IBM OPERATING SYSTEMS STRATEGIES

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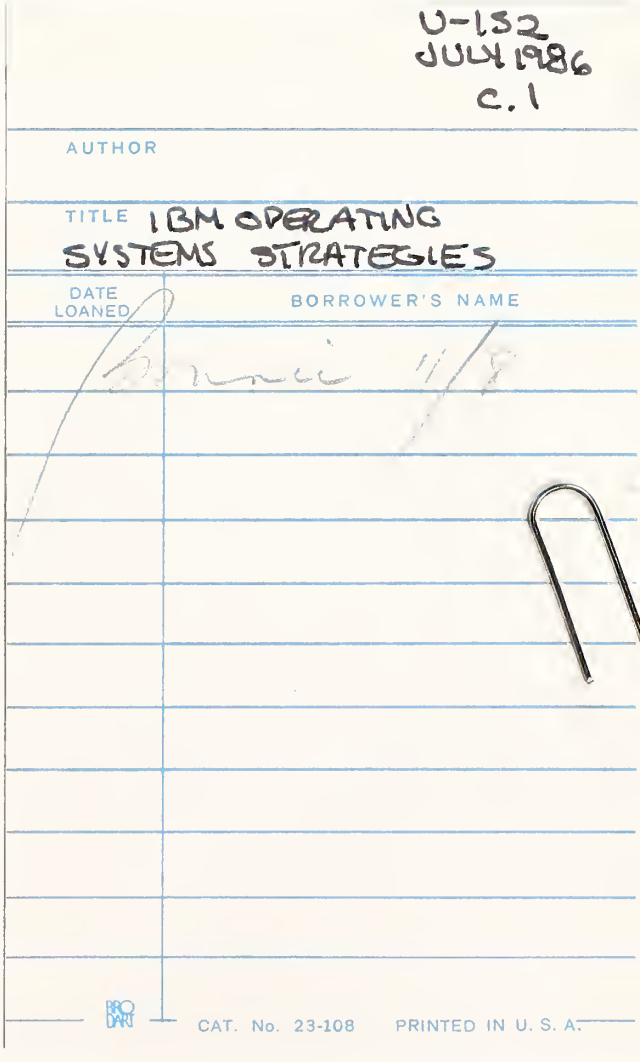

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Information Systems Program (ISP)

IBM Operating Systems Strategies

IBM OPERATING SYSTEMS STRATEGIES

ABSTRACT

Operating systems are becoming more important to the overall effectiveness and productivity of the increasingly complex applications which users plan to implement during the next five years.

Important driving forces are at work which will shape the future characteristics and directions of these mainstream operating systems.

This report analyzes and forecasts the market impact and implications for the period 1986 to 1991 of five major operating systems which support IBM 370 and XA architecture (MVA/XA, MVS, VM, DOS, UNIX), as well as PC-DOS, the major OS player for smaller systems that will be evolving into mid-range processors.

- Operating systems of the future will have more strategic business-related demands placed on them as top management looks to automation to enhance their competitive edge. As a result of this emphasis, operating systems will be actively changing and expanding their role and functions.

- The continued growth of end-user computing and the corresponding scarcity of technical personnel will put major demands on operating systems in terms of flexibility and general ease of use.

- The magnitude of the economic investment in hardware, software, communications, training, policies, and procedures which is embodied in existing systems.

This report contains 202 pages, including 80 exhibits.

IBM OPERATING SYSTEMS STRATEGIES

CONTENTS

EXHIBITS

1 INTRODUCTION

I INTRODUCTION

A. IMPORTANCE OF ANALYSIS

- Operating Systems (OS) define the operational limits of the computer products they support and, hence, the framework of present and future information systems. Since IBM is the leading vendor in the hardware and OS market, their OS strategies directly impact not only other hardware vendors but also add-on equipment suppliers and software product companies.

- Users are facing increasingly important OS questions that affect costs and migration paths. These, coupled with more complex hardware and software relationships and the interaction of differing OS and applications software, are further increasing the importance of following IBM's OS directions.

B. USE OF RESEARCH

- The research included in this report can be used in a variety of ways users, such as:

  . OS selection and timing.

  . Identifying new people skill requirements.

. Hardware assessments.

. Systems design tradeoffs.

. Applications software products evaluations.

. Vendor viability.

C. RESEARCH METHODOLOGY

- Since OS impact all areas of the information systems and services market, the research for this study is the sum total of INPUT's research base from the past year. In addition to analysis extracted from INPUT's existing data base, in-depth interviews were conducted with:

  - Leading-edge users.
  - OS experts.
  - Software and service vendors.
  - User group members.
  - Computer manufacturers.

- This primary research was coupled with extensive secondary research. Computer Intelligence, La Jolla, California's hardware census data base, helped to establish a baseline for INPUT's hardware forecasts.

D. SCOPE OF STUDY

- This study discusses in depth IBM's standard operating systems.
  - MVS.
  - MVS/XA.
  - DOS.
  - VM.
  - PC-DOS.
- UNIX, as it applies to IBM 370 and XA architecture, is also covered along with several other non-IBM standard OS offerings such as TPF.

E. FORECAST PARAMETERS

- INPUT's forecasts are based on the U.S. business installed base of hardware and OS units and extend from 1986-1991.
- Appendix A contains several case studies of users sites. Contained in Appendix B are INPUT's year-by-year forecasts of OS by hardware type for 1985-1991.

II EXECUTIVE SUMMARY

II EXECUTIVE SUMMARY

- The Executive Summary is given in presentation format to help the busy reader quickly review key research findings. It also provides an executive presentation, complete with script, to facilitate group discussions.

- The key points of the entire report are summarized in Exhibits II-1 through II-8. On the left-hand page facing each exhibit is a script explaining that exhibit's contents.

A. DRIVING FORCES IMPACTING OS FUTURE

- Operating systems are becoming more important to the overall effectiveness and productivity of the increasingly complex applications which users plan to implement during the next five years. This report analyzes and forecasts the impact and implications for the period 1986 to 1991 of four major operating systems which support the IBM 370 and XA architecture (MVA/XA, MVS, VM, DOS) as well as PC-DOS (IBM's main OS player for personal computers that will be increasingly competing with mid-range processors such as the System 36 and System 38, particularly with the multitasking capabilities recently announced by Microsoft).

- Important driving forces are at work which will shape the future characteristics and directions of these mainstream operating systems.

  - Operating systems of the future will be increasingly complex and performance oriented to accommodate business-related demands placed on them by a management structure that is looking to automation to enhance their competitive edge. As a result of this emphasis, operating systems will be actively changing and expanding their role and functions.

  - The continued growth of end-user computing and the scarcity of technical personnel will put major demands upon operating systems in terms of flexibility and general ease of use. The "rat's nest" of obscure codes and brain-taxing formats will (fortunately) become more scarce as OS vendors respond to user requirements in this area.

  - The huge investment in existing hardware, software, communications, training, and policies and procedures will place an increasing premium on OS compatibility as a primary way to leverage yesterday's investment with tomorrow's opportunities.

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DRIVING FORCES IMPACTING OS FUTURE

- Automation as Competitive Edge
- Demand for End-Specific Interfaces
- Scarcity of Technical Personnel
- Investment in Existing Systems Requiring Upwards Compatibility

B. CHANGING COMPUTING ENVIRONMENT TO SHAPE OS DIRECTIONS

- Operating systems directions during the next five years will be heavily influenced by the evolution of ever more complex and more tightly interconnected hardware and software. Examples of this changing computing environment include:

  - Design of systems for multi-tiered environments--the hierarchical processing structure of host-to-departmental-to-personal-to-mobile computers will become the commonplace, thus placing major demands on communications-oriented OS that are capable of easy coexistence with multiple product lines.

  - Sophisticated peripherals--technology will continue to provide important new peripheral-related capabilities in areas such as optical storage (e.g., CD ROM), network control, speech recognition, and pattern recognition. Properly configured operating systems will be needed to provide efficient access to these powerful subsystems.

  - Specialized-processing hardware--many large-scale computers of the future will incorporate subprocessors, each of which will be dedicated to a specialized computing function such as artificial intelligence/expert systems, data base management, or array processing. Operating systems will be changed to become more capable of directing and optimizing these functions.

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CHANGING COMPUTING ENVIRONMENT TO SHAPE OS DIRECTIONS

- Multi-tiered Systems
- New, Sophisticated Peripherals
- Specialized Processors

C. COMPETITIVE FORCES ALSO IMPACT OS DIRECTIONS

- Business forces will also influence future OS characteristics. Examples include:

  - The high cost, labor-intensive/scarce-resource nature of supporting operating systems and their enhancements is encouraging IBM (and others) to seek ways to reduce the number of supported operating systems. When this is combined with the user's desire to minimize the number of operating systems used (for the same reasons), a major market pressure develops to reduce the variety of operating systems in the marketplace.

  - On the other hand, vendors are being forced to offer and/or support non-proprietary operating systems. For example, market pressures on IBM from UNIX adherents finally resulted in IBM's belated support of that operating system via their IX/370 offering.

  - Expansion of market scope via strategic alliances will change the marketplace. AT&T, Microsoft, and INTEL have entered into cooperative agreements which will assist the standardization of UNIX implementation.

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COMPETITIVE FORCES IMPACT OS DIRECTIONS

- High Cost of Multiple OS Support
- Willingness to Support Non-Proprietary OS
- More Strategic Alliances

D. OS OBJECTIVES ARE CHANGING

- Design and implementation objectives of operating systems must change to accommodate new priorities in user requirements. Examples of OS characteristics that will receive significantly more emphasis in the future include:

  - Ease of use--this capability truly occurs only when the person-machine interface for all three types of users (end users, programmers, and operators) is significantly simplified. OS vendors will place increasing emphasis in this area.

  - Efficiency of operation--the explosion of on-line applications will place continual pressure on OS to become more efficient. However, the increasing demands for more complex OS functionality will result in only moderate progress in this area.

  - Ease of modification--frequency of OS source code changes will fade as the Object Code Only (OCO) policies of IBM and others becomes more commonplace and as the rate of change of OS functionality accelerates. However, ease of standard modifications will expand as OS vendors place increasing emphasis on expanded user exits to help users more easily adapt operating systems to their own environment.

  - Portability--with the advent of more mixed-vendor shops, the ability of an OS to reside on differing types and sizes of CPUs (i.e., portability) becomes more critical as a resource conservation strategy.

  - Continuity of operations--the inexorable movement of information systems toward the heartbeat of the enterprise places a premium on continuous processing. Operating systems of the future will become significantly more fault tolerant.

OS OBJECTIVES ARE CHANGING

OS OBJECTIVE	PAST (1970s)	PRESENT (1980-1985)	FUTURE (1986-1991)	TREND (1985 vs. 1991)
Ease of Use	Low	Medium-	High	↑
Efficiency of Operation	Low	Medium	Medium	→
Ease of Modification				
- Non-Standard	Low	Medium	Low-	↓
- Standard	Low	Medium	Medium+	↑
Portability	Low	Medium	Medium+	↑
Continuity of Operations	Low	Medium	Medium	→

E. IMPLICATIONS OF OS FOR PLANNING

- The rate of change of operating systems will accelerate during the next five years. The new demands of an on-line, highly interconnected, multiprocessing level world, in concert with an explosion of vendor options and higher expectations from users concerning both functionality and ease of use, will all serve to cause frequent and significant expansions/modifications to operating systems.

- Many operating system functions will gravitate to specific levels within the processing hierarchy. Storage management, protection, and security will tend to be centralized on host mainframes. Resource allocation will become th primary function of departmental processors where software routines will determine where the most economical processing and data sources are on the network. Processing of functions will be distributed over a wide range of intelligent workstation levels.

- Guest-host solutions to operating systems concurrency will become more popular since they allow different OS to co-exist, thus preserving application investments and minimizing conversion costs, at least for the short term.

- No single operating systems solution will evolve. The diversity of processing requirements combined with the complexity of required OS functions and the magnitude of the installed bases make a monolithic consolidation of OS functions unlikely for the foreseeable future. However, a slow consolidation of operating systems is expected as both users and vendors attempt to standardize on fewer, but more comprehensive, operating systems.

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IMPLICATIONS OF OS FOR PLANNING

- OS Changes to Accelerate
- Function to Gravitate to Specific Levels
- Enhanced Popularity of Host-Guest Solutions
- No Single OS Solution to Evolve
- Slow Consolidation of OS Types

F. MVS, MVS/XA, VM, UNIX TO SHOW MAJOR GAINS

- The growth rates for major operating systems will vary widely. MVS/XA, VM, and UNIX will show the greatest gains in the next five years in terms of increases in installed base (as well as percentage increase) on 370 and XA architecture systems.

- MVS/XA will have 12,400 additional installations by 1991, an increase of 45% annually. As IBM's primary host-based operating system, a greatly expanded MVS/XA will account for 45% of all MVS-type operating systems by 1991, up from 18% in 1986.

- VM will increase its installed base by more than fourfold to become the most popular operating system by 1991 with an installed base of 36,000. VM will benefit primarily, but not solely, from its ability to serve as a powerful conversion tool as more organizations attempt to integrate formerly disparate computing environments into a single hardware system.

- UNIX will show the greatest percentage gain with an impressive 83% average annual growth rate over the five-year period. UNIX's rapid ascension from a small 1986 base is being stimulated by widespread acceptance of a System V standard combined with its economies of scale when developing software for multiple computer sizes and architectures.

- In contrast, MVS will grow only 9% annually to 18,000 units by 1991 from a base of 11,600 in 1986. It will, however, still be a major operating system throughout this forecast period.

- The erosion of the DOS base will continue, but at a slow 3% annual decline. The 1986 installed base of 10,900 units will contract to 9,200 by 1991. Smaller, slow-growth organizations will continue to embrace it for mid-range systems, while larger and/or faster growing firms will convert to the more actively supported operating systems.

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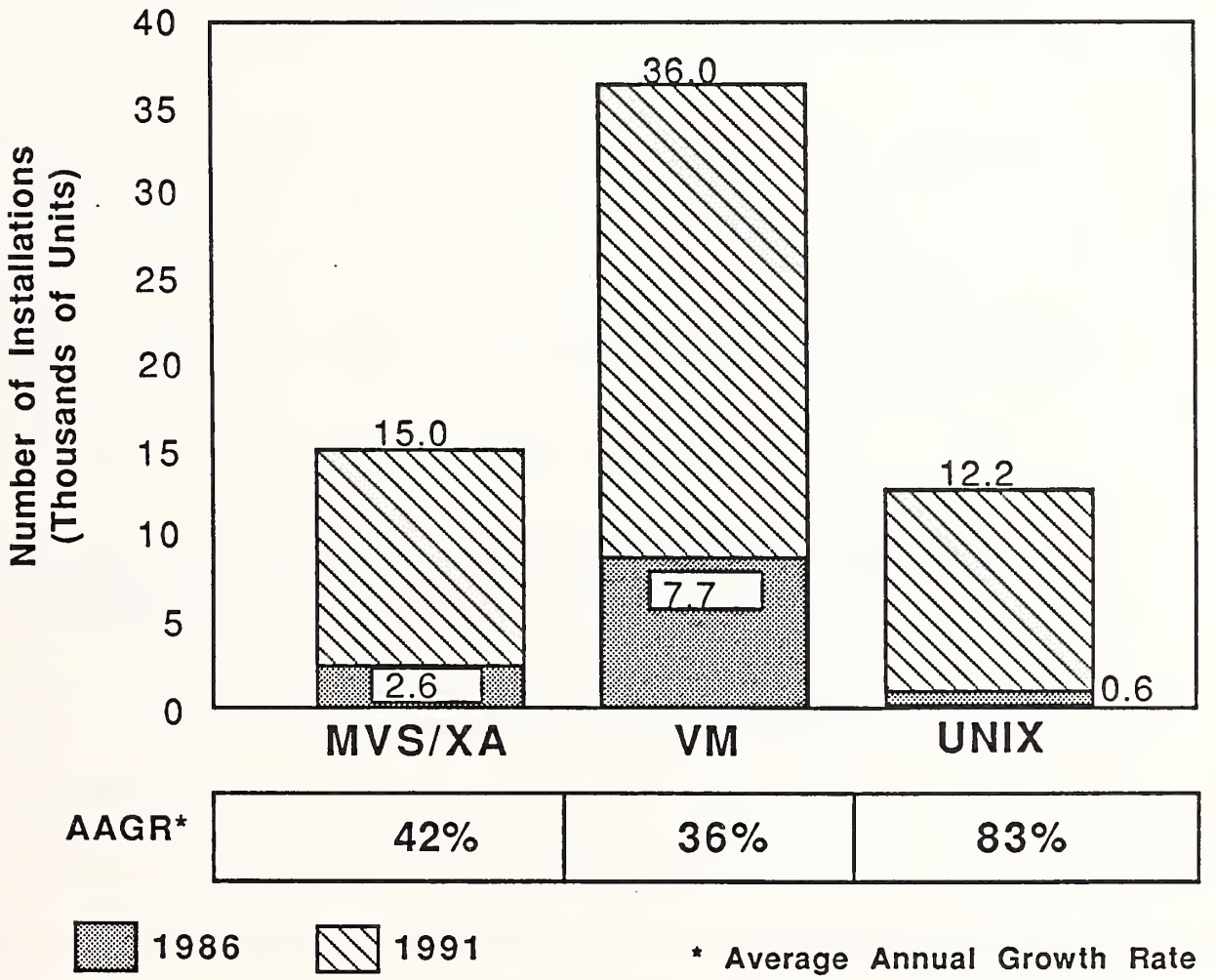
MVS/XA, VM, AND UNIX INSTALLATIONS, 1986-1991



G. CONCLUSIONS: OS DIRECTIONS

- As IBM's designated primary strategic operating system, MVS/XA will be the OS winner for the large-scale IBM 370 architecture commercial computing environment. IBM can be expected to continue to make major efforts to reduce the cost and complexity of implementing and using XA. Additional conversion tools and migration aids as well as increased automation of operator functions will be aggressively introduced and marketed.

- VM will increase in popularity and importance as it expands its appeal to small, mid-range, and mainframe system users seeking multiple OS operation and/or helpful interactive facilities. As the primary IBM offering supporting host-guest processing, VM can be expected to be actively supported not only by IBM, but by a large group of vendors providing VM-related systems and applications software.

- DOS is the operating system that refuses to die. Its final demise will be postponed by its existence as a VM guest and by the sheer momentum of a large installed base, many of which are smaller organizations with little or no growth requirements.

- UNIX is the non-IBM proprietary "up and comer" to the 370 architecture world. UNIX will experience increasing commercial appeal and will emerge as a major operating system within the IBM 370 environment, although a distant third place to MVS/XA and VM. Key driving forces for UNIX are favorable vendor economics resulting from UNIX portability and wide-scale implementations to date, rapid increases in smaller-scale multiuser systems, and the emergence of System V as a widely adopted UNIX standard. Prime markets for UNIX will be in the scientific, engineering, and development environments.

- PC-DOS will not only be IBM's mainstream microcomputer operating system on individual systems, but will play an important role as a host OS or as a VM guest on non-370 architecture, multiuser, mid-range systems.

CONCLUSIONS: OS DIRECTIONS

- MVS/XA: Rapid Evolution, the Large-Scale Winner
- VM: Increasing Importance, All Size Systems
- DOS: a Slow, Not Fast, Decline
- UNIX: Up and Coming Multi-User OS for Commerical Users
- PC-DOS: Important Impact on Mid-Range Systems

H. RECOMMENDATIONS

- The choice of operating systems should be viewed as a strategic business decision and thus should be made with great care. As the role and functionality of operating systems expand during the next several years, the investment by both users and vendors in the use and support of these systems becomes major. Mainstream operating systems, such as those profiled in this report, should be given first preference unless circumstances strongly mitigate against them.

- Multiple computer installations should favor either VM or UNIX. These operating systems are widely used and provide important commonality of function across a variety of sizes and types of hardware. The benefits in terms of efficiency of training and support resources are significant.

- The efficiency and effectiveness of information systems, which are fundamental competitive business tools, will be increasingly impacted by OS capabilities. Because operating systems will evolve extremely rapidly during the next several years, users and vendors must stay current on new OS releases to benefit from increased functionality, which in turn will mean increased competitiveness.

RECOMMENDATIONS

- Select Operating Systems Carefully
- Multiple Computer Installations Should Favor VM or UNIX
- Stay Current on New OS Releases for Optimum Competitiveness

III ENVIRONMENTAL FRAMEWORK

III ENVIRONMENTAL FRAMEWORK

A. HISTORICAL PERSPECTIVE

- In 1963, in preparation for the announcement of System 360, IBM conducted a comprehensive customer survey of all its "large" systems users (1410, 707X, 7080, and 709X installations) to determine what programming systems they were using, what they thought of them, and what the most important attributes of such systems were. To the best of our knowledge, this is the first and only time IBM has seen fit to ask specifically what a large segment of its customer base liked (or disliked) about specific programming systems offerings as well as their opinions on the most important attributes of such systems. From that time on, assistance has been sought primarily as guidance from customers on functional priorities.

- Before the announcement of System 360, IBM did not use the term operating system. However, there were operating subsystems called loaders, monitors, and input-output control systems (IOCSs) which incorporated most of the functions of today's operating systems in some limited fashion. In 1963, IBM asked its customers to rank a list of 12 attributes of these subsystems and other important components of programming systems support (Languages, RPGs, Sorts). The six most important attributes for the subsystems are presented in Exhibit III-1.

EXHIBIT III-1

RANKING OF MOST IMPORTANT ATTRIBUTES

ATTRIBUTE	MONITORS	IOCS	LOADERS
Ease of Use (Operating)	100		100
Minimize Storage Requirements	77	69	77
Speed of Operation	73	76	91
Documentation	68	79	72
Ease of Use (Programming)	59	100	60
Object Program Efficiency		75	

- For the first time, "ease of use" was clearly established as the most important attribute of programming systems support. However, the rankings presented in the exhibit require some explanation.

  - As mentioned above, respondents were asked to rank the subsystem on 12 attributes and only the top 6 are presented. The most important attribute is given a rating of 100, and the other attributes were given a rating based on their weighted rankings.

  - Therefore, these ratings do reflect relative importance based on forced rankings. (Unlike so many "evaluations" which use average respondent assigned ratings to discriminate relative importance.) This means it is impossible for everything to be important, and the lowest six attributes for the subsystems fell within the following ranges:

    . Loaders - 31 to 12.

    . Monitors - 29 to 13.

    . IOCSs - 45 to 21.

  - Therefore, it can be seen that such attributes as "speed of operation" and "minimize storage requirements," while less important than "ease of use," were significantly more important than the other attributes which were ranked by users.

- The results of this study were used to establish the primary design points of what was to become OS/360, and such attributes are clearly reflected in the general objectives of operating systems which are still being used to this day. The COmputer Science and Engineering Research Study (COSERS), sponsored by the National Science Foundation in the mid-to-late 1970s (and later published by MIT Press in 1980 under the title What Can Be Automated?), was probably the most comprehensive research study ever

attempted on the subject of computer science and engineering, and it laid down the general objectives of operating systems which will be used for this study. They are as follows:

- Maximize ease of use.

- Maximize use of equipment (thereby increasing efficiency and reducing the cost per user by sharing resources).

- Provide for the effective development, testing, and introduction of new system functions without at the same time interferring with service.

- It is apparent that IBM was aware of these general objectives from the design stage of its operating systems development and may even have influenced their establishment in the 1960s. The degree to which IBM has met these objectives over the years since System 360 was announced will be left to the reader. One thing is certain, IBM operating systems have provided a degree of account control which is still being exercised to this day.

- In addition to the general objectives of operating systems, the COSERS research emphasized five "abstract areas of implementation" which will be important in analyzing what is going on in the operating systems area. Simply stated, these areas are:

  - Process, which refers to a program being executed and the problems of concurrency between such programs and devices and among programs in a multiprogramming and/or multiprocessing mode. This abstraction of process in the implementation of operating systems evolved in response to problems which become critical in both the architectural (hardware) distribution of processing (dyadic, vector processors, etc.), and the geographical distribution of processing over both hierarchical and local area networks. It sometimes is not apparent that those involved with either personal computers or office automation are

aware of the progress which has been made or the problems which still exist.

- Memory management refers primarily to the concept of virtual storage which has developed over the last 20+ years and is currently so widely accepted that it threatens to impede the development of new concepts which may be required for new storage media and to meet the performance requirements of many of the complex systems being developed or contemplated.

- Information protection and security has long been a matter of concern to many people, but has all too frequently been ignored by both computer scientists and systems developers interested in getting things "up and running." While substantial progress has been made in certain aspects of access control, the problems of information flow have only recently come under serious consideration. The information protection and security problems associated with distributed data bases are not currently understood, and even access control is weak in most operating systems.

- Scheduling and resource management has been the subject of substantial theoretical progress over the last several decades. The primary reason for this has been the very visible impacts of poor performance in terms of turnaround time and response time. Intuitive judgments such as getting the short jobs out of the system as rapidly as possible have been proven mathematically correct, and queuing networks have been proven to be effective predictors of operating systems performance despite the fact that the models are not intuitively appealing to most computer scientists (and mathematicians). Unfortunately, there has been a general tendency to throw hardware at IBM operating systems peformance problems rather than use proven tools to assure improved internal performance of the systems.

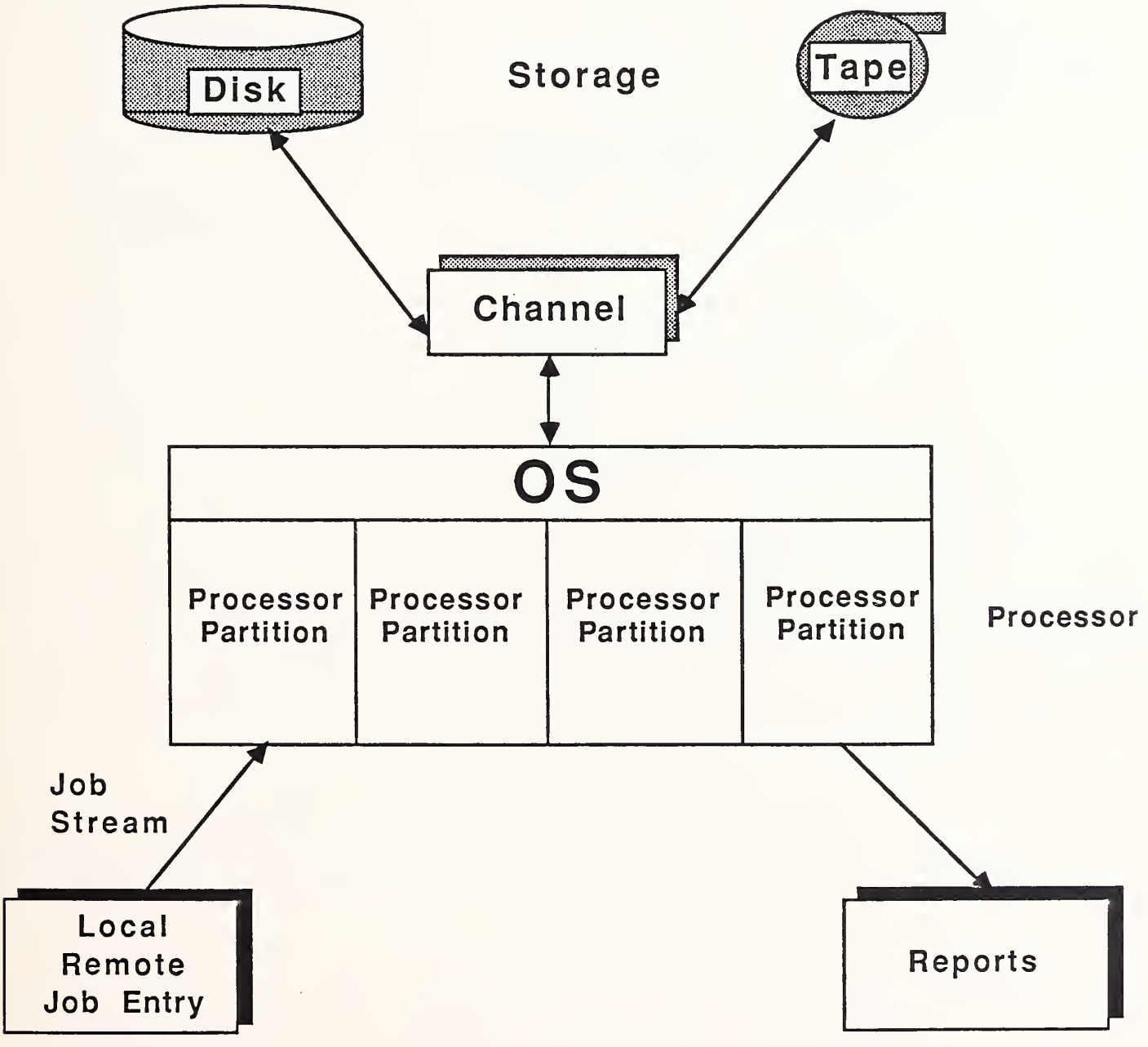
- System structure covers everything from the concept of subroutines through structured programming to virtual machines. The COSERS study makes the point that virtual machine (VM) operating systems are not design tools but rather are machine simulation. As such, each virtual machine is considered to be a "passive entity" and therefore more primitive than the abstraction process. It is INPUT's opinion that VM has traditionally been used as a tool of integration (usually during major operating systems conversions--such as DOS to OS) and that such a tool is desparately needed in today's environment--if it had not already existed, IBM or someone would have had to invent it. As it was, IBM kept it under wraps for about 20 years because it was not mainstream.

