than any other technological development. For over the last 10 years, the primary purpose of this awesome systems software strategy has been to keep minicomputers from assuming their proper place, as described by INPUT, in the hierarchical network.

- IBM's software strategy is pivotal to its business strategy, both for issues and challenges as well as for opportunities. INPUT examined this strategy in Market Impacts of IBM Software Strategies, 1984, and the General Systems Theory concepts of progressive centralization, integration, differentiation, and mechanization have been used to analyze the architecture of large-scale systems and networks in this series of reports (Large-Scale Systems Directions: Large IBM and Software-Compatible Mainframes, INPUT, 1984). The IBM Software Strategies report used General Systems Theory concepts to break IBM's strategy down into four strategic periods:

- The <u>SNA/DDP</u> strategic period (1985-1990) during which IBM will continue to pursue a highly centralized strategy with emphasis on large host mainframes.

- The <u>Electronic Office</u> strategic period (1900-1995) during which IBM will integrate data processing systems with office systems (including paper based systems) and effectively make obsolete and replace most current office automation systems and products.

1990!

- The <u>Expert Systems</u> strategic period (1995-2000) which will be characterized by differentiation into specialized systems emphasizing common data/information/knowledge services to various segments (industries and professions) and individuals.

- The <u>Custom Products</u> strategic period (beyond the year 2000) which will see the mechanization (automation) of information services down to the individual. (In other words, by providing individualized services at the end user level, IBM will effectively shift account control to that level.)

- It is obvious that IBM is already involved tactically in all of the above areas. For example, SCANMASTER facilitates electronic handling of documents, and Prolog has been announced along with an "Expert System Environment" under VM. However, the strategic periods isolate the systems developments most important to IBM in achieving its revenue objectives during the specified timeframe.

• Assuming INPUT's analysis of IBM's long-range strategy is reasonably accurate (see the cited report for this analysis), it is possible to draw certain conclusions about IBM's endorsement (or rejection) of certain technologies. The most convenient way to comment on IBM's position is to proceed down the hierarchical network described by INPUT.

- There is no question that IBM will continue to depend upon mainframes and magnetic disk storage for the bulk of its revenue and growth during the late 1980s. This continued emphasis on Level I of the processing hierarchy represents a continuing battle against the proper role of minicomputers which extends back to the time when SNA was announced. Some of the confirmations and conclusions which can be reached about the SNA/DDP strategic period are as follows:

  . It has been obvious for some time that IBM has opted for a multi-operating system (VM and MVS/XA) and data base system (IMS and DB2) environment at Level I. This all adds up to continued centralization of data base control on large host processors with enormous storage capacity.

  . The entire Sierra announcement with its emphasis on scientific processing and the announcement of UNIX (under VM) running on mainframes are designed to absorb the interactive computing which has been so successfully implemented on minicomputers.

- IBM's continuing battle with minicomputers at Level II has been complicated by the emergence of LANs and, specifically, ETHERNET. An initial IBM reaction were controller-based systems for point of sale and financial systems and general purpose 3790/8100 clusters for LANs. That attitude has evolved into one bordering on condescension as IBM points out the many complexities associated with LANs, emphasizing that LANs address the cabling problem and not the problem of attaching terminals. Independence in attaching terminals must consider the requirements of noncoded information (voice to full-motion color images), coded data (thousands of bits per screen), and coded information (images with hundreds of thousands of bits per screen). If users only want to cable once, they had better go slow. The answer from IBM's point of view is obviously SNA, and IBM has been quite explicit in its preferences and ultimate direction.

- IBM prefers Ring topology and Token protocols (although they may implement others).

- Very large networks will be supported with expanded addressing capability (MVS/XA will be obsoleted in the late 1980s) and will permit network interconnection.

- Non-SNA device attachment is anticipated and will theoretically be facilitated.

- There will be new data network attachments and enhanced network management capabilities.

- New communications products from IBM will emphasize new functions, ease of use, and interconnection.

- Software distribution will be incorporated under SNA.

- All of the above sounds great, and this will be IBM's emphasis during the SNA/DPP strategic period, but the issue and challenge remain as to timing and the potential cost of either going forward or waiting for IBM to establish standards.

- When we view Levels II, III, and IV (to say nothing of V) with the rich variety of products arriving practically on a daily basis, it is little wonder that both the present and the future of office automation is in such a state of disarray. This suits IBM's business objectives during the SNA/DDP strategic period, but IBM has been preparing for the Electronic Office period for some time.

- Since IBM has established the standard(s) for intelligent workstations, it can also be assumed that the linkage to mainframes will await IBM's leadership. The most popular candidate for a micro-to-mainframe link is currently LU6.2 which provides a direct application-to-application link from Level I to both Level II and Level III. Referred to as "Peer-to-Peer," it must be noted out that during the SNA/DDP strategic period it is probable that some peers will be more equal than others, and it does not take much imagination to figure out which are which.

- As pointed out earlier, IBM's primary emphasis during the Electronic Office strategic period will be on integration, and IBM has been forging its set of software tools for office systems integration for over five years. Unfortunately, the tools themselves were developed to solve IBM's hardware problems. The primary vehicle which has been put forth is DIOSS (Distributed Office Support System), announced in 1978. It has been extended to include two sets of protocols:

  - Document Content Architecture (DCA) defines the structure under which all IBM documents will be stored.

  - Document Interchange Architecture (DIA) defines the rules to be used by all IBM office systems when sending documents to and from one another.

  - While DIOSS is far from a standard for office systems today, competitive vendors are beginning to recognize the direction and announce compatible products.

- Considering the problems of the DSD environment, it is possible to make a good argument that IBM's strategy not only makes sense but is the only one which can be adopted.

  - Certainly, strong central control is necessary if problems of data base integrity and synchronization, privacy, and security are to be avoided.

- Standards are necessary for the industry unless all of the problems are to be exacerbated.

- The networking environment is complicated at all levels, and it would be unwise to proceed more rapidly than IBM.

- In addition, users are incapable of developing applications systems quickly enough to keep up with technological developments.

- However, there are several reasons to be concerned about IBM's dominance:

  - Performance at the Hardware/Software level may not only be unacceptable from a cost point of view, but may actually prove unworkable. IBM systems software and SNA have evolved into increasingly complex environments, and IBM's technical achievement in making the whole thing work should not be minimized. However, the obvious direction toward multiple operating and data base systems with layer upon layer of overhead cannot go on forever, and eventually the big engines will be unable to get many systems off the ground.

  - This limitation in Hardware/Software performance will limit productivity improvement at other performance levels (as described earlier in this report), and some of this impact can already be seen.

    - Delays in micro-mainframe links result from the complexity of the mainframe software, but once the link is made it is found (or will be found) that performance of the mainframe will be the limiting factor on productivity at the Human/Computer Dyad level (either because of response time in file transfer or because the cost is prohibitive).

    - The continuing battle to keep high performance minicomputers from assuming their proper functions at Level II in the processing hierarchy (in favor of mainframe hardware/software architectures) has the same impact on productivity at the Work Unit Network (LAN) performance level.

. Executive dissatisfaction with realizing the benefits of new technology at the Institutional Performance level is already apparent, and miscalculations concerning performance at the Hardware/Software level can result in disastrous or even catastrophic impacts on an institution.

- Given IBM's leadership role (especially with IS management), there is also the potential for IBM to control the acceptance of valuable new technology. The case with minicomputers in the office environment has been emphasized and that battle continues. However, INPUT anticipates a similar battle against emerging optical memories which will soon threaten IBM's magnetic disk revenues.

B. THE IMPACT OF MAJOR ISSUES

- The major issues associated with large-scale systems directions (as described above) suggest strongly that careful analysis and thought be given to their potential impact on white collar productivity at the four performance levels which were defined as: Hardware/Software, Human/Computer Dyad, Work Unit Network, and Institutional. It is INPUT's opinion that questions of whether the residual value of hardware will be 25% or 10% of manufacturer's list price in five years is a trivial consideration compared to the potential "residual expense" associated with the development of computer/communications systems subject to the impact of the major issues which have been described.

- "Residual expense" includes not only routine maintenance and operating expenses of the system (which are known to exist but are seldom deemed critical or quantified before the system is developed), but those continuing expenses which may be hidden in the system over its life cycle and even after it has theoretically been replaced. While most of these expenses can be anticipated and even avoided with good systems design, the issues which have been defined would not exist if good systems were prevalent at the present time (or even anticipated in the future). While potential residual expenses will vary tremendously on an application-by-application and company-by-company basis, it is possible to give some representative examples of negative impacts at the four performance levels.

1. HARDWARE/SOFTWARE PERFORMANCE (PERFORMANCE LEVEL ONE)

- If the residual expense of quick and dirty (sloppy) systems work currently running in production on large scale systems could be measured, many systems personnel would be embarrassed and/or looking for work. The DSD environment, with its emphasis upon getting things up and running and the myth that hardware costs are coming down so rapidly that gross inefficiencies can be justified in order to improve productivity in the systems development process, can only add to this hidden operating expense of large-scale systems already burdened with oppressive multi-level operating systems and multiple data bases.

- Unless processing is distributed in an orderly fashion from the overburdened mainframes, the fragmented applications with "peer to peer" communications will result in greater total residual expense on the two (or more) systems.

- As systems become more complex and data/information/knowledge bases grow, they exhibit increased entropy--which is the irreversible tendency toward chaos which can only be contained by the application of increasing amounts of energy (computer processing power). And, there is every indication that the requirement for MIPs (energy) increases more rapidly than overall data base size (see Large-Scale Systems Directions: Disks, Tapes, and Printers, INPUT, 1985). There is a residual expense associated with the decision to centralize data bases on large-scale hosts--a nonlinear increase in necessary computer power.

- The residual costs of operating systems functions or data base systems continue long after the heavy use which may have prompted their original use has demanded. For example, when and if 90% of IMS data base applications migrate to DB2, the reduction in IMS hardware/software cost will not approach 90%. In fact, it is probable that if 90% of the total applications systems processing burden on a host mainframe was distributed to other nodes in the network, it would be impossible to replace the host and the residual costs would remain at approximately the same level as the fully loaded system.

- Data bases and communications services exhibit similar high residual costs when use diminishes or traffic patterns change.

2. HUMAN/COMPUTER DYAD (PERFORMANCE LEVEL TWO)

- Once the human at a personal computer is linked to mainframes and enters the wonderful new world of being "unconcerned" about where data resides or even where processing occurs, residual expense has exponential potential for growth because both internal and external services on networks create expense regardless of whether or not they are used (just as magazine subscriptions are not based on whether you read them or the quality of the information you receive).

- In addition, while the user "need not concern himself" with where that data/information/knowledge resides, he had better concern himself with its intelligent use and quality (in other words, changing dictionaries and directories must be understood and many new data/information/knowledge sources must be evaluated). In addition, once all this wonderful data is available, the human becomes intimately involved in maintenance of both programs (regardless of how simple) and various data/information/knowledge bases (regardless of how complex). Performance at the Human/Computer Dyad level cannot be measured solely by how long it takes the human to ask another "what if" question and jockey numbers around in a spreadsheet--it will also have to include the time spent keeping personal data bases maintained.

- The case of knowledge based system is going to be especially difficult in this regard since the user of an expert system must determine whether or not the "solution" generated by the expert system is acceptable (and continues to be acceptable). The need for an expert system to explain what it is doing has been recognized, but the responsibility for understanding and rejecting crazy solutions and for improving the knowledge base rests with the expert (even if he must communicate his changes through a knowledge engineer). It is probable that an expert system will create substantial residual expense regardless of the quality of its solutions and/or decisions.

- Indeed, there is good reason to contemplate the master-slave relationship at the Human/Computer Dyad. Certainly, response time on the part of the system is beyond the control of the human. Fast response may establish the machine as master because humans cannot possibly analyze all of the data/information/knowledge the computer uses in generating information and in reaching solutions--the human must either accept his subordinate role or revolt. On the other hand, poor response time or sloppy interfaces can keep human beings from continuing their work. There is substantial risk that the Human/Computer Dyad level will not only devalue the human side (as Norbert Weiner feared many years ago), but that the machine, by unresponsiveness or by being demanding (unfriendly), may actually lower human productivity. It is certainly true that when the computer "takes a vacation," the human's productivity drops sharply. It becomes a little scary when it is recognized that the conduct of the computer resembles that of master (keeping the slave waiting, going on unscheduled vacations, demanding menial work, being spoon fed, etc.) and the human, regardless of his station among other humans, has no alternative but to adjust his behavior. Philosophy aside, there are substantial residual expenses on the human side of the Human/Computer Dyad level.

3. WORK UNIT NETWORKS (PERFORMANCE LEVEL THREE)

- There are substantial realignments of responsibilities and functions as electronic work units are established, and both have the potential for substantial residual expense. Managers and professional personnel are performing secretarial (typing), clerical (filing and document distribution), and technical (report formatting, graphics, printing) functions. Secretarial, clerical, and technical personnel as skilled operators of workstations are being reclassified into professional categories (the work they are doing looks professional, and they may actually be more skilled at the Human/Computer Dyad level). Thus, there is a tendency to overpay both professionals and nonprofessionals for what they are <u>actually</u> doing.

- The changes required when (LANs) evolve into true electronic offices are also nonreversible, and the residual expense will exist regardless of the effectiveness (performance) of the resulting Work Unit Network level. While the physical restrictions of the office are removed, the very flexibility will result in more complex and informal organizations being formed which may be uncontrollable. The ability to bring experts or consultants (either internal or external) into the Work Unit Network level will tend to effect permanent (an perhaps expensive) changes in the organizational structure.

- In addition, the improved ability to generate traffic at the Human/Computer Dyad level will tend to increase the flow of low quality information within the Work Unit Network level (it will be even easier to copy everybody on everything and a lot of gossip and unrelated communication is inevitable). The filtering process to extract value out of the information flow will represent substantial residual expense.

4. INSTITUTIONAL PERFORMANCE (PERFORMANCE LEVEL FOUR)

- The cost (both real and residual) of Performance Levels One, Two, and Three are going to be substantial, and there is absolutely no guarantee or hard evidence that the value of the resulting data/information/knowledge will improve institutional performance. You may have the best data/information/knowledge base in the world and be run out of business by a competitor in Tibet using an abacus. Or, consistent 90% solutions from expert system may not be able to compete against a competitor with a human expert who scores in the 95% range.

- Spectacular failures of systems can have disastrous and even catastrophic impacts on institutional performance, but the residual expense of entering the information age may have comparable long-term results.

- The purpose of INPUT's Large-Scale Systems Directions report series is to provide insight into the problems as well as the promise associated with the advance of computer/communications technology. Next year, the report series expects to focus on identification of potential residual expense as we continue to provide projections of the residual values of hardware investments. It is hoped that this will provide both IS and corporate management with the ability to ask the questions which will permit them to achieve the maximum benefit from their total investment in information systems.

III RESIDUAL VALUE FORECASTS

A. FACTORS AFFECTING RESIDUAL VALUE FORECASTS

- Computer equipment residual value forecasts are based upon:

  - Analysis of historical events and trends leading to judgements about whether (and in what ways) such trends may change.

  - Predictions by computer industry experts on expected actions by IBM and responding strategies by both software-compatible mainframe manufacturers and vendors of alternative hardware/software network architectures. (Increasingly, INPUT has come to rely on its own past research for major industry trends and strategies, and the first two years of this report series have summarized (and referenced) the major conclusions which can be reached from that research as it pertains to factors affecting residual values.)

  - Analysis of variables affecting residual values as listed in Exhibit III-1.

- The most visible factor affecting IBM mainframe residual values is the announcement of a new series of large-scale mainframes, and this has been a banner year with the long awaited (and delayed) Sierra being announced and the somewhat predictable reactions of the software-compatible competitors following in its wake. The specifics of the IBM 3090 announcement were

EXHIBIT III-1

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.

presented in the last Large-Scale Systems Directions report, and the NAS response was reported in Large-Scale Systems Directions: Disks, Tapes, and Printers earlier this year. Amdahl's response is covered in this report.

B. ANNOUNCEMENTS

- Amdahl announced its response to the IBM 3090 series in late October with three models of a new 5890 series which are not field upgradable from existing Amdahl 58XX mainframes. The new Amdahl processor models compare to the IBM 3090 series as follows:

  - The low-end Amdahl 5890, Model 200 roughly equals the IBM 3090, Model 200 in internal throughput, sells for 18% less, and will not be delivered until the first quarter of 1987.

  - The 5890, Model 300 is priced approximately the same as the IBM 3090, Model 200, boasts a 32% performance improvement, and will be delivered in the second quarter of 1986.

  - The 5890, four-processor, Model 600 is priced the same as the IBM 3090, Model 400, provides 30-35% more throughput, and will be delivered in the third quarter of 1987.

  - While some analysts have tended to downplay the Amdahl announcement because of the delivery schedules, positioning the Model 300 for first delivery is not such bad strategy--it has substantially more performance than the IBM 3090, Model 200 and throughput will be closer to the 3090, Model 400 than MIPs ratings would indicate. If attention can be focused on price/performance, IBM may be forced to make price adjustments before its Model 400 is ever delivered.

- A year ago, in Large-Scale Systems Directions: Large IBM and Software-Compatible Mainframes, INPUT presented the need for differentiation of function in order to break the "von Neumann bottleneck." In early October, IBM announced a vector processor for its 3090 series which is reported to improve performance of arithmetic and logical operations by "1.5 to 3.0 times."

  - IBM refused to assign a megaflop rating to the system, and this is probably appropriate because it is not designed to compete against supercomputers and is not in a class with the Amdahl 1100 and 1200 vector processors. It appears to be more competitive with the National Advanced Systems AS/9100 which was originally announced as an "entry-level supercomputer" capable of outperforming IBM 308x uniprocessors 14-fold on vector processing. IBM is wise not to get in a megaflops race, and the last thing the industry needs is a set of entry-level, mid-range, and super-super computer classifications to contend with.

  - It is INPUT's opinion that the announcement is very much in line with our analysis of the 3090 announcement--IBM is beefing up its general purpose mainframes to compete against dedicated minicomputers for scientific and engineering work. The 3090 operating in a multi-operating system environment (VM/MVS/UNIX) is going to need help when jobs requiring heavy computation are slipped into the job stream.

  - While it has originally been supported for scientific processing (a new Engineering and Scientific Sub-routine Library and Fortran Language Conversion Program was announced for the vector processor), the hardware (16 vector registers, containing 128, 32-bit, elements) has some intriguing possibilities for improving the performance of DB2 whether or not it is ever isolated and identified as a data base machine.

C. PROJECTED USED MARKET PRICES AND RESIDUAL VALUES

- Exhibits III-2 and III-3 contain projected used market retail values in dollars and the projected residual values as a percent of vendor list price. It should be understood that, at any given time, three price levels exist.

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

  - "Dealer price" is the amount a dealer would pay another dealer for the equipment.

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

- Exhibits III-4 through III-35 graph the range of anticipated values (as a percent of list price) for 1987 through 1991.