- A quick look at some of the early systems which employed these abstractions are revealing because they remind us of where we have been and where we might be going.

  - Exhibit III-2 illustrates a simple batch, multiprogramming system from the mid-1960s and it clearly illustrates the concept of process by overlapping computing with I/O activity. It was also pointed out long ago that even a simple channel necessitates "multiprocessing." (IBM has recently pointed out channels are "RISC" machines, which of course they always have been.) The diagram also illustrates multiprogramming, which was really the beginning of complex scheduling and resource allocation problems associated with memory management due to the fragmentation of main storage (which was small and expensive when System 360 was announced). It should be understood that the fragmentation problem was relatively easy to solve through standardization of problem program size, but the memory limitation of 1 meg. on a System 360, Model 65 did not permit a deep enough level of multiprogramming to make effective use of the System 360's processing power.

EXHIBIT III-2

A SIMPLE BATCH SYSTEM - OS/360 (1966)



- While a little more storage would have permitted the balancing of processing power with I/O for commercial work in a simple multiprogramming environment, the same was not true for timeshared engineering and scientific work with the requirements of many active users for matrices of data. (It is important to recognize that spreadsheets are matrices and will have many of the same attributes of engineering and scientific processing because of similar views of data.) IBM was aware of virtual storage concepts prior to the announcement of System 360 and experimental systems were in operation in the early 1960s, but the mainstream operating systems effort had no such facilities in its plan. The competitive environment at the time prompted IBM to start a separate Time Sharing System (TSS) effort incorporating virtual storage (VS).

  - Even the simple diagram in Exhibit III-3 demonstrates clearly the primary resource problem associated with VS. As much as you pretend, virtual storage is spread across a real storage hierarchy and must be moved (paged) back and forth to relatively slow I/O devices.

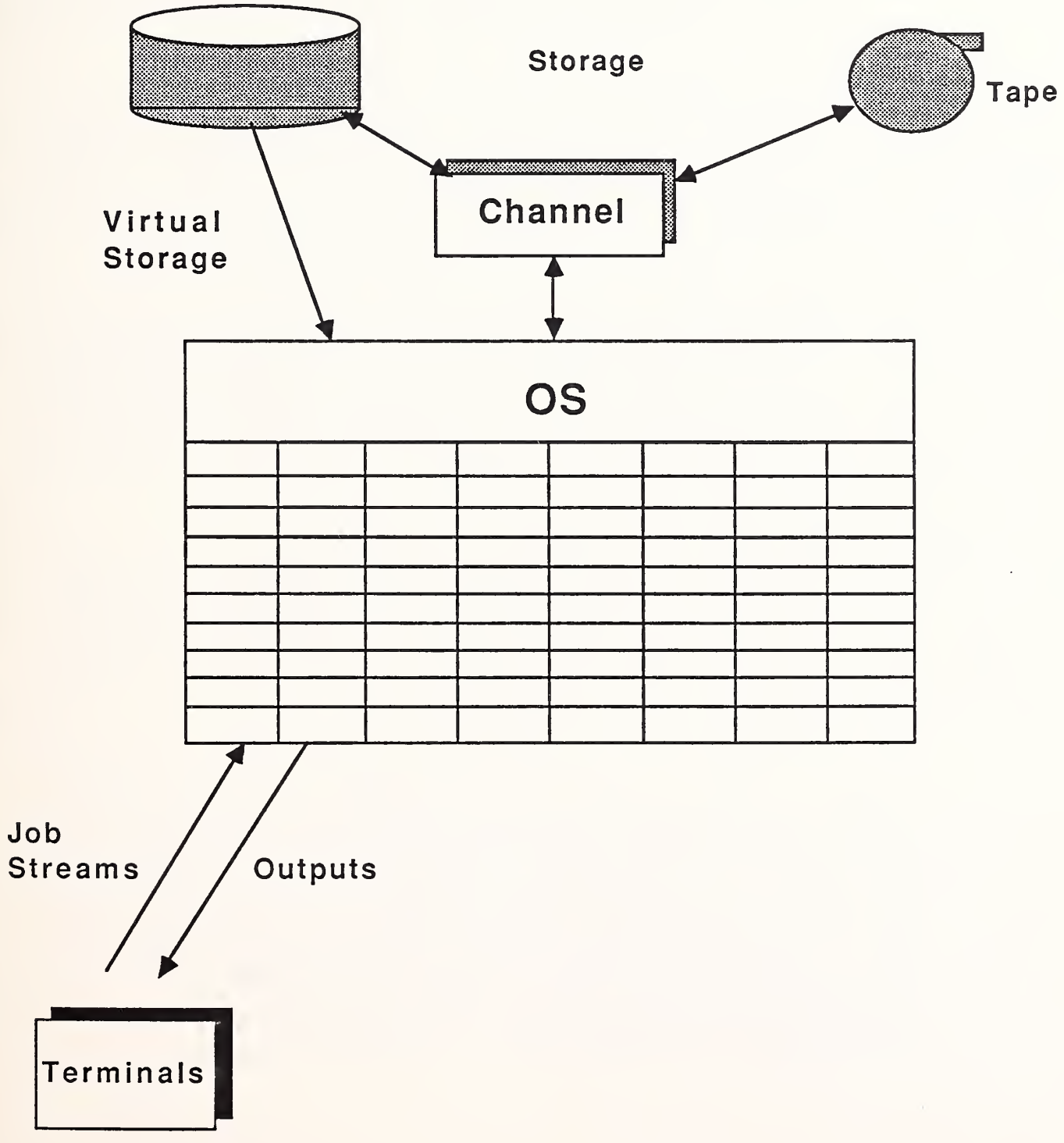
  - Research had disclosed general tendencies toward "locality of reference" in both programs and data associated with engineering and scientific work--in other words, programs tended to spend most of their time in their inner loops and matrices tended to be sparsely populated.

  - It was, therefore, assumed that the paging problem would not be severe--an assumption which ignored commercial applications such as sorting.

  - As virtual systems have evolved, they have encountered numerous performance problems, including the classic "thrashing" problem which, while "counter-intuitive," simply

EXHIBIT III-3

A SIMPLE TIME SHARING SYSTEM - TSS (1967-68)



meant that nonproductive work got done--the CPU could be kept busy merely keeping track of where everything it was supposed to be doing was located.

. By employing a lot of creative analysis and software effort, and by absorbing most of the advances in processor performance and system storage size, VS has been made to work and is now the accepted solution to the storage management problem.

. The real cost of virtual storage on large general purpose mainframes has been largely obscured, but there is little question that it has been the primary contributor to the overhead associated with IBM mainframe operating systems.

. The possibility of direct cost comparisons between micro and mainframe applications as micro-mainframe links develop may provide at least a rough approximation of these costs, and the development of VS operating systems for micros may bring the problem into even sharper focus.

. The point is that VS is not the best answer to all storage management problems in all environments, and as processing and data bases are distributed over network hierarchies, this is going to become increasingly apparent.

- The experimental work on virtual storage systems at the IBM Research Center at Yorktown Heights in the early 1960s was done on an experimental machine (M44X) which had the interesting characteristics of being able to look like different machines. (The data analysis for the IBM Programming Systems Evaluation Survey mentioned earlier was done on the machine when it reverted to its native state--a 7044.) The M44X was the first virtual machine (VM), and the concept became very attractive for the development and testing of systems software

(operating systems) and for conversion from one operating systems environment to another. Exhibit III-4 highlights a simple virtual machine system. One of the primary advantages of VM is to isolate the machines--this effectively precludes shared data. VM has traditionally been a tool for development and conversion, and in that environment shared data has not been important. As it moves into the production environment, some means of sharing data across machines becomes essential. This will be discussed later.

- The basic hardware/software concept of System 360 was one compatible line of general purpose systems for both scientific and commercial processing. This was even carried to the level of languages where PL/I was intended to replace both Fortran and COBOL. While it was IBM's desire to keep everything under one cover, it became necessary to isolate certain functions quite early in order to provide a buffer between central processors and slower speed communications lines. Esentially, HASP and ASP (which will not be discussed at length in this report) provided for effective spooling of input and output queues for both remote and local job streams. This meant that the primary operating system needed support in the form of either a separate processor or a high-performance subsystem. As the operating systems absorbed more and more of the individual processors, the tight coupling of an additional processor (MP) supplied more power (see Exhibit III-5). The desire for a single solution and a single system view remains the primary emphasis of IBM's operating systems efforts to this day.

- The mainstream of IBM's operating systems strategy has been the OS, VS, MVS, and MVS/XA strategy which has been so successful in supporting the profitable IBM mainframe strategy. The reasons for TSS and VM have already been explained, but IBM was also forced to develop DOS because OS could not be implemented on the smaller System 360 systems (believe it or not, OS was originally specified to run on 16K systems). The last 20 years have seen a

EXHIBIT III-4

A SIMPLE VIRTUAL MACHINE SYSTEM - VM (1960s)

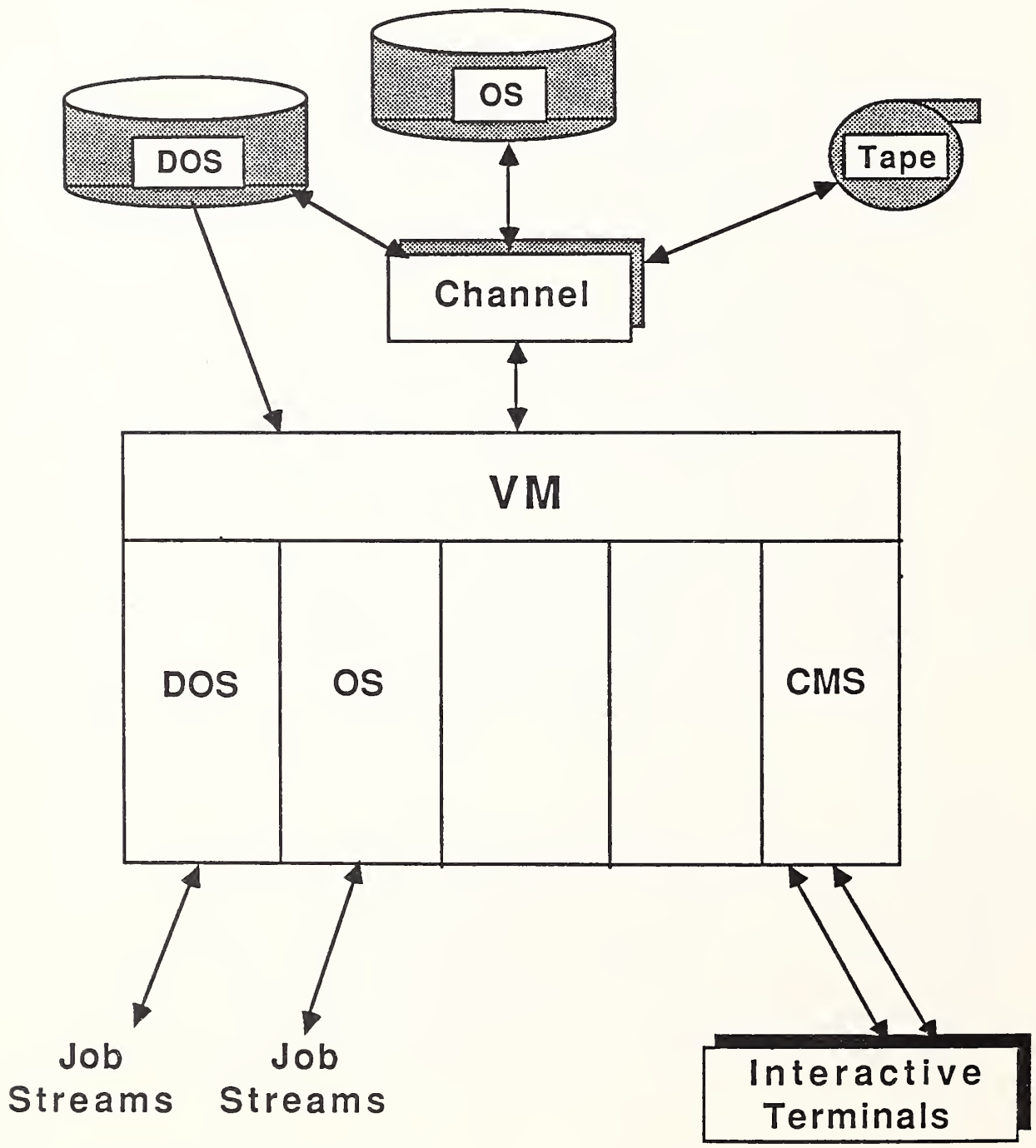
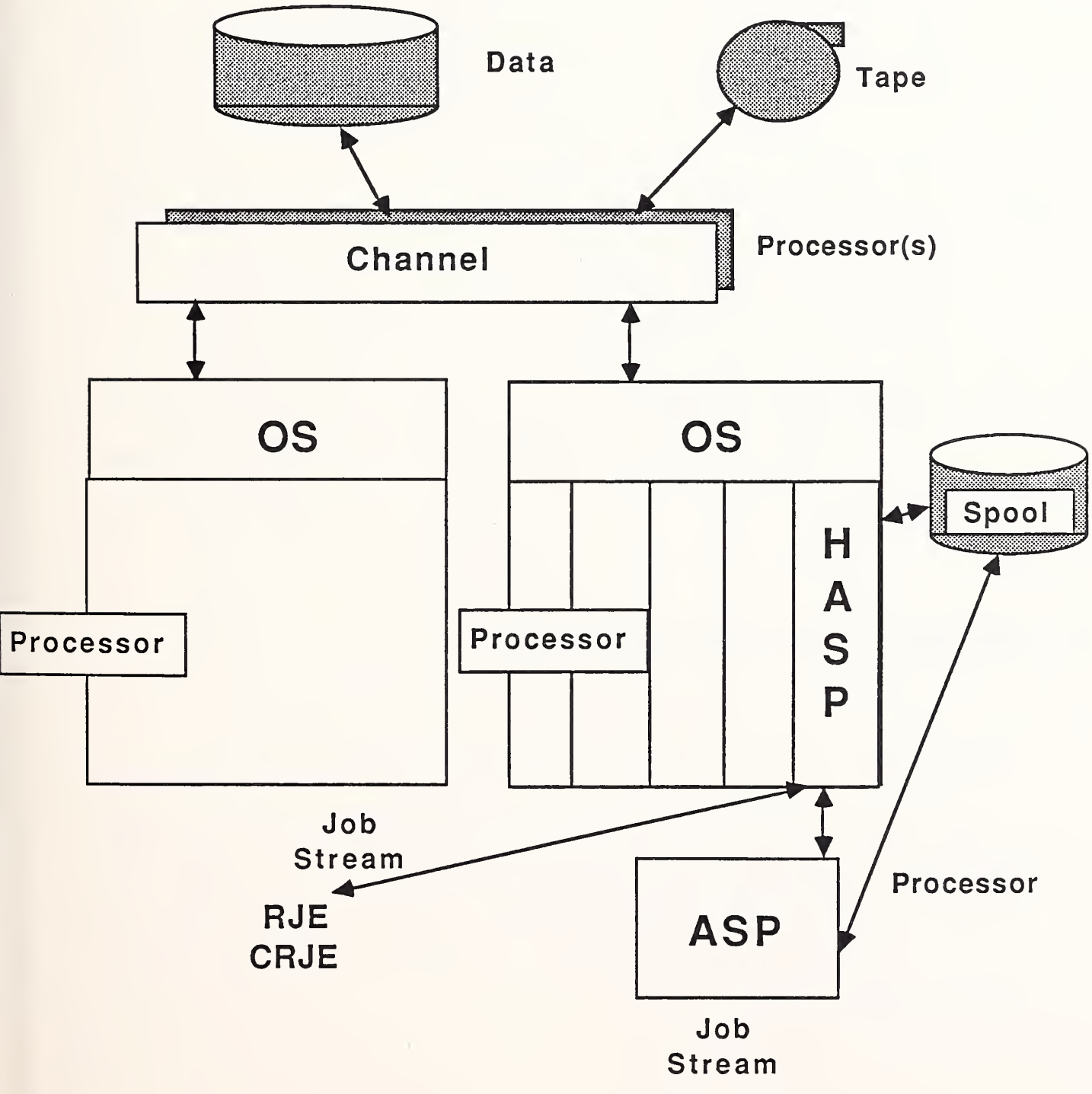


EXHIBIT III-5

HASP/ASP/MP (LATE 1960s, EARLY 1970s)



continuing effort to integrate interactive processing (timesharing) and DOS into the mainstream, and this has been accompanied, until recently, by the desire for VM to fade away.

- There is one additional bit of historical information which must be added in order to understand from where IBM is coming and to place operating systems into proper perspective.

  - It has already been pointed out that IBM operating systems were particularly deficient in communications capability (QTAM did not solve many of the problems) and IBM took ten years to announce SNA.

  - The same was true of data base management systems (DBMSs), where some in IBM felt that ISAM was all that was necessary to counter the emergence of DBMSs around System 360 announcement time. The later announcement of IMS/CICS/GIS as a "solution" has gradually evolved into a dual DBMS approach with IMS and DB2.

  - To view SNA and DBMS as being separate from operating systems is only convenient because of terminology (and as Fred Brooks, one of the architects of System 360, stated: "We have more terms than we do concepts").

B. IBM'S OPERATING SYSTEMS DIRECTIONS

- Projecting IBM's OS directions is no simple task since IBM appears to be going in all (or at least many) directions at once. This problem was fully explained in Market Impacts of IBM Software Strategies, INPUT, 1984, and it was determined that some means of describing "directions" was required. The means of describing directions in the software area was adopted from General Systems Theory (GST) and consists of four fundamental concepts which can be applied to all systems.

- Progressive integration which states that the parts of a system tend to become more dependent upon the whole.

- Progressive differentiation which states that the parts tend to become more specialized.

- Progressive mechanization which states that individual parts become limited to a single function.

- Progressive centralization which states that "leading parts" develop which dominate the behavior of the system.

- These concepts were used to classify IBM's predominant directions at all levels of the "software pyramid" and contrast these directions with what was technologically possible, desirable, and necessary. It was concluded that appropriate competitive strategies for software vendors could be developed by identifying those areas where IBM's predominant direction lagged that dictated by technology. (The model also proved effective in predicting IBM's use of VM for integration and its acceptance of UNIX.)

- IBM's primary strategy has been, and continues to be, centralization on large mainframes. This strategy is more important to IBM than any other hardware, software, or networking development or concept. SNA has been around for over 10 years and precious little processing has been distributed. "Departmental processors" and PCs may have their own operating systems, but differentiation has not been too popular in IBM--they are still fundamentally oriented toward large general purpose mainframes.

- Over the last 10 years, INPUT has defined and refined a "proper" hierarchical network of mainframes, minicomputers, intelligent workstations, and terminals. Exhibit III-6 presents this hierarchy.

EXHIBIT III-6

NETWORK HIERARCHY

- Level I (Large Mainframes)
- Level II (Minicomputers)
- Level III (Intelligent Workstations)
- Level IV (Terminals)
- Level V (Mobile Terminals)

- Level I is represented by highly centralized mainframes.

- Level II minicomputers have never really been recognized by IBM as having a proper place in the network hierarchy, and much of IBM's hardware and software strategy has been directed against them. During that period of time, minicomputer vendors have replaced mainframe vendors as IBM's chief source of competition.

- Level III consists of microcomputers or intelligent workstations.

- Level IV terminals include a wide variety of input/output devices, including sensing devices. Frequently, their operation is real time in nature (for example, intrusion alarms) and "operating systems" are normally customized. As more powerful microprocessors are placed in printers, modems, etc., these Level IV "operating systems" will become more complex.

- From an operating systems point of view, Level I represents centralization, Level II represents integration, Level III represents differentiation, and Level IV represents mechanization.

• IBM's emphasis upon centralization on large host mainframes essentially turns them into enormous data base machines. Exhibit III-7 highlights this.

- It is obvious that there will be a substantial amount of batch processing in this environment. For example:

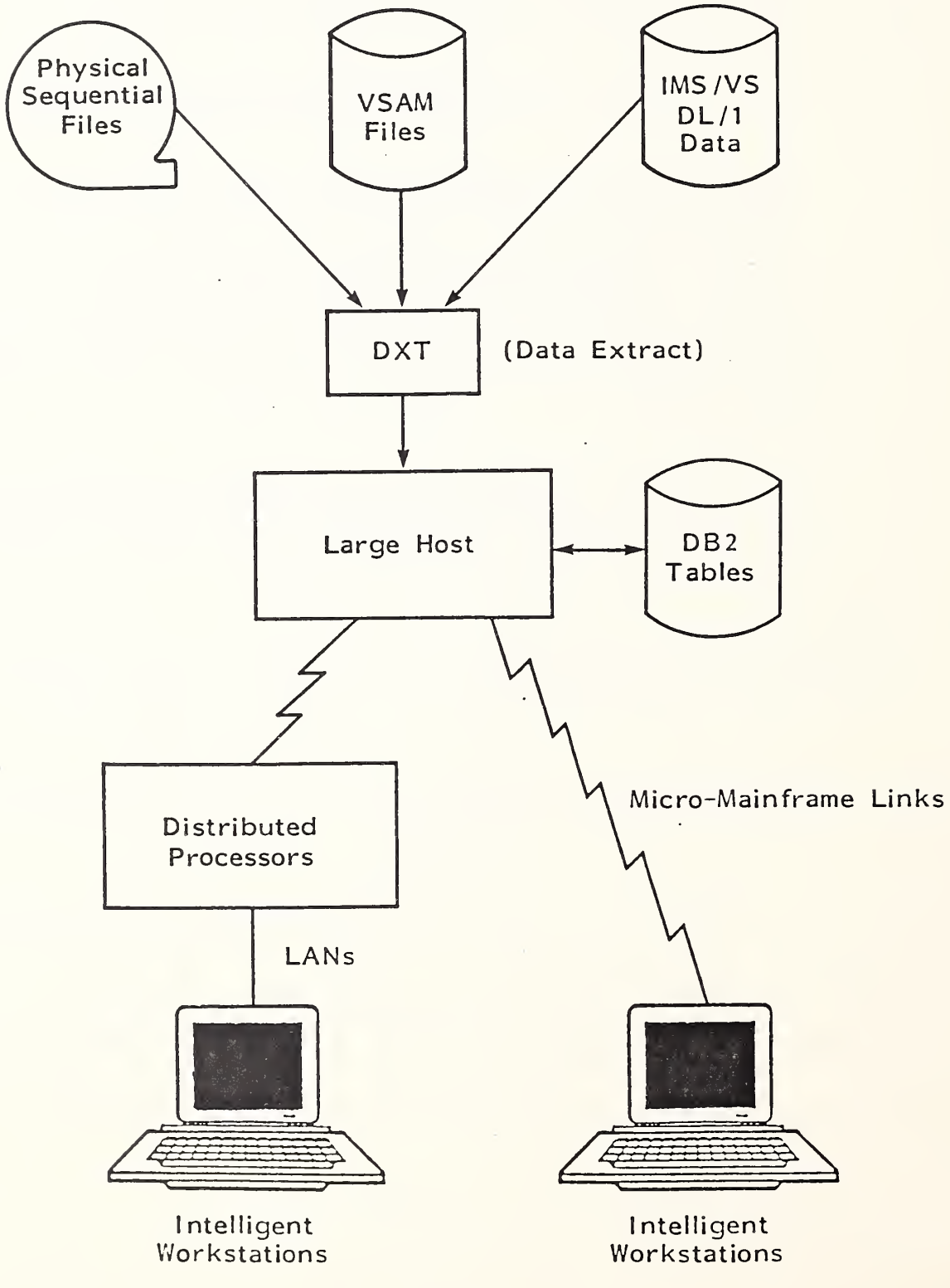
  . Extracts from other files and data bases to build DB2 tables.

  . Batched updating of these large central data bases.

  . Backup of both the host and any distributed data bases.

EXHIBIT III-7

LARGE HOST DATA BASE MACHINES



  - Extraction and transmission of data bases (primarily Selects against DB2 tables) to Levels II and III.

  - Heavy computation for purposes of data reduction and analysis using the tools of operations research and artificial intelligence (expert systems).

  - It is INPUT's opinion that as more Level II and IIIs are connected to hosts the batch processing load is going to increase dramatically (much greater than the 20-30% growth rate IBM is currently quoting).

- In fact, it is doubtful that the large host data base machines will be able to support both batch processing and any significant amount of interactive processing with acceptable response time (much less the "subsecond response time" which is currently seen as being a requirement). It will therefore be necessary to distribute data bases in some fashion, and this can be done in several ways (see Exhibit III-8), all of which have profound implications for operating systems design. It is possible to distribute in the following ways:

  - To hardware data base machines.

  - To multiple data bases and/or DBMSs.

  - To multiple mainframes (either loosely or tightly coupled).

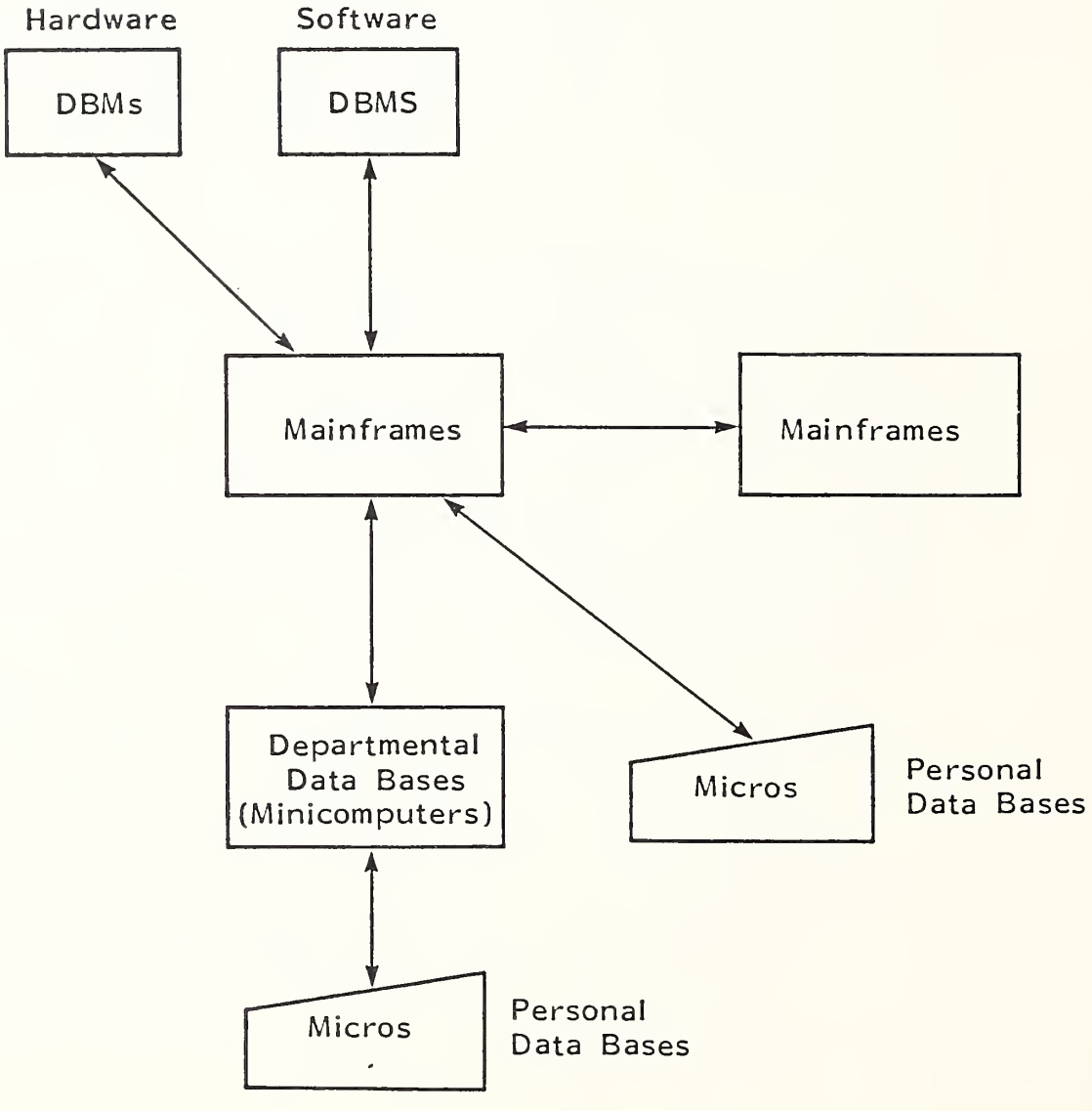
  - To Level II processing nodes.

  - To Level III processing nodes.

- IBM's highly centralized operating systems strongly places emphasis upon multiple host data bases and multiple host management software

EXHIBIT III-8

DISTRIBUTED DATA BASES



which must also address the three general objectives of operating systems.

- Over the last two years in Large Scale Systems Directions, INPUT has expressed concern that the big systems, operating under the substantial software burden of a multi-operating system and DBMS environment, might not be able to keep up with the demands made upon them. While it is not appropriate to pursue this analysis in any detail in this study, it is important to review some of our concerns.

  - IBM's hardware growth projections are based upon the following observed growth among its large scale customer base.

    . Transaction processing exhibits a compound growth rate of 40-50%.

    . End-user computing is growing at 60-70%.

    . Batch is "only" growing at 20-30%.

    . Installed workstations (between 1983 and 1990) have been projected to grow at a compound growth rate of 60-80%.

  - INPUT believes that if the growth rates hold up, batch processing on IBM mainframes is going to increase substantially more than 20-30%. This is due primarily to IBM's highly centralized strategy of connecting everything to those mainframes for purposes of data base management. (Which incidentally makes a lot more sense now than it has in the past.) While it is possible that IBM is aware of this increased burden on mainframes, it is also probable that the full impact has not been anticipated, for the following reasons:

- IBM's main concern has always been, and continues to be, the sale of hardware; and, traditionally, that concern has always been how to absorb advances in processor technology with systems software--it is not easy to reverse this strategy and worry about whether the systems will be able to support the environment. (The obvious answer from IBM's point of view is to add more systems and tie them together.)

- There is also the disturbing (and unrecognized) possibility that as data bases grow and information proliferates, entropy (the natural tendency toward chaos) increases and the requirements for processing power (as manifested in systems overhead) will increase more rapidly than data base size. (See Large-Scale Systems Directions: Disks, Tapes, and Printers, INPUT 1985.)

C. MACRO FACTORS

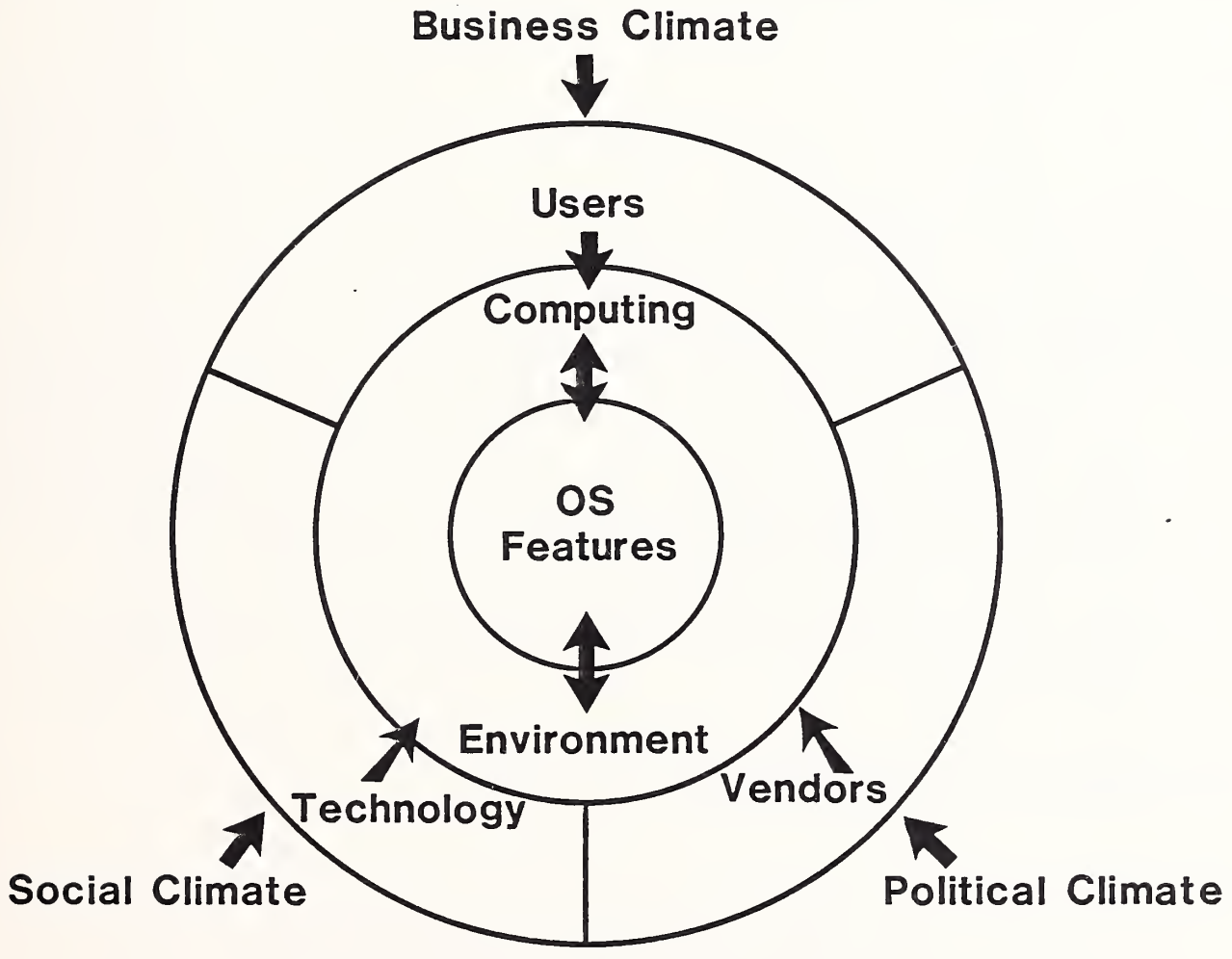
1. DEFINITION AND PURPOSE

- Macro factor analysis is the means by which important environmental driving forces can be identified and assessed for the purpose of determining likely future marketplace activities. For example, the price of petroleum is a macro factor that shapes future decisions related to automobile design (e.g., engine efficiency required, weight tradeoffs for various driver conveniences, etc.). Similarly in the computer industry, a macro factor such as the rate of decline of memory costs impacts market offerings such as available functions and speed for a certain type of software.

- Exhibit III-9 summarizes certain types of macro factors that ultimately impact the features, functions, and benefits of operating systems.

EXHIBIT III-9

MACRO FACTORS AT WORK



- The general business, political, and social climate has broad, important, but often underevaluated factors that influence operating system directions.

- The next level of impact concerns two types of organizations (vendors and users) and the material (technology) that one develops and the other implements.

- The third level, the computing environment, most directly impacts operating systems. This macro factor category deals with the hardware, software, communications, people, and facilities that comprise the computing entities within the organization.

- These macro factors directly and indirectly shape such operating system-related business considerations as user demands for certain OS features/functions/benefits and competitive market strategy decisions (including facilities, resource requirements, support, pricing, sales promotion, and timing) as well as the economics of OS implementation and ongoing usage.

- Each of these macro factor categories will be discussed in more detail in the following section.

2. BUSINESS, POLITICAL, SOCIAL CLIMATE

- The business climate in the U.S. is expected to be generally favorable during the balance of the 1980s. As a result, commercial as well as governmental and education organizations will aggressively expand their investment in information systems. The systems they select to implement will be more complex and closer to the heart of the enterprise than those implemented during the 1970s and early 1980s. This boldness will be derived from top management's realization that computer success and business success are increasingly intertwined. Operating systems will be impacted in terms of a higher level of decisionmakers becoming involved in their final selection.

- The social and political climate will also have important impacts. Society is evolving to the point where reliance upon computerization is expected. To not be effectively automated is becoming a social stigma rather than the reverse. As the use of computers expands, however, legal and regulatory restraint loom larger. Concern over privacy and security issues will result in renewed efforts to incorporate appropriate safeguards into both systems and applications software.

3. USER NEEDS

- User needs is one of the most significant macro factors impacting operating systems directions, primarily because information services vendors are making good progress in reorienting themselves to become market (i.e., user needs) driven, rather than technology driven.

- Exhibit III-10 reviews the results of INPUT's research concerning major issues which information systems executives cite as being significant to their decision making. These issues ultimately impact their attitudes and expectations concerning operating systems.

  - External considerations include factors that impact the overall organization that the information systems department services as their "clients."

    . The health of the economy directly affects the level of funding which top management is willing to allocte to automation for a given year. Experience in recent years has shown that practically every industry in the economy is suseptible to economic swings, the timing and extend of which is extremely challenging to anticipate. Those on the receiving end of the computing budget find it difficult to predict how much will be received and for how long.

EXHIBIT III-10

MAJOR INFORMATION SYSTEMS ISSUES

- External
  - Health of the Economy
  - Deregulation
  - Nontraditional Competitors
- Internal
  - Integrate IS and Corporate Planning
  - Apply New Technology
  - Cost Containment

. Deregulation, particularly for the banking, transportation, insurance, and telecommunications industries, has brought both rewards (i.e., new markets, new funding sources, etc.) as well as problems (major revenue/profit swings, shortages or new skills, etc.). The IS department often finds itself in the uncomforable position of being faced with reduced budgets and with expectations of meeting increased user demands.

. Entry of nontraditional competitors. Banks now compete with insurance companies and brokerage houses. Giant Fortune 50 firms bring money and staying power to new markets such as the information services industry. New types of competition bring renewed demands for new methods of planning, management, and product development, all of which can benefit from astute automation.

- The net impact of these external issues is that IS finds itself responsible for systems which must be increasingly reliable and cost-effective in order to perform satisfactorily in such a volatile environment. Again the operating system decision assumes increasing importance.

- The internal issues as summarized in Exhibit III-9 are a reflection of the impact of the external issues.

  - The desire to more closely integrate IS and corporate business planning underscores the central role of computerization within the organization. It also results in OS considerations becoming more visible outside the IS department.

  - Application of new technology is high on the list of IS executive concerns. The options proliferate, the cost of application increases, yet the risk of misapplication remains a very real threat.

- Cost containment is the special challenge in these times of ever-increasing computing demands. This issue puts a premium on proper selection of operating systems since they impact on a daily basis all related software and hardware resources.

- The result of considerations such as those cited above are a number of driving forces which will impact operating systems directions from a user point of view. These forces include:

  - Use of information systems to gain a competitive edge.

  - Continued growth of end-user computing.

  - Scarcity of technical personnel.

  - Increased dependency upon automation.

  - More emphasis on security.

  - Implementation bottleneck due to increased automation projects in the recent past.

4. TECHNOLOGY

- The rate of technological change will accelerate during the next five years in ways that will require operating systems to evolve at a much faster rate than was required in years past. Areas of technology that will have direct impact on OS features and functions include:

  - Larger, cheaper storage. The commercialization of cost-effective optical storage, for example, will place new demands on techniques for accessing, managing, manipulating, and transmitting gigabytes of information.

- Higher speed, lower cost telecommunications using fiber optic and other media will alter the centralization/decentralization balance. Other technologies such as scanning and pattern recognition will advance the processing of image, voice, and video, requiring operating system and information management changes.

- More sophisticated peripherals. Laser printers, scanners, digitizers, voice recognition, and speech synthisizers as well as back end data base machines must be efficiently handled within the context of not just standalone systems, but complex network environments.

- Advances in semiconductors. Emitter Coupled Logic, for example, will bring greater speed. New chips such as the INTEL 80386 will provide cost-effective multiprocessing. Thus, hardware capabilities will expand significantly, thereby requiring clever OS solutions to make the technology pay off for the ultimate user.

- Processing-specific hardware. Large-scale individual computers of the future will have numerous subprocessors optimized to offer cost-effective specialized processing for such areas as artificial intelligence/expert systems, array processing, data base inquiry, etc.

5. VENDORS

- The ability of hardware, software, and services vendors to compete and prosper within a business environment has a direct impact upon the variety, cost, and timing of products and services needed by the user community. Operating systems and the systems and applications software that depend upon them will benefit from the following vendor-related developments.

  - Hardware vendors will increasingly focus on software for their value added. That means more resources will be applied to develop solutions to perplexing user problems.

- Software and services vendors within the computer industry are becoming significant economic entities in their own right. Firms such as EDS, Automatic Data Processing, and Computer Sciences Corporation are near to or exceed the billion-dollar milestone of size and scope.

- Easier access to financial resources. The stock market as well as the venture capital community are active, although not necessarily consistent, supporters of the computer industry. These suppliers of capital enable vendors to take larger risks to develop ever more complex yet cost-effective solutions for users.

6. IMPLICATIONS FOR OPERATING SYSTEMS

- Implications of the above macro factors are many. For the most part they are positive in terms of accelerating both the scope and the timing of operating systems-related solutions. Users and vendors can expect to see, as a result of these forces:

  - Accelerated expansion of OS features. To accommodate the rapid extension of hardware and software facilities, operating systems will have their capabilities extended at a much faster pace.

  - Emerging need for network-wide operating system facilities. IBM's recent Netview offering, for example, is a step in the direction of getting more operational control over the multitude of nodes, processors, communications lines, controllers, and terminals that comprise the complex networks of the future.

  - Evolution toward more highly specialized OS subfunctions. Operating systems of the future must be adaptable to the differing needs of processing that users require. As a result, operating systems will

become increasingly functionalized around specific areas, such as on-line transaction processing, expert systems access, etc.

- Emphasis on non-technical interfaces. End-users will continue to assume increasing responsibilities for the design and operation of automated systems within their departments. Poorly designed interfaces will rapidly become a thing of the past.

IV SYSTEMS DIRECTIONS

IV SYSTEMS DIRECTIONS

A. LARGE SYSTEMS ARCHITECTURE DIRECTIONS

1. IBM 370 ARCHITECTURE

- Since hardware is the fundamental driving force for OS (there is a limit to the number of OS that can be installed per CPU), this chapter will focus on analysis and forecasting of IBM's major product offerings in the 370 environment.

- All of IBM's current large system offerings fall under the 370 architecture umbrella with extensions. INPUT believes that IBM future product families (e.g., Summit) will also have a similar hardware architecture.

- IBM considers most of their large System 370 products to be mainframes. Those products that are not included as mainframes include less than two MIPS products such as 4331, 4341, and 4361, which INPUT labels as mid-range systems and IBM calls minicomputers

- In 1986 the U.S. installed base of large systems with 370 architecture was 26,000 units. In 1991, there are expected to be 70,000 units installed for a 22% AAGR.

2. PLUG-COMPATIBLE MANUFACTURERS (PCMs)

- Today, these venodrs are more "software compatible" than "plug compatible," primarily because of the firmware content of the system.

- PCM vendors have had the challenge of being IBM compatible while at the same time being "IBM-plus" in added functionality, decreased price, and innovation. These vendors were able to take the XA architecture from scratch and produce it in their products in a timely fashion.

- Large system vendors in general will be hurt by IBM increased competition, but PCMs are increasingly coming under attack.

  - IBM has increased the productivity of their manufacturing plants to the point that they can deliver products closer to announcement dates than in previous years. This limits one advantage PCMs have had of delivering products similar in capability to IBM but prior to IBM's shipment dates.

  - PCMs (especially Amdahl) have been strong in technologically innovative products; however, IBM's vector processing facility for the Sierra series threatens Amdahl's lead with innovation.

  - IBM has aggressively cut the prices on older systems as well as on the as of yet undelivered Sierra 400. Pricing had been a major selling point of NAS.

  - The newly formed company Burroughs/Sperry is aggressively looking into the 370 market and may soon become a PCM vendor.

3. 370 ARCHITECTURE MARKET SHARE

- The following forecasts include all IBM products of 370 architecture excluding micro products such as the PC 370.

  - Products with other than 370 architecture (primarily mid-range systems or minis) are forecast as a group in the mid-range systems chapter.

  - The remaining piece of non-370 IBM products encompasses traditional microcomputers which are forecast in the small systems section.

  - PCMs are included in the analysis since their customers purchase OS from IBM, which adds to IBM's overall OS revenue.

- Exhibit IV-1 presents the large systems 370 marketplace in terms of present market share by series. As can be seen by the exhibit, the product series with the largest installed bases in 1986 are not the leaders in 1991.

  - The 43XX series in 1987 has about 62% of the installed base or 16,000 units. In 1991 market share increases to 76% or 53,000 units, or a threefold increase in the 43XX installed base.

    . The primary factor contributing to this increase will be a new 43XX low-end CMOS product to be introduced in 1987. This product will be targeted toward small businesses, engineering and scientific departments, and as general business departmental processors. It will be priced about $50,000. In 1987, 250 units are expected to be shipped, significantly increasing to 10,000 units shipped in 1990 and 7,000 in 1991.

    . The 4381 product family will remain relatively healthy through 1991.

EXHIBIT IV-1

COMPUTER MARKET SHARE
370 ARCHITECTURE

COMPUTER MODEL	INSTALLED BASE (Percent of Units)	
	1986	1991
43XX	62%	76%
308X	15%	3%
309X	8%	14%
PCM	10%	6%
303X	3%	0%
360/370	2%	0%
SUMMIT	0%	1%

- The 3090 products will have significant growth during the forecast period (2,000 units to 10,000 units--a 28% AAGR). IBM is aggressively encouraging users to migrate to this product line as their strategic product of the late 1980s which will account for the large increase in installed base from 1986-1991. In 1991 the 3090s will be almost as common unit-wise as the 43XXs are in 1986.

- IBM, through price and technology improvements, will be successful in phasing out the 308X (as they have already done with the 360/370 and 303X) as a viable computer family.

- PCMs will hold their marketplace while installed base units will increase to 4,000 in 1991.

- INPUT anticipates that IBM will continue to release new product families about every four to five years. Consequently, INPUT anticipates one family to be announced in 1989 and shipped in 1990 (Summit series).

4. INSTALLED BASE TRENDS

• Exhibit IV-2 shows overall product growth trends.

- Generally speaking, 303X and 308X will experience similar rates of decline at three-year intervals since both have become orphaned families.

- 43XX, in contrast, will have a large increase in installed base over the forecast period.

  . Again, this will be due to the introduction of a low-end CMOS processor or family of processors.

EXHIBIT IV-2

COMPUTER INSTALLATION TRENDS
(1983-1991)

COMPUTER MODEL	1986 INSTALLED BASE (Thousand Units)					
	1984	1986	1988	1989	1990	1991
43XX	14.0	16.0	21.0	29.0	43.0	53.0
308X	3.9	3.9	3.9	3.5	3.0	2.0
309X	0	2.1	6.4	8.0	9.3	9.9

. The departmental systems of the future will be low-end 43XXs.

5. PRODUCT FAMILIES

a. Overview

- IBM introduces products at the same or increased reliability of the top of the line of existing products. This includes mean time between failures and mean time to fix. This is a major challenge as well as a strong selling point of IBM.

- The following section elaborates on specific families, their unique characteristics, and product trends. The summaries will be brief to provide background for OS trends as opposed to specific architectures and functions.

b. 303X

- Exhibit IV-3 lists characteristics of the 303X family. The product family is older and discontinued, but the high-end 3033 is still a viable product in moderate use.

- Since the products have been superceded by the 308X family (with the ensuing increase in service), their decline in installed base will be steep, as highlighted in Exhibit IV-4.

c. 43XX

- The 43XX series is generally labeled as superminis in spite of the fact that IBM considers its high-end 4381 to be a mainframe (see Exhibit IV-5).

- In 1986 and 1987, two new high-end 43XX (4391?) will be introduced to close the large gap in price per MIPS between the 4381 model 14 and the low-end 3090.

EXHIBIT IV-3

303X SERIES CHARACTERISTICS

- Older IBM Large System Product
- Predecessor to the 308X Line
- OS
  - OS/VS1 and 2
  - VM/370
  - MVS
  - DOS
- 3033 Largest Host
- 3031, 32 Smaller Processor

EXHIBIT IV-4

COMPUTER INSTALLATIONS, 1986-1991
303X

COMPUTER MODEL	INSTALLED BASE (Units)	
	1986	1991
3033	650	0
3032	35	0
3031	75	0

EXHIBIT IV-5

43XX SERIES CHARACTERISTICS

- Products Labeled Superminis
- Compete in Commercial and Engineering and Scientific Markets
- CPU Price with Memory $60K - $1M
- OS
  - SSX/VSE
  - DOS/VSE
  - VM
  - IX/370
  - MVS/370 (XA for 4381 only)
- 4341 Being Phased Out
- 4361 Weak - Replacement in 1987
- New 4381 Models

- The products run a large number of OS including SSX/VSE for the 4361 which is a subset of DOS/VSE for small systems and users with limited DP skills.

- The 4361 is targeted toward departmental computing and as an engineering and scientific workstation. It has specific engineering capabilities built into the hardware.

  - To be truly office-worthy from a packaging point of view, the product would need an internal Winchester which is not available.

  - IBM's Cadam CAD/CAM software is available on the 4361 as well as turnkey products from other companies such as Computervision. With the introduction of the RISC-PC, and the unannounced low end 43XX, the 4361's long-term strategic place as an engineering workstation is in question.

- The 4381 series of products (#11-14) are the only products with the XA architecture in this product family and consequently are able to run MVS/XA.

  - The products run all 370 OS as well as XA.

  - They range in price from $200,000 for the model 11 to $1 million for the model 14.

  - IBM has discontinued the original models 1 through 3.

- Exhibit IV-6 shows the drastic increase of the 43XX family that will occur due to the aforementioned reasons.

d. <u>308X</u>

- Major characteristics of the 308X product line are found in Exhibit IV-7.

EXHIBIT IV-6

COMPUTER INSTALLATIONS, 1986-1991
43XX

COMPUTER MODEL	INSTALLED BASE (Units)		
	1986	1988	1991
4331	500	300	0
CMOS 43XX	0	1,900	23,000
4341	4,000	2,200	250
4361	5,000	7,000	11,000
4381	6,000	9,000	20,000

EXHIBIT IV-7

308X SERIES CHARACTERISTICS

- Large-Scale Mainframe with Tenfold Growth Path
- $600K -$6M
- 31-Bit Architecture
- OS
  - VM/SP
  - MVS/370
  - MVS/XA
- 3083CX - Low End
- 3081 - Dyadic
- 3084 - Quadratic (= (2) 3081KX)

- Users are aware that there are no new enhancements due for the 3081 and 3084 and IBM is encouraging the migration of users to the Sierra series in a number of ways.

  - The 3081KX is comparable to the 3090/150 while the 3084QX is comparable to the 3090/200.

  - IBM has cut the price on Sierra products including the as of yet undelivered model 400.

  - The maintenance cost on the 3090s is generally lower than on 308Xs ($6,000/month model 3090/200 versus $7,000/month 3084/QX).

  - The 308X family is not field-upgradeable to the 3090.

- Even though the product is not one of long-term strategic importance to IBM, it is in general a good processor and will be moved in many organizations to an information center or service bureau and kept in use. INPUT expects sales to increase short term due primarily to price cuts and a slow decline in installed base (see Exhibit IV-8).

e. 3090

- In 1985, IBM introduced its 3090 or Sierra series of mainframes. The products include:

  - Faster processing cycle times than previous models.

  - Expanded storage capability.

  - New scientific and engineering instructions.

EXHIBIT IV-8

COMPUTER INSTALLATIONS, 1986-1991
308X

COMPUTER MODEL	INSTALLED BASE (Units)	
	1986	1991
3084	700	150
3081	1,500	1,150
3083	1,740	650

- The enhancement of VM/XA and MVS/XA by the ability to make greater use of the 3090 architectural design.

- Exhibit IV-9 provides key product characteristics.

- Due to the increased price/performance of the 3090 series, INPUT believes sales of the product family will be healthy and that this family alone could deliver almost $8 billion in sales worldwide to IBM in 1986.

- A key add-on to the high-end products is the vector processor that provides raw speed for scientific and engineering functions. With its use, the computer runs 1.5 to 3 times faster than the base unit. Each processor can have a vector processor, therefore on the model 400 there can be four.

- Historically, for the 3084 product, IBM based the product on water cooling whereby they could run faster and hotter chips in the thermal conduction module (TCM). Emitter Coupled Logic (ECL) chips as found in the 3090 series operate at 500 watts as opposed to Transistor to Transistor Logic (TTL) chips that run at 300 watts. IBM's TCM can run at up to 1,400 watts, leaving much potential for processing speed in the future.

- Both the model 200 and the model 400 include tightly coupled processors (two in the case of the model 200 and four in the case of the model 400, hence dyadic and quadratic processors). This procedure was also used in the 3084 and was thought to be a temporary method to increase system capability until the next series of products was built. IBM has chosen to stay with proven technology linking processors. This is due to economies of scale with production and stable products requiring less support.

- The biggest issue for vendors and users alike, however, is not what has been anounced for the Sierra series, but what has not been announced and is awaiting disclosure. Historically with its large system family, IBM has delivered products with latent capabilities. With the 370 product line, virtual

3090 SERIES CHARACTERISTICS

- Extended Growth Path for 308X Family
- $1.6M - $10M
- Vector Processor (Engineering and Scientific)
- ECL
- High-Density 288K Chips
- OS
  - MVS
  - VM
  - MVS/XA
- 150, 180 Uniprocessors
- 200 Dyadic (29 MIPS, $5M)
- 400 Quadratic (50 MIPS, $9M)

memory was present but not initially announced, while with the 308X XA was included but revealed at a later date.

- In the near future it is possible that IBM will introduce another 3090 product to fill the gap in price/performance between the 150 and the 4381/14. There will also be higher-end products from the 43XX family, and larger processors will also be introduced.

- Exhibit IV-10 shows the increased growth in the 3090 installed base throughout the forecast period. The low-end products are expected to level out as prices of the higher-end products come down around 1988.

  - 3090 products below the 150 are included in the 150/180 forecast.

  - 3090 products above the 400 are included in the 400 forecast.

f. Summit

- In general, IBM tends not to radically change its product architecture due to its large installed base of customers and the economies of scale for production. Consequently, INPUT believes the Summit series to be an extension of the 370 architecture. A broad product profile is provided in Exhibit IV-11.

- The Summit is expected to be a high-end family with:

  - Multiple processors tightly coupled (more than four with a theoretical maximum of 16).

  - One hundred MIPS and above capability.

- The processors will have the optional capability to be dedicated, meaning that there would be one processor for computation (array), one for business decisions (AI-expert system), and one that would allow users to run existing

EXHIBIT IV-10

COMPUTER HARDWARE FORECAST
309X

COMPUTER MODEL	INSTALLED BASE (Units)		
	1986	1988	1991
150/180	0	700	3,700
200	400	1,250	3,650
400 and Above	0	100	2,575

EXHIBIT IV-11

SUMMIT SERIES CHARACTERISTICS

- Summit To Be Announced 1989
- High-End Product Family
- More Open Architecture
- Multiple Processors Capable of Being Dedicated to Specific Function
- Increased Fault Tolerance
- Processing Power > 100 MIPS

software for obsolete systems whereby the user could also take advantage when necessary of the added features of the new system.