EXHIBIT III-2

PROJECTED USED MARKET RETAIL VALUES

VENDOR	PROCESSOR MODEL	CURRENT LIST PRICE*	PROJECTED USED MARKET RETAIL VALUE AT JAN. 1 OF:					
			1986	1987	1988	1989	1990	1991
IBM	4331-Grp I	79500	5565	2385	1590	795	795	0
	4331-Grp II	88500	26550	13275	7080	3540	1770	885
	4341-Grp I	202900	12174	4058	2029	2029	2029	0
	4341-Grp II	315400	34694	22078	9462	6308	3154	3154
	4361-OK4	126900	64719	43146	22842	12690	7614	2538
	4381-OM2	500000	370000	280000	190000	105000	50000	20000
	3083-CX	605000	296450	181500	84700	42350	24200	6050
	3083-EX	695000	312750	173750	69500	34750	13900	6950
	3083-BX	1125500	540240	315140	135060	90040	56275	22510
	3083-JX	1850000	962000	573500	277500	185000	148000	55500
	3081-GX	2190000	1029300	481800	284700	131400	65700	21900
	3081-KX	3010000	1535100	963200	541800	331100	210700	120400
	3084-QX	6010000	3365600	2283800	1502500	961600	601000	360600
	3090-200	4600000	4830000	4232000	3772000	2622000	1242000	552000
	3090-400	9300000	-	8928000	7905000	5673000	2883000	1581000
AMDAHL	5850-24	1950000	994500	604500	429000	234000	156000	58500
	5860-24	2250000	1080000	630000	337500	180000	112500	45000
	5868-32	3410000	1807300	988900	579700	375100	238700	102300
	5870-32	3470000	1804400	1145100	728700	485800	277600	138800
	5880-48	4130000	2395400	1610700	1115100	619500	371700	206500
	5890-200	4250000	-	-	3357500	2550000	1062500	425000
	5890-600	9330000	-	-	9796500	5504700	2799000	1306200
NAS	AS/6630	341500	105865	61470	27320	17075	6830	3415
	AS/6660	475000	156750	99750	52250	33250	19000	9500
	AS/8023	650000	234000	162500	78000	39000	13000	6500
	AS/8083	2871000	1291950	947430	516780	315810	143550	57420
								0
	AS/9050	1794000	484380	215280	125580	71760	35880	17940
	AS/9070	3041000	912300	456150	243280	121640	60820	30410
	AS/9150	2165000	1082500	606200	346400	173200	86600	43300
	AS/9160	2425000	1285250	751750	436500	218250	121250	48500
	AS/9170	3590000	2010400	1256500	753900	430800	251300	107700
	AS/9180	4430000	2613700	1683400	1063200	620200	398700	177200

* IBM prices are for processor only; Amdahl and NAS include console, power supply and coolant distribution unit

EXHIBIT III-3

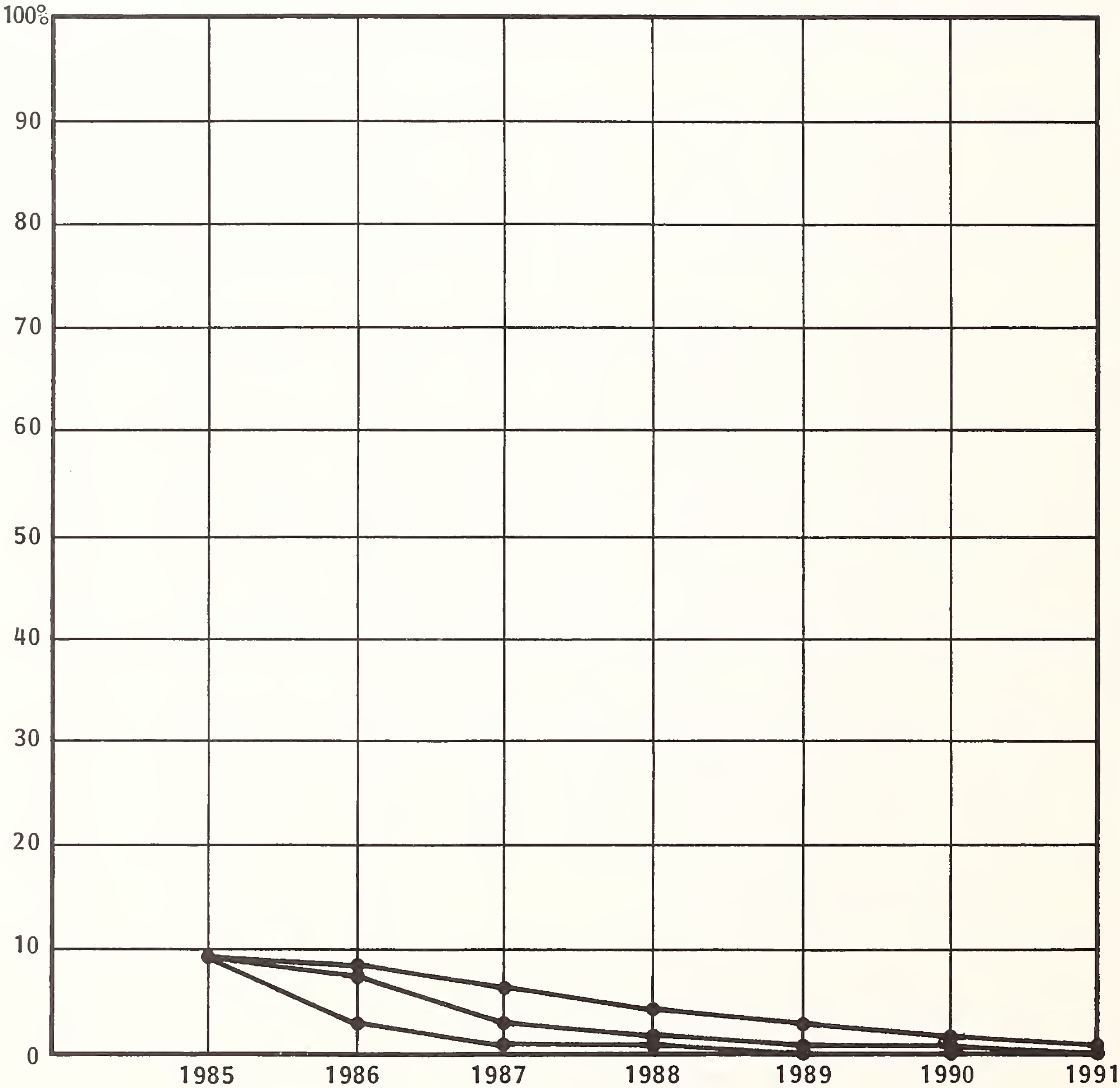
PROJECTED RESIDUAL VALUES

VENDOR	PROCESSOR MODEL	CURRENT LIST PRICE*	PROJECTED RESIDUAL VALUE AS A PERCENT OF VENDOR LIST PRICE VALUE AT JAN. 1 OF: 1986	1987	1988	1989	1990	1991
IBM	4331-Grp I	79500	7%	3%	2%	1%	1%	0%
	4331-Grp II	88500	30%	15%	8%	4%	2%	1%
	4341-Grp I	202900	6%	2%	1%	1%	1%	0%
	4341-Grp II	315400	11%	7%	3%	2%	1%	1%
	4361-OK4	126900	51%	34%	18%	10%	6%	2%
	4381-OM2	500000	74%	56%	38%	21%	10%	4%
	3083-CX	605000	49%	30%	14%	7%	4%	1%
	3083-EX	695000	45%	25%	10%	5%	2%	1%
	3083-BX	1125500	48%	28%	12%	8%	5%	2%
	3083-JX	1850000	52%	31%	15%	10%	8%	3%
	3081-GX	2190000	47%	22%	13%	6%	3%	1%
	3081-KX	3010000	51%	32%	18%	11%	7%	4%
	3084-QX	6010000	56%	38%	25%	16%	10%	6%
	3090-200	4600000	105%	92%	82%	57%	27%	12%
	3090-400	9300000	-	96%	85%	61%	31%	17%
AMDAHL	5850-24	1950000	51%	31%	22%	12%	8%	3%
	5860-24	2250000	48%	28%	15%	8%	5%	2%
	5868-32	3410000	53%	29%	17%	11%	7%	3%
	5870-32	3470000	52%	33%	21%	14%	8%	4%
	5880-48	4130000	58%	39%	27%	15%	9%	5%
	5890-300	4250000	110%	82%	79%	60%	25%	10%
	5890-600	9330000	-	-	105%	59%	30%	14%
NAS	AS/6630	341500	31%	18%	8%	5%	2%	1%
	AS/6660	475000	33%	21%	11%	7%	4%	2%
	AS/8023	650000	36%	25%	12%	6%	2%	1%
	AS/8083	2871000	45%	33%	18%	11%	5%	2%
	AS/9050	1794000	27%	12%	7%	4%	2%	1%
	AS/9070	3041000	30%	15%	8%	4%	2%	1%
	AS/9150	2165000	50%	28%	16%	8%	4%	2%
	AS/9160	2425000	53%	31%	18%	9%	5%	2%
	AS/9170	3590000	56%	35%	21%	12%	7%	3%
	AS/9180	4430000	59%	38%	24%	14%	9%	4%

* IBM prices are for processor only; Amdahl and NAS include console, power supply and coolant distribution unit

EXHIBIT III-4

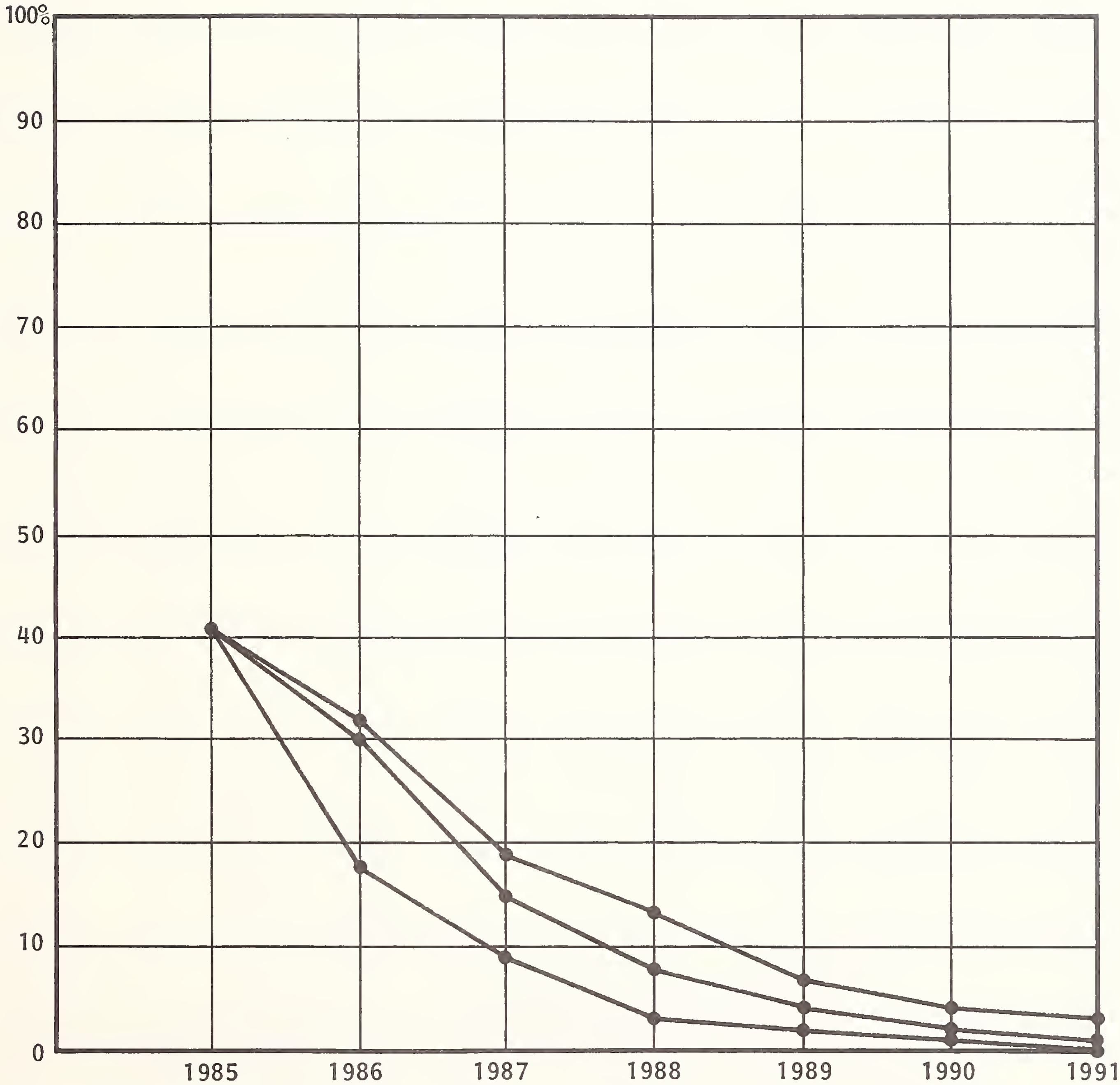
RESIDUAL VALUE FORECAST FOR
IBM 4331-GRP I PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	8	6	4	3	2	1
Expected	7	3	2	1	1	0
Medium	3	1	1	0	0	0

EXHIBIT III-5

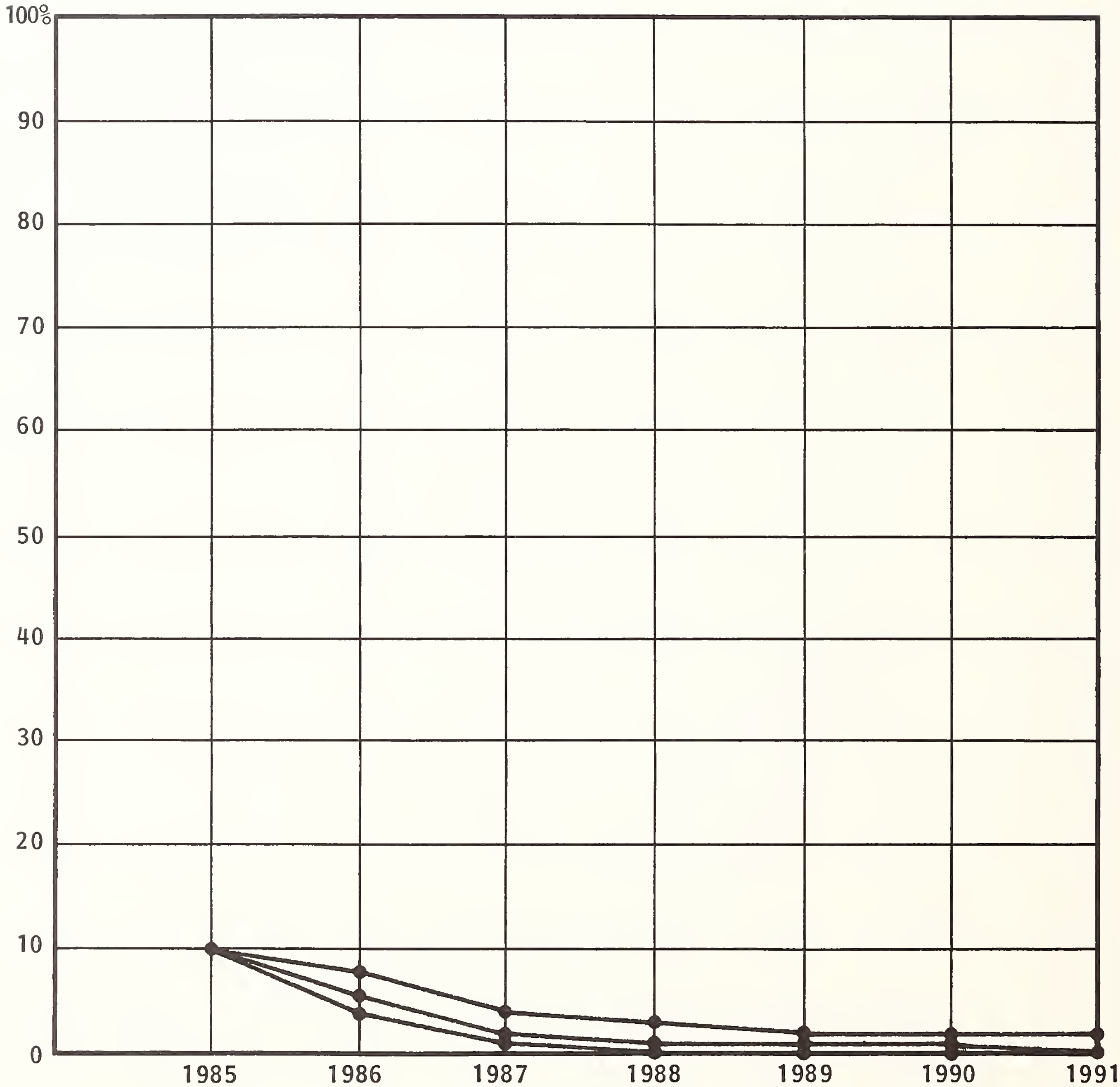
RESIDUAL VALUE FORECAST FOR IBM 4331-GRP II PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	32	19	13	7	4	3
Expected	30	15	8	4	2	1
Medium	18	9	3	2	1	0

EXHIBIT III-6

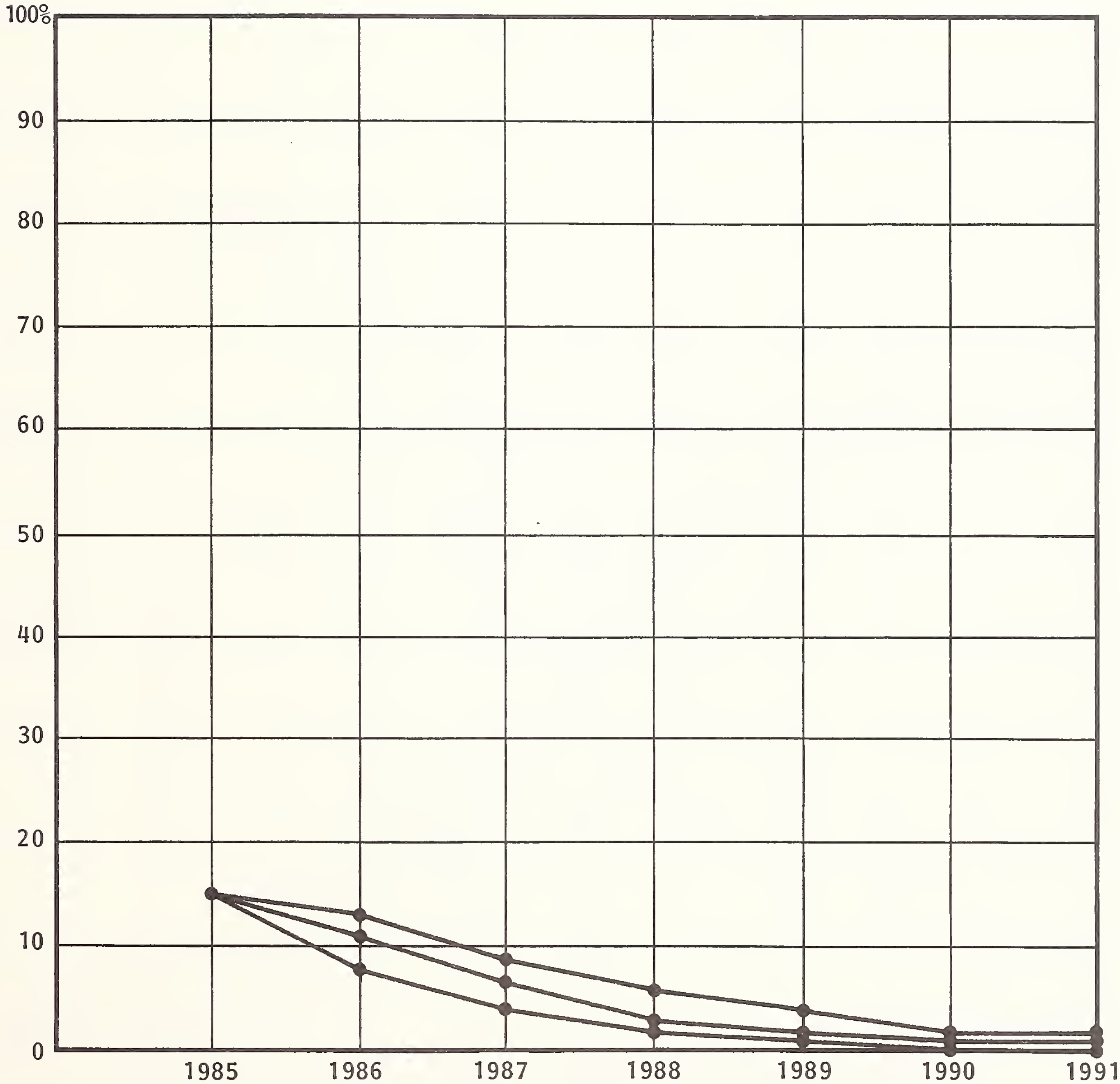
RESIDUAL VALUE FORECAST FOR IBM 4341-GRP I PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	8	4	3	2	2	2
Expected	6	2	1	1	1	0
Medium	4	1	0	0	0	0