- The Summit RAS (Reliability, Availability, Serviceability) enhancements will move toward the low end of the fault tolerant spectrum.

- Exhibit IV-12 forecasts the Summit market.

B. LARGE SYSTEMS OS DIRECTIONS

1. PROCESSING TYPE

- Exhibit IV-13 lists the major IBM OS and in what capacity each functions best.

- INPUT's projects that there will be no universal OS in the near future since computing is too complex and diverse to be satisfied by one "panacea" product. However, there will be a convergence/merging of OS functions over the next five years, especially in the areas of connectivity, user interfaces, application program support, and I/O device support. The net effect will be almost transparency to the end user.

2. OS CHARACTERISTICS

- Historically, OS tend to be identified with certain types of hardware (see Exhibit IV-14). In the future, however, this will be less true.

- VM and UNIX are the only two OS that span the whole range of hardware sizes. This will continue in the future.

EXHIBIT IV-12

COMPUTER INSTALLATIONS, 1990-1991
SUMMIT

COMPUTER MODEL	INSTALLED BASE (Units)	
	1990	1991
SUMMIT	100	700

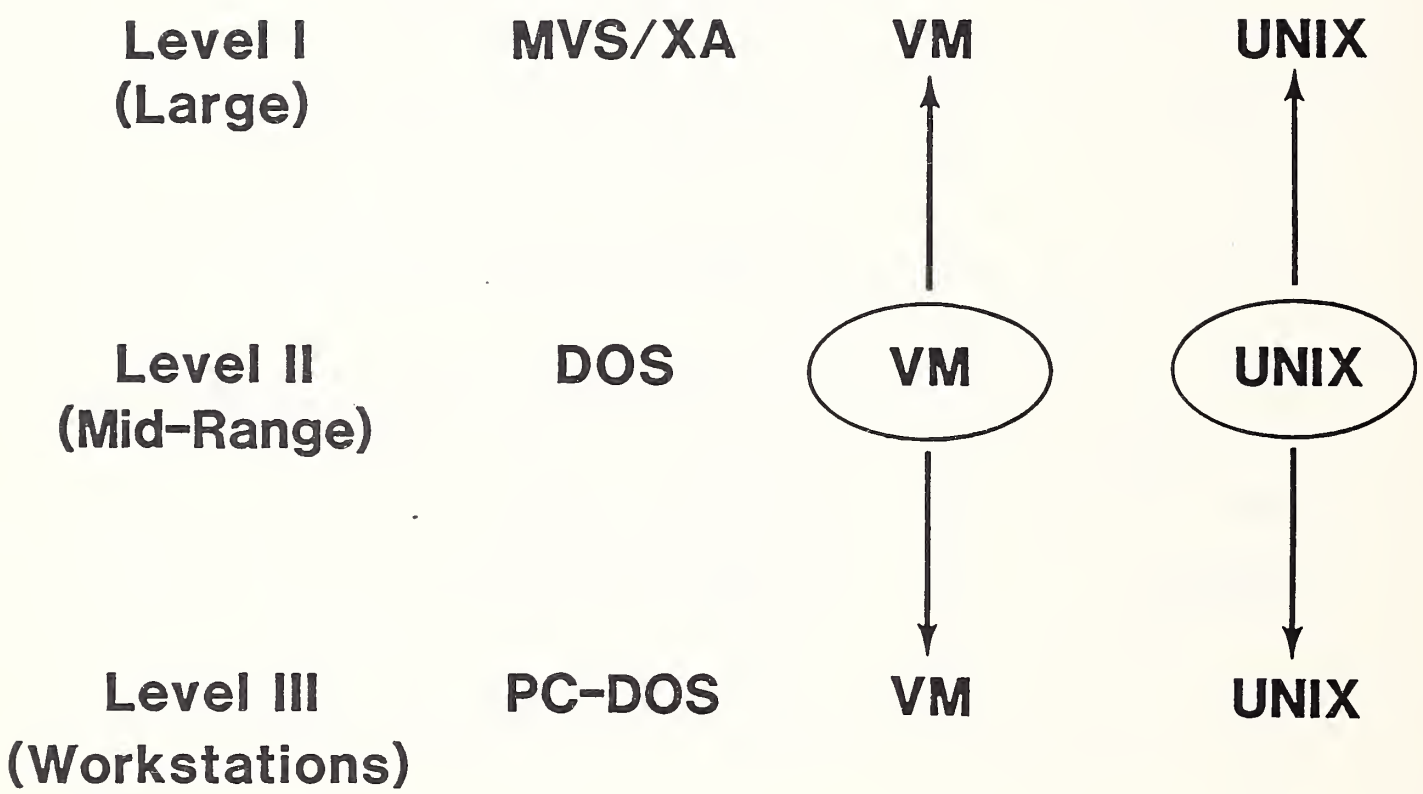
EXHIBIT IV-13

MAJOR IBM OS CHARACTERISTICS

OS TYPE	CHARACTERISTIC
MVS/XA	• Large-Volume Batch Production
MVS	• Large DB/Data Communications
	• On-Line Transaction Processing
TPF	• High-Performance On-Line Transaction
VM	• Interactive Inquiry
VM/CMS	• Program Development
DOS	• Smaller Volume Batch Production
UNIX	• Medium-Volume Production, Scientific/ Engineering
PC-DOS	• Small Volume Interactive

EXHIBIT IV-14

OPERATING SYSTEMS BY SYSTEM SIZE



3. 370 OS UNITS

- As shown in Exhibit IV-15, the installed base of major OS for 370 computers will grow at an AAGR of 22% through 1991. The average of 1.3 OS per computer is expected to stay relatively constant throughout the forecast period.

- The rapid growth of VM installations will be due to the use of departmental processors, for which VM is a strategic product, and its valuable role as a conversion tool. Also, VM/Entry will be the primary OS on the CMOS 43XX, and shipments of these systems from 1988-1991 account for a large part of the VM market.

4. COMPUTER INSTALLATIONS FORECAST

- From a computer hardware perspective, the low end of the large system market (4361 and equivalent) is increasing more rapidly than the high end, as shown in Exhibit IV-16, because of:

  - Use of departmental processors in large companies.

  - Migration in the standalone environment from System 36 and 38 to 370 and extended architecture in small and medium-sized installations.

5. OS FORECAST

a. 370 Architecture Computers Over Two MIPS

- From an OS perspective, MVS (including MVS/XA) not surprisingly dominates the large environment, as shown in Exhibit IV-17.

  - Of all computers with 370 architecture, MVS is 42% of the installed base in 1986; however, it is two-thirds of all OS of those computers over two MIPS.

EXHIBIT IV-15

OS INSTALLATIONS ON 370 ARCHITECTURE COMPUTERS, 1986-1991

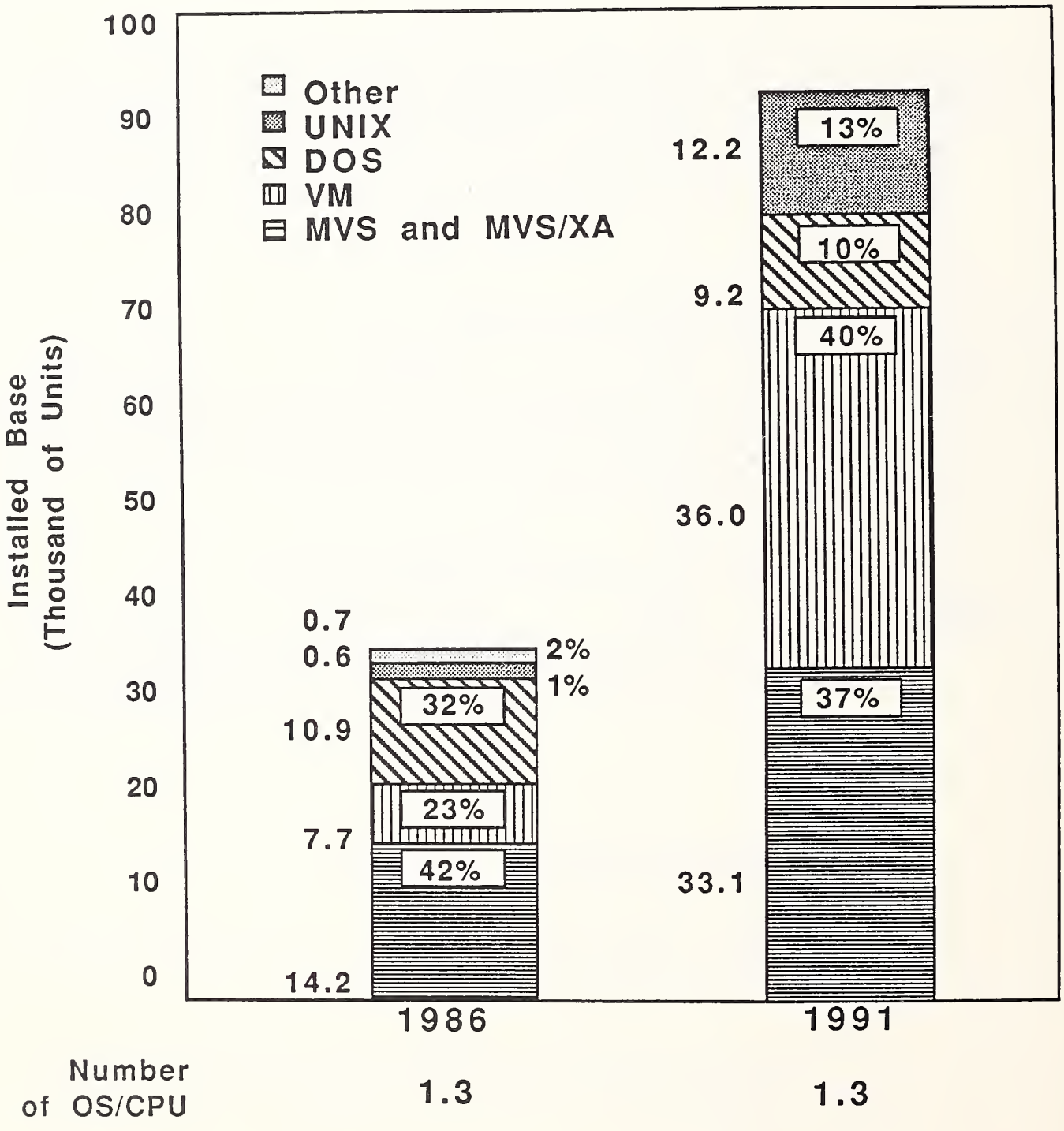


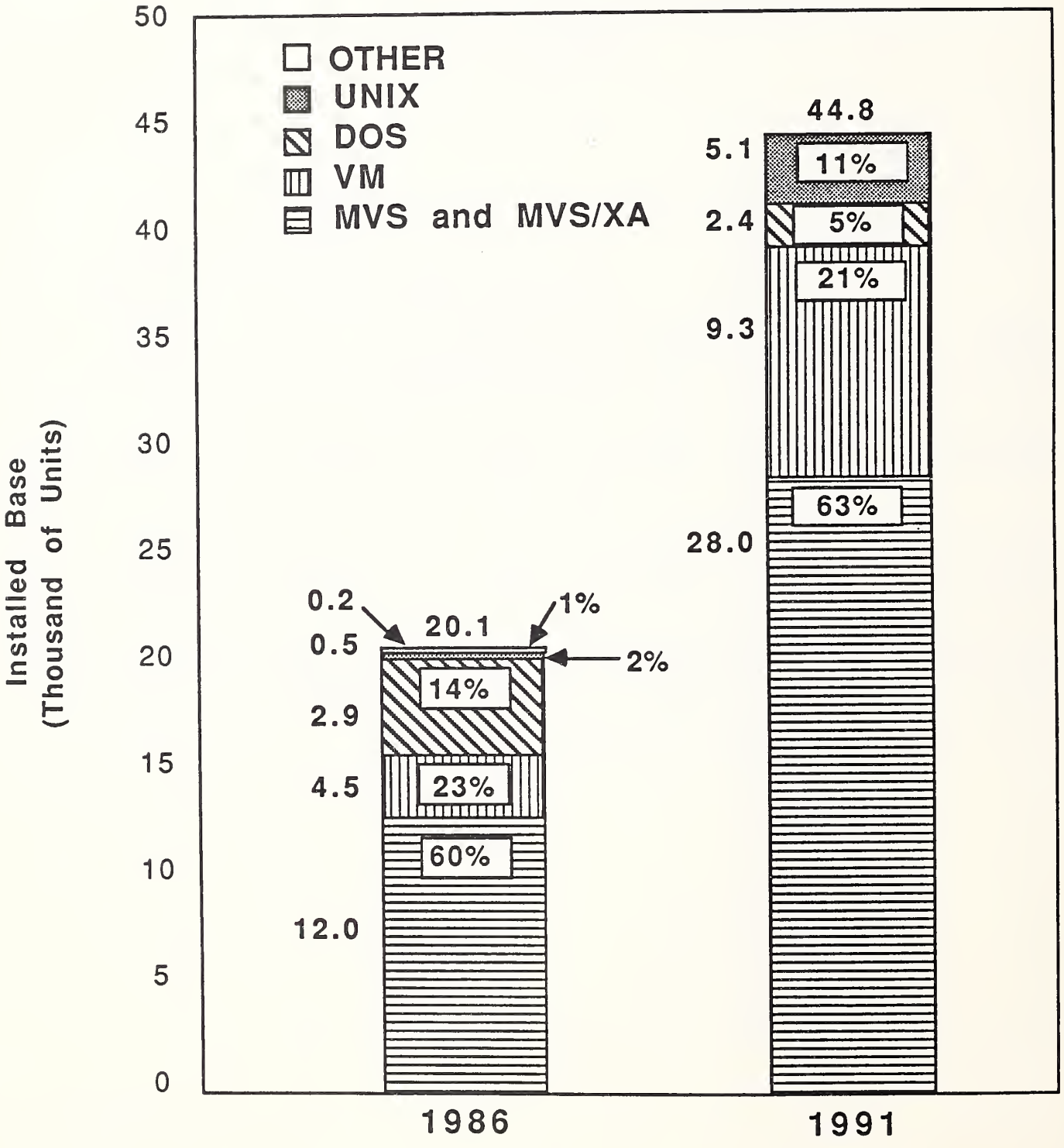
EXHIBIT IV-16

370 ARCHITECTURE COMPUTER INSTALLATIONS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units (Thousands)	%	Units (Thousands)	%	
>2MIPS	15.6	60%	36	51%	18%
<2MIPS	10.3	40%	34	49%	-27%
TOTAL	25.9	100%	70	100%	22%

EXHIBIT IV-17

OS UNITS
COMPUTERS OVER 2 MIPS



- Even though the market share will increase slightly (60-63%), the number of units will more than double.

- VM is a very versatile operating environment whose market share for large systems will remain more or less constant. For over two MIPS systems, the number of VM units in the OS installed base will double during the forecast period.

- DOS units installed will remain almost constant from 1986 to 1991; market share, however, will decrease from 14% to 5%.

- The majority of the UNIX population will continue to be on systems under two MIPS.

b. 370 Architecture Computers Under Two MIPS

- Exhibit IV-18 reflects the large increase in the under two MIPS OS base (similar to the hardware forecast).

  - The under two MIPS systems in large companies are mainly departmental and specialized processors primarily for scientific and engineering applications.

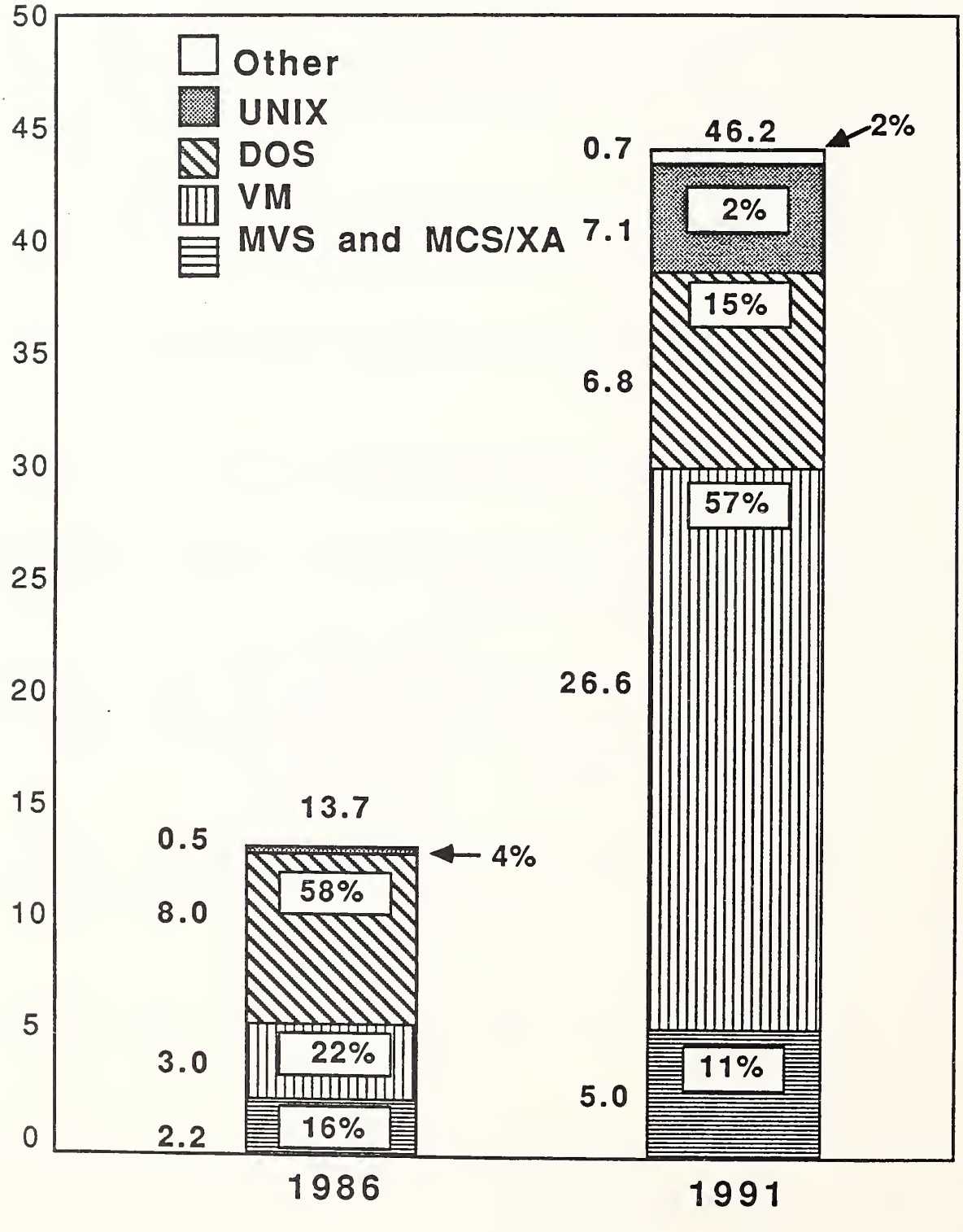
  - DOS will be discontinued as the primary OS for this segment of the market. It will have a 58% to 15% decline in installed base market share.

  - VM will more than double in market share from 22% in 1986 to 57% in 1991.

  - UNIX will grow from zero market share in 1986 to 15% or the same percentage as DOS in 1991. These will be primarily UNIX units running as guests under VM for scientific applications.

EXHIBIT IV-18

OS INSTALLATIONS ON 370 ARCHITECTURE COMPUTERS UNDER 2 MIPS, 1986-1991



- MVS will continue to be a less significant player throughout the forecast period, primarily because of the overhead involved.

- For purposes of further evaluation, the under two MIPS 370 architecture systems are included in the mid-range analysis in the following section.

C. MID-RANGE SYSTEMS

1. DEFINITION

- Mid-range products are either departmental systems or main processors in small business units and are otherwise known as minicomputers (minis).

  - Mid-range products have been thought to have been poorly planned since there are too many products from which to choose (five in total--4361, System 36 and 38, Series 1, and 8100) and they all are incompatible.

    . However, the 4361 is very price competitive with DEC in the scientific and engineering environment and has gained a reasonable market share.

    . The System 36 may be less capable than newer departmental systems on the market today, but IBM has shipped 100,000 units worldwide by 1985, which makes it a financially sound product offering.

    . The System 38 is an offshoot of "future systems" and although incompatible with other mid-range IBM products, it is being made compatible and provided as an upgrade path for System 36 users.

- The Series I is an excellent communications controller, and over 70,000 have been shipped worldwide as of year end 1985.

- Combining all of IBM's mid-range offerings (including low-end 370 products), IBM has about 12% of the mini market.

2. IBM MID-RANGE PRODUCTS

- IBM's System 36 is a replacement for the System 34. It runs the SSP OS and accounts for the largest percent of IBM's installed mid-range products.

  - The product's assets include:

    - Excellent product for small business data processing.

    - Reliable.

    - Over 4,000 applications software packages available.

  - Liabilities include:

    - Underpowered and not well suited for large amounts of data processing.

    - No DBMS.

    - No obvious growth path.

    - Poor utilities and end-user interface.

  - In 1985, a desktop version of the 36 was introduced. It was priced at $6,000, but to have a workable system the investment was closer to $20,000.

- The System 38 was thought at one time to be IBM's mainframe architecture of the future; however, the 370 architecture seems to have retained that role. It runs the CPF OS (a real time operating system), has an excellent integrated data base, and real time OS. It is expected that in late 1986 an emulation capability will be added to the System 38 whereby it will run SP (System 36) software. This would allow 36 users to upgrade to a more capable system while still retaining their applications software base.

- The Series I runs the EDX/RPS OS and is an excellent, cost-effective communications controller. It has finally matured into a viable family of programmable communications systems currently exhibiting:

  - An advanced technology.
  - Broad IBM/OEM device attachability.
  - Powerful application development tools.
  - LAN-PC affinity.
  - Office interconnect capability.
  - Extensive SNA management support.
  - Open modular architecture.

- As a result, the Series I is currently being installed to fulfill the role of:

  - Gateway between dissimilar networks (X.25 and SNA).
  - Network manager.

- Transaction processing system.

- Industrial automation.

- Program development.

- Communication network concentrator.

- As a result of the new interest in the Series I, it experienced its best year of shipments in 1985.

- The 8100 with the DPPX/DPCX OS is a communications-oriented system that has been recently downplayed by IBM.

- Exhibit IV-19 shows that IBM's mid-range products with product-specific OS will increase in installed base size by 12% per year over the forecast period.

- INPUT expects that all existing mid-range systems will receive strong competition from 43XX products as well as new micros based on the 80386 chip.

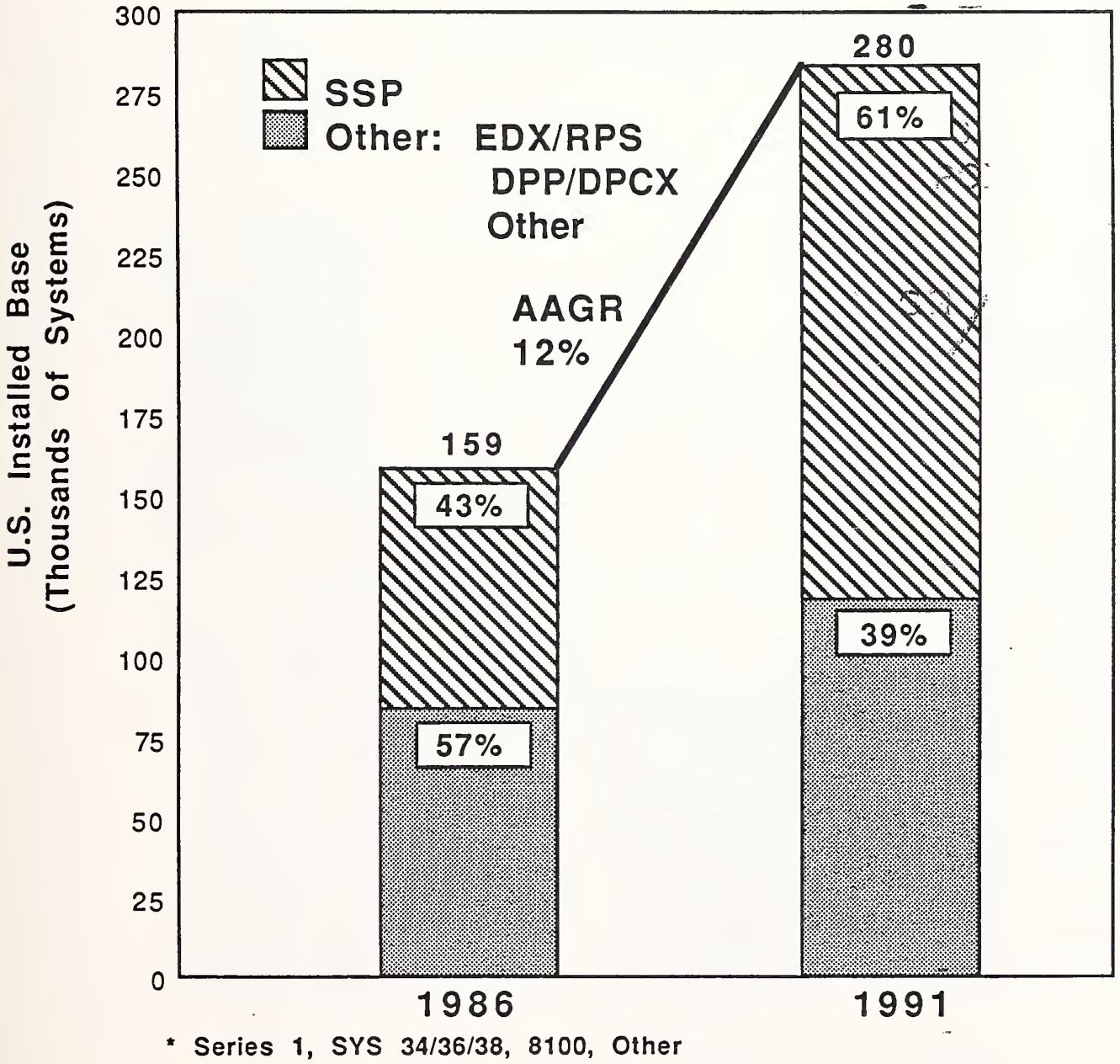
3. MID-RANGE SYSTEMS FORECAST

- Exhibit IV-20 shows INPUT's mid-range market forecast, which highlights an overall increase in installed base of mid-range systems by 58% in spite of the fact that those traditional IBM mini systems with specific OS will decrease significantly from 94% of the mid-range market in 1986 to 29% of the market in 1991.

  - Systems of 370 architecture less than two MIPS will decrease in market share (6% to 4%), but significantly increase in units (10,000 to 34,000) due to low-cost (under $50,000) systems.

EXHIBIT IV-19

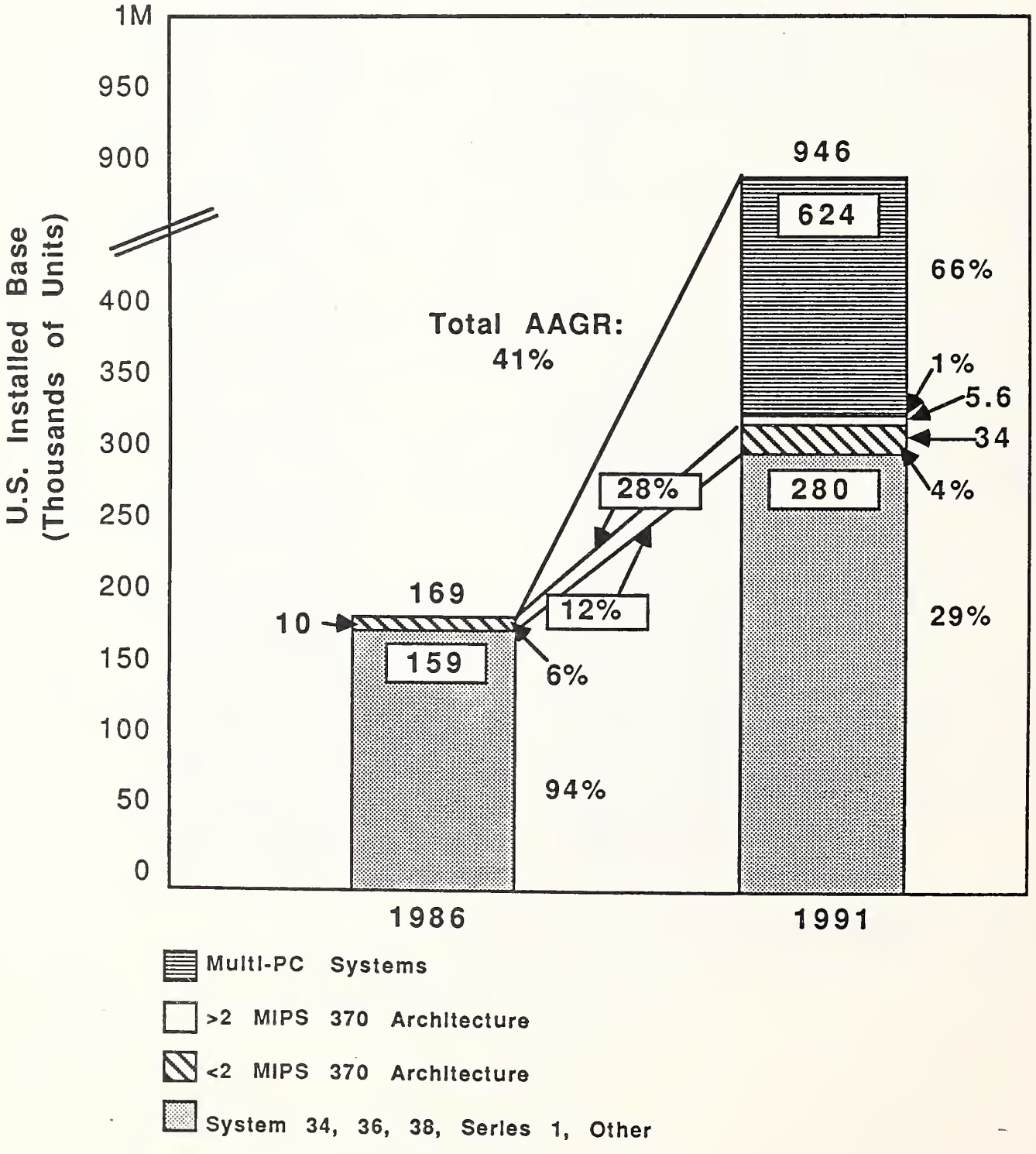
INSTALLATIONS OF IBM MID-RANGE PRODUCT-SPECIFIC OS*
1986-1991



* Series 1, SYS 34/36/38, 8100, Other

EXHIBIT IV-20

IBM OR COMPATIBLE MID-RANGE SYSTEMS INSTALLATIONS, 1986-1991



- During the same time period, high-end PC-type products will be 66% (624,000 units) of the 1991 market. Of the 23 million micros in the installed base in 1991, 3% will be mid-range multiuser, multitasking units in 1991. Several operating systems will be used separately and together including VM, UNIX, and PC-DOS variants.

- There will also in 1991 be a small percent (1%) of more than two MIPS 370 architecture machines used as departmental processors. These would include primarily 4381s.

D. SMALL SYSTEMS DIRECTIONS

- The installed base of micros will triple from 1985-1991 (see Exhibit IV-21). Contributing to the increase in installed base are:

  - Increased system capacity.

  - Increased end-user and small business computer literacy.

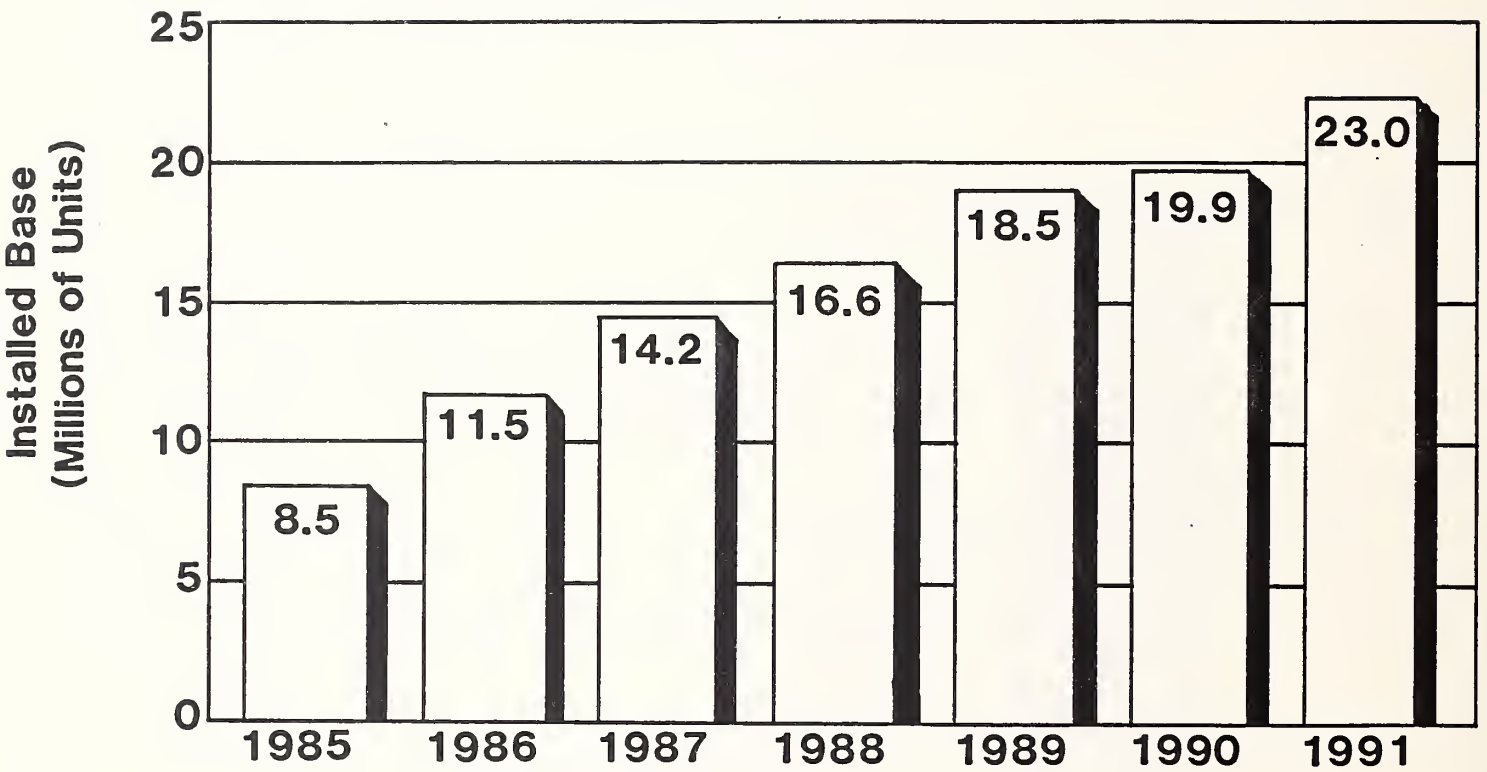
  - Increased availability of applications software.

  - Decreased system cost.

  - Development of comprehensive micro strategies by large businesses.

- The primary OS today for micro products is PC-DOS (MS-DOS) with over 50% of the installed base.

U.S. INSTALLATIONS OF MICROCOMPUTERS IN BUSINESS*, 1985-1991



*Microcomputer systems selling for less than $15,000 that are used for business.

V OPERATING SYSTEMS DIRECTIONS

V OPERATING SYSTEMS DIRECTIONS

A. MVS AND MVS/XA

1. MVS EVOLUTION

- In 1974, IBM introduced OS/MVS for its system 370. The OS included multiple virtual storage (MVS) in which a virtual storage (storage space that appears to be real but is not) address space of 16 MB was available to each of several concurrent users. Since that time it has been IBM's primary mainframe OS (see Exhibit V-1).

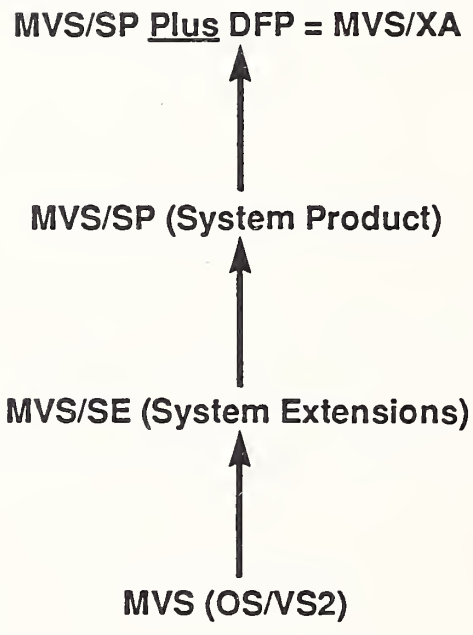
- The MVS architecture continued to evolve with SE and SP. SE enabled users to take advantage of 303X, processors which implemented several frequently used system routines in microcode, and SP, which included further enhancements and architecture extensions.

- As larger capacity processors became available, effective management of system resources became difficult, and as user workload increased the requirement for system resources, major capacity constraints also became apparent.

- Consequently, in 1981 IBM introduced a new systems architecture to alleviate these constraints. The architecture was called XA (extended architecture) and the OS to complement the hardware was MVS/SP2 or MVS/XA.

EXHIBIT V-1

MVS EVOLUTION



- MVS/XA includes all of the features of preceding MVS products, but also includes data facility product (DFP).

  - DFP integrates data management support into a single software package for MVS/XA and MVS/370. It includes:

    . Data management.

    . Device support.

    . Program library management.

    . Utilities function.

    . Access methods.

    . User and systems catalog support.

  - DPF replaced five IBM program products previously available for data management.

- Other MVS/XA enhancements include additional storage and 31-bit virtual addressing (MVS/370 was 24-bit for programming). This increase in address area gave each user 2GB of user area. Only the Basic Control Program (BCP) and data management functions were changed.

2. XA KEY FEATURES

- The initial incentives for customers to install MVS/XA were to relieve the constraints imposed on their system by the 370 architecture.

- Virtual storage constraint relief was the primary reason for initial migration. Main storage capacity is the key limiting factor to system performance growth. Consequently, XA takes advantage of both extended virtual and real storage to support larger programs than MVS.

- It also has a dynamic channel subsystem:

  . Increases channel capabilities to 256 channels.

  . Increases device capability to over 65,000 devices from 4,000.

  . Supports dynamic reconnection.

- As on-line transaction processing (OLTP) and end-user computing (EUC) continue to increase, so too must system reliability levels. XA provides for increases in RAS (reliability, availability, and serviceability), primarily by enhancing the BCP error detection and recovery features.

• Today there are new incentives to take advantage of new functionality provided by MVS/XA architecture.

- VSCR (virtual storage constraint relief) is still very important.

- Higher speed processors.

- Support for 3084 and 3090/400 processors.

- Ability to support increasingly large system capacity requirements (in CPU memory, I/O) through improved management of resources.

- Over 80 enhanced RAS features.

- New capabilites such as vector processors and expanded storage.

3. XA USER NEEDS

- Users interviewed have several key issues regarding MVS/XA. They include:

  - Conversion.

    . How? Conversion to XA is being primarily done through VM/XA in which the day-to-day processing is ongoing on a 308X running MVS while MVS/XA is being tested.

    . Costs? XA costs about three times MVS ($13,000-14,000 initial fee with $2,000-4,000 monthly charge). This cost is exclusive of the cost of training staff, retuning the system to maximum performance, and converting applications and systems programs. Users must weigh all these costs against XA benefits.

  - Exploiting XA features. In reality it takes years to exploit XA features. Users must redesign old applications to take advantage of the increased storage size, I/O capabilities, multiprocessing, and new functionality.

4. FORECASTS

- The four environments of MVS are: running in native MVS or MVS/XA, as a guest under VM, or as one of several quests under VM. Forecasts for MVS appear in Exhibits V-2 through V-4.

  - XA, due to IBM's aggressive marketing and product benefits, will emerge as the dominate MVS type in 1991 in spite of the fact that MVS has the larger installed base in 1986.

  - The three types of MVS other than XA (MVS, VM/MVS, VM/MVS/DOS) will maintain a steady installed base and as a group will have modest growth.

EXHIBIT V-2

MVS INSTALLATIONS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
MSV/XA	2,600	18%	11,700	35%	35%
MVS	7,800	55%	14,900	45%	14%
VM/MVS	1,700	12%	3,200	10%	14%
VM/MVS/DOS	2,100	15%	3,300	10%	9%
Total	14,200	100%	33,100	100%	18%

EXHIBIT V-3

MVS INSTALLATIONS* ON LARGE SYSTEMS OVER 2 MIPS
1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
MSV/XA	2,600	22%	11,700	42%	35%
MVS	7,000	58%	13,200	47%	14%
VM/MVS	1,500	13%	2,200	8%	9%
VM/MVS/DOS	900	7%	900	3%	-1%
Total	12,000	100%	28,000	100%	18%

* 370 Architecture

EXHIBIT V-4

MVS INSTALLATIONS* ON LARGE SYSTEMS UNDER 2 MIPS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
MSV/XA	-	0%	-	0%	-
MVS	800	36%	1,700	33%	16%
VM/MVS	200	9%	1,000	20%	37%
VM/MVS/DOS	1,200	55%	2,400	47%	15%
Total	2,200	100%	5,100	100%	18%

*370 Architecture

- Exhibit V-5 highlights the growth of MVS/XA.

  - The success of MVS/XA is one of IBM's major corporate goals. Consequently, it is aggressively encouraging users to migrate to XA in several ways:

    . Six months test allowance.

    . Packaging programming product and OS in order to make it easier for users to install XA; i.e., migrate faster.

    . Significant hardware features on newer products require XA.

    . Providing conversion tools as VM.

    . Providing more professional service help in the form of consulting and/or software development.

  - XA will have a 35% AAGR for total systems of the 370 architecture. Due to XA requirements, all XA systems are in the more than two MIPS category.

5. XA FUTURE DIRECTIONS

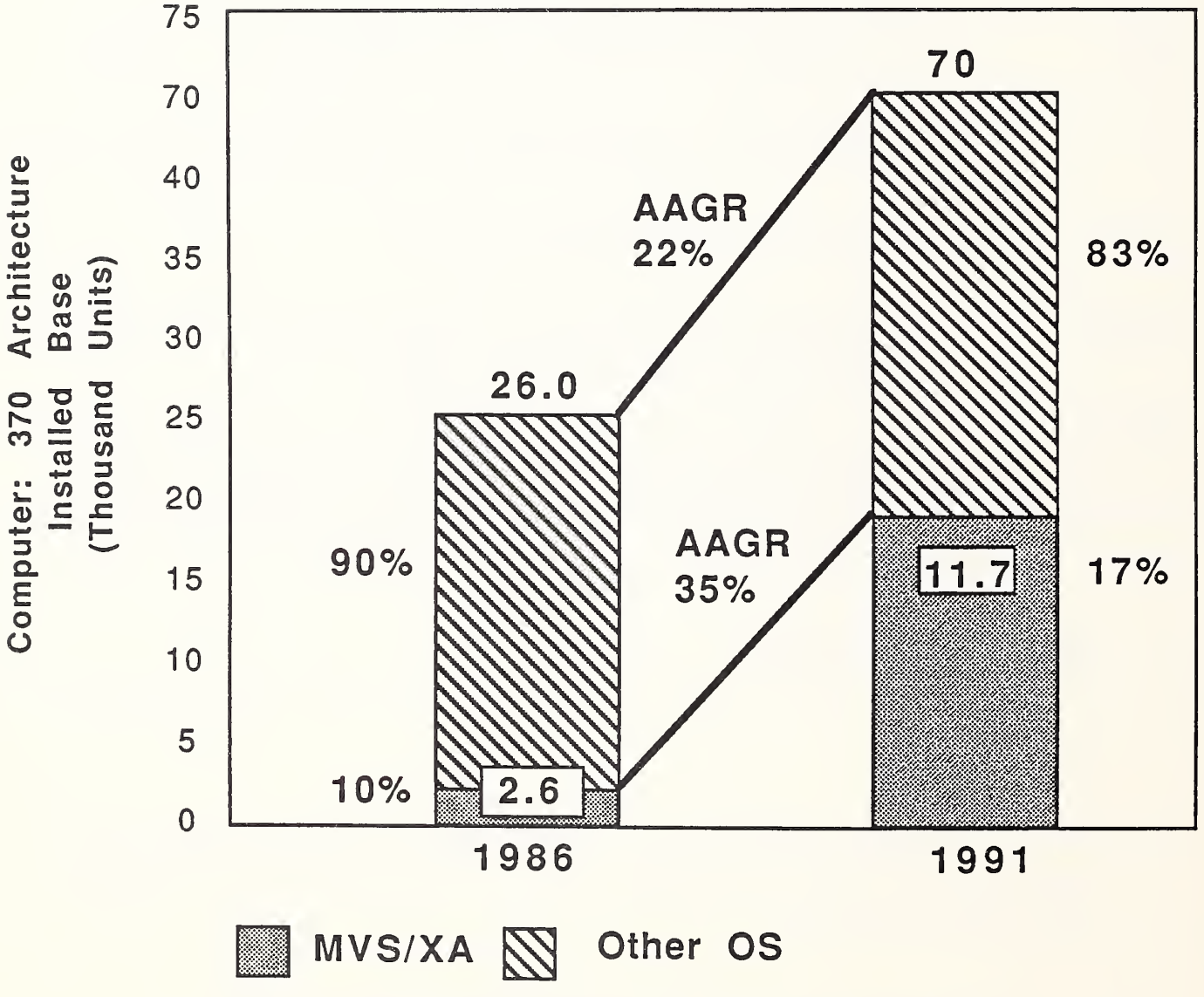
   a. Overview

- IBM will continue to announce for XA additional and enhanced capabilities. Customers can expect new releases every six months to one year, which is IBM's release timeframe.

  - Hidden features in the XA architecture will emerge gradually.

EXHIBIT V-5

MVS/XA CONTINUES TO GROW



- An example of this is the potential ability of parts of XA being pulled off the host and put into the 3092 I/O process controller to free up CPU cycles.

- IBM will attempt to minimize changes to the JCL and general operator complexity by the use of YES/MVS.

- XA will have more functional subsystem capabilities and will become a modular OS. This will be done to support the modular computer architecture of the future, depicted in Exhibit V-6, using specialized processors for various functions, such as DBMS, AI, transaction handling, etc. Consequently, OS of the future will need to be recast in smaller parts to support these new products.

b. On-Line Transaction Processing (OLTP)

- One of the functional subsystems that could be part of XA in the future could be for on-line transaction processing. The on-line transaction market is growing very rapidly, particularly in industries such as banking, finance, and transportation. In 1987, demand in this area for 100 transactions per second (TPS) performance will be common, and this will grow to 1,000 TPS by 1991.

- Presently, most users of IBM products that perform OLTP use CICS/IMS under XA. However, the 30 TPS capability of this product is stretched. IMS extensions include IMS/DC at 60 TPS and IMS/FASTPATH at 80 TPS.

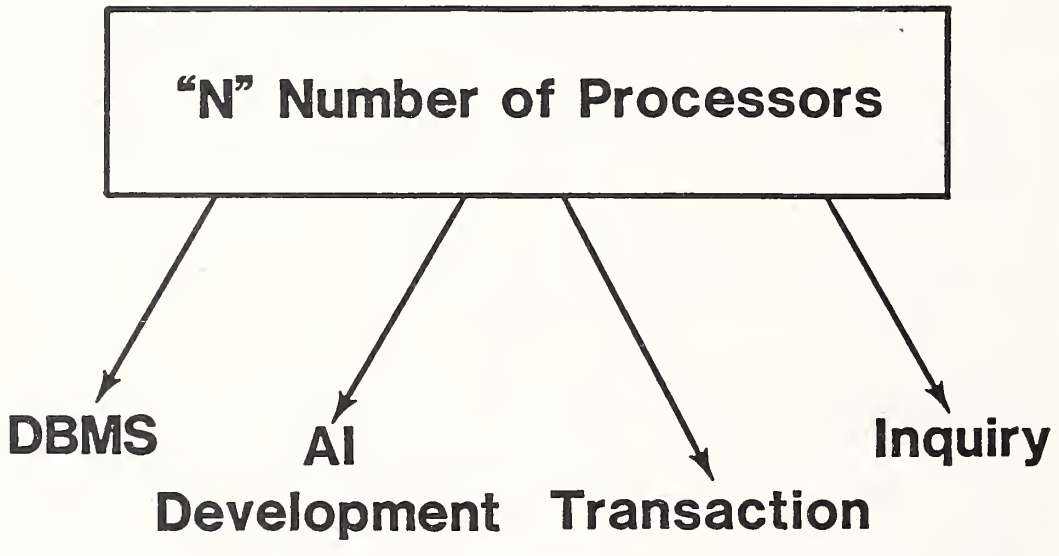
- An alternative product that IBM has begun to market is TPF2. The product is an upgrade of the old airlines control program (ACP).

  - It handles the growing TP rates and is not burdened by an underlying data base as is IMS.

  - However, functionality is sacrificed.

EXHIBIT V-6

FUTURE MVS/XA COMPUTERS



- Presently there are over 75 users of TPF2/HPO at a one-time enterprise (per location) license charge of $428,000 and $42,800/month.

- Consequently, IBM customers with present product offerings cannot have both functionality and speed for OLTP applications.

- Potential future IBM directions in this market include:

  - Combine the functionality of TPF and CICS/IMS and make them MVS compatible.

  - Improve the performance of IMS with new hardware, perhaps the Sierra series.

  - Utilize the fault tolerant Stratus product (System 88) as a target OLTP product.

B. VM

1. VM EVOLUTION

- VM/370 is a multiple access time sharing system that was developed in the 1960s at IBM's Cambridge Scientific Center. At the time it was not considered a mainstream product and was developed as a development and test environment.

- In the 1970s VM/SP was introduced as an enhanced product for the commercial environment.

- Subsets of the VM OS have since been released.

  - VM/XA is a migration aid to assist users in transferring from DOS to MVS or MVS/XA. It allows existing applications to be run while the conversion process is taking place.

  - VM/ENTRY is an easy to install "load and go" system for selected 4300 systems. It is low priced and aimed primarily at the departmental level CMS environment with 128 users or less. VM/ENTRY is used as a base product for VM/SP End User Software Support-ES(3) which is:

    . A family of general business, office, and engineering and scientific application solutions.

    . In addition, ES 3 has eight optional packages--text office systems, intelligent workstation support, engineering/scientific program development support, data base query, APL, problem solving languages, network and support, and communication controller support.

  - VM-HPO is used in conjunction with VM/SP, hardware improvements, and microcode assists. It offers in the large systems environment:

    . Performance improvements.

    . Operational improvements.

    . RAS improvements.

  - VM/SNA provides native SNA support at a level compatible with MVS/SNA support. The product was announced in late May 1986.

- VRM is a hypervisor that runs on three custom 68000 chips on the PC-RT. PC-VM that runs on the XT or AT 370 is also a hypervisor. A hypervisor is not an OS per se, but a lower-level task master. It has no utilities or resource management, but allows VM to run in non-370 environments. It also ensures compatibility with future chip architectures.

- VM is a highly strategic IBM OS and is used in 70% of IBM's internal development. It is also IBM's present answer to UNIX on a supermicro.

- VM consists of four major components:

  - CP controls the resources of the real computer to provide multiple virtual machines, each capable of running different OS.

  - CMS is an operating system by itself. It has the capability of supporting two times as many simultaneous users as MVS on a given IBM mainframe. In many cases CMS is used for program development even though the actual program execution is under MVS/TSO.

  - RSCS (remote spooling communication subsystem).

  - Interactive problem control system.

2. VM BENEFITS

- VM's benefits are:

  - It is an interactive as opposed to batch OS. This means that the computer responds immediately as opposed to in minutes/days/hours for a batch request.

- It is IBM's strategic product as an information center host operating system, primarily since it is interactive in nature. VM/PROFS is the primary departmental host product for end-user computing. A link between PROFS and DISOSS and support for IBM's Advanced Function Printing Architecture were announced in May 1986.

- It runs multiple OS under it as quests--significantly important for programming at the same time daily processing is being transacted or as a migration aid.

3. VM CHARACTERISTICS

- VM is the only OS by IBM that is available for products from the PC to the 309X series. Exhibit V-7 is a graphic portrayal of the specific processing characteristics of VM for levels of computers. As previously mentioned, VM's primary role is on Level Two systems for information centers.

4. VM USER ISSUES

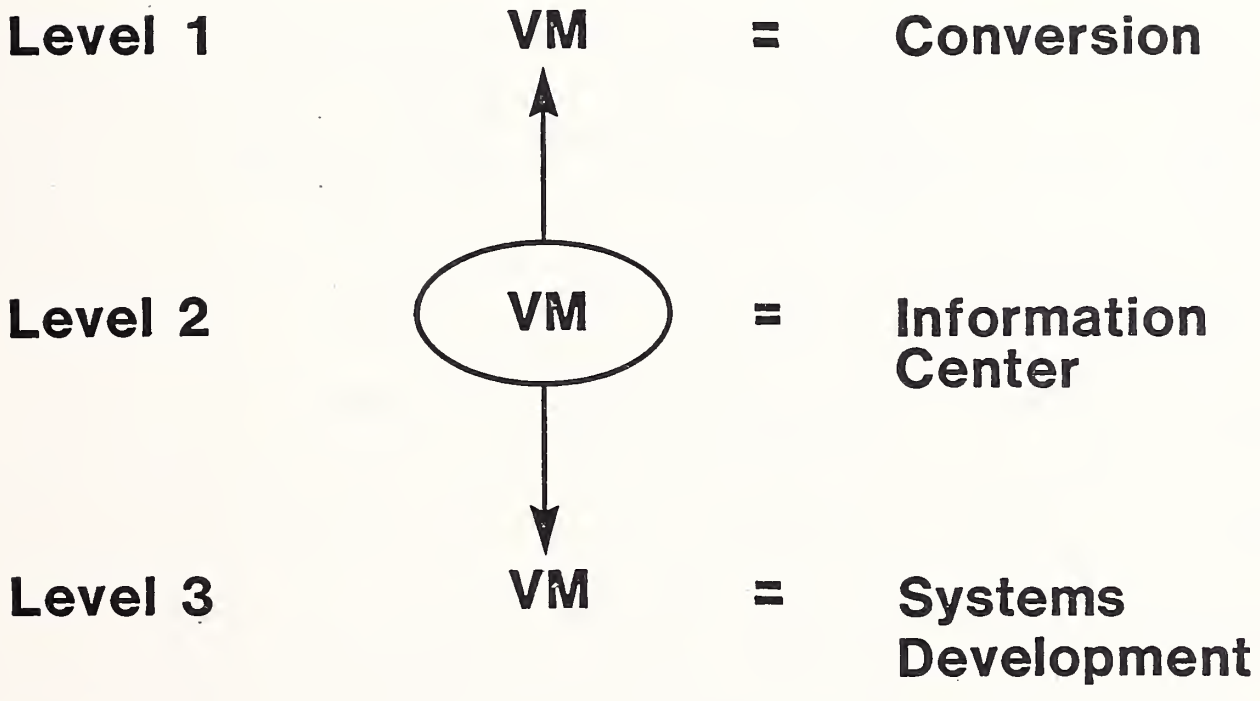
- Several key user issues regarding VM arose during the research process.

  - IBM's overall commitment to VM.

    . VM is a major IBM emphasis--second, however, to MVS. The company is traditionally a batch company and it is difficult to switch allegiances; consequently, VM development has not kept pace with MVS development. But recent announcements such as support of SNA and DISOSS links affirm IBM's choice of VM as a strategic product. Other difficiencies in VM provide opportunities for add-on vendors in areas such as scheduling and sorting.

EXHIBIT V-7

RANGE OF VM CHARACTERISTICS



- Using VM as a production tool.

  . Due to the efficient use of VM paging, users find that DOS runs more efficiently under VM than in standalone mode. With MVS, however, the paging function is duplicated, thereby creating a less efficient operating environment and higher overhead.

- How long to support multiple OS?

  . Overhead is not only the only consideration of a multiple OS strategy; users must also consider the resource expense, i.e., programmers and maintenance that increase with multiple OS usage.

5. FORECASTS

- Exhibits V-8 through V-10 forecast the VM marketplace.

- The VM market as a whole will have an AAGR of 36% from 1986 to 1991.