EXHIBIT III-7

RESIDUAL VALUE FORECAST FOR IBM 4341-GRP II PROCESSOR

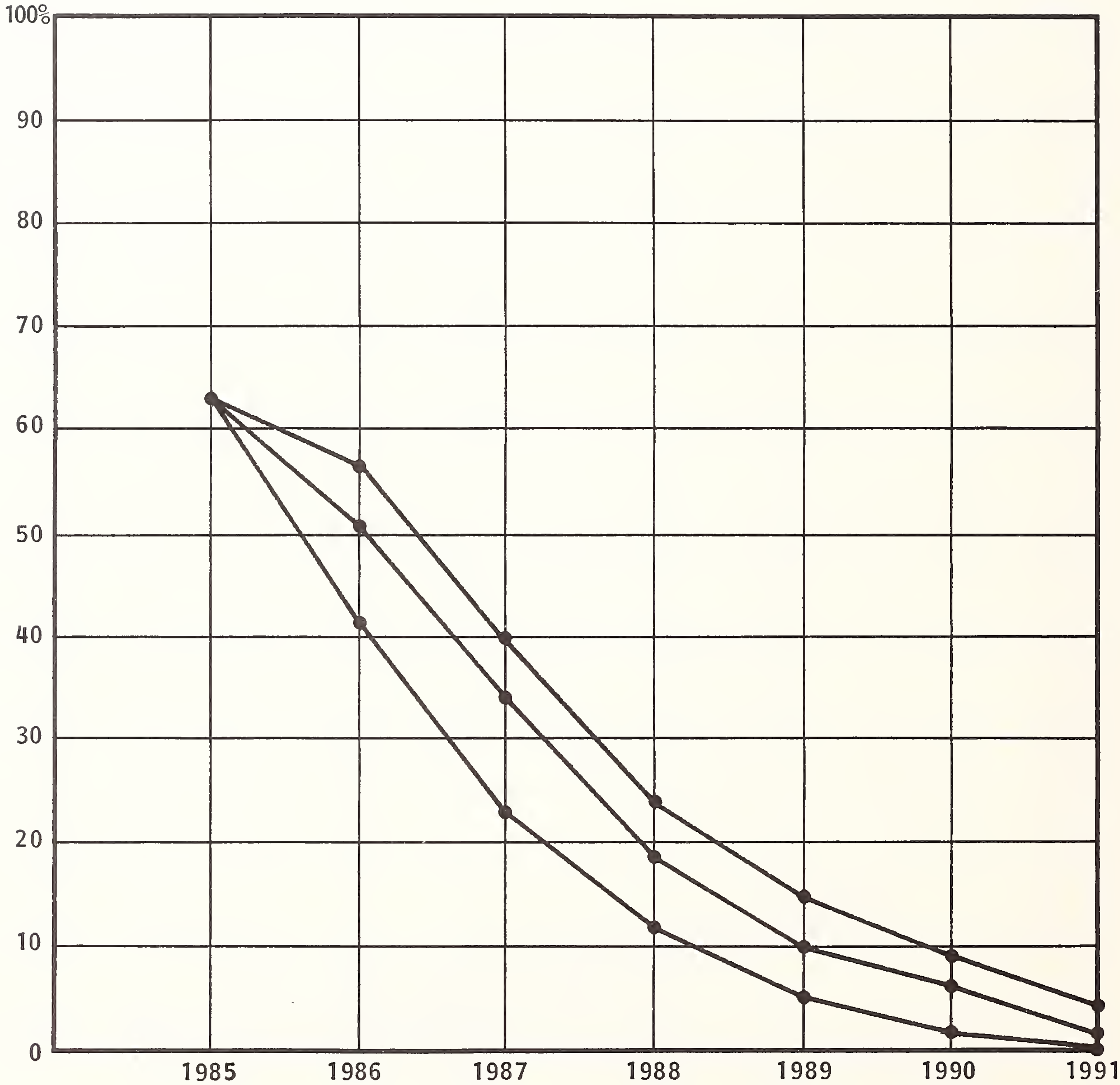


PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	13	9	6	4	2	2
Expected	11	7	3	2	1	1
Medium	8	4	2	1	0	0

EXHIBIT III-8

RESIDUAL VALUE FORECAST FOR

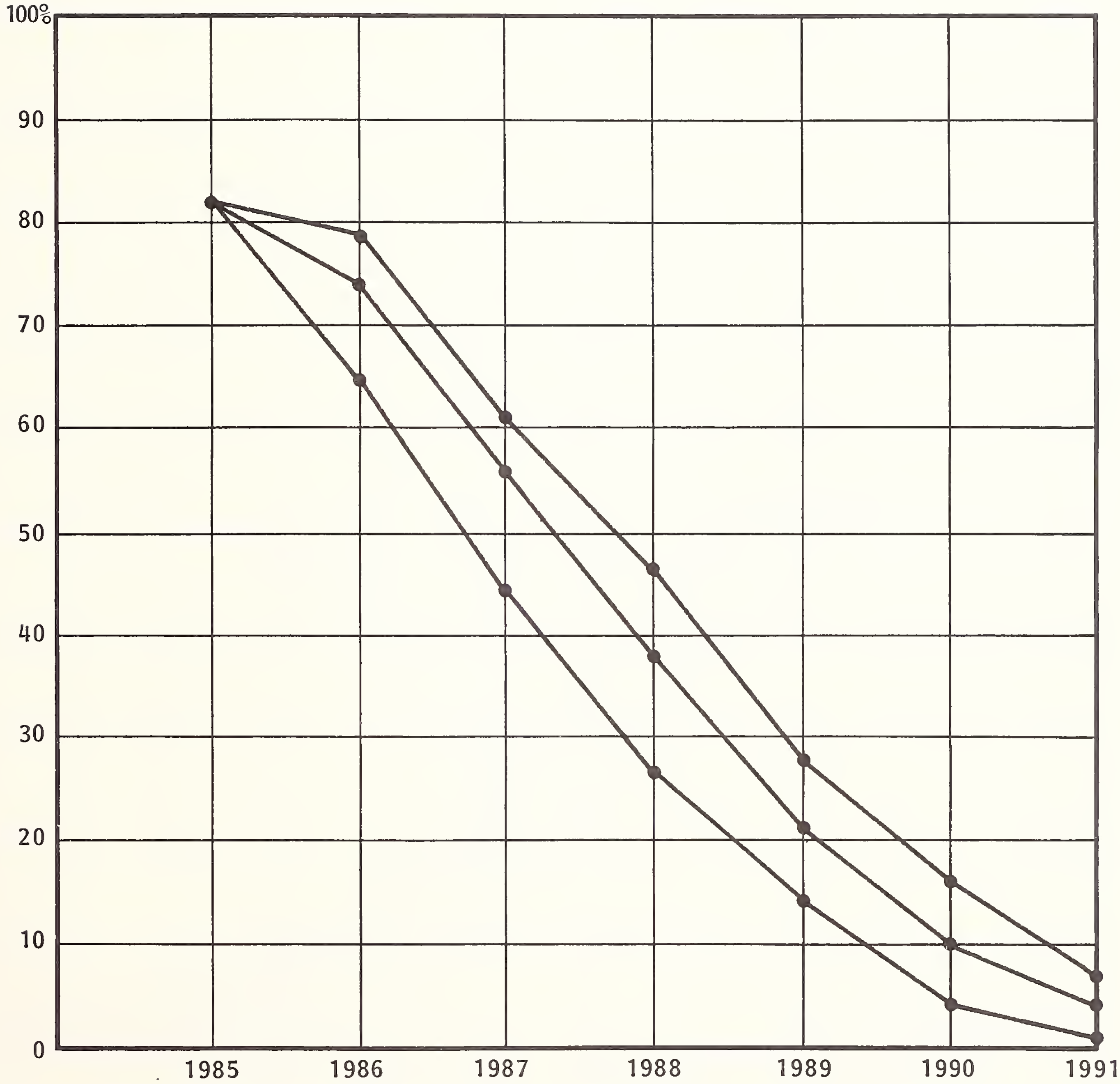
IBM 4361-OK4 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	57	40	24	15	9	4
Expected	51	34	18	10	6	2
Medium	42	23	12	5	2	0

EXHIBIT III-9

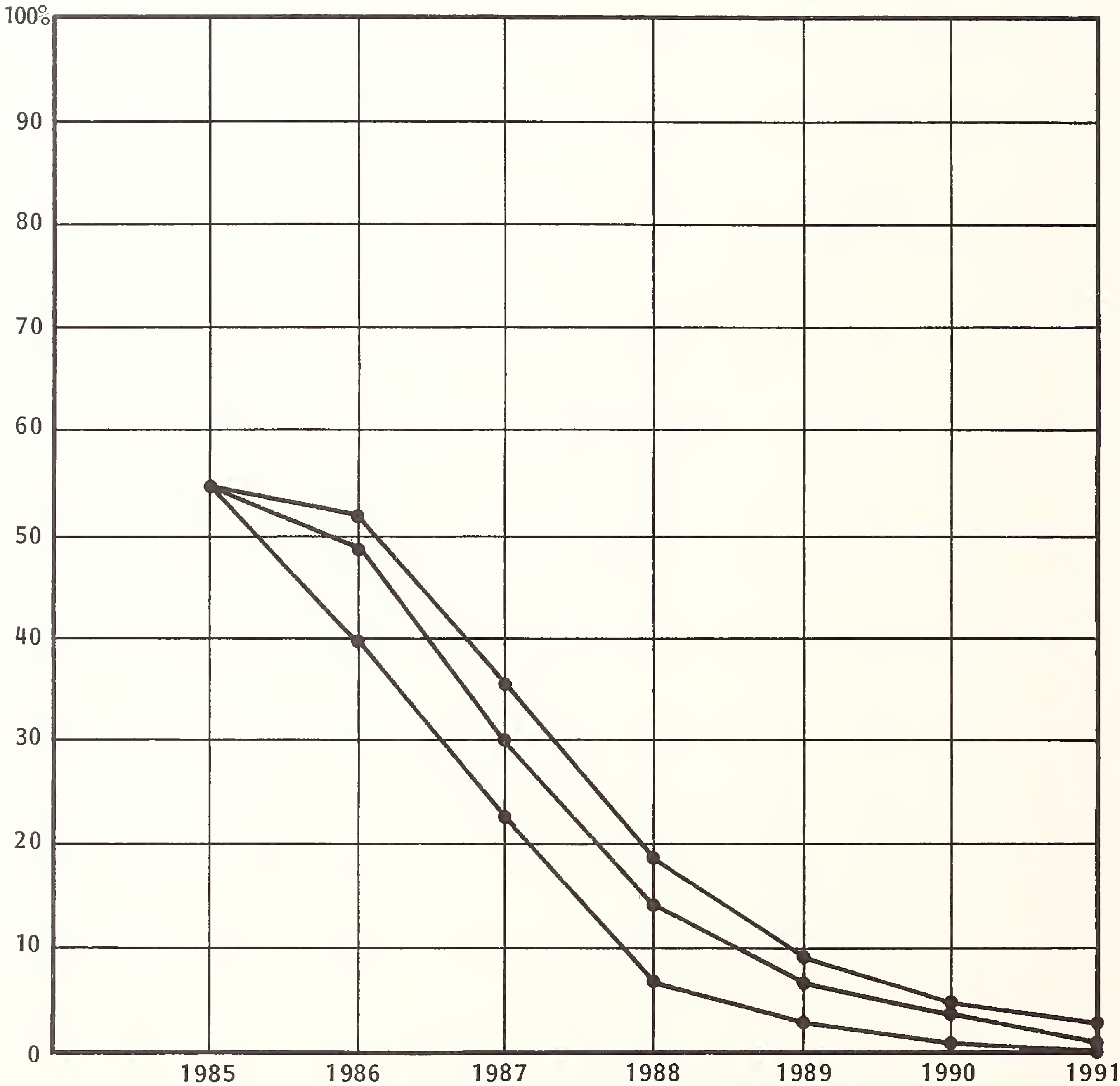
RESIDUAL VALUE FORECAST FOR
IBM 4381-OM2 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	79	61	47	28	16	7
Expected	74	56	38	21	10	4
Medium	65	45	27	14	4	1

EXHIBIT III-10

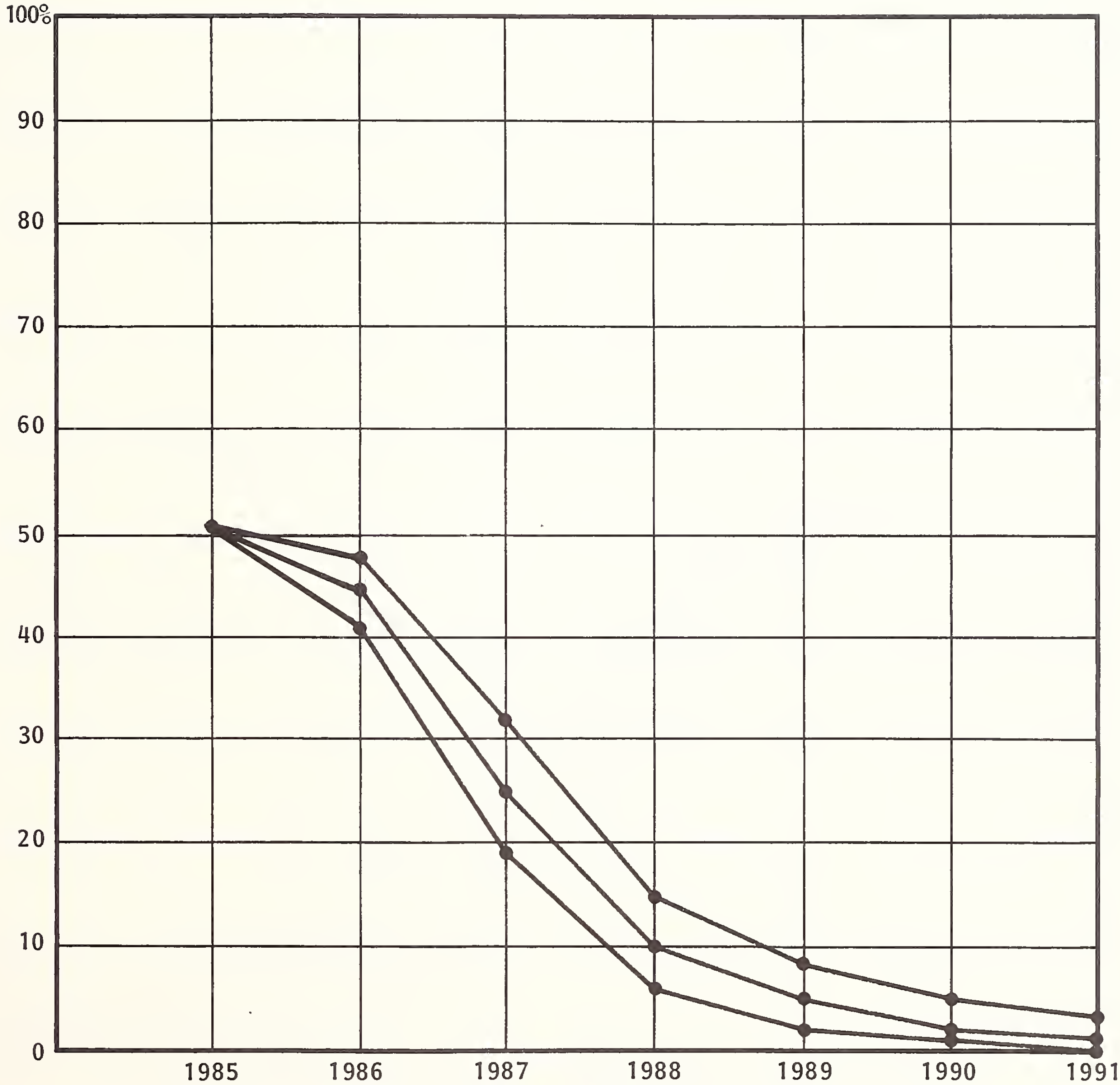
RESIDUAL VALUE FORECAST FOR
IBM 3083-CX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	52	36	18	9	5	3
Expected	49	30	14	7	4	1
Medium	40	23	7	3	1	0