  - The number of units will increase significantly due primarily to low-end 43XX that will be aggressively shipped from 1988-1991. These products will run primarily VM/CMS (VM/ENTRY) or VM/UNIX.

  - VM/DOS will decrease in share of VM installations from 18% to 4% by 1991 due to the migration from DOS to MVS that will be completed by that time.

  - UNIX/VM will have the most rapid growth of VM operating environments. More information on UNIX will follow in the UNIX chapter.

EXHIBIT V-8

TOTAL VM INSTALLED BASE*
(Large Systems)

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
VM CMS	1,600	21%	18,000	50%	64%
VM/MVS	1,700	22%	3,200	9%	14%
VM/MVS/DOS	2,100	27%	3,300	10%	9%
MV/DOS	1,400	18%	1,500	4%	2%
VM/UNIX	300	4%	9,300	25%	95%
VM/Other	600	8%	700	2%	4%
Total	7,700	100%	36,000	100%	36%

* 370 Architecture

EXHIBIT V-9

VM INSTALLATIONS* ON LARGE SYSTEMS OVER 2 MIPS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
VM CMS	1,000	20%	1,500	16%	10%
VM/MVS	1,500	33%	2,200	24%	9%
VM/MVS/DOS	900	20%	900	10%	-1%
VM/DOS	900	19%	500	5%	-10%
VM/UNIX	200	4%	4,200	45%	79%
VM/Other	200	4%	10	-	-
Total VM	4,700	100%	9,310	100%	16%

*370 Architecture

EXHIBIT V-10

VM INSTALLATIONS* ON LARGE SYSTEMS UNDER 2 MIPS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
VM CMS	600	20%	16,500	62%	94%
VM/MVS	200	7%	1,000	4%	37%
VM/MVS/DOS	1,200	40%	2,400	9%	15%
VM/DOS	500	16%	1,000	4%	15%
VM/UNIX	100	3%	5,100	19%	121%
VM/Other	400	14%	700	2%	11%
Total VM	3,000	100%	26,700	100%	55%

*370 Architecture

6. VM FUTURE DIRECTIONS

- VM will continue to be IBM's information center OS. It will be extended as the office system environment OS.

- It will be a common IBM OS for all major computer types. On micros, VM will continue to be a modification of the 370 large system version and will be used primarily in a multisystem office environment.

- VM will become more efficient using microcode assists and more user friendly. True support (for CMS) of 31-bit addressing will be available.

- VM concepts such as running multiple OS and specialized processor support will be heavily imbedded in new IBM computers. This implies that there will continue to be different operating environments, such as batch and interactive processing and development.

- VM will have more "hooks" for security purposes. This is especially important for C2 certification (even RACF that runs on MVS cannot get security clearance). This feature would increase the sales of VM to government agencies and thereby increase the market potential for add-on vendors.

C. DOS

1. CHARACTERISTICS AND EVOLUTION

- DOS/VSE is the latest version of the almost two decades old operating system whose impending death has been actively predicted by many almost since the day it was announced. In the original conception of OS/360 by IBM in the early 1960s, DOS did not exist. However, the complexities of operating system development overrode the architects' lofty goals and DOS became a

"temporary" solution for smaller users until they could convert to the real "OS."

- Even though DOS has long been considered a dead-end diversion from the mainstream of operating systems evolution, in fact DOS refuses to die. The reality is that the IBM 360, 370, 43XX, 303X, 308X, PCMs, and others actively support DOS/VSE, the latest version of DOS. IBM continues to enhance DOS/VSE for the thousands of users who depend upon it. Although IBM has been actively encouraging conversion from DOS to MVS for some time, the actual rate of conversion is less than IBM desires.

2. FORECASTS

- Exhibit V-11 shows that the DOS installed base will decline at the rate of -3% per year for the period 1986-1991. From a 1986 population of 10,900 units, DOS will decline to 9,200 units during this five-year period. The rate of conversion of DOS users to larger, primarily MVS and/or VM operating systems exceeds 20% per year. However, the significant increase in computer population, primarily among mid-range 43XX machines, during this same five-year period provides an avenue of expansion that almost completely offsets the conversion activity.

- Standalone DOS installations will show the greatest decline with a -10% average annual decrease. In contrast, VM/DOS and VM/MVS/DOS will experience a 2% and 9% increase respectively. VM is especially attractive to DOS users because it not only provides a smooth avenue for conversion to MVS, for example, but it also may, in some cases, improve the performance of DOS itself, due the superior paging and other facilities within VM. As a result, these factors will help increase the market share of VM-related DOS from 32% in 1986 to 52% by 1991.

- The percentage of DOS installed on "under two MIPS" machines will remain in the vicinity of 73% for the five-year forecast period. As shown in

EXHIBIT V-11

DOS INSTALLATIONS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
DOS	7,400	68%	4,400	48%	-10%
VM/DOS	1,400	13%	1,500	16%	2%
VM/MVS/DOS	2,100	19%	3,300	36%	9%
TOTAL DOS UNITS	10,900	100%	9,200	100%	-3%

Exhibit V-12, the most vigorous portions of the DOS "under two MIPS" marketplace are the VM/DOS and VM/MVS/DOS segments which are increasing at a 15% annual growth rate. These segments will benefit from the introduction of thousands of small 43XX/CMOS systems that will be introduced into the marketplace beginning next year.

- In contrast, the segment showing the greatest decline (-15% annually) is the standalone DOS market for these same size machines. Buyers of the newer technology 43XX/CMOS systems will be more sensitive to and thus prefer VM-related solutions.

- Exhibit V-13 profiles the DOS marketplace for hardware over two MIPS in size. While the "over two MIPS" DOS installed base overall is declining at the same rate (-3%) as the "under two MIPS" segment, the largest contributor to the decline is the VM/DOS portion at -10%. The larger systems can more easily accommodate MVS, thus the preference for a VM/MVS/DOS solution, which is a conversion mode solution.

3. ISSUES AND FUTURE DIRECTIONS

- The rate of conversion from DOS to VM and/or MVS is slower than IBM prefers. Supporting and extending DOS requires a large commitment of technical resources which IBM would prefer to allocate elsewhere. This slowness of upgrades is due not only to the reluctance of users to incur a major conversion cost, but also to the aggressiveness of independent software product vendors in offering systems and applications software for the DOS user. Computer Associates, one of the largest vendors of this type continues to actively promote and support its DOS-oriented systems software. Corodale, also a vendor of DOS systems software, recently received a significant busines boost via its acquisition by UCCEL Corporation, a leading vendor of OS systems software.

EXHIBIT V-12

DOS INSTALLATIONS* ON LARGE SYSTEMS UNDER 2 MIPS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
DOS	6,300	79%	3,400	50%	-12%
VM/DOS	500	6%	1,000	15%	15%
VM/MVS/DOS	1,200	15%	2,400	35%	15%
TOTAL DOS UNITS	8,000	100%	6,800	100%	-3%

*370 Architecture

EXHIBIT V-13

DOS INSTALLATIONS* ON LARGE SYSTEMS OVER 2 MIPS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
DOS	1,100	40%	1,000	41%	-1%
VM/DOS	900	28%	500	21%	-10%
VM/MVS/DOS	900	32%	900	38%	-1%
TOTAL DOS UNITS	2,900	100%	2,400	100%	-3%

*370 Architecture

SP1

- IBM knows that it cannot ignore the needs of its large base of DOS mid-range systems users, particularly given the onslaught of competition in the departmental systems area from DEC, DG, WANG, et al. Since conversion to MVS is often close in difficulty to converting to another vendor's operating system, IBM has a strong incentive to both protect its DOS installed base for those who do not want to convert and assist those who do want to move up to larger systems.

D. UNIX

- As shown in Exhibit V-14, a number of actions have contributed to the proliferation of UNIX. As the original developer of UNIX, AT&T initially encouraged its spread during the 1970s by offering very inexpensive licenses to educational institutions. By 1978 this "seeding" had resulted in over 600 UNIX installations around the world. By 1979 imitators began to flourish since AT&T made little effort to preserve and/or enforce a standard version of the system.

1. CHARACTERISTICS AND EVOLUTION

- It was during the first half of the 1980s that forces finally came into play that provided UNIX with its most significant boost into the non-educational realm. In 1981 AT&T introduced System III as a new version. It was also at this time that personal computer versions such as XENIX (from Microsoft) began to expose a wider range of programmers to its special characteristics.

- Momentum further increased in 1983 when AT&T announced System V, an improved version. It was also during this year that Amdahl introduced UTS and thus became the first vendor of IBM-compatible hardware to offer a UNIX-based operating system.

EXHIBIT V-14

UNIX HISTORY

- 1969 - Creation at Bell Labs/DEC-Based
- 1978 - 600 Installations
- 1979 - Imitators Flourish
- 1981
  - System III Appears
  - PC Versions Proliferate
- 1983
  - AT&T Announces System V
  - Amdahl Announces UTS
- 1984
  - Mainframe Versions Appearing
- 1985
  - Major AT&T Push in Commercial Environment

- By 1984 numerous mainframe versions began to appear. Sperry announced UNIX availability on its full range of systems. Thus, UNIX now was in the unique position of being widely implemented not only on different vendor machines, but also on different sized machines covering the full spectrum of minis, mainframes, and micros.

- The slow but increasingly widespread acceptance of UNIX (and its many variants) in the non-IBM 370 environment finally caused IBM to conclude that, rather than lose important computer sales to customers who insisted upon UNIX, it would introduce a UNIX-based solution for 370 systems. Thus, IBM announced its own version of UNIX called IX/370. This system was developed for IBM by Interactive Systems of Santa Monica, California.

- 1985 saw AT&T further push UNIX into the commercial environment by undertaking special efforts to standardize the mainstream UNIX variants. Thus, AT&T and Microsoft as well as AT&T and Intel reached accords to bring their respective systems closer to a common standard.

- Exhibit V-15 summarizes the characteristics of the UNIX-based operating systems currently available on IBM architecture computers.

2. PRIMARY USE

- To date the main users of UNIX have primarily been installations with one or more of the following characteristics: need for multiuser systems support, heavy software development, commitment to the "C" programming language, and need to support a mixed-vendor hardware environment with a common operating system. Scientific and engineering environments have been especially attracted to UNIX because of its positive interactive characteristics, its effective file sharing, and its multiple user capabilities.

EXHIBIT V-15

UNIX IMPLEMENTATIONS ON IBM COMPUTERS

System Name	Hardware	Compatibility	Memory Required	Date of Introduction	Seller	Author	Notes
Small Systems							
PC Xenix 2.0	PC AT	System V		1986	IBM	Microsoft	
PC Xenix 1.0	PC AT PC XT	System III		1980	IBM	Microsoft	
PC/IX	PC XT PC AT	System III			IBM	Interactive Systems	
XENIX	PC AT	System III			Microsoft	Microsoft	
AIX	RT PC				IBM	Interactive Systems	
Mid-Range/ Large Systems							
Series 1/IX	Series 1	System V			IBM	IBM	
CP/IX	Series 1	System III			Univ. Ohio Rutgers Univ.		
IX/370	3090 43XX 303X S/370	System V	4MB	10/85	IBM	Interactive Systems	Uses VM/SP
UTS	Amdahl 470 3090 43XX 303X S/370		4MB	5/81	Amdahl	Amdahl	Uses VM/370 or VM/SP
UTS/V	Amdahl 470 3090 43XX 303X S/370 PCMs		6 MB		Amdahl	Amdahl	Requires VM/SP

3. STRENGTHS AND WEAKNESSES

- Whether or not to commit to UNIX has been a perplexing issue to many vendors and users during the past several years. UNIX popularity through the years has been frequently overestimated by many proponents, and yet often underestimated by opponents.

- Exhibit V-16 contrasts numerous strengths and weakneses of UNIX. Strengths include:

  - Programmer productivity. Users of the system who can benefit from the speed by which software can be developed are especially attracted to UNIX programmer productivity advantages. The powerful, terse commands were created specifically for software developers by the original UNIX developers at Bell Labs. In addition, the more than 150 built-in utilities further aid technicians' creation of software code. The underlying elegance of the internal design of UNIX not only contributes to its functional effectiveness, but also adds a psychological appeal to programmers technical enough to appreciate its implementation.

  - Large pool of trained programmers. An important factor that contributes to UNIX overall strength is the large pool of trained programmers that currently exist. AT&T's seeding of UNIX at universities almost two decades ago is now paying off as UNIX enthusiasts graduate to positions of responsibility in installations throughout the country.

  - Wide range of CPU size and vendor implementation. Mixed-vendor environments are becoming increasingly commonplace within information systems departments of all sizes as advances in technology, standards, and communications connectivity provide a synergy previously unattainable. UNIX is uniquely able to provide a single

EXHIBIT V-16

UNIX STRENGTHS AND WEAKNESSES

Strengths

- Programmer Productivity
  - Powerful, Terse Commands
  - Good Development Tools
  - Elegant Design
- Large Pool of Trained Programmers
- Wide Range of CPU Size and Vendor Implementations

Weaknesses

- Compatibility Problems
- Memory Requirements
- Weak Supermicro-Mainframe Transferability
- Less Support in IBM Environment

operating system solution for those users desirous of reducing the expense and overhead associated with support of multiple operating systems.

- There are, however, a number of weaknesses that serve to reduce the appeal of UNIX to many installations. These negative factors include:

  - Compatibility problems. There exist more than 40 actively marketed versions and variants of UNIX. Because AT&T did little to encourage standardization during UNIX formative years of the 1970s, many approaches were developed which resulted in significant compatability problems. Exhibit V-17 provides an overview of the evolution of UNIX.

  - Memory requirements. The abundance of capabilities and utilities within UNIX result in large memory requirements. Microcomputer-based UNIX systems often require 256K or more of memory, while mainframe versions can run in the 2-6 MB range.

  - Weak supermicro-mainframe transferability. UNIX was originally developed in a DEC environment with much concern for interaction between multiple users of the same CPU, but with little consideration given to UNIX use within a hierarchy of machines. As a result, connectivity capabilities have been underdeveloped. In today's era of widely networked systems, this deficiency becomes increasingly unacceptable.

  - Less support in IBM environment. As discussed above, UNIX arrival within the IBM 370 world has been relatively recent. As a result, the variety of resources, software, and expertise while increasing, is much less than that available for DEC, DG, etc. systems.

EXHIBIT V-17

UNIX EVOLUTION

DATE	NAME	DEVELOPER
1983	System V UTS	AT&T AMDAHL
1981	System III Version 4.2	AT&T UC-Berkeley
1980	XENIX	MicroSoft
1979	Version 7 Version 6	Bell Labs Bell Labs
1969	Original Versions	Bell Labs

4. FORECASTS

- Within the IBM 370 architecture marketplace, UNIX will have the fastest growth rate of the operating systems profiled in this report. As shown in Exhibit V-18, the UNIX installed base will enjoy an 83% average annual growth rate for the period 1986 to 1991.

- A number of factors are contributing to this significant growth. They include:

  - Favorable software development economics for vendors marketing revisions to multiple computer types.

  - Standardization successes by AT&T (Microsoft, Intel, etc.).

  - Endorsement by IBM.

  - Powerful appeal of the applications software whereby users are less concerned with UNIX underneath.

  - User desire to minimize the number of operating systems to support.

- Whereas there currently exists a 50-50 ratio of standalone UNIX to VM/UNIX, in 1991 the scales will tip in favor of VM/UNIX with more than three-quarters of the installed base preferring this approach. VM/UNIX benefits from IBM's emphasis in offering this option. In addition, UNIX residence in commercial environments often requires coexistence with other operating systems. VM helps make this coexistence more effective.

- Exhibit V-19 divides the market into installations of either under or over two MIPS in size. Twenty percent of the UNIX installation in 1986 are on systems under two MIPS. However, by 1991 this percentage share will increase to almost 60%. This will be due to the popularity of smaller 370 architecture systems, primarily in the 43XX series.

EXHIBIT V-18

LARGE SYSTEMS* UNIX INSTALLATIONS, 1986-1991

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
UNIX	300	50%	2,900	24%	62%
VM/UNIX	300	50%	9,300	76%	95%
Total	600	100%	12,200	100%	83%

* 370 Architecture

EXHIBIT V-19

UNIX LARGE COMPUTERS*
INSTALLED BASE

SIZE	1986		1991		AAGR 1986-1991
	Units	%	Units	%	
Under 2 MIPS					
UNIX	-	-	2,000	28%	-
VM/UNIX	100	-	5,100	72%	121%
Subtotal	100	-	7,100	100%	-
Over 2 MIPS					
UNIX	300	60%	900	18%	27%
VM/UNIX	200	40%	4,200	82%	79%
Subtotal	500	100%	5,100	100%	59%
Total:	600		12,200		83%

* 370 Architecture

5. ISSUES AND FUTURE DIRECTIONS

- A number of issues surround the evolution of UNIX that impact its future appeal to both users and vendors. These issues include:

  - Outlook for UNIX standardization. The primary key to UNIX future acceptance is the extent to which a standard version will emerge that is supported by the major vendors. INPUT believes that major progress will be made in this area during the next few years, but that a single UNIX will not emerge. Instead, users and vendors can expect to see a convergence of systems into three major categories.

    . The first category will be built around the AT&T System V. Most of the major computer and software firms will embrace this approach. System V will not be dictated by AT&T, but instead will be the result of compromises between leading UNIX vendors such as AT&T, Microsoft, et al. Thus, Microsoft's XENIX will become more similar to System V and vice versa as a result of these two vendors' decisions to move toward a common standard.

    . The second category will be IBM's IX/370 which will be much like System V, but will include a number of proprietary elements designed to maintain some degree of account control for IBM. While not radically different from System V, IBM will continually seek to maintain a distinctiveness that keeps it distanced from AT&T, its computer-communications rival. INPUT believes that the differences will become increasingly small over time because IBM will find that its late entry into the UNIX arena gives it much less market "clout" than it desires. The primary momentum will be with the System V standard.

- The third category will be a continued proliferation of non-standard UNIX systems that have carved out relatively small, but viable market niches. The number of viable, actively supported, and nationally distributed UNIX variants in this tier will decrease by more than 75% during the next five years. However, either through stubborness, lack of resources, satisfaction with protection of a small market segment, or a combination of all of these factors, numerous vendors will hold their own in this specialty tier for the balance of the decade.

- Extent of commercial marketplace penetration. Use of UNIX for other than scientific and engineering environments will increase significantly during the next five years. While use of UNIX for commercial applications currently comprises less than 15% of all UNIX processing, INPUT estimates that commercial implementations will grow to more than 50% by 1991. This increase in commercial market share will be driven by factors such as:

  - The increasingly favorable economics of UNIX applications software development for software vendors. The popularity of UNIX among such a wide variety of non-IBM vendors combined with the attainment of a critical mass of UNIX installations in the 370 world (over 1,000 installations by 1987) provides a market potential that becomes sufficiently large to support amortization of applications development costs over a large base.

  - Existing shortage of applications software for commercial purposes. Because of the historical orientation of UNIX toward the engineering and scientific community, commercial software has been neglected. With the increasing advent of multiuser systems in a departmental environment, vendors are finding an eager market for software which addresses business needs.

- During the next few years UNIX versions will not only be increasingly compatible, but will also be strengthened functionally to increase their fit into the more heavily networked end-user computing oriented environment of the future. INPUT expects to see better distributed data processing connectivity, improved user interfaces, and faster transaction processing capability.

E. SMALL SYSTEMS OS DIRECTIONS

1. OVERVIEW

- PC-DOS is the primary OS of personal computers. It is a product IBM licenses from Microsoft of Bellevue, WA. It is clear that IBM had no idea as to the incredible acceptance of microcomputers in the business place or it would not have had an outside company develop such a strategic product.

2. IBM'S OFFICE SYSTEM STRATEGY

- Since 1981, when IBM entered the PC marketplace, they have quickly achieved over 50% of the 1985 installed base. In 1985 IBM accounted for almost 60% of business microcomputer shipments.

  - As in the other segments of the information services industry that IBM dominates, their future strategies and products determine the overall market direction.

  - There has been speculation about IBM's microcomputer operating system strategy. Several schools of thought have evolved.

    . IBM will port their mainframe operating system VM down to the microcomputer level.

- IBM will support UNIX on present and future microcomputer product offerings.

- IBM will abandon PC-DOS or adapt it slightly to lock out "PC clones" and close the PC market.

- IBM will continue to support an upgrade of PC-DOS.

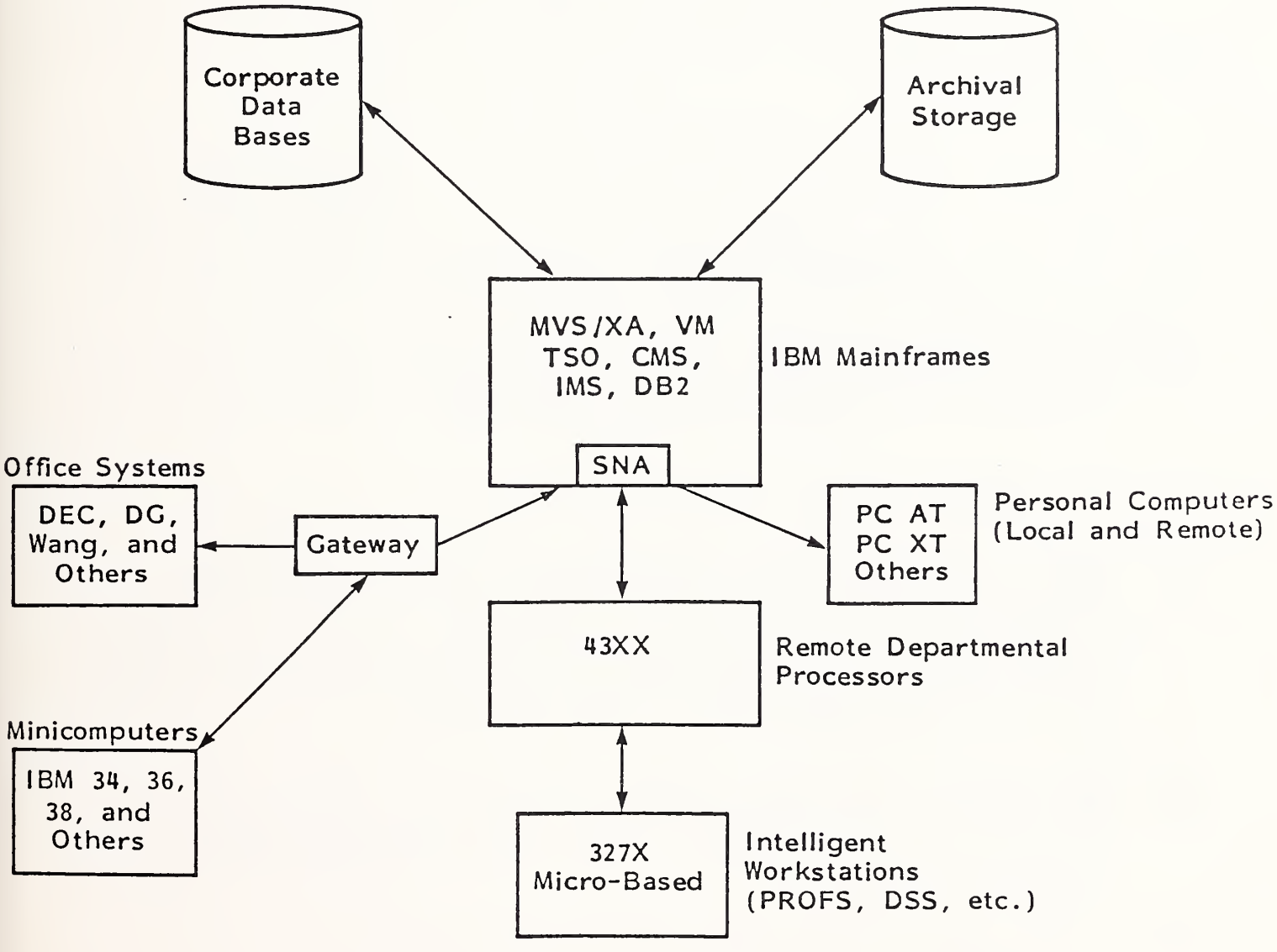
- IBM's microcomputer operating systems strategy must be viewed as part of the company's overall office strategy. Exhibit V-20 shows IBM's idea of centralization and differentiation of functions within the office. Microcomputers are part of the overall configuration linked to the SNA architecture. In Exhibit III-7 they fit within the category of intelligent terminals for display and the control of office products with fewer capabilities.

  - IBM's response to the proliferation of standalone personal computers in the corporate environment has been based on two perceived threats: true off-loading of processing from mainframes, and the potential of personal computers to be used as cheap, intelligent terminals. Over two years ago, Don Estridge of IBM stated: "The PC is communications oriented. The day of the standalone is over." The primary impetus for micro-mainframe links from IBM's point of view is integration. Intelligent workstations are going to become more dependent upon other parts of the system--specifically, mainframe hardware, software, and data.

  - Over a year ago, IBM announced that there were more installed MIPS in PCs than there were in mainframes--and this trend has obviously accelerated since that time. IBM's direction in resource allocation will be to assure that those MIPS are not employed to diminish the ever-increasing demand for mainframe MIPS. Since a high percentage of mainframe MIPS are used to execute IBM operating systems software,

EXHIBIT V-20

IBM CENTRALIZATION AND DIFFERENTIATION OF FUNCTIONS



maintaining central control of resource allocation is not only necessary, but self-fulfilling. This will result in the following:

- As intelligent workstations are added, requirements for mainframe power will increase sharply.

- For every dollar spent on workstations, substantially more will be spent (over the life cycle) on host services (processing and storage).

- Host processing will be extended to the workstation only when it receives its "fair share" of the host operating system burden. (The XT/370 is a good example of how to burn microprocessor MIPS without substantially off-loading mainframes.)

- Considering IBM's overall strategy of centralization, what are its microcomputer operating system options for the future?

a. VM

- IBM runs a version of VM on the PC-RT as well as the XT/370 micro. As previously mentioned, it is not a complete OS in that it has no utilities, resource management, or accounting features, but does allow VM key features such as running multiple OS in a non-370 environment.

- The machine capabilities have limited VM on a micro, but, with an 80386 chip, PC-DOS, UNIX, and SSP could run under VM in a multiuser environment for departmental systems.

b. UNIX

- IBM offers a version for its IBM PC XT called PC/IX. The product is developed by Interactive Systems Corporation, Santa Monica (CA) and costs

$900. IBM's decision to have Interactive Systems rather than Microsoft develop their product could indicate their desire not to be locked into a single third-party vendor for microcomputer operating system products.

- Microsoft, however, offers XENIX for the IBM PC and IBM has announced XENIX for the PC AT as well as an upgraded UNIX PC/IX. INPUT believes this shows IBM's overall ambivalence toward the UNIX marketplace.

- IBM is committed to UNIX insofar as it can sell machines, but as a strategic OS for workstations it is insignificant.

c. PC-DOS

- The micro industry has grown tremendously in the past five years. By 1986, 11 million micros were installed in busines. Along with the increased installed base come more sophisticated end users who have encountered OS problems with PC-DOS that are due primarily to OS constraints.

- More sophisticated users require the ability to address more than the 640 KB of internal memory which is constrained by PC-DOS. Sales of the PC AT have been much slower than IBM has expected due primarily to this factor. The extra $2,000 a user must pay over the price of a PC or PC XT does not provide any more significant capabilities than faster speed of processing.

- When Intel designed the 80286 chip used in the PC AT, it did not allow for an easy redesign of MS-DOS (PC-DOS). Consequently, to extend the chip's power it allowed for two modes.

  - Real mode which emulates the 8088 chip and allows users to utilize their existing base of applications software.

  - Protected mode that utilizes the increased memory of the chip and processes more quickly. In this mode new applications would need to be written.

- Unfortunately, Intel made it difficult to switch between these modes on the 80286 chip.

- Users are asking for a multiuser DOS. Presently to run the PC AT as a multiuser product, UNIX is the only OS that will work. DOS 3.1 is a type of multiuser OS, but for use on a LAN not as a multiuser system.

- Another demand is for multitasking. Topview, IBM's strategic operating environment, is multitasking, but not PC-DOS itself. Concurrent DOS by Digital Research (DRI) is multitasking, but not an IBM OS. DRI is expected to introduce a multiuser, multitasking DOS for the 80386 chip to be shipped at the end of 1986 with new machines by Convergent Technologies. The OS would operate in the protected mode, which means it would not be compatible with existing PC-DOS applications.

d. Proprietary

- IBM is in a difficult position:

  - It is very dependent on Microsoft since it has a large installed base of software for its systems based on Microsoft's DOS.