EXHIBIT III-11

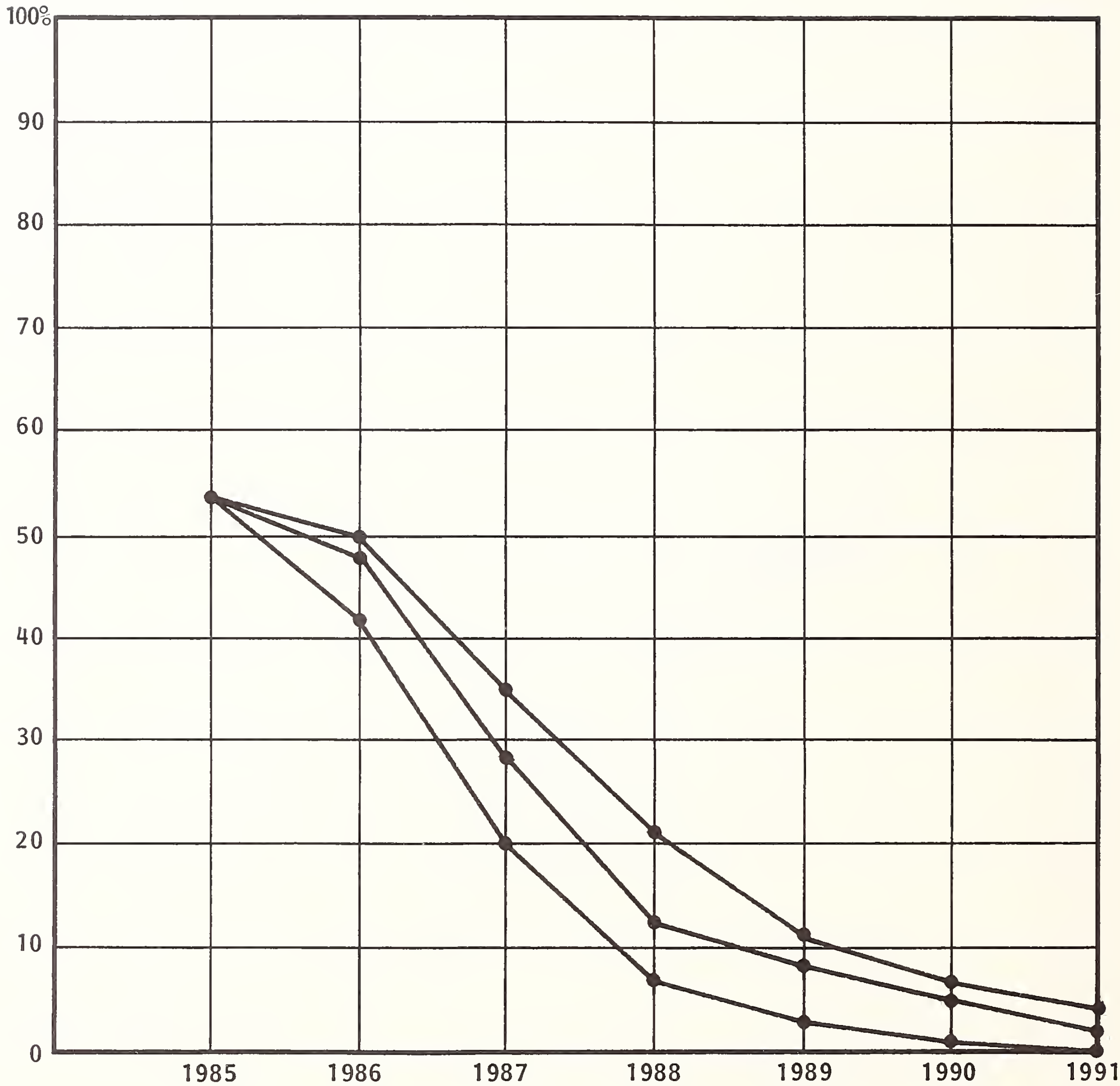
RESIDUAL VALUE FORECAST FOR
IBM 3083-EX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	48	32	15	8	5	3
Expected	45	25	10	5	2	1
Medium	41	19	6	2	1	0

EXHIBIT III-12

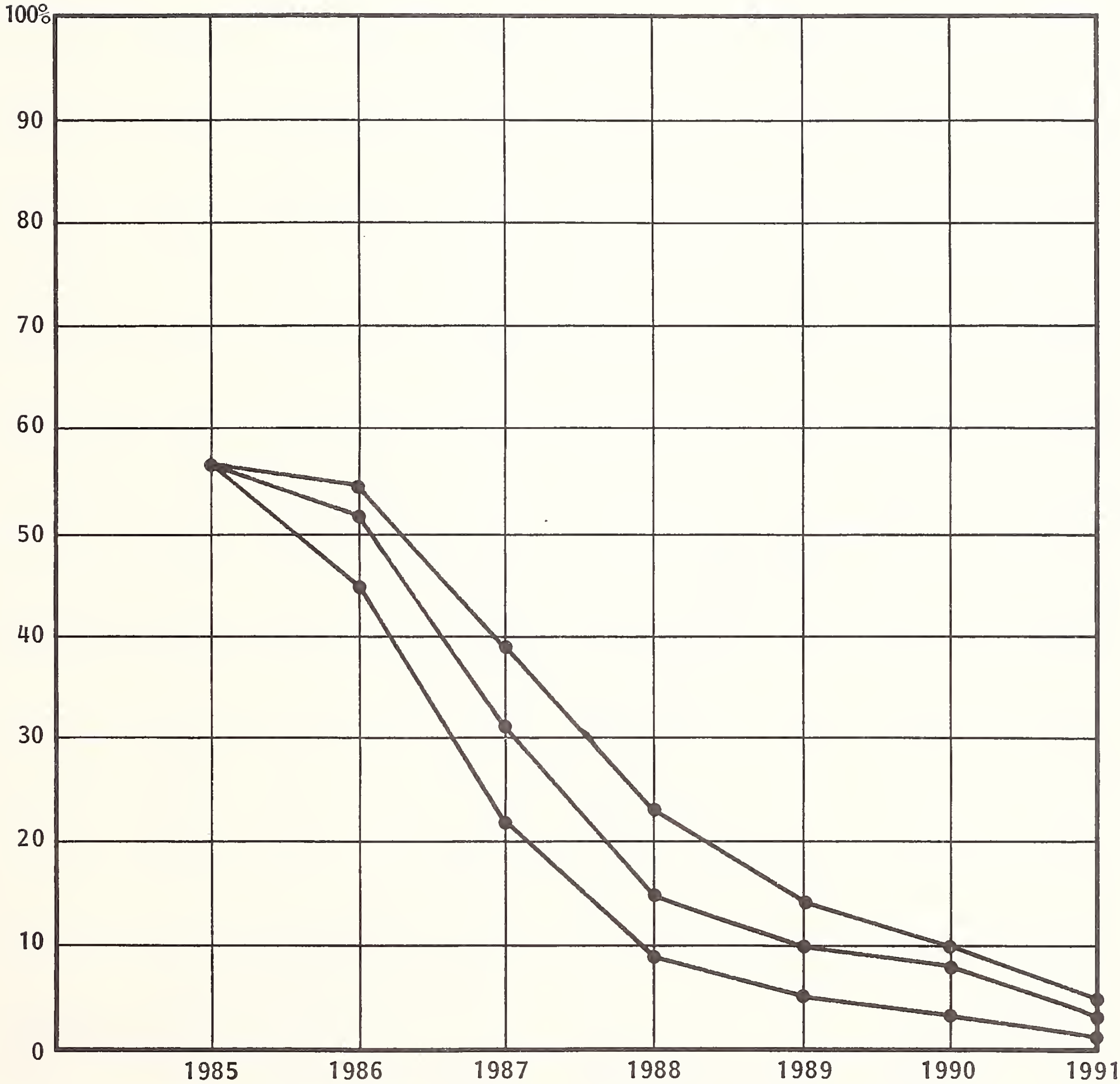
RESIDUAL VALUE FORECAST FOR IBM 3083-BX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	50	35	21	11	7	4
Expected	48	28	12	8	5	2
Medium	42	20	7	3	1	0

EXHIBIT III-13

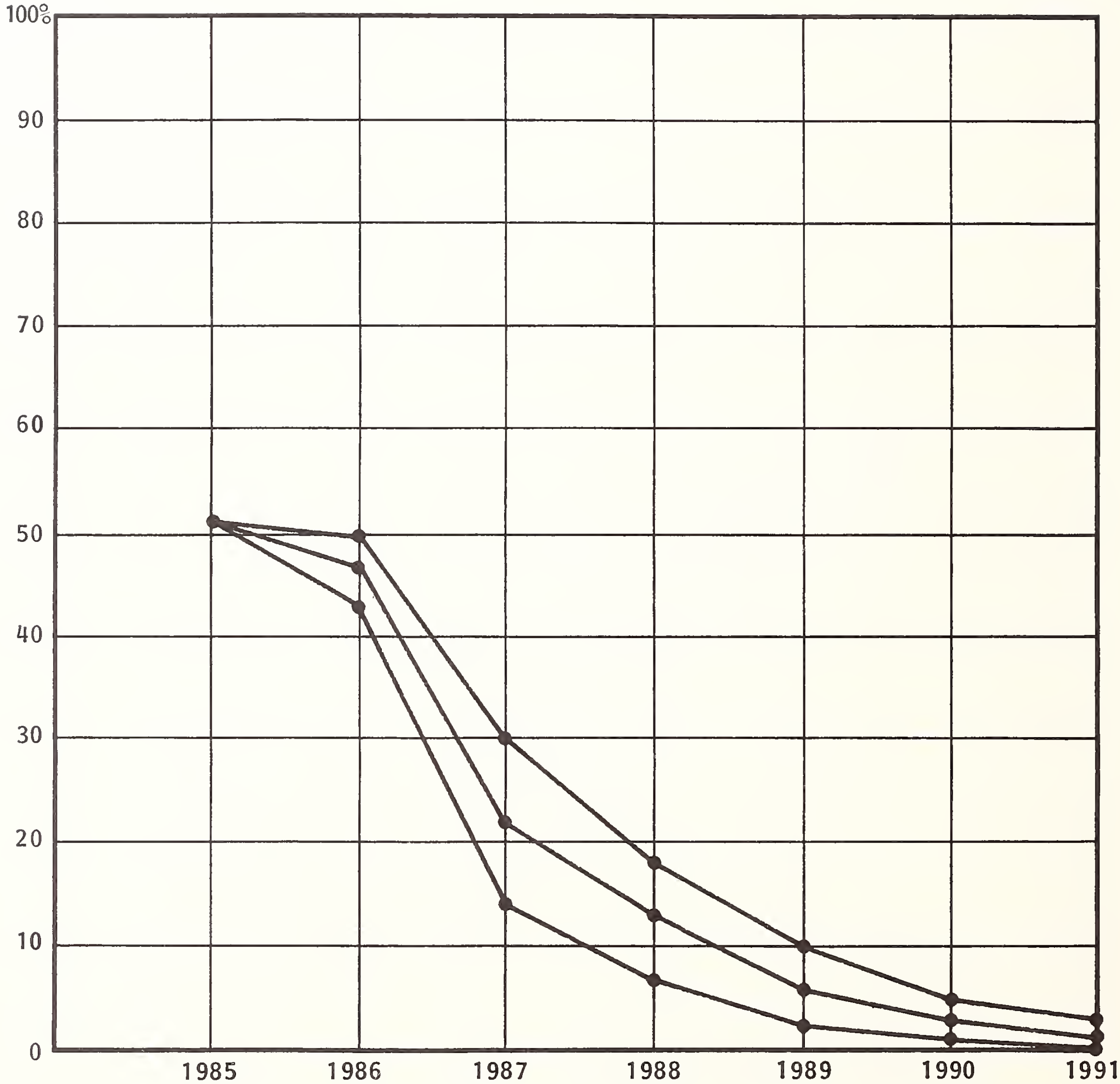
RESIDUAL VALUE FORECAST FOR
IBM 3083-JX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	55	39	23	14	10	5
Expected	52	31	15	10	8	3
Medium	45	22	9	5	3	1

EXHIBIT III-14

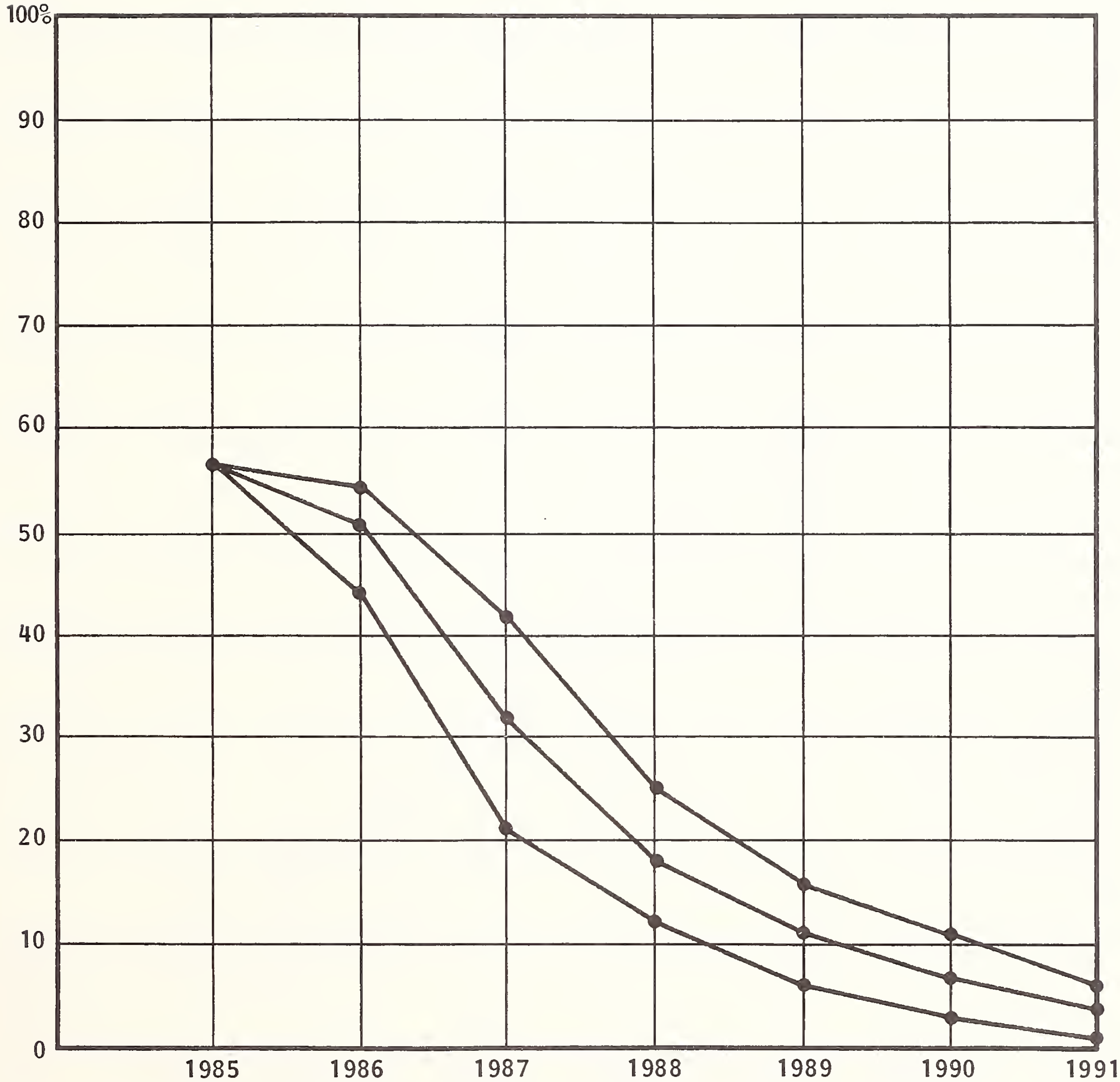
RESIDUAL VALUE FORECAST FOR
IBM 3081-GX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	50	30	18	10	5	3
Expected	47	22	13	6	3	1
Medium	43	14	7	2	1	0

EXHIBIT III-15

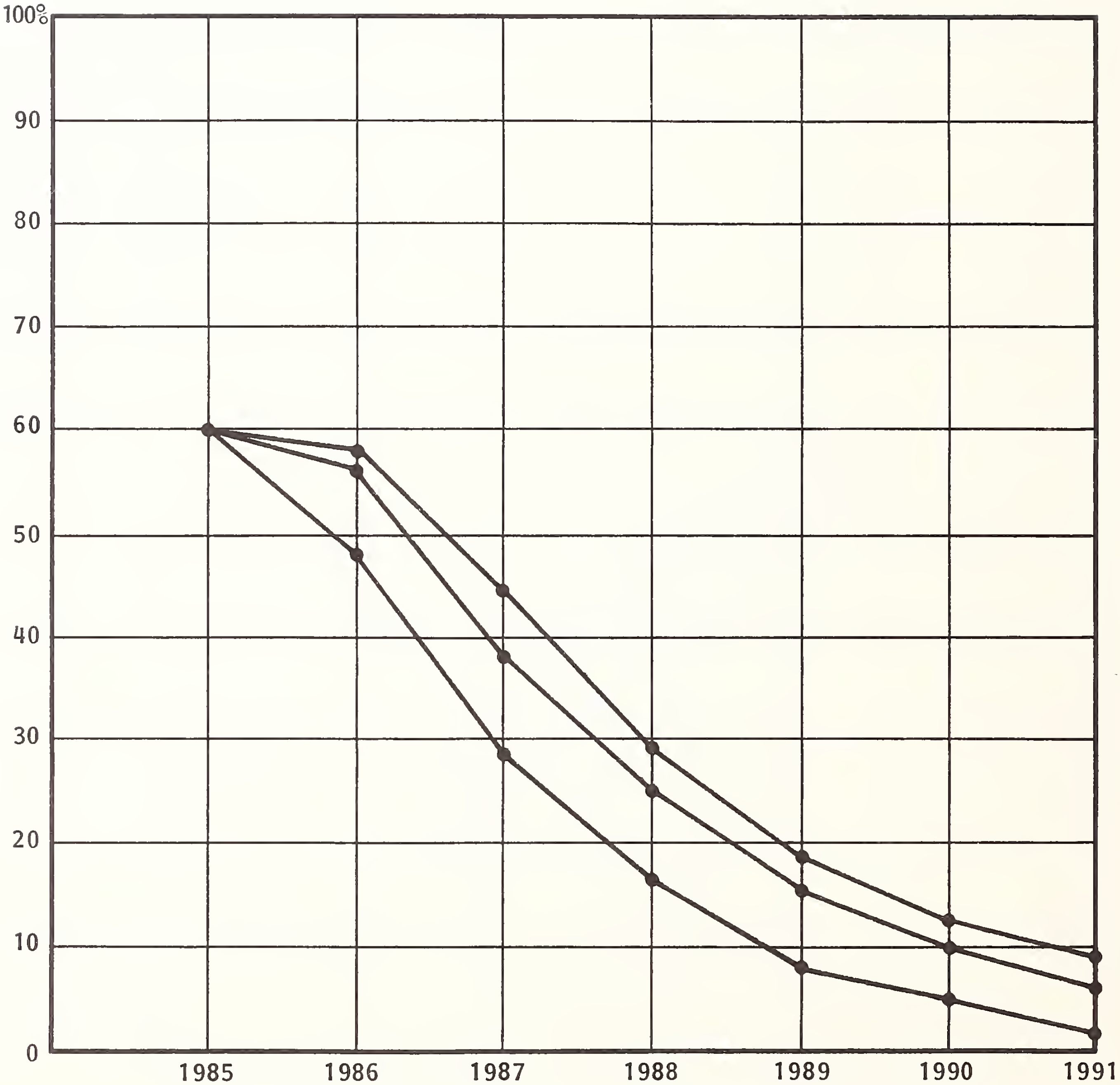
RESIDUAL VALUE FORECAST FOR
IBM 3081-KX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	55	42	25	16	11	6
Expected	51	32	18	11	7	4
Medium	44	21	12	6	3	1

EXHIBIT III-16

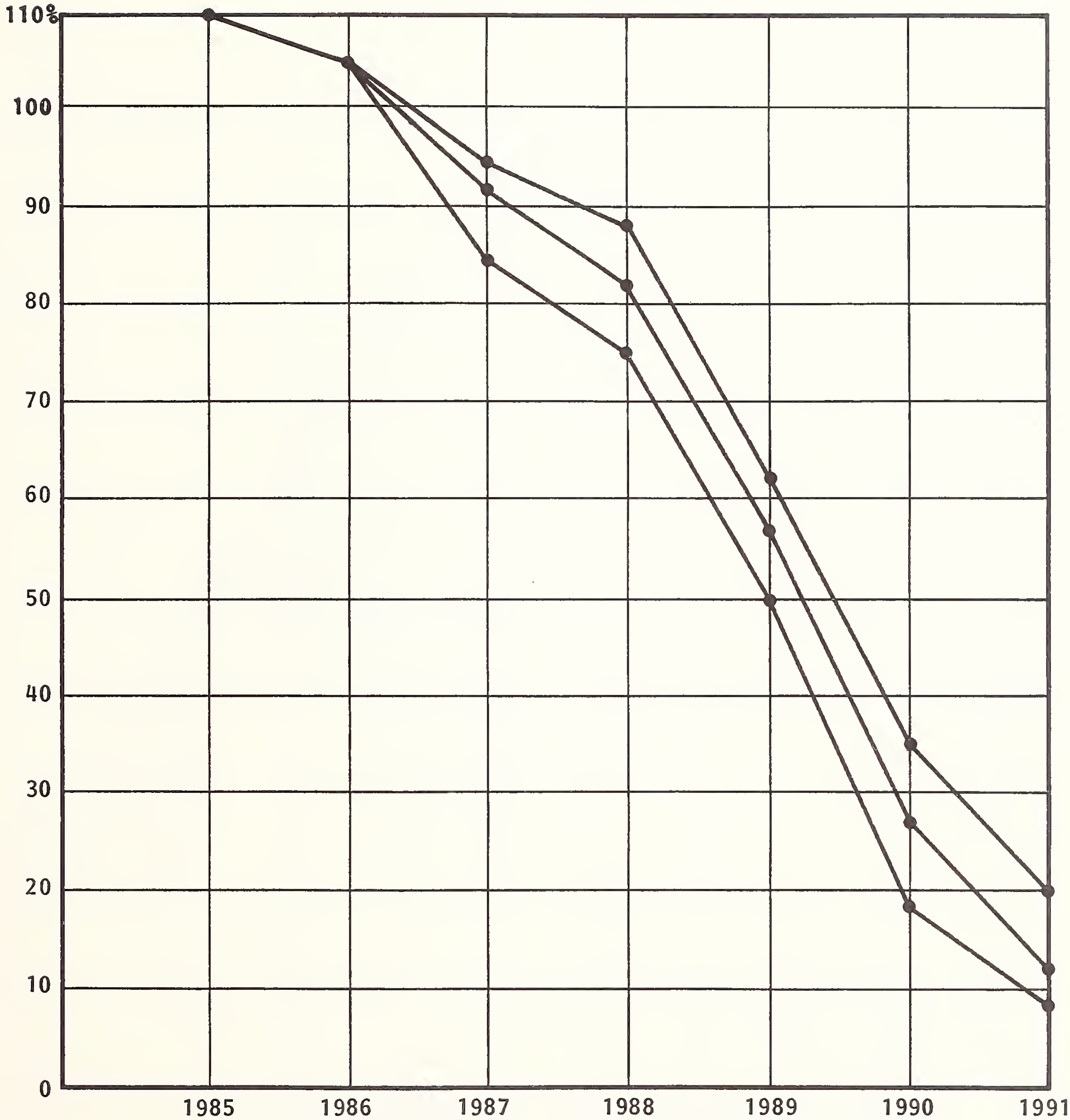
RESIDUAL VALUE FORECAST FOR IBM 3084-QX PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	58	45	29	19	13	9
Expected	56	38	25	16	10	6
Medium	48	28	17	8	5	2

EXHIBIT III-17

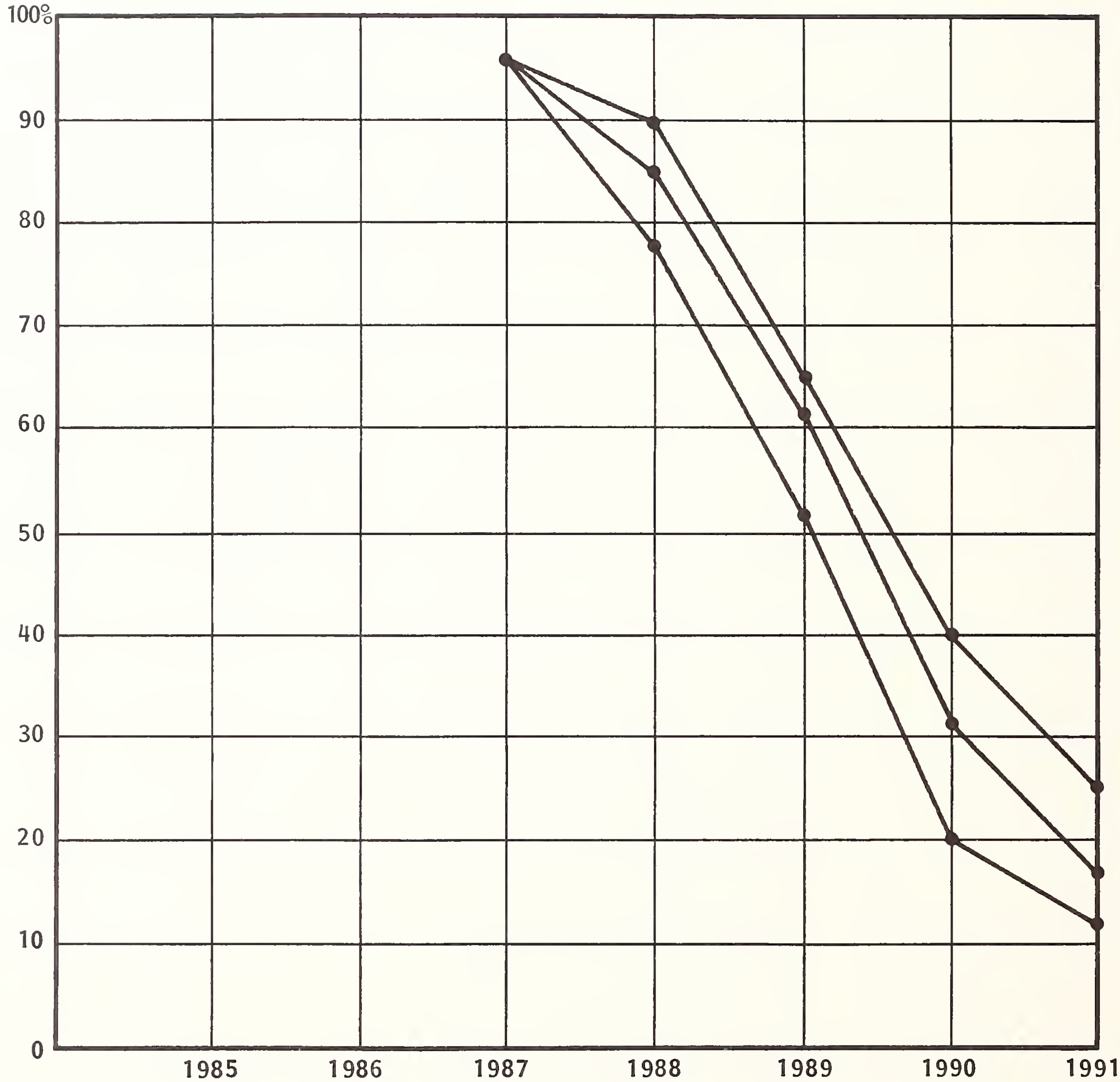
RESIDUAL VALUE FORECAST FOR
IBM 3090-200 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	105	95	88	62	35	20
Expected	105	92	82	57	27	12
Medium	105	84	75	50	18	8

EXHIBIT III-18

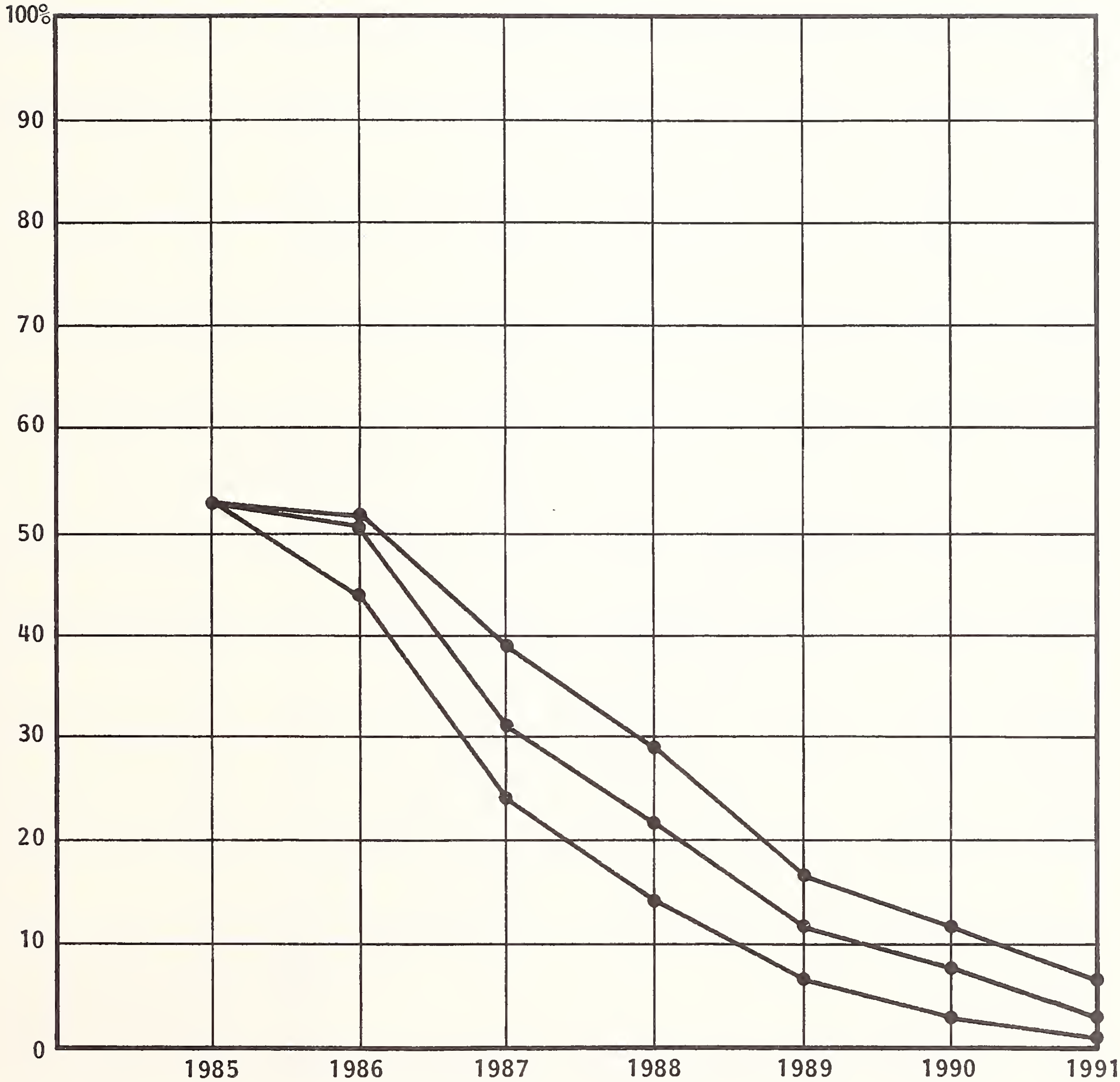
RESIDUAL VALUE FORECAST FOR IBM 3090-400 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	–	96	90	65	40	25
Expected	–	96	85	61	31	17
Medium	–	96	78	52	20	12

EXHIBIT III-19

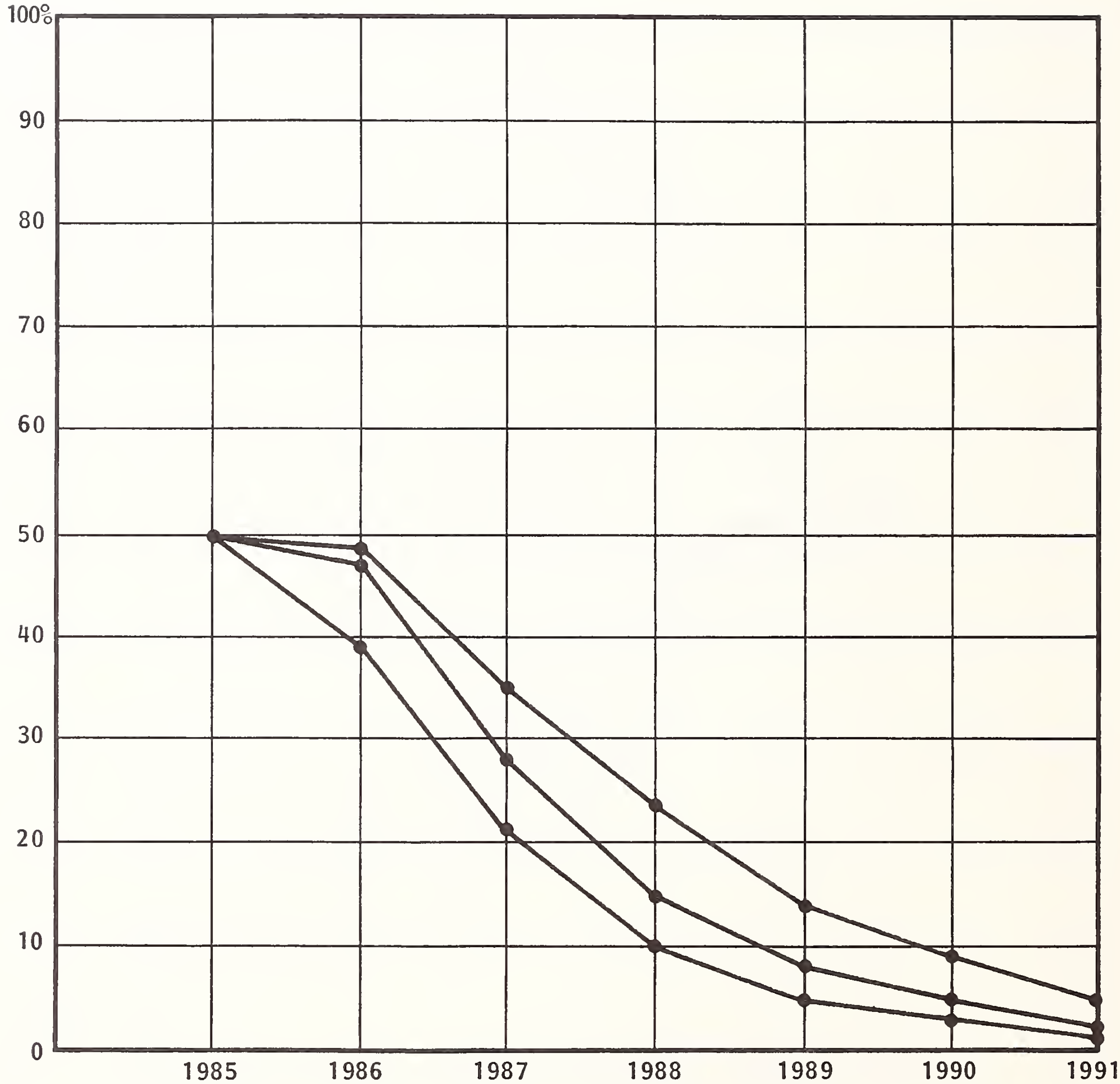
RESIDUAL VALUE FORECAST FOR
AMDAHL 5850-24 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	52	39	29	17	12	7
Expected	51	31	22	12	8	3
Medium	44	24	14	7	3	1

EXHIBIT III-20

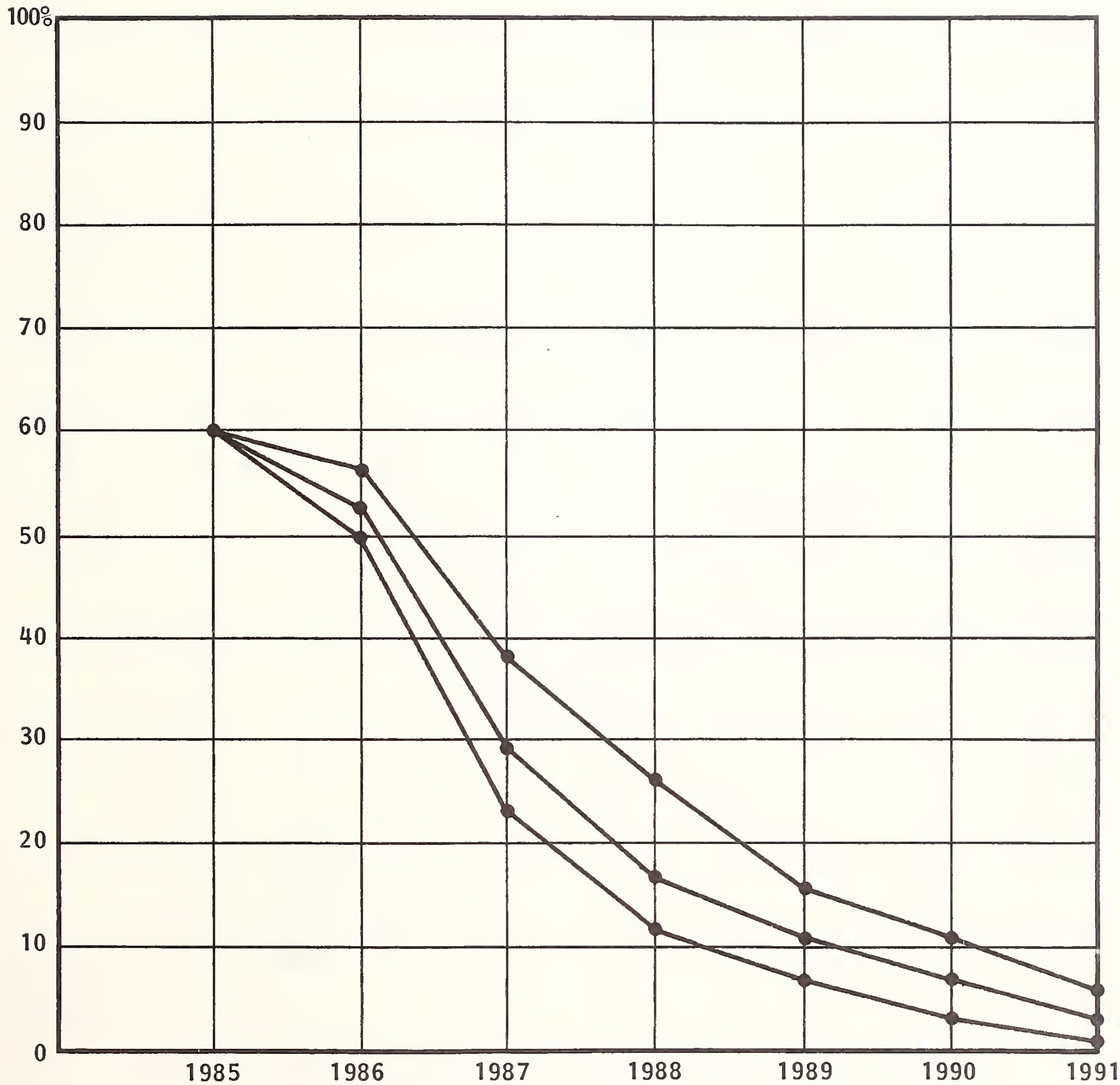
RESIDUAL VALUE FORECAST FOR
AMDAHL 5860-24 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	49	35	23	14	9	5
Expected	48	28	15	8	5	2
Medium	39	21	10	5	3	1