  - But low-priced PC-clone sales are increasing rapidly under the umbrella of PC-DOS-compatible operating systems produced by Microsoft.

- Consequently, a proprietary OS or operating environment that could "lock-out" compatible vendors yet protect the installed base of PC-DOS users would be very attractive. IBM has told developers to "write to Topview--it's a strategic product."

- Topview is a multiuser, multitasking operating environment.

  - It requires 200K of memory. Consequently, it is not a viable product for existing microcomputers with their limited memory constraints.

  - Software developers are not presently writing software for Topview.

  - Major software packages that write their calls directly to screen (as Lotus and dBase) will not work with Topview.

  - The product, however, will not run on PC clones.

- With the 80386 chip and its inherent increased capabilities and memory, it is possible that Topview could cease being a product unto itself and have its capabilities incorporated in the OS for a consistent user interface for the entire IBM product line from mainframe to micro. Any OS could run under Topview.

- So, IBM may introduce a proprietary workstation OS, but will users convert to it? IBM does not hold the control it once did in computing. More sophisticated users are weighing alternatives. They do not want to be locked into one vendor's OS as in the past if competitive products have good features.

- INPUT sees IBM's microcomputer operating system strategy as a combination of products.

  - The company will continue to want to capitalize on the large installed base of PC-DOS software.

  - INPUT believes that IBM will port VM down to its high-end PC products for the reason of market dominance as well as office centralization around SNA. PC AT-type and as yet unannounced 32-bit products will have the availability of a VM PC host as early as the end of 1987. PC-

DOS software could be run under VM as well as UNIX, but IBM by 1990 will have its own offerings of new software applications taking advantage of Topview as well as VM. Third-party packages will be available for VM, but to a lesser degree. The high-end VM products will be used primarily as minis:

  - Linking to mainframes.
  - Running office automation systems.
  - Used in smaller companies as hosts.

- In the mid- and lower-range PC products, whose function is to be primarily intelligent workstations, there will be some type of concurrent PC-DOS provided, perhaps version 6.0 providing multiuser capability, multitasking, user-friendly interface, windowing, and high speed. Small businesses would also be key purchasers of this product since many units will be sold through VARs (value-added resellers) with vertical packages.

- Another significant trend that affects the transition from single user/single tasking to multiuser/multitasking is technology. The present or near future availability of more powerful 16- and 32-bit microprocessors such as the Motorola 68000, National 16032, and Intel 80386 have stimulated the growth of operating systems from collections of programs to products as powerful as operating systems in mainframes and minicomputers were a few years ago. The new chips provide the ability to address more memory than earlier 8- or 16-bit processors with increased speed. These chip characteristics greatly influence the operating system's ability to solve or at least contribute to solving the user needs mentioned.

3. SMALL SYSTEMS FORECAST

- From an OS perspective, IBM PC-DOS and MS-DOS compatibles are the leaders with 56% of the installed base (see Exhibit V-21). Including extensions into proprietary areas as described above, PC-DOS and its derivatives will dominate the market even more by 1991.

- Proprietary operating systems (such as Apple-DOS) and UNIX will still remain viable, but only from a few large vendors with large installed bases of quality generic applications software packages or specialized quality vertical systems. Apple presently is aggressively soliciting VAR support for the latter approach.

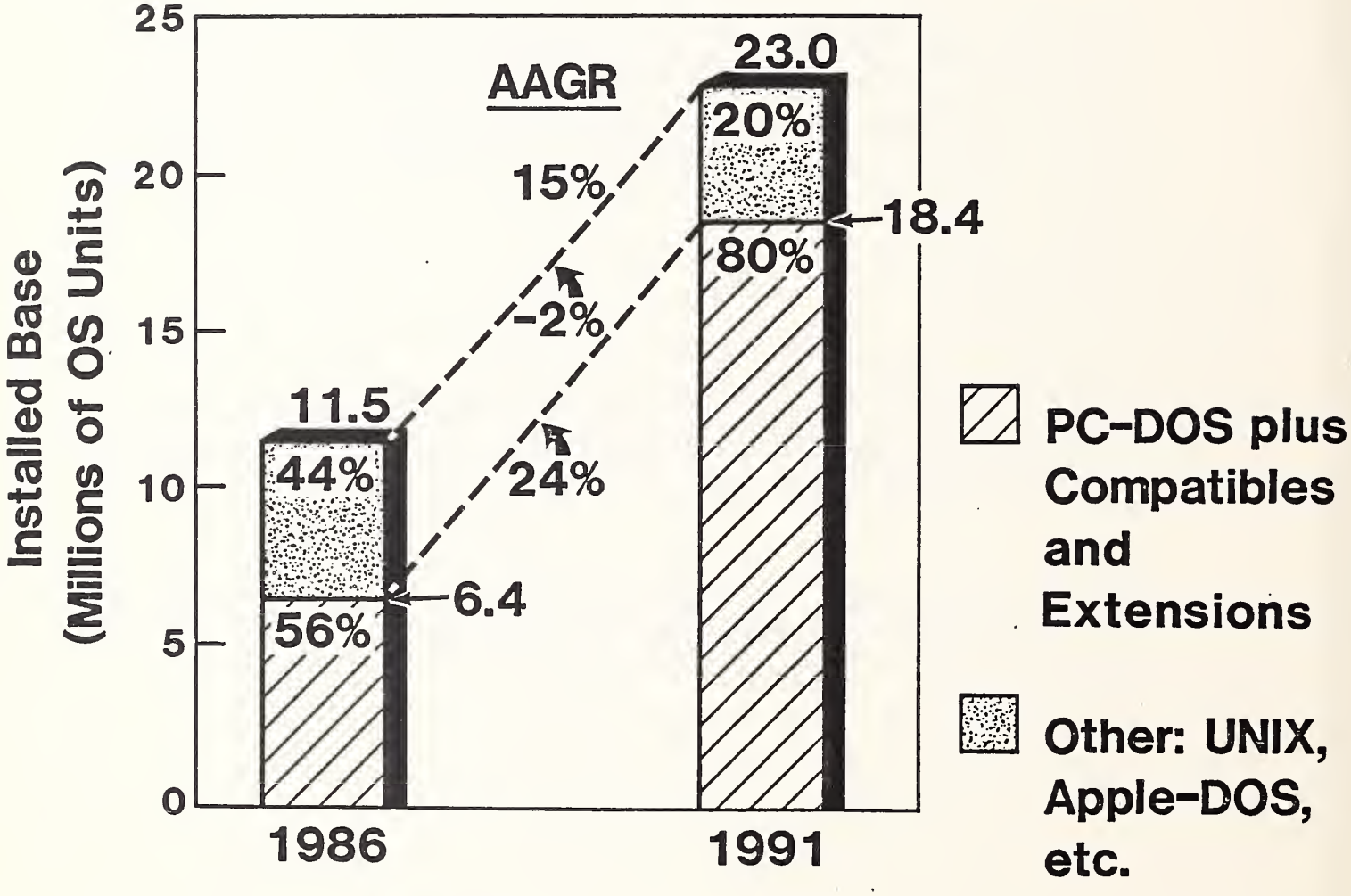
4. CONCLUSIONS

- PC-DOS will be IBM's mainstream microcomputer OS--on standalone systems as the primary OS and on high-end multiuser systems in late 1987 as both the host OS and as a guest under VM.

- IBM will retain an open architecture with DOS but will attempt to move the total environment under control using proprietary products such as VM and Topview.

EXHIBIT V-21

BUSINESS MICROCOMPUTER OS FORECAST



MSP1

VI CONNECTIVITY AND OTHER ISSUES

VI CONNECTIVITY AND OTHER ISSUES

A. OVERVIEW

- With connectivity comes challenges and opportunities related to OS.
  - Is a common OS necessary or will communications protocols suffice?
  - What is IBM's connectivity strategy and how will it relate to OS?

B. IBM'S INTERCONNECT STRATEGIES

1. OVERVIEW

- IBM is encouraging a three-tiered office system strategy--one that includes linking mainframes, minis, and micros.
  - They do acknowledge, however, that not all of their customers will be large enough to need all three different types of computers.
  - The goal of IBM is to increase its revenue from computer sales, and selling three levels of computers and links is consistent with this goal.

- Exhibit VI-1 presents IBM 1985 stated interconnect strategies. In 1986 the strategies have been refined to downplay the PC-Net as a strategic departmental group LAN and include the newly delivered Token-Ring. Originally, this product was planned to be an intermediate departmental LAN linked to a mainframe in the SNA network. However, it is now being marketed also as a work group LAN.

2. SNA AND APPC

- Two protocol products are inherent in IBM's present and future office interconnect strategies (see Exhibit VI-2).

- SNA is IBM's foundation for interconnection in the office environment. There are about 20,000 SNA installations in 1986. One concern relative to SNA's ability to handle future communications needs is its voice transmission capability.

- As users demand DDP, the strategic implications of APPC (Advanced Program to Program Communications) become even clearer. APPC is key to IBM's current and future interconnect strategies in that it provides enhanced SNA support for distributed processing through the evolutionary addition to the System Network Architecture of:

  - Logical Unit Type 6.2 (LU6.2).

  - Physical Unit Type 2.1 (PU2.1).

- Together, LU6.2 and PU2.1 provide the capability for direct communication (peer to peer) between users in a SNA network. This enables applications to converse directly with other applications without the requirement for host intervention.

EXHIBIT VI-1

1985 - IBM'S STATED FOUR INTERCONNECT STRATEGIES*

- DISOSS and Personal Services/PC
- PROFS
- System 36
- PC-Net

*All Under SNA

EXHIBIT VI-2

SNA AND APPC CHARACTERISTICS

- SNA: Set of Protocols Used to Communicate in an Organization's Private Network
  - Rich in Function
  - Hierarchical Structure
- APPC: Defines Two-Way Communications under SNA
  - Key to SNA's Transition from Hierarchical to Peer-to-Peer Structure
  - Key to Universal Network OS

- IBM is using APPC to provide the foundation upon which to build additional distributed processing functions such as:

  - DIA specifies how devices are to interchange content and data; i.e., documents.

  - SNADS provides the asychronous store and forward capabilities for distributing documents throughout a network.

  - SNADS and DIA, in conjunction with DCA, then provide a major part of the architectural definition for major office system products such as DISOSS.

- Most of the other significant vendors in the office system market provide SNA and LU6.2 support for their products for connecting to IBM equipment in the office environment.

3. DISOSS

- DISOSS (DIStributed Office Support Systems) is an interconnect product that is of primary importance to IBM (see Exhibit VI-3 for product components).

  - It is a highly complex and highly functional host product for document file, management, and distribution, providing text compatibility under SNA across computer levels.

  - It runs under DOS or MVS with CICS.

  - It is expensive to acquire ($45,000 license fee, $1,400 monthly charge), and the implementation process takes a long time; consequently, few users have installed it.

EXHIBIT VI-3

DISOSS (DISTRIBUTED OFFICE SUPPORT SYSTEM)

- DIA (Document Interchange Architecture)
- DCA (Document Connect Architecture)
- SNADS (SNA Distribution Services)

- Also impeding the growth of DISOSS is the fact that since it is an architectural type of product, there is a long selling cycle. Users must do a systems design of how it will be incorporated prior to its purchase, which at times creates a tough internal sell.

4. PROFS

- PROFS (Professional Office System), another strategic IBM product, is a VM product for the 43XX series of computers. It provides text processing, e-mail, and scheduling. Infocenter I is a decision support application that supports PROFS on the 43XX host.

  - Rolm recently announced phone mail support to PROFS which is a sign that IBM is beginning to integrate Rolm products strategically to key IBM products.

  - VM/PC was also announced by IBM in which a master tape is put on a host and the program is downloaded to licensed users' disks.

  - Another key announcement is that there is now a bridge between DISOSS and PROFS.

5. OTHER IBM CONNECTING STRATEGIES

- The major backbone of IBM's connectivity strategy involves architecture, protocols, and applications (SNA and DISOSS) as its backbone. These products are primarily host based. However, there are other connectivity strategies that will be of significance over the years.

- In 1990, INPUT believes that 70% of all micros (20 million) will be linked in some form--multiuser, micro-mainframe links, PBX, LAN. IBM's strategy will ultimately include product offerings in all these areas; however, presently only its LAN strategy is obvious.

- IBM offers three different LAN products: cluster program, PC-Net, and Token-Ring.

  - The Cluster Program is for sharing storage and exchanging files. It has a single network interface and can support six users. It will not, however, be a mainstream link product.

  - The PC-Net is for sharing information locally. It is based on broadband technology and distributed through retail channels. The product, however, lacks multiuser software.

  - The Token-Ring is IBM's serious long-term LAN product. It is based on DOS 3.1 and NETBIOS, a network interface specification.

- IBM is targeting its Series 1 computer as a key to office connecting via LANs. It is now DIA/DCA and SNADS supported.

C. OTHER ISSUES

1. CHANGING OBJECTIVES OF OS

- To remain viable, operating systems must change over time to reflect the special characteristics of the computing environment of which they are so integral a part. To assist users and vendors in anticipating certain types of changes in future operating systems, Exhibit VI-4 shows the evolution of five special aspects of this type of software and predicts their future directions.

  - Efficiency of operation, while a relatively low priority in the 1970s, has assumed more importance during the 1980s as information systems budgets come under closer top management scrutiny. The increasing

EXHIBIT VI-4

CHANGING OBJECTIVES OF OPERATING SYSTEMS

OS Objective	Past (1970's)	Present (1980-1985)	Future 1986-1991)	Trend (1985 vs. 1991)
Efficiency of Operation	Low	Medium	Medium	—
Ease of Use	Low	Medium	High	↑
Ease of Modification				
- Non-Standard	Low	Medium	Low	↓
- Standard	Low	Medium	Medium +	↑
Portability	Low	Medium	Medium +	↑
Continuity of Operations	Low	Low	Medium	↑

popularity of on-line systems, with their attendant major demands on systems resources, has also served to highlight the importance of efficient operating systems.

- Ease of use will see the greatest change in emphasis of the five characteristics profiled in this exhibit. Going from a low importance rating in the 1970s, ease of use will rate a "high" during the next five years. A major cause for this important change in emphasis is the proliferation of personal and departmental systems with their reliance on end users rather than data processing professionals for programming and/or operation,

- The ease of modification to the operating systems themselves will increase in importance during the next five years for standard modes (i.e., non-source code related alterations). In contrast, non-standard (i.e., source code changed) modifications will become less significant as users back away from this expensive and time-consuming approach.

- Portability will continue to increase in importance through the end of the decade as mixed-vendor shops become more commonplace.

- Continuity of operations, while slow to acquire importance until recently, will become a very important characteristic during the next five years. The ubiquity of on-line systems combined with their deep involvement in the mainstream of many business operations results in a high value being placed on "staying up" regardless of problems that arise.

2. OBJECT CODE ONLY (OCO)

- IBM's gradual but steady implementation of its Object Code Only (OCO) policy will have important impacts on the strategies of both users and vendors concerned with operating systems directions. This section provides an overview of the issues and implications of this controversial business decision.

- OCO is the practice of not releasing source code of a software product to users or vendors, but instead only providing object code whenever a product is licensed. Adoption of this policy is a difficult decision for any software products vendor because there are clear cut advantages as well as disadvantages to both the customers and the program's owner.

- Exhibit VI-5 summarizes the advantages and disadvantages of OCO for IBM, users, software product vendors, and information services vendor.

  - The net impact of the seven characteristics listed in the table is that IBM realizes the greatest advantage (+5) from the OCO policy.

  - Using this same criteria, users have a net zero advantage. For example, they enjoy less costly conversions and faster conversions because they do not have to worry about having to undo special modifications they may have made to the currently installed software release. On the other hand, OCO reduces the opportunity to incorporate company-unique facilities that require source code modifications in the software.

  - Both software products vendors and other information services vendors receive a net disadvantage (-2), primarily because of their inability to modify source code to create unique competitive-edge facilities.

- INPUT believes that IBM will determinedly pursue an OCO policy, but that user resistance will primarily limit the application of this policy to the release of new products and/or new additions to existing programs. Thus, users and vendors need not fear that overnight their in-place operating systems and/or applications software will become "untouchable."

EXHIBIT VI-5

IMPACT OF IBM'S OBJECT CODE ONLY POLICY

Object Code Only (OCO) Characteristic	Impact On			
	IBM	Users	S/W Vendors	Service Vendors
Faster Conversions	++	+	+	+
Less Costly Conversions	NA	++	+	+
Reduced Opportunity for Company-Unique Features	NA	-	-	--
Reduced Support Costs	+	NA	NA	NA
Enhanced Account Control	++	-	-	-
Higher Barriers to Competition	+	NA	NA	NA
Reduced Opportunity for Add-On Products	-	-	--	-
Total	+5	0	-2	-2

+ = Advantage - = Disadvantage NA = Not Applicable

VII CONCLUSIONS AND RECOMMENDATIONS

VII CONCLUSIONS AND RECOMMENDATIONS

A. XA

- MVS/XA will continue to be IBM's primary host OS throughout the forecast period.
  - New hardware features will require XA support.
  - IBM will manage the complexity of XA whereby users will be able to travel directly from DOS to MVS/XA without first going through MVS.
  - IBM will de-emphasize other OS (except VM).
  - Rate of change in MVS/XA functionality will accelerate.
- INPUT's recommendations are to:
  - Convert/support XA as soon as possible.
  - Use MVS/XA complementary departmental and workstation systems--think through interconnect strategy for cooperative processing.
  - Avoid source code changes.
  - Avoid heavy dependence on specific releases.

B. VM

- VM is and will continue to be a strategic product for IBM. Users are basically very happy with the product and it is a tool for IBM to use to encourage conversion to MVS/XA. Consequently, VM will have a long life.

- Since IBM considers MVS/XA to be its OS of primary importance, there will continue to be deficiencies of VM which will leave opportunities for add-on vendors.

- There will be a convergence of VM toward MVS. The products will continue to be separate, but will interlink with common interfaces whereby users will be able to switch back and forth relatively easily.

- Users should expand VM commitment where appropriate, especially if three levels of computing (with an information center) is an integral part of the IS environment.

C. UNIX

- UNIX has a bright outlook within the IBM 370 architecture world. While MVS and VM will be more popular from an installed base point of view, UNIX will carve out for itself an important role as a third major operating system. INPUT's optimism regarding UNIX stems from a number of factors, including:

  - The evolution of System V as a leading standard.

  - The recognition that many of the UNIX functional deficiencies are temporary and will be overcome via redesigns and additions (including shells).

- The increasing commercial appeal of UNIX.

- Its evolution as a mid-range system operating system, an area anticipated to have explosive growth during the next five years.

- Its ability to effectively co-exist with other operating systems under VM.

- INPUT recommends that users undertake the following approaches concerning UNIX:

  - Select UNIX for business reasons, not because of programmer biases. Programmers assigned to evaluate UNIX as a possible operating system for a future applications software product must be careful that UNIX technical "cult" appeal, which stems from the elegance of its internal design and its reputation among "supertechies," does not override the business considerations required for economic justification.

  - The best match for UNIX is within a computing environment that has these characteristics: mid-range systems are the primary hardware implementation and support is required of a wide variety of vendor hardware.

  - Implement a System V standard UNIX. Avoid features and facilities that are unique to a single vendor, even if that vendor is IBM.

  - Anticipate a primarily VM environment for UNIX implementations in the IBM 370 world.

- Users should expect vendors to:

  - Develop facilities to improve the connectivity of UNIX.

- Develop UNIX shells that improve the appeal to end-user computing environments.

D. DOS

- INPUT believes that IBM will continue to reluctantly enhance DOS/VSE to a modest degree for the next several years. Its main efforts, however, will be to offer tools, aids, and other incentives to facilitate conversion. IBM's first preference is to have a complete conversion away from DOS and onto MVS. If DOS must exist at an installation, IBM wants it as a VM guest, not as a stand-alone system.

- Evidence of IBM's aggressiveness in encouraging DOS to MVS conversion is its acquisition of the nonexclusive marketing rights to UCC TWO, the DOS under MVS system originally developed and still marketed by UCCEL Corporation. UCC TWO enables installations to execute DOS programs under MVS with little or no source code changes.

- Another incentive to conversion which will be heavily utilized by IBM in the ensuing years is the introduction of hardware that has new facilities that are available only to MVS or VM users. Thus, over time the gap between DOS capabilities and the full potential of both medium- and large-scale systems will be lengthened even more.

- Thus, on balance users can anticipate that DOS will shrink but will not die during the next five years. INPUT suggests that:

  - Any installation that anticipates computing growth of more than 20% annually can anticipate conversion pressure to increase significantly as the decade progresses.

- Users recognize that vendors currently offering only DOS applications will seriously evaluate how to extend their offerings up to at least the lower end of the VM or MVS environment.

- Vendors will take advantage of significant opportunities that exist for not only DOS-to-VM, MVS conversion tools and aids, but also for the professional services required to assist installations in making it happen.

E. SMALL SYSTEMS OPERATING SYSTEMS

- IBM's microcomputer products, based on PC-DOS X.X, will continue to have healthy growth rates. In the future, IBM PC AT-type products and above will be able to have multiple operating systems running as guests under VM. This would include an enhanced version of PC-DOS (multiuser, multitasking) and perhaps a third choice such as UNIX. The PC-DOS operating system would allow the usage of PC-DOS applications software from the large installed base. The inclusion of other operating systems would depend upon uniqueness of application packages for that environment as well as the tools for program modification or development available under that specific operating system.

F. CONNECTIVITY

- IBM's connectivity strategy will continue to evolve. In 1987, IBM is expected to introduce a factory LAN to complement its existing product line.

- IBM has successfully implemented links for text transfer (DISOSS) and graphics (GDDM). Links will next be needed for image and voice transfer.

Image transfer will be a viable opportunity before voice. All of these capabilities in the long term will need to be transparent to the end user.

- Users should stay abreast of linking technologies and alternatives but be aware that this area will continue to change very rapidly.

- Vendors should develop complementary products to enhance IBM's linking products; e.g., bridges and gateways. Opportunities for applications for the Token-Ring LAN are substantial--IBM will keep the architecture open for this product in order to capture market position.

- All vendors should develop links and bridges to DISOSS, SNA, and Token-Ring LAN.

APPENDIX A: CASE STUDIES

APPENDIX A: CASE STUDIES

- As described earlier in this report, it is possible (and perhaps even necessary) to view a computer/communications network as a single operating system in terms of both general objectives and essential functions. When the network hierarchy of mainframes, minicomputers, and microprocessors is viewed in this manner, the general architectural trends of centralization, integration, differentiation, and mechanization can be used to recognize and describe operating systems directions.

- It has been INPUT's position that while all of these general architectural trends proceed in parallel, the emphasis of particular vendors varies significantly, and the specific trends are supported in varying degrees by state-of-the art hardware/software technology. Specifically:

  - IBM has traditionally supported a highly centralized, large mainframe-oriented operating systems strategy; whereas, minicomputer technology supports distributed processing and requires operating systems to support the integration of the distributed nodes.

  - The rapid development of microprocessor hardware technology is an obvious precursor of operating system functional differentiation (specialization of function) and mechanization (dedication to a specific function).

- With this in mind, four organizations were selected as case studies based on their relative degrees of adherence to IBM's operating systems strategy. These four organizations can roughly be categorized as follows:

  - Case Study #1 is an organization which closely follows IBM's perceived operating system and networking strategy.

  - Case Study #2 is an organization which has made major modifications within the IBM operating system architecture and is attempting to maintain a presence in both camps between the IBM mainframe orientation and an equally strong (and uncontrolled) minicomputer environment.

  - Case Study #3 is an organization which integrated administrative and engineering processing into an international network.

  - Case Study #4 is an organization (or at least an individual) who believes that current operating systems architectures are obsolete and contribute substantially to the problems associated with the development of high performance, cost effective computer/communications networks. (In other words, operating systems are not meeting their general objectives because they were not designed in anticipation of the current trend toward merging of communications and data processing.)

- During the evaluation of each case, the following terms will be referenced: Level I, Level II, and Level III periods.

A. CASE STUDY #1

- The first case study is a major bank with 30 to 35 mainframe processors (IBM 4361s and above) installed. While software compatible mainframes (such as Amdahl) are considered a viable alternative to IBM hardware, the banks is "true blue" as far as operating systems software is concerned. In fact, the Vice President of Technology Support, who was interviewed for this study, had a sign in his office which literally said, "I'm True Blue," and when asked about it he stated: "We might go red (Amdahl) on hardware, but not on software."

- His view of Amdahl operating systems alternatives and IBM compatible enhancements can be summarized as follows:

  - While they had naturally heard of ASPEN and were curious as to whether it would ever be announced, there was no intention to consider it seriously.

  - It was their understanding that there was a lot of internal competition within Amdahl between ASPEN and UTS (an opinion which seems to be widely shared among Amdahl users), and they could see little use for a UNIX-based mainframe system, such as UTS, in their environment. The internal conflict for resources was considered a good reason to discourage serious consideration of ASPEN even if it were announced.

  - While Amdahl's Multiple Domain extension of MVS was interesting, there was no indication that it was considered of sufficient value to justify incompatibility with IBM.

- Of course, with so many mainframes installed, the question of compatibility exists even if you are "true blue." MVS/XA has been established as a standard on all 308X and above processors, but there is still some MVS 370 around. The intention is to phase it all out by December 1986. (The bank was a beta test

site for MVS/XA so the conversion effort has literally been going on for years.) Even having MVS/XA installed on all of the 30XX processors does not assure everyone will be on the same release, and it was confided that over the years individual locations had made modifications or deviated from the standard.

- In addition, IBM's multiple operating system and DBMS strategy leads to an especially complex operating environment depending upon systems type. For, while MVS/XA is fine for production (batch), it will not support heavy, real time transactions (such as ATMs); the high response required for interactive program development; or the flexibility necessary for decision support systems installed in information centers. Therefore, in addition to MVS/XA, the bank has:

  - TPF installed as a front end, transaction processing switch.

  - Both TSO and CMS installed under VM for development.

  - VM with the XA system facility and up to 12 guests to provide the flexibility for information centers.

- Not surprisingly, IMS is the primary host subsystem (although it was admitted that there was some CICS), but DB2 is required to provide the desired flexibility for decision support. Thus dual DBMS strategy gets rather clumsy across systems where it becomes necessary to extract data from an IMS host production system and build relational tables for DB2 on a development or information center system. The mode of operation can be a batch run with magnetic tape output for reloading on the other system. The impact on ease of use as an operating systems objective and the implications for data base synchronization and integrity are obvious.

- The above is a good example of the impacts of a multiple operating system and DBMS approach on performance (productivity) at all four levels.

- Hardware/Software performance problems dictate separate production, development, and decision support system (although the purpose of IBM's operating systems architecture was originally to support diverse operating environments on large mainframes and avoid duplicating data bases).

- The Human/Machine Dyad refers specifically to the operational complexities that operating systems are designed to address. In the case above, extract runs are scheduled and tapes are mounted, transported, and scheduled to update data bases on another system--all by human beings.

- At the Work Unit level, the tools being used for prototyping on a development system may have unpredictable impacts at the Hardware/Performance level when installed in a different operating environment on a production system. And, the decision support systems must be designed to accommodate the lag between operating and planning (and control) data bases, with the potential for developing inadequate systems in terms of providing timely information.

- At the Institutional level, there is the potential for conflicting management reports, and differences must be resolved in order for the information to have value. (The subject bank has had cases where published numbers have had to be adjusted by tens, and even hundreds, of millions of dollars.)

- Since the case study organization has essentially adopted IBM's software strategy, they are currently in the SNA/DDP strategic period, and a stated objective is the elimination of minicomputers. As the Vice President of Technology Support stated: "I am a 'centralist.' We don't believe in distributed processing the way Citibank has gone about it." Since it has long been INPUT's position that IBM's strategy is directly aimed at eliminating mini-

computers from the processing hierarchy, this was not an unexpected attitude. However, it did lead to the next logical question--what about departmental processors? The answer was that LANs would be installed and LU6.2 would be used to tie them in.