EXHIBIT III-21

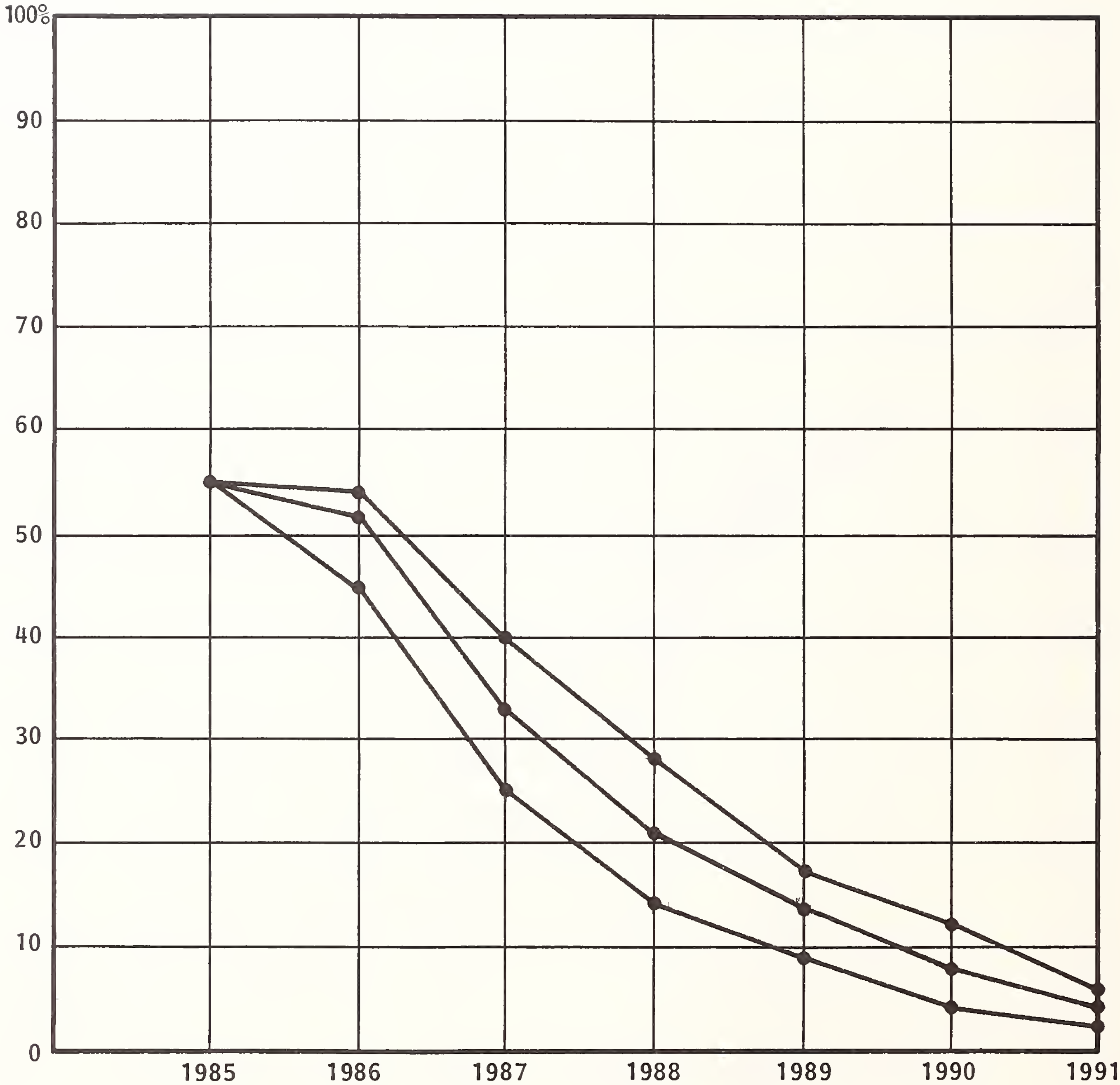
RESIDUAL VALUE FORECAST FOR
AMDAHL 5868-32 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	57	38	26	16	11	6
Expected	53	29	17	11	7	3
Medium	50	23	12	7	3	1

EXHIBIT III-22

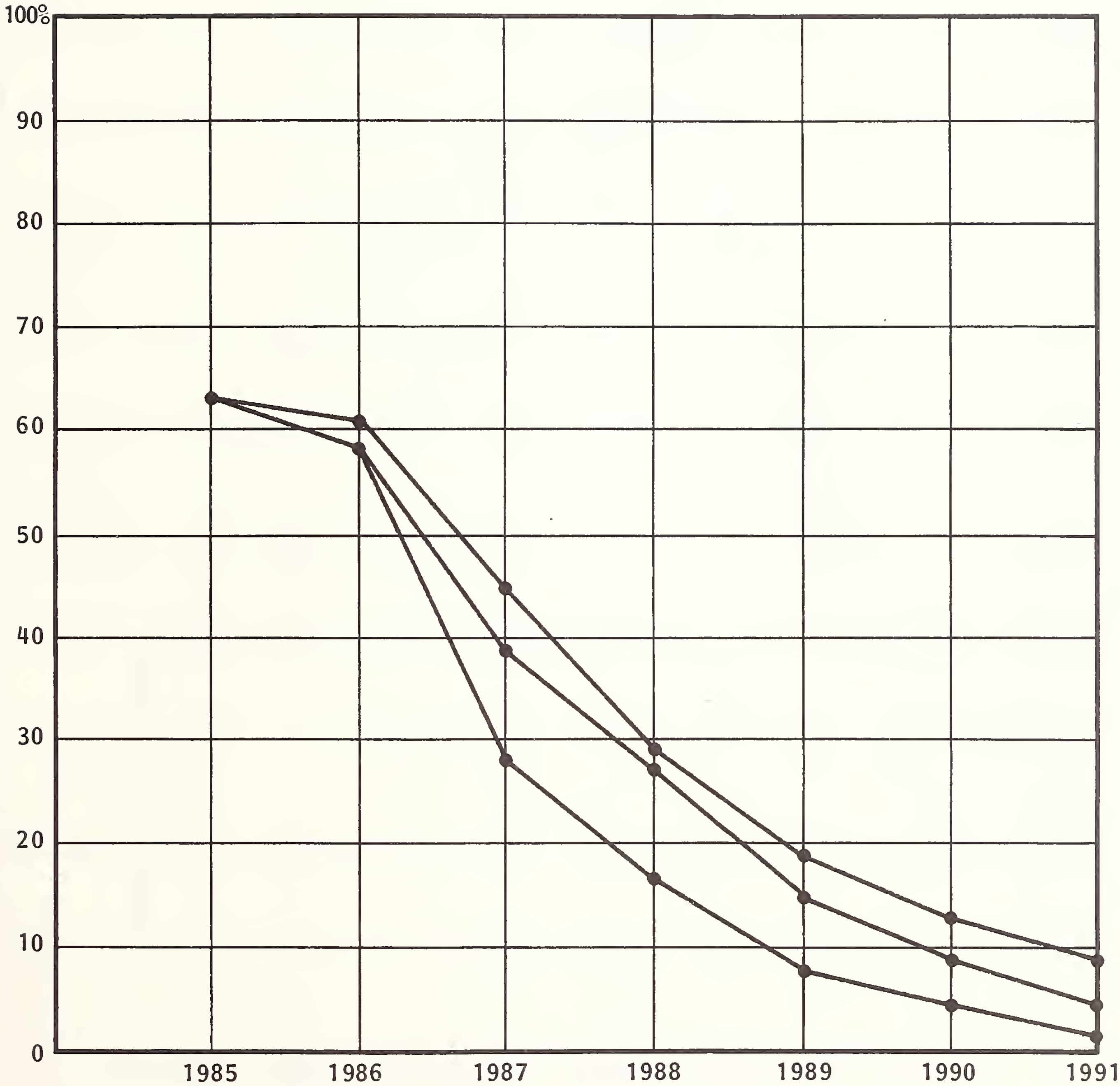
RESIDUAL VALUE FORECAST FOR AMDAHL 5870-32 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	54	40	28	17	12	6
Expected	52	33	21	14	8	4
Medium	45	25	14	9	4	2

EXHIBIT III-23

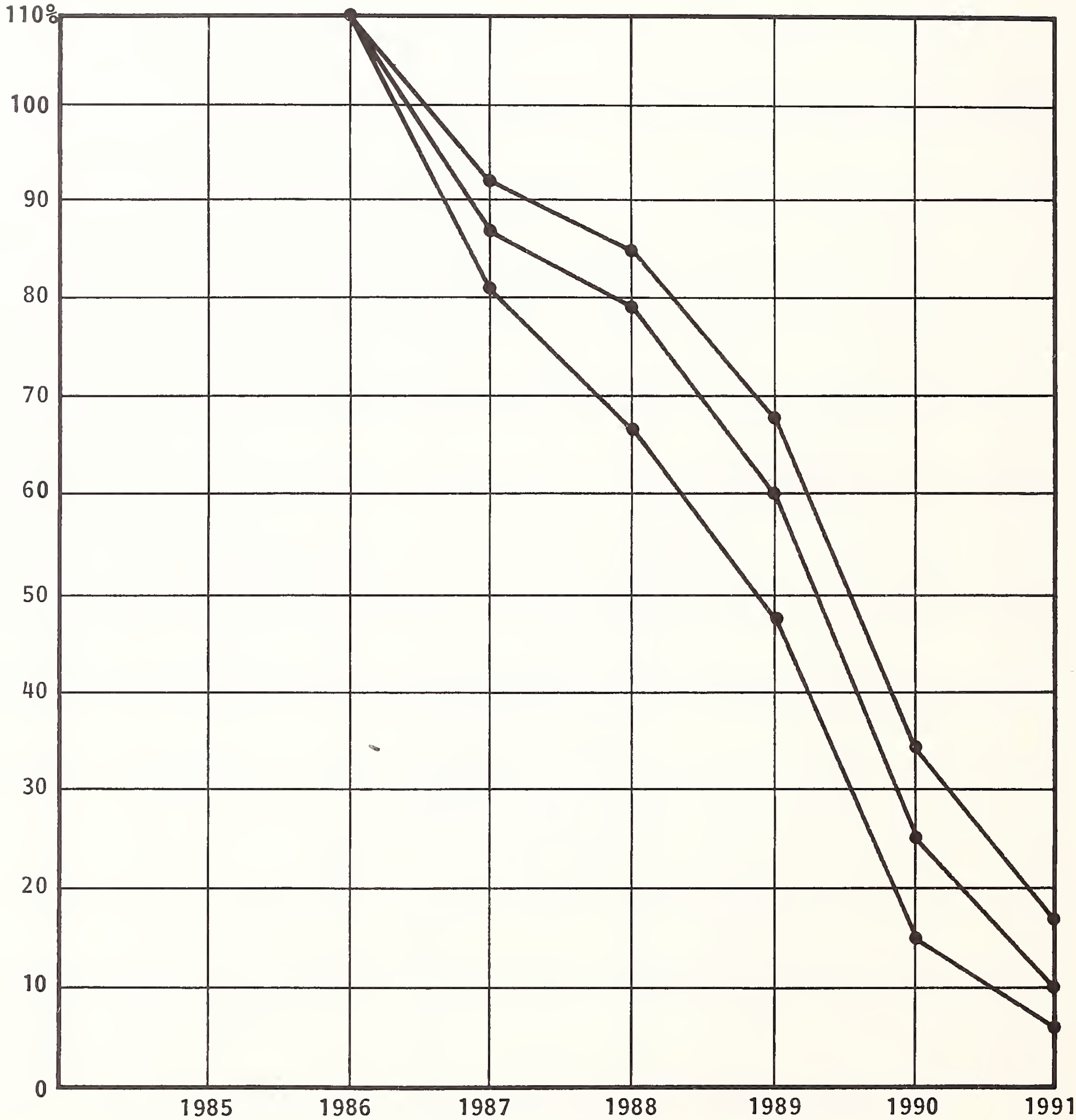
RESIDUAL VALUE FORECAST FOR AMDAHL 5880-48 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	61	45	29	19	13	9
Expected	58	39	27	15	9	5
Medium	58	28	17	8	5	2

EXHIBIT III-24

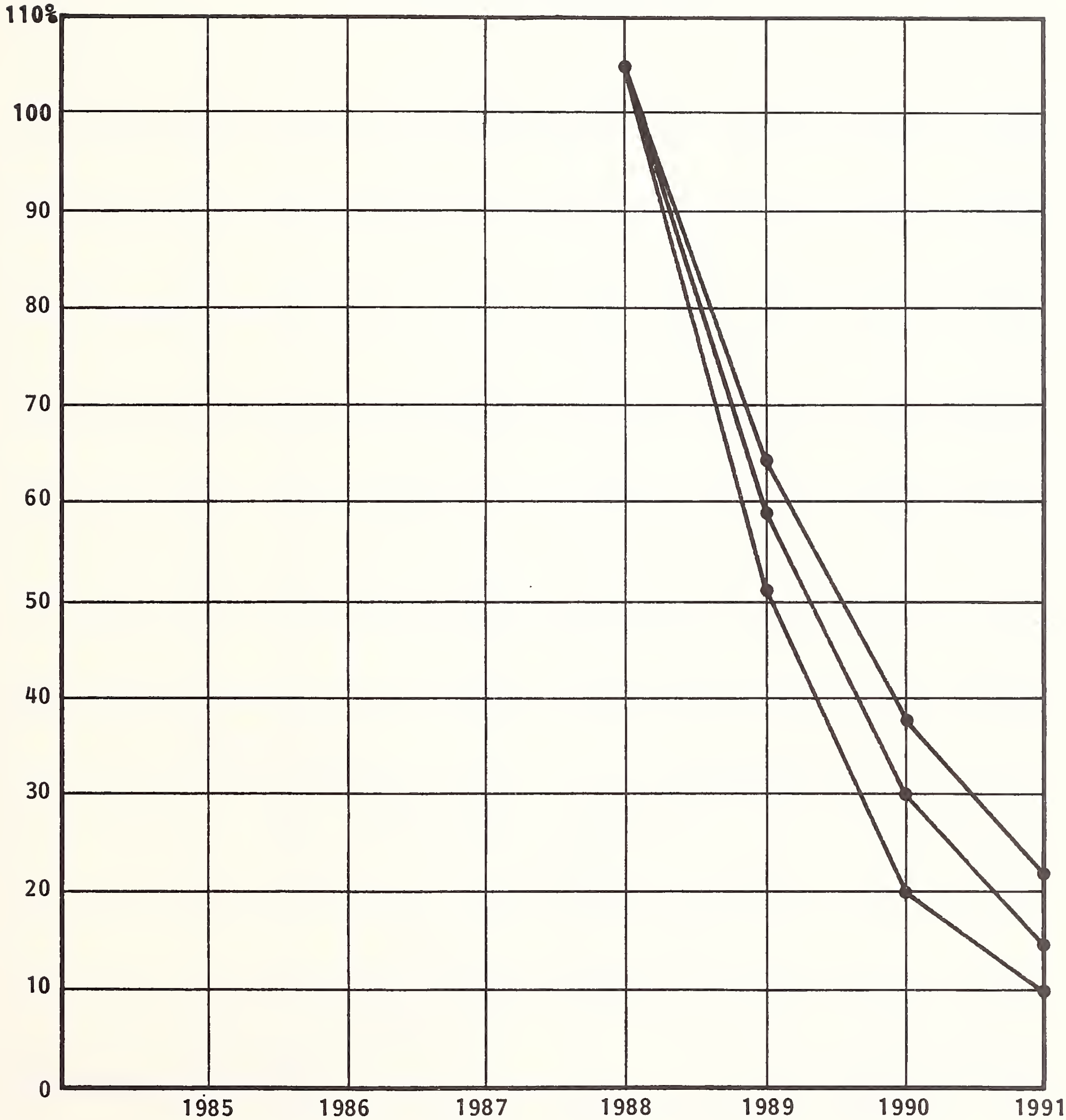
RESIDUAL VALUE FORECAST FOR
AMDAHL 5890-300 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	110	92	85	68	34	17
Expected	110	87	79	60	25	10
Medium	110	81	67	48	15	6

EXHIBIT III-25

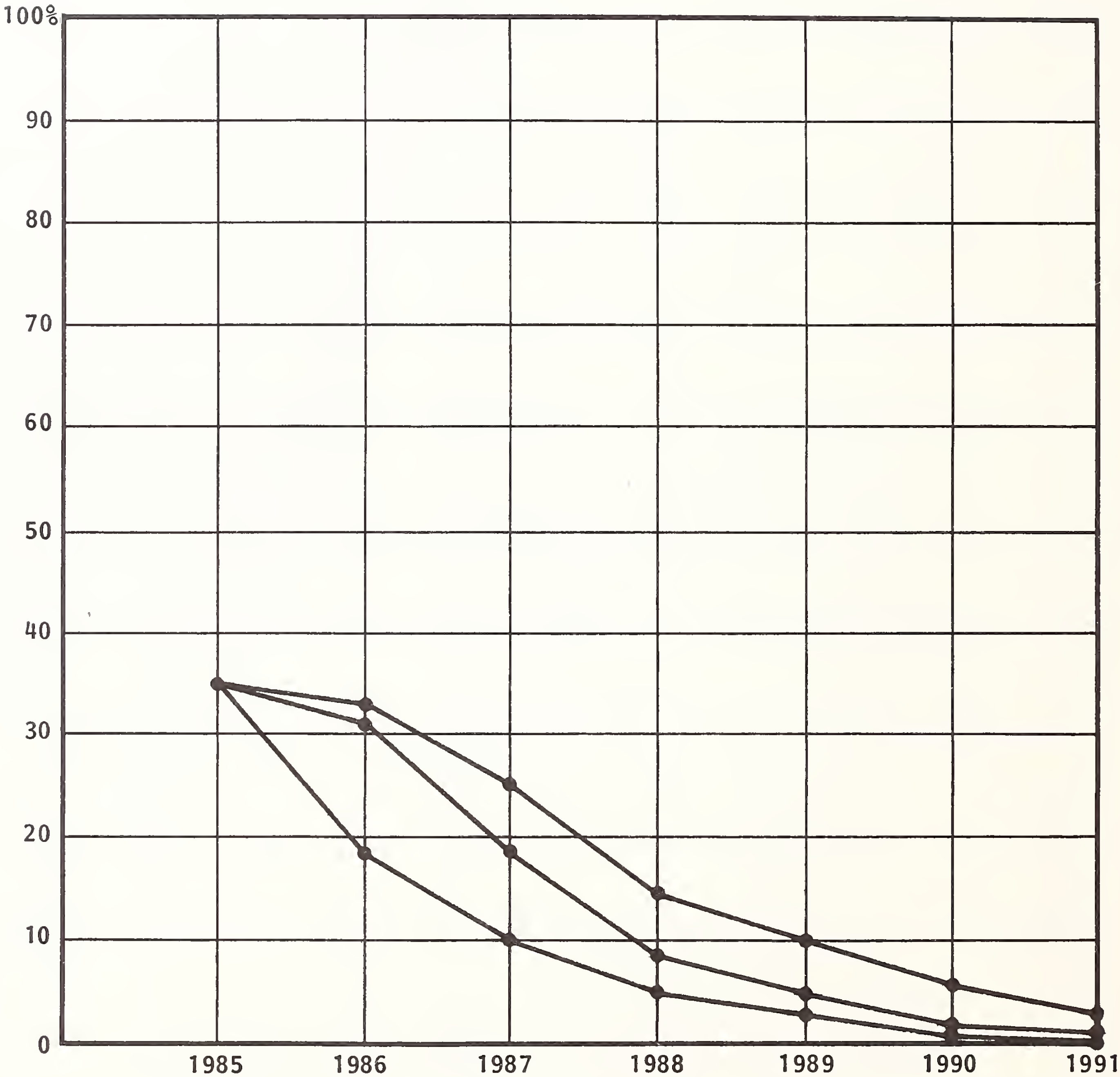
RESIDUAL VALUE FORECAST FOR
AMDAHL 5890-600 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	-	-	105	64	38	22
Expected	-	-	105	59	30	14
Medium	-	-	105	51	20	10

EXHIBIT III-26

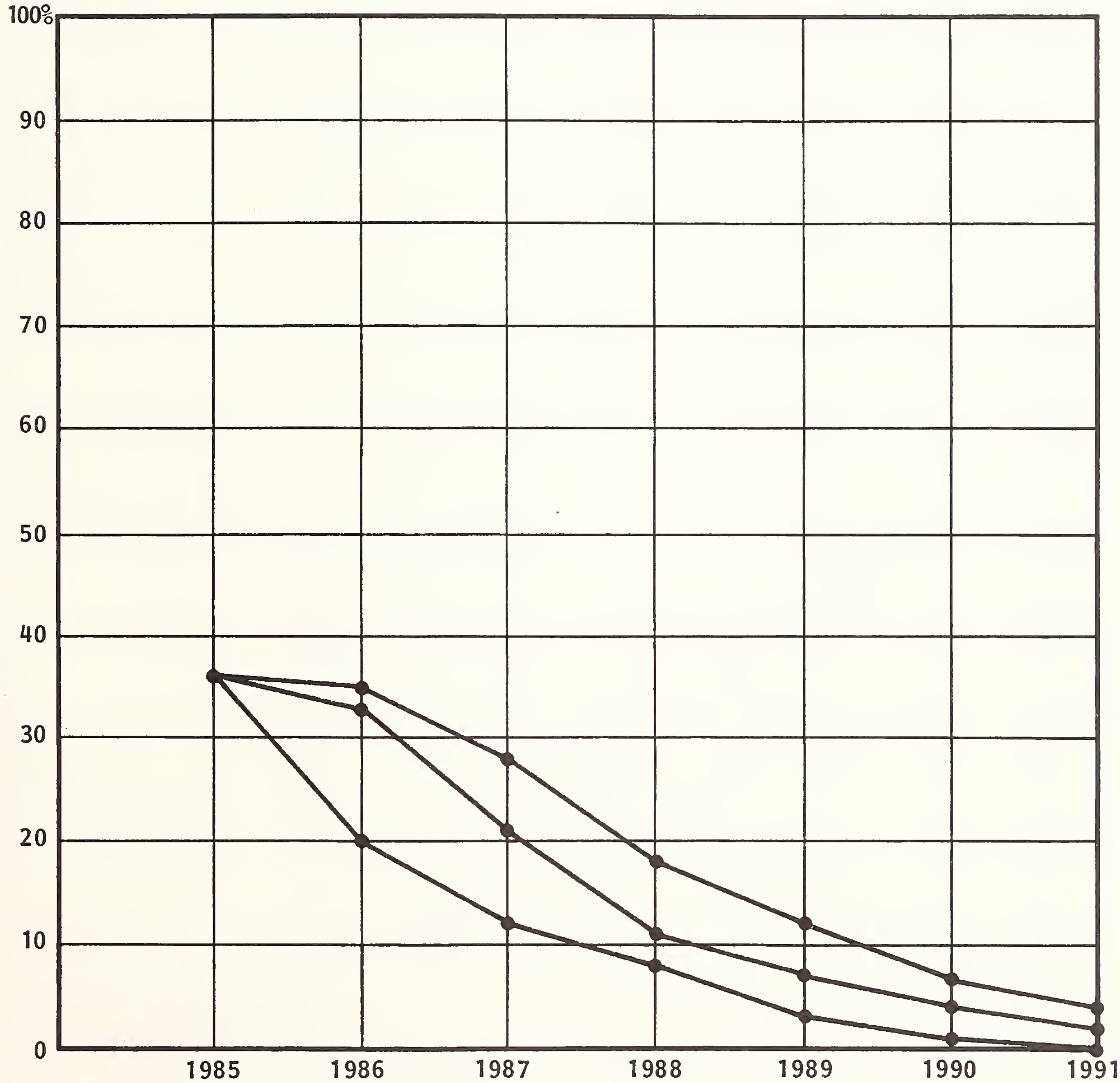
RESIDUAL VALUE FORECAST FOR
NAS AS/6630 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	33	25	14	10	6	3
Expected	31	18	8	5	2	1
Medium	18	10	5	3	1	0

EXHIBIT III-27

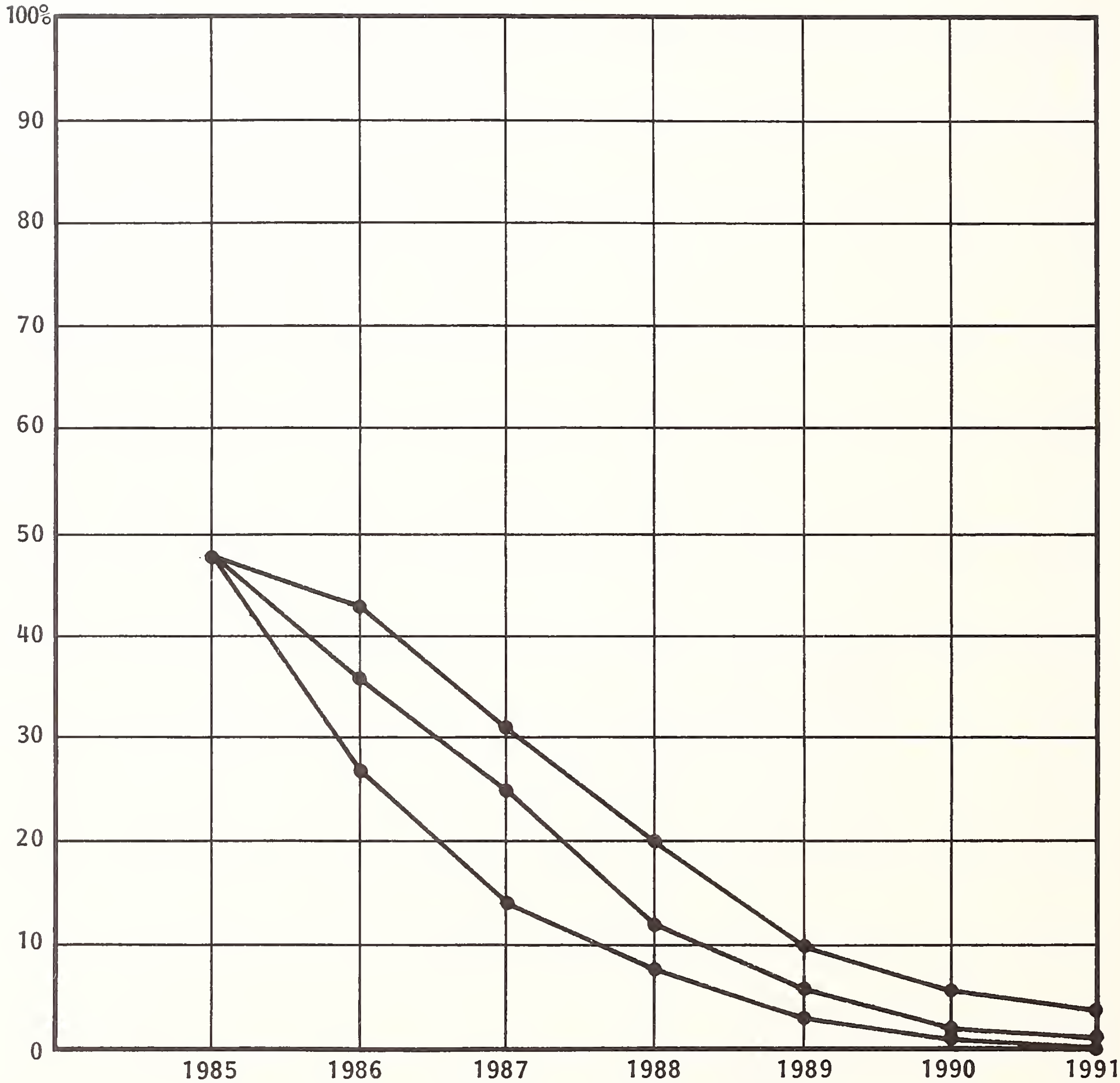
RESIDUAL VALUE FORECAST FOR
NAS AS/6660 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	35	28	18	12	7	4
Expected	33	21	11	7	4	2
Medium	20	12	8	3	1	0

EXHIBIT III-28

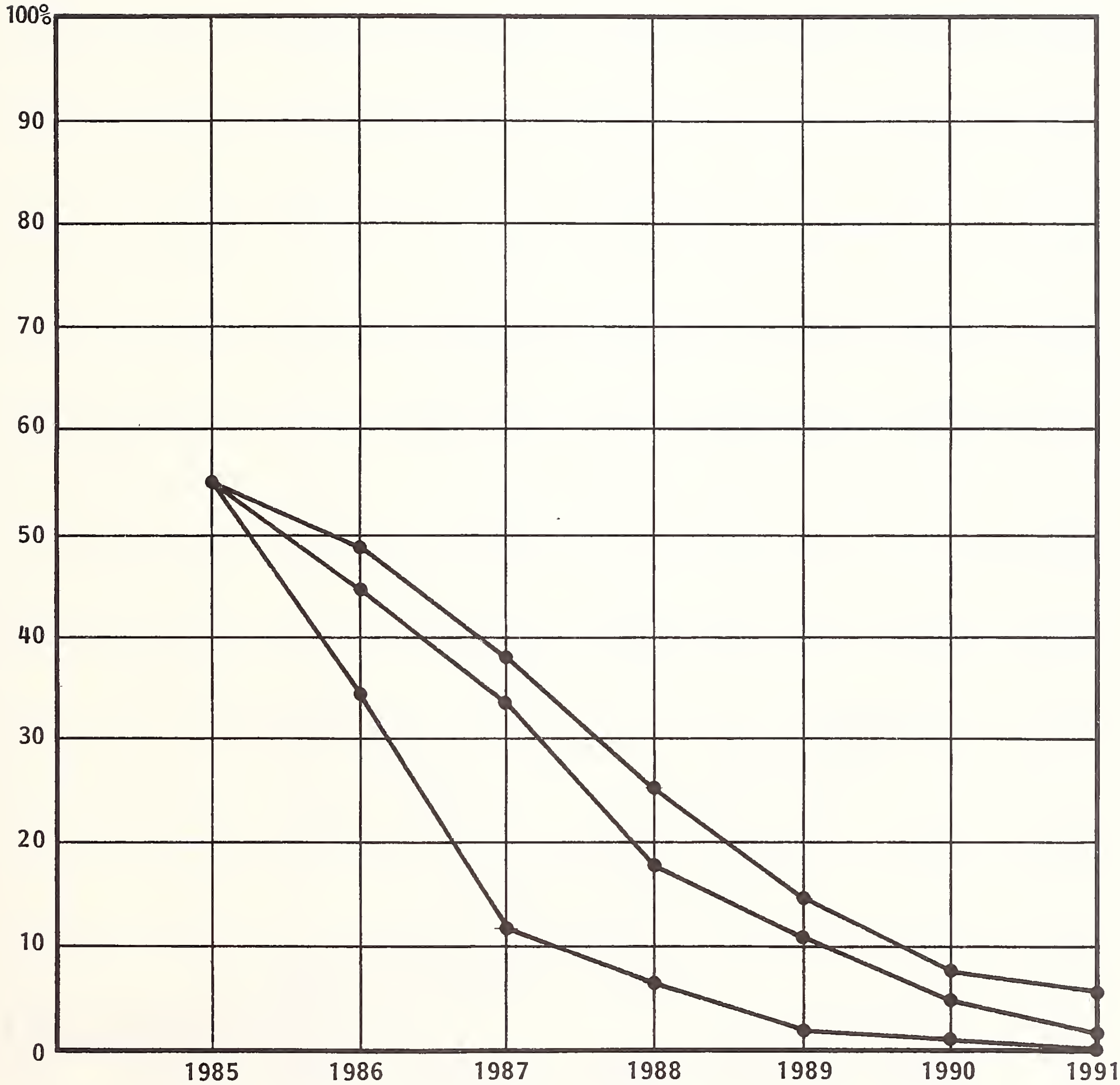
RESIDUAL VALUE FORECAST FOR NAS AS/8023 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	43	31	20	10	6	4
Expected	36	25	12	6	2	1
Medium	27	14	8	3	1	0

EXHIBIT III-29

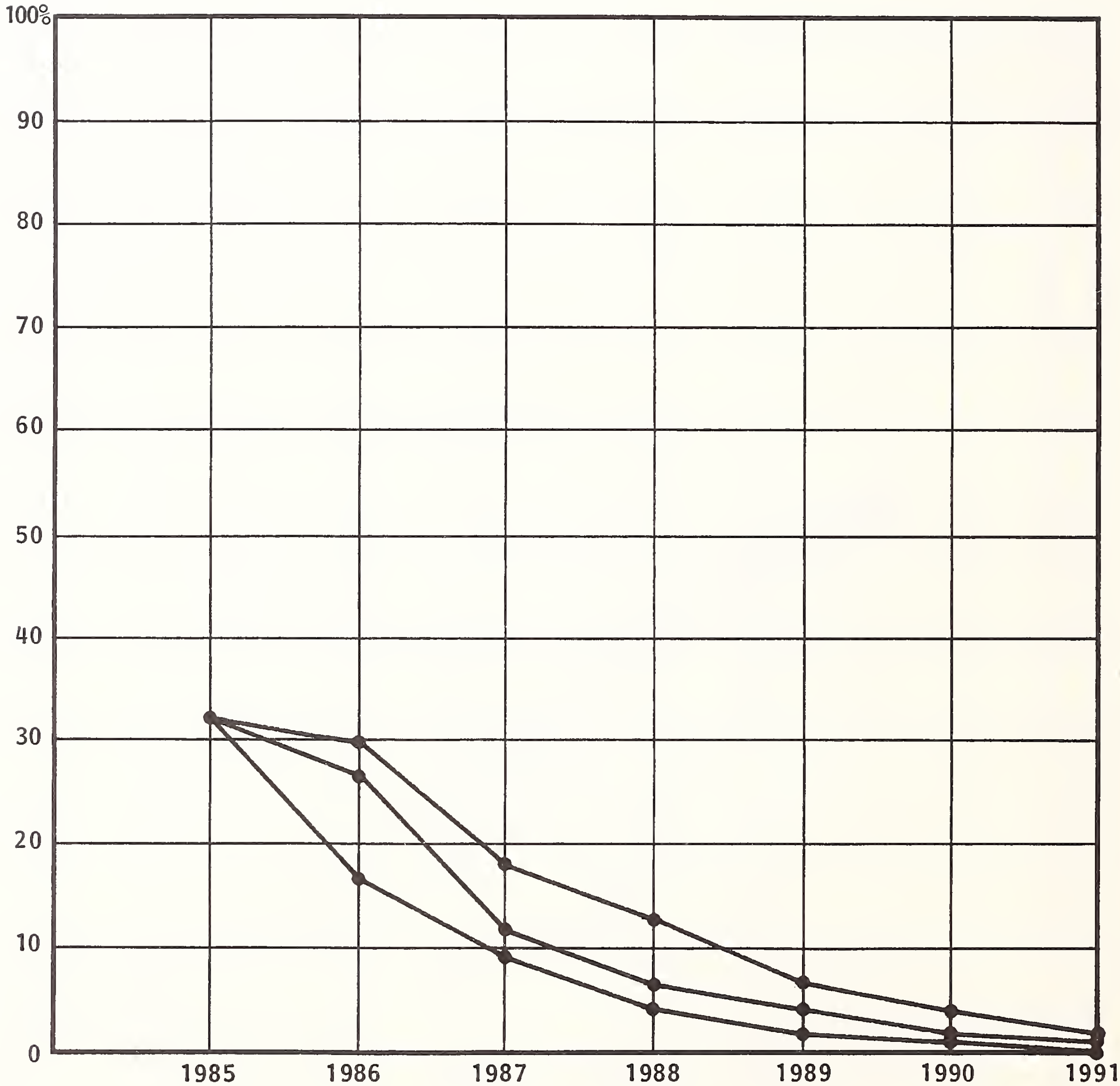
RESIDUAL VALUE FORECAST FOR
NAS AS/8083 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	49	38	25	15	8	6
Expected	45	33	18	11	5	2
Medium	34	12	7	2	1	0