- Responsibility for technology architecture and entry level systems fell outside the realm of the Vice President of Technology Support, who is primarily concerned with engineering network operating systems for mainframes and whose direction is very clear and understandable because it is the IBM strategy. The clarity and direction became substantially less clear when talking with the Vice President of Entry Level Systems, who is confronted with office automation, intelligent workstations, and lower levels in the Network Hierarchy.

- Being an unusually large account, the bank studied is the subject of much special attention from both IBM and competitive vendors. However, the net result of all this inside information and confidential briefings is hardly very illuminating as far as operating systems directions at Levels II and III of the Network Hierarchy are concerned. What the Vice President of Entry Level Systems has been able to discover from numerous trips to IBM, MicroSoft, and other vendors is as follows:

  - An IBM briefing on the System/36 as a departmental processor left him so incensed that he promptly scheduled trips to Wang and Digital. Barring executive pressure from IBM on his management, it is probable he would have committed to an alternative office automation strategy, but IBM can be very persuasive at the executive level. Therefore, the current "no mini" strategy assumes the following:

    . With chip development, it will soon be possible to have the powr of a 370/168 on the desktop, so who needs a mini.

- The form of the desktop processor may be either 370 or PC AT architecture (or maybe both).

- The architecture of the software will "hang the workstations, file servers, and printers on the LAN," and the departmental processor will be an intelligent workstation with more storage for backup and will serve as the gateway to Level I mainframes.

- The unmistakable impression is that the IBM jury is still out as far as Level II in the Network Hierarchy is concerned, and IBM has not yet established a plan which will facilitate moving from the SNA/DDP strategic period to the Electronic Office strategic period.

- At Level III, the direction of Microsoft seems clear as they forge ahead with increased integration, not only under windows, but with the promise of gateways to Level I and interfaces to other intelligent workstations. The Vice President of Entry Level Systems feels comfortable with the candor of Microsoft executives, but there is concern because conversations with IBM give the sense that the Microsoft connection provides only an expedient solution until IBM gets its internal act together.

- It takes a lot of faith to follow IBM's software strategy beyond Level I mainframes (especially for anyone who remembers the 3790, the 8100, and all the cluster controllers which have gone before), but a substantial number of IBM customers have an excess of that. The more serious problem would seem to be that these customers do not have a very clear picture of the operating systems functions which will be required to support advanced technology. For example, the bank has numerous experimental projects going with data base machines and optical memories with little regard for what this will mean in terms of fundamental operating systems functions. In other words, planning seems to be an exercise in accommodating today's hardware devices and existing applications systems with little regard for what LANs, micro-main-

frame links, and potential paperless systems are really all about. (This will be explored in some detail in INPUT's forthcoming study on departmental software.)

- Getting back to some general observations made about IBM mainframe operating systems by the Vice President of Technology Support:

  - MVS is IBM's mainstream operating system--VM will never catch up.

  - VM is really a tool and is difficult to use as a production system. Running MVS/XA under VM continues to exact a substantial performance penalty which simply cannot be tolerated on certain systems.

  - As far as performance measurement is concerned, the belief is that IBM is satisfied to let third-party vendors have the market for monitors to use SMF and RMF data. They have Candle's IMS/MVS installed.

  - Generally speaking, he feels IBM is slow in coming to market with both security and performance monitoring systems. The bank is obviously concerned about security and is evolving a security architecture. At present, RACF is used on mainframes, but they must develop something for TPF, and SNA presents obvious, and unanswered, problems as processing and data bases are distributed. Encryption is being considered as a vital part of the security architecture, but it was not apparent that thinking was very far along on the overall security (or privacy) problems.

- While no specific estimates of the cost of standardizing on IBM's operating systems was obtained, one source estimated that there are approximately 200 systems programmers (+ or -25%) associated with the operation. This would indicate an annual budget approaching $15 million for the care and feeding of the IBM operating systems, plus license fees which probably fall within a range of $8 to $10 million.

B. CASE STUDY #2

- The first case study clearly indicates a lot of tough problems that both IBM and those who adhere closely to its operating systems strategy are confronted with. However, it should be pointed out here that many of the problems do not have any easy technical solutions (especially given the investment in current software systems), and many of the alternatives being proposed in the industry only compound the already existing technical problems associated with distributed processing and data bases. The second case study is of a major university which has a long history of enhancing IBM operating systems while attempting to remain under the general IBM architectural umbrella.

- In order to understand the motivation for developing enhancements to IBM operating systems and for maintaining these enhancements over a 15-year period, it is necessary to review a little history. The Manager of Systems Programming who was interviewed was in a good position to provide this because he has been in his job through seven or eight changes of administrative management of the computer operation, and the question has been raised frequently. His succinct summary provides a brief review of IBM's meandering systems software strategy over the last 20 years.

  - IBM announced System/360 in 1964 with a heavy dependency on operating systems' access methods to support two fledgling concepts which were beginning to appear--timesharing systems (interactive terminal support) and data base management systems. IBM's solutions to both of these developments were QTAM (Queued Terminal Access Method) and ISAM (Indexed Sequential Access Method). With these advanced tools, as opposed to the more rudimentary access methods (BTAM and BDAM), users were supposed to be able to develop and build such systems quite easily.

- A number of internal IBM developments which were outside the mainstream were initially held in reserve for later announcement to address some of the problems, and some are still around (IMS, CICS, and GIS). However, the timesharing problem exposed a flaw in the System/360 architecture--it did not support virtual memory and the top of the line only had 1 meg. of storage. While it was there was substantial defensiveness on the part of the System/360 architects (years later, Gene Amdahl's first effort was not a VS machine), loss of two key accounts (MIT and Bell Labs) prompted IBM to mount a massive effort in the form of the System/360 Model 67 Time Sharing System (TSS).

- Over the next four or five years, IBM poured untold millions into TSS, but few customers (mostly universities) were ever very happy with it. When IBM abandoned TSS (TSO had been announced and System/370 was in the plan), VM continued to develop "out of the mainstream" in IBM, and our case study university decided that TSO, VM (of which it was aware), and IBM's fuzzy DBMS direction were not sufficient to meet its needs. It therefore proceeded to develop its own interactive program development tools, storage management system, resource allocation system, and data base management system.

- Now approximately 15 years later, the university still feels IBM does not provide reasonable timesharing with file sharing. TSO falls short on the timesharing side, and VM falls short on file sharing. While MVS/XA is considered to be a rather neat solution to the addressing problem IBM had, it is felt that IBM remains behind their continuing enhancement work--just as they feel VM will continue to lag behind MVS/XA in IBM's multi-operating system approach.

- As IBM has added attractive features to its operating systems; they have been employed by the complementary enhancements which the university has added. For example, at the present time the systems have preferred guest

status running under MVS/XA (CMS has also been placed under MVS/XA) and take advantage of the Start Interpretive Execution (SIE) assist. With unlimited file systems supported and improved paging rates (as compared to MVS/XA), it is felt that they make better use of the IBM architecture than IBM does.

- The systems programming group also has responsibility for two Amdahl systems which provide services to external customers, and their impression is that Amdahl has not really handled multi-processing very well and their enhanced version of MVS runs 20% slower. The question was also asked about ASPEN and whether or not it would ever be released; the assessment was that it was just an improved "hypervisor," and the interest was literally academic.

- The position which has been established by the university is that intelligent enhancements can be maintained at a level which will keep them ahead of major operating systems improvements by IBM. The interviewee said that new management always questioned why the systems programming group did not accept IBM operating systems as is, but always came around to the position that IBM was not able to provide the performance and functionality they already had. IBM, on the other hand, has been playing catch up for nearly 15 years and has not succeeded. It was the belief of the university that the same principle applied to major operating systems enhancements by vendors; in other words, VM would never catch up with MVS/XA in certain essential functions (as a production system), and a major replacement system such as ASPEN would miss the moving mainstream target (MVS/XA).

- While the central, administrative computer facilities for the university are IBM oriented (a 3084, 3083, and two Amdahls), the academic side of the house is heavily minicomputer oriented (DEC), and the central processors are viewed as a node on Ethernet. By providing access to both DEC and SNA terminals, the central systems programming facility attempts to "keep a foot in both camps." However, the operating environments of the minicomputers are not under the control of the central facility (which does provide electronic mail and centralized data base services across the entire campus).

- Miscellaneous information obtained on various topics is as follows:

  - Although the proprietary DBMS effort (which has been established as a university standard) was not under the systems programming group, it was pointed out that the system was run on the XT 370 within a week after its announcement by IBM. (This was used as an example of the flexibility of in-house developed systems if properly designed.)

  - As an example of the type of maintenance required by operating system enhancements, a major project is currently underway to establish appropriate interfaces to take advantage of Extended Memory on the IBM 3090 processors which the university has on order.

  - In addition, the lack of control and standardization below the mainframe level leads to a continuing effort to support over 60 different types of terminals. Support must be provided to faculty and students with a variety of personal computers both on and off campus through their computer literacy program.

  - Security was stated to be a terrible problem which only gets worse as the network grows. The university has had its own security system, but is in the process of going to RACF on the mainframes. This was not explored in detail, it was pointed out that no security system was effective against skilled systems programmers familiar with the system, and they attempted to keep trusted, long-term employees on security programs. It is possible that merely installing another security package adds an additional level of security beyond an in-house system.

  - Performance monitoring and tuning utilizes RMF statistics, but most of the improvements are associated with specific tuning of systems components developed by the university (paging and I/O activity). Candle products are also used, but network performance presents an

additional level of complexity which is being explored by a Ph.D. in Operations Research.

- The primary quality problem presented by the Manager of Systems Programming was stated in the form of a question: "How do you develop and introduce change without impact on service--or at least perceived impact on service?" At this point, being familiar with the problems in the early days of OS, it is probably appropriate to take off our collective hats to IBM; considering the increased complexity of the operating systems being supported, IBM has certainly improved in this area. In fact, the quality of major IBM systems compares favorably with the relatively simple operating systems associated with personal computers, and IBM is substantially more proficient at introducing change.

- The natural question which is raised by every new manager of the university computing center is: "How much does it cost us to modify and enhance IBM operating systems?" And, this question has a rather surprising answer. The systems programming group has 17 people and a budget of $1.2 million to support four IBM 308X (or equivalent) mainframes and spends $600,000 on software licenses.

  - This means that even with substantial development work (enhancements), the university has 4.5 systems programming support personnel per mainframe compared to an estimated 5.7 per mainframe at the bank in Case Study #1. Since the bank does not make significant enhancements, but does use more operating systems (e.g., TPF), it would appear that enhancements may not be the unnecessary expense which is immediately assumed by data center management.

C. CASE STUDY #3

- While the fundamental system programming philosophies of case studies #1 and #2 may seen quite different (the first humbly accepting IBM's leadership, the second steadfastly blazing its parallel but separate trail), there is a striking affinity in sharing IBM's aversion for minicomputers in the Processing Hierarchy. The third case study involves a semiconductor company which, while maintaining an IBM mainframe orientation for administrative processing, has established an interconnected network of DEC minicomputers.

- The Director of Corporate Information Services (CIS) was interviewed for this study shortly after his department was featured in the in-house monthly newspaper (March 1986). The first paragraph of the article was as follows:

  - "During the past few years, CIS has been diligently turning localized, manual systems throughout the company into global, electronic systems. These advanced, interconnected information systems are bringing us closer, step-by-step, to the highly efficient, 'paperless' society of the future."

  - The article concluded with this quote from the pragmatic Director of CIS: "High tech has got to go high tech. If we don't, we're dead."

- There are three primary networks which are interconnected:

  - An MVS/SNA network hosted off an IBM 3083J operating under MVS/SP and connected to terminals located in eight buildings on the "campus" and two remote locations. In addition, the 3083s 3725 connects to three 4343s through remote 3705s (one in the U.S. and two in the Far East).

- A VM network hosted off an IBM 3081G which connects to the U.S. 4341, a public network (TymNet), various terminal clusters, various workstations (Printronics RJE Stations, Tektronics Workstations, Wang Processors), dial-up home terminals, the campus LANs (through Ethernet and a K200 gateway to the fiber optic backbone connecting the local LANs), and DECNet.

- The DEC Network uses the K200 Gateway for fiber optics connection with six "campus" buildings wired with DECNet and connecting 35 minicomputers (mostly DEC PDP-11 and DEC VAX 7XX), connects with three PDP-11s in the Far East through a DEC MicroVAX II, and uses a LAN bridge to two remote locations in the U.S. with another 30 minicomputers connected on DECNet.

• The MVS to VM, and VM to DEC Network interfaces are depicted in Exhibits A-1 and A-2.

- MVS/XA has not been installed on the 3083 primarily because it is being used primarily as a backend production machine and any addressing problem will surface on the 3081 system which is the primary link to the rest of the world. They are waiting for VM/XA, but have no intention of running MVS under VM. (The Director of CIS stated: "I had MVS under VM twice before I came here and that is (expletive deleted).")

- The VM to DEC Network is relatively self-explanatory except to state that the "SERI Network" connects affiliated organizations in Europe and is the X.21 companion of an MVS/SNA (X.25) network in Europe. (Europe recently rejected IBM's offer of LU6.2 as a standard.) The European networks will not be discussed because they are not under the control of the Director of CIS.

EXHIBIT A-1

MVS TO VM NETWORK INTERFACE

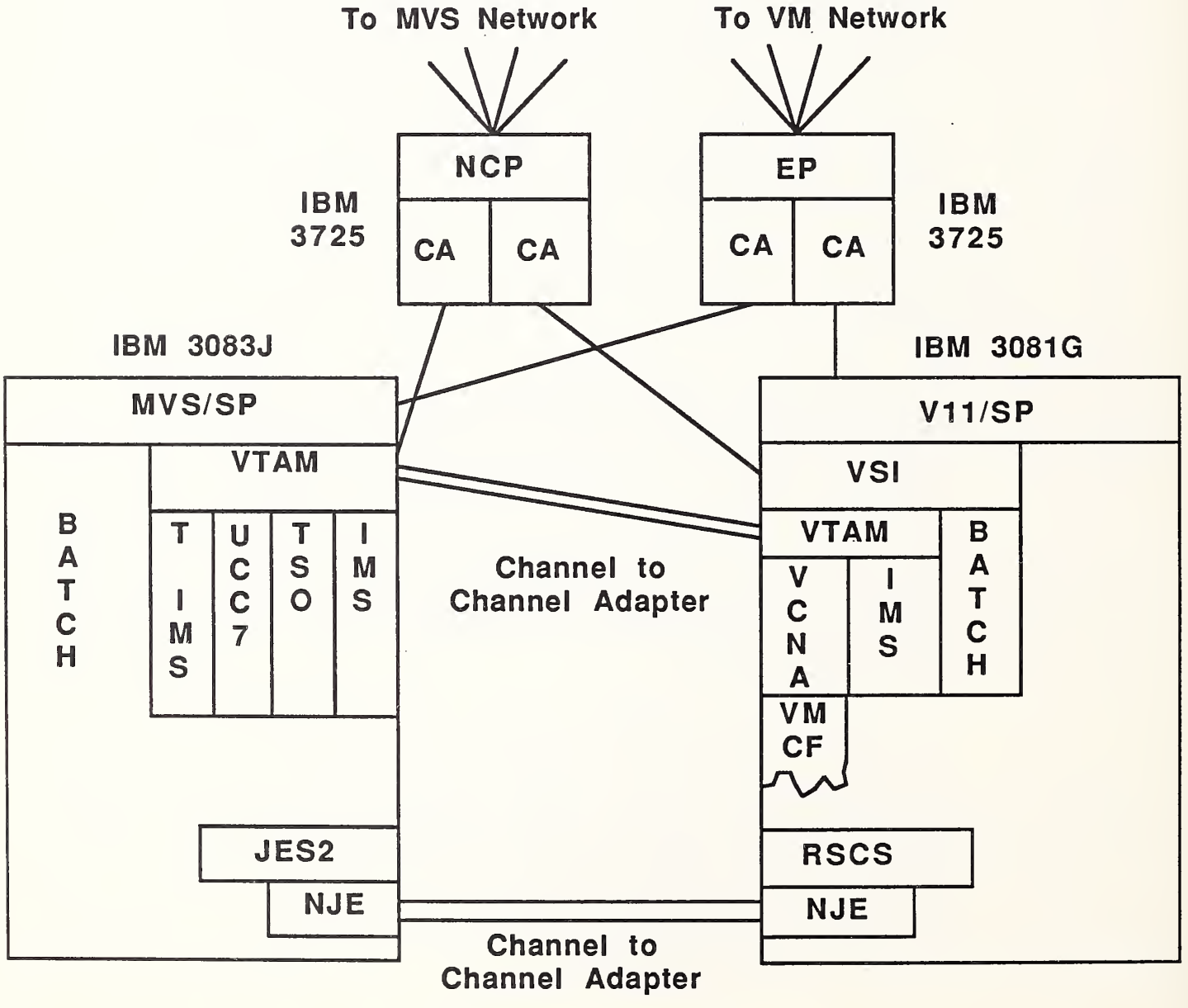
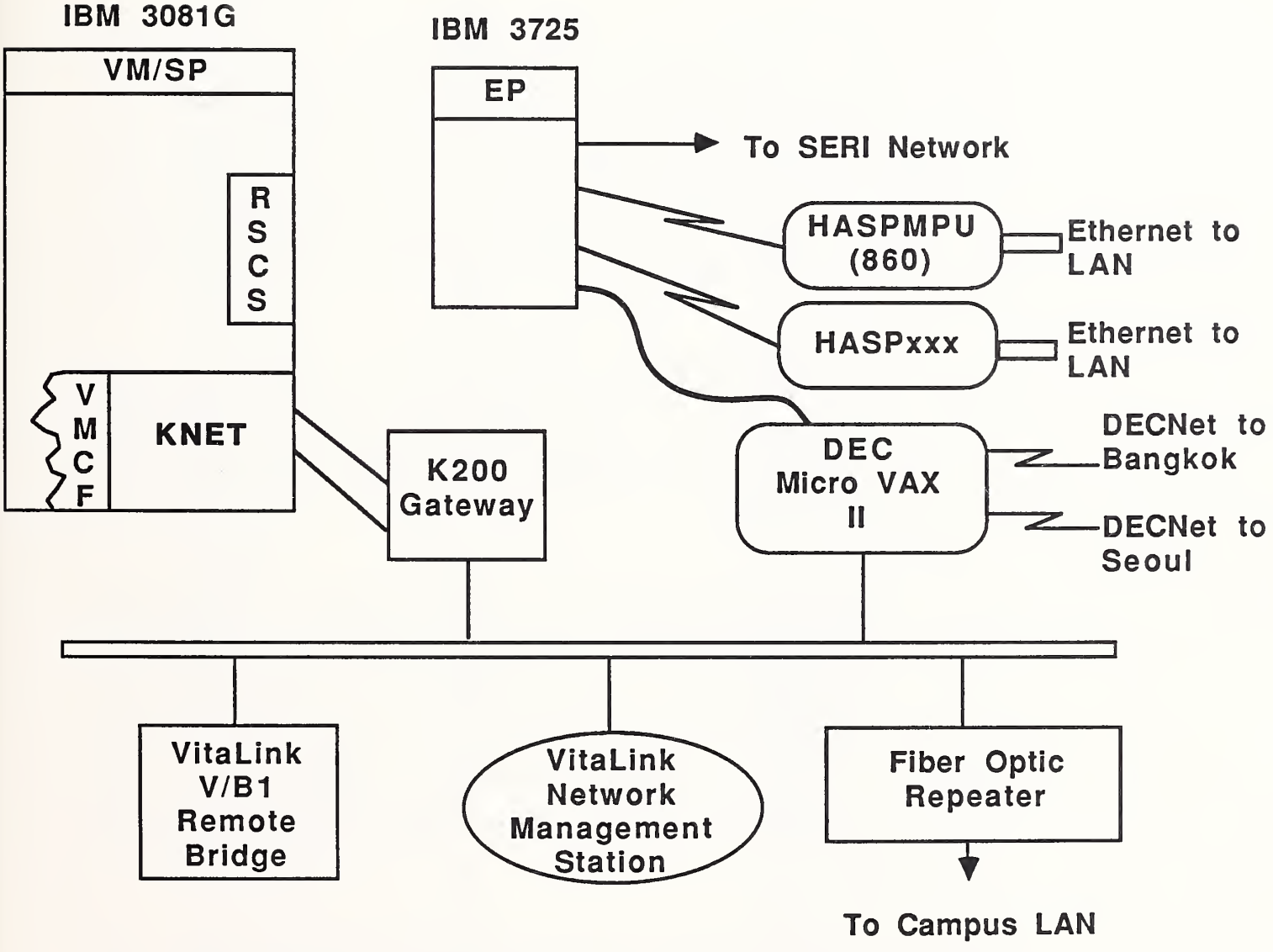


EXHIBIT A-2

VM TO DEC NETWORK INTERFACE



- The general software configurations of the IBM 308X systems as well as complete listings of software products for the IBM systems are shown in Exhibits A-3 and A-4. One of the remote 43XXs operates under MVS and the other two (located in plants) operate under VM. The DEC systems operate primarily under VMS. UNIX is installed on only one system primarily because of security problems. General comments concerning IBM systems software products were:

  - TSO is used to develop the 17 major commercial systems and it has a heavy overhead. FOCUS (under VM) has been used to develop 250 end-user systems, and they are reasonably well satisfied with it. However, the Director of CIS wants to see all development on micros. There are 800 end users tied in through personal computers (95% of which are IBM PCs).

  - They are committed to DISOSS on their LANs, and the Director of CIS feels IBM will announce a 4300 micro which will be VM/DISOSS-oriented as a departmental processor. He also has a rumor--it will not talk to an IRMA board.

  - The 3725 does not have sufficient capacity to provide desired response time on the network, and some administrative data is currently routed over the engineering (DEC network) because of speed. (INPUT has been critical of 37X5s for over ten years because they do not have the capacity to offload network management functions from the mainframes; however, we have stopped predicting when IBM might replace them.)

  - Electronic Data Interchange (EDI) with vendors and customers is of major priority, and they are now in the process of determining the hardware and protocols which must be supported in order to satisfy most of these requirements. (The importance of communications standards is recognized, and the Director of CIS decided years ago that

EXHIBIT A-3

INSTALLED SOFTWARE LIST

Products Run on 3083 CPU and/or 43XX

Product Name	Vendor	Code
ACEP	AAI	n/a
ACF/NCP	IBM	5735-XX9
ACF/SSP (MVS)	IBM	5735-XXA
ACF/VTAM	IBM	5665-280
ACF2	Cambridge Sys Grp	n/a
ASI-ST	ASI	n/a
ASM2	Cambridge Sys Grp	n/a
ASSEMBLER (H)	IBM	5668-962
BEST/1	BGS Systems	n/a
CAPEX		n/a
CAPTURE/MVS	BGS Systems	n/a
CASORT	Computer Assoc.	n/a (Cancelled 2/85)
CBIPO	IBM	5751-CS1,CS2
CDNDT	IBM	5798-DAE
COBOL	IBM	5740-CB1
DATAXPERT	XA Systems	n/a
DF/DSS	IBM	5740-UT3
DFP	IBM	5665-295
DITTO	IBM	5798-ARD
DSF Stand/Alone	IBM	5747-DS1
FASTDASD	Software Corp.	n/a
FAST SCAN Util	IBM	5798-DFN
FOCUS		
FORTRAN	IBM	5734-LM3,???,???
GPSS	IBM	5734-XS2
HDAM Seq Random	IBM	5798-CQG
IMS	IBM	5740-XX2
IMS Auto Op Fac	IBM	5740-XYD
IMS BTS	IBM	5668-948
IMS BTS II	IBM	5796-PGT
IMS DATA COMP	IBM	5798-DCJ
IMS DBDC DICT.	IBM	5740-XXF
IMS Prototype II	IBM	5796-PJK
IMS EMER LOG TRM	IBM	5796-ATN
IMS LOCAL COPY	IBM	5798-CLZ
IMS MAP	IBM	5796-PCY
IMS SPACE UTIL	IBM	5796-PJJ
IMS STRUC MAP	IBM	5796-PBC
INFO	IBM	5665-950,952,953,955
IPCS	IBM	5748-SA1
ISPF	IBM	5668-960
JARS	Computer Assoc.	n/a
JCLCHECK	Triangle Software	n/a
MANAGE/IMS	Computer Assoc.	n/a
MICS	Morino Assoc.	n/a
MVS/IPO	IBM	5750-AA9
MVS/JES2	IBM	5740-XYS
MVS/SP IPO	IBM	5750-AAM
NCCF	IBM	5735-XX6

Continued

EXHIBIT A-3 (Cont.)

INSTALLED SOFTWARE LIST

Products Run on 3083 CPU and/or 43XX

Product Name	Vendor	Code
NETMON	IBM	5796-PPB
NMPF	IBM	5798-DPC
NPDA	IBM	5668-920
OMEGAMON	Candle Corp.	n/a
OMEGAMON/IMS	Candle Corp.	n/a
OPT3270	BMC Software	n/a
PAN/SPF	Pansophics	n/a
PANVALET	Pansophics	n/a
PL/I	IBM	5734-LM4, LM5
PME	Kodak	n/a
PROJACS	IBM	5740-XP1
RACF	IBM	5740-XXH
RDS	Mantissa	n/a
RMF	IBM	5740-XY4
SAS		
SDSF	IBM	5798-DGN
SMP/E	IBM	5668-949
SYNCSORT		
TSO/E	IBM	5665-285
TSO PCF	IBM	5798-CLW
TSO Utils	IBM	5734-UT1
TSO/VTAM Prnt	IBM	5798-CPF
UCC1	UCCEL	n/a
UCC7	UCCEL	n/a
UCC11	UCCEL	n/a
VPS	Levi, Ray, & Shoup	n/a
XeroX 9700	XeroX	n/a

EXHIBIT A-4

INSTALLED SOFTWARE LIST

Products Run on 3081 CPU and Remote Plant 43XXs

Product Name	Vendor	Code
ASSEMBLER/H (HASM)	IBM	5668-962
ACEP	AAI	n/a
ACF2	Cambridge Sys Grp	n/a
ACF/NCP	IBM	5735-XX9
ACF/SSP (VM)	IBM	5735-XXA
ACF/VTAM (VS1)	IBM	5662-280
CCS1-PLOT	Cerritos Comp Serv	1001-420T
COBOL	IBM	5740-CB1
CRWTH	CRWTH Comp.Software	n/a
DCF (SCRIPT)	IBM	5748-XX9
DFDS (VS1)	IBM	5740-AM6
DF/DSS	IBM	5740-UT3
DIRMAINT	IBM	5748-XE4
EP/3725 (VM)	IBM	5735-XXB
FOCUS	Information Builders	n/a
FORTRAN HX	IBM	5734-F03
FORTRAN INT DBG	IBM	5734-F05
FORTRAN VS R3	IBM	5748-F03
FORTRAN VS R4	IBM	5748-F03
GDDM/PGF	IBM	5748-XXH/01,02
Host Doc Intrchg	IBM	5799-BKE
IFPS	Execucom Systems	n/a
IPCS	IBM	5748-SA1
IPF	IBM	5748-MS1
ISPF/PDF	IBM	5668-960 5664-172
KNET	Spartacus	n/a
MINITAB	Minitab	n/a
PASCAL	IBM	5796-PNQ
PASCALX	Imperial College	(n/a)
PASSTHRU	IBM	5748-RC1
PHOENIX CBT	Goal Systems	n/a
PL/I F compiler	IBM	?
PL/I libraries	IBM	5734-LM4, LM5
PROFS (EMAIL)	IBM	5664-176
RSCS	IBM	5748-XP1
RUMMAGE		
SAS		
SIM3278/VM	Simware	n/a
SMART	IBM	5796-PNA
SPEAKEASY		
SSP	IBM	?
STC PM2	STC	n/a
SYNCSORT		
VCNA	IBM	5735-RC5
VLIB	IBM	5796-PNZ
VMAP	IBM	5798-CPX
VM Archive	VM Software Inc	n/a
VM Backup	VM Software Inc	n/a
VM Batch Subsys	IBM	5796-BCY

Continued

EXHIBIT A-4 (Cont.)

INSTALLED SOFTWARE LIST

Products Run on 3081 CPU and Remote Plant 43XXs

Product Name	Vendor	Code
VM/CMS SORT	IBM	5798-BDW
VM IPO	IBM	5750-AAK
VM/SP	IBM	5664-167
VM/SP HPO	IBM	5664-173
VM Tape	VM Software Inc	n/a
VM/370	IBM