EXHIBIT III-30

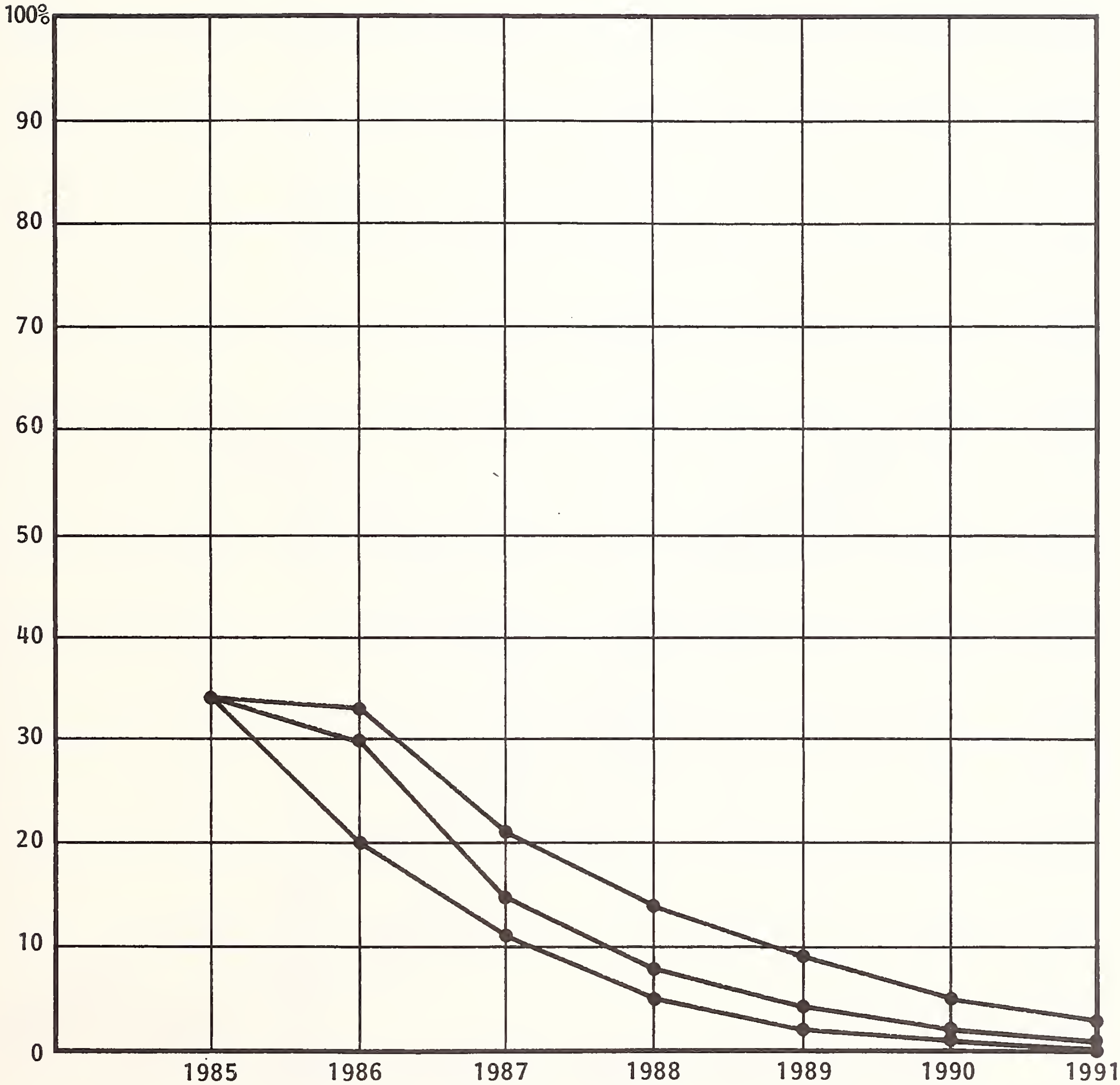
RESIDUAL VALUE FORECAST FOR
NAS AS/9050 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	30	18	13	7	4	2
Expected	27	12	7	4	2	1
Medium	17	9	4	2	1	0

EXHIBIT III-31

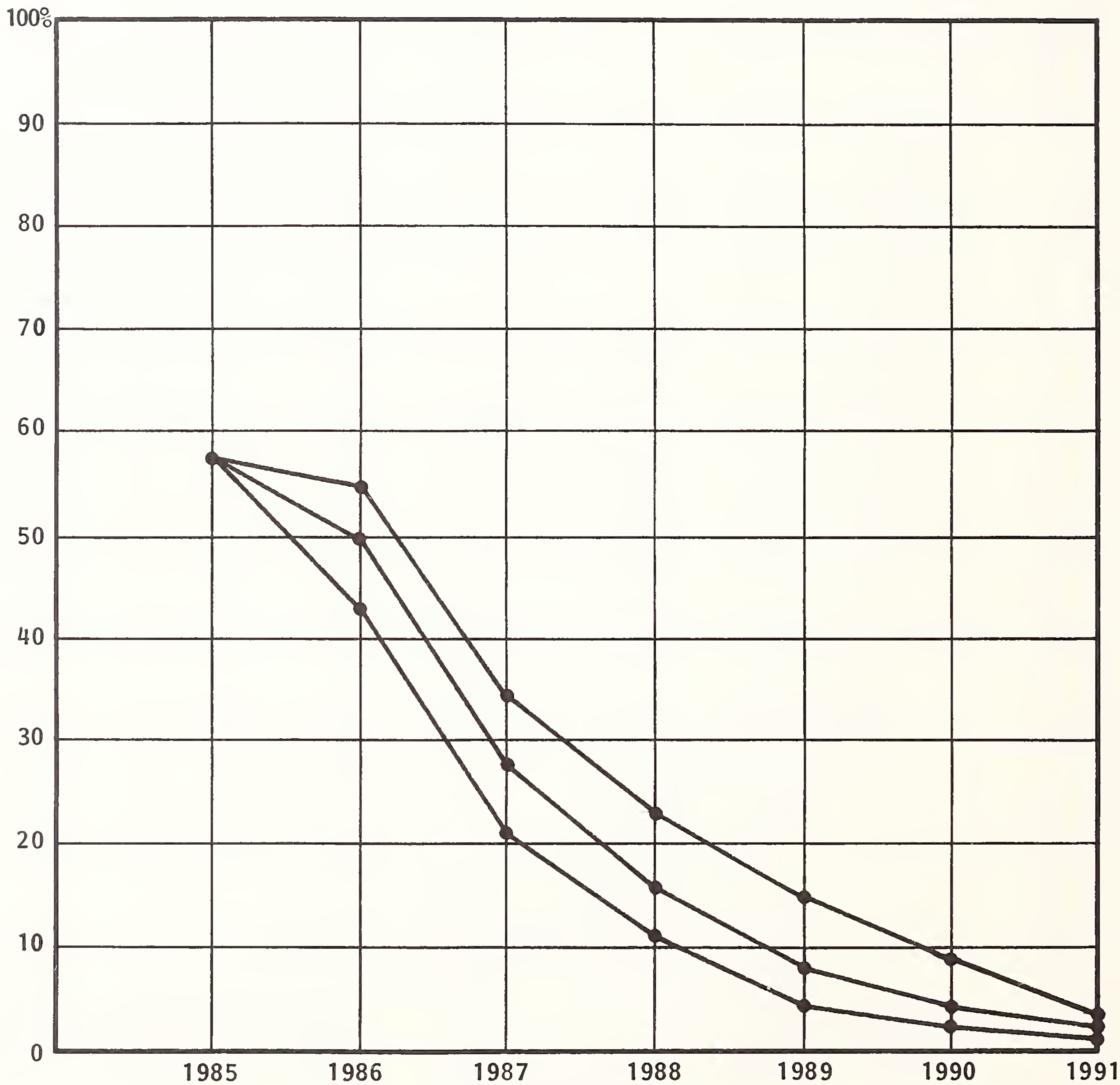
RESIDUAL VALUE FORECAST FOR NAS AS/9070 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	33	21	14	9	5	3
Expected	30	15	8	4	2	1
Medium	20	11	5	2	1	0

EXHIBIT III-32

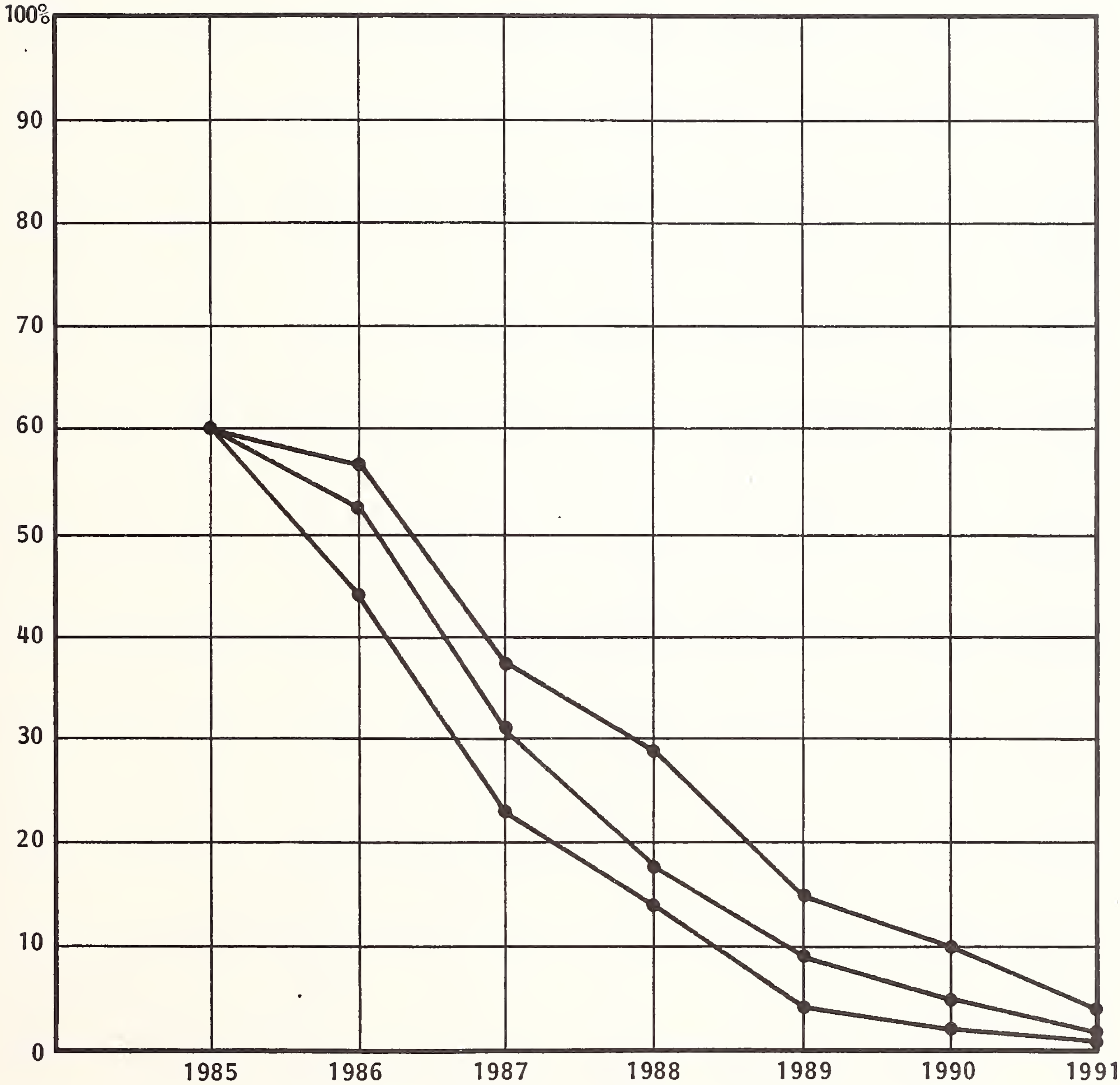
RESIDUAL VALUE FORECAST FOR NAS AS/9150 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	55	34	23	15	9	3
Expected	50	28	16	8	4	2
Medium	43	21	11	4	2	1

EXHIBIT III-33

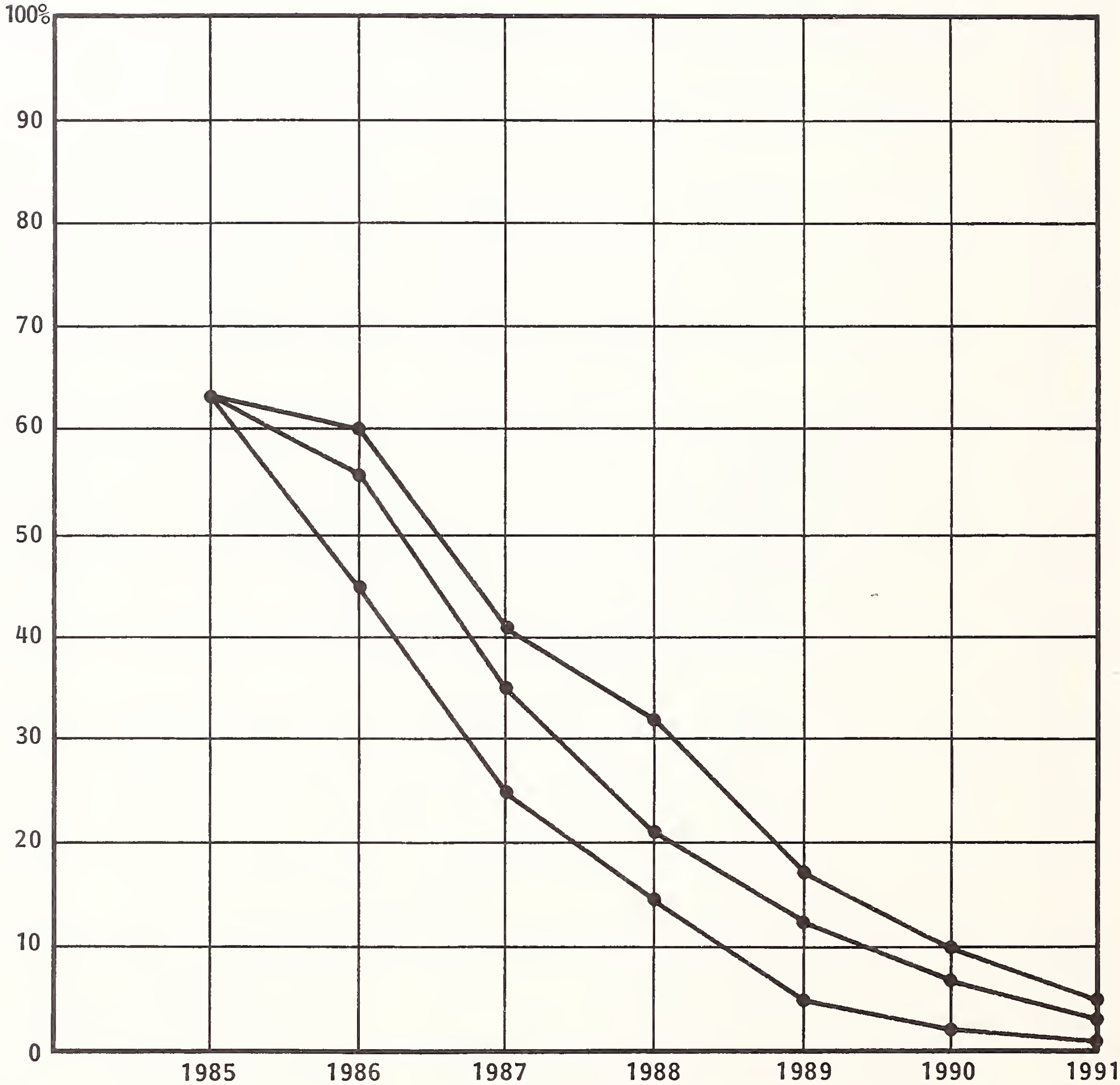
RESIDUAL VALUE FORECAST FOR NAS AS/9160 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	57	38	29	15	10	4
Expected	53	31	18	9	5	2
Medium	44	23	14	4	2	1

EXHIBIT III-34

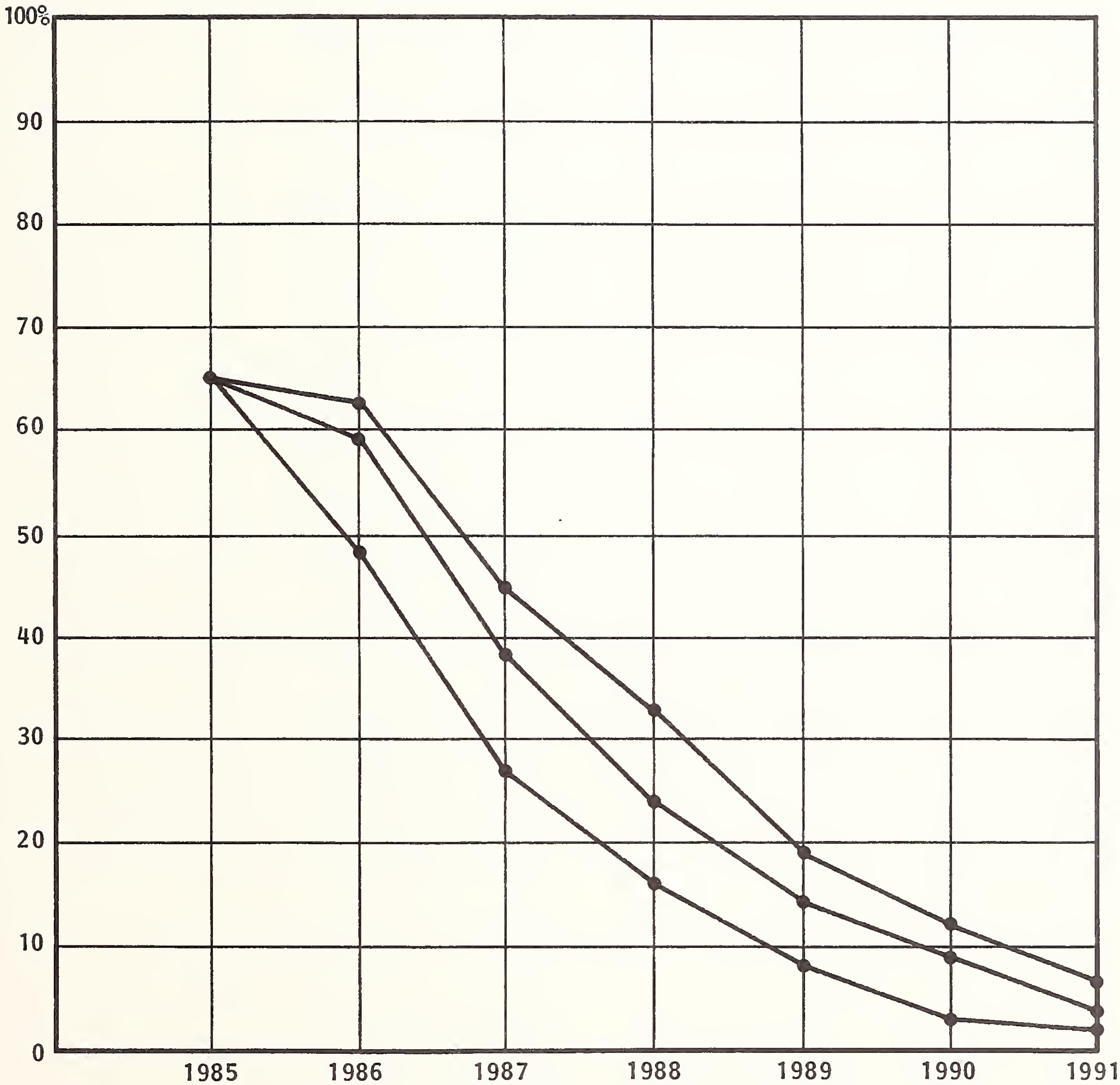
RESIDUAL VALUE FORECAST FOR
NAS AS/9170 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	60	41	31	16	10	5
Expected	56	35	21	12	7	3
Medium	45	25	14	5	2	1

EXHIBIT III-35

RESIDUAL VALUE FORECAST FOR NAS AS/9180 PROCESSOR



PROJECTED VALUES RANGE	As of January 1st					
	1986	1987	1988	1989	1990	1991
High	63	45	33	19	12	7
Expected	59	38	24	14	9	4
Medium	48	27	16	8	3	2

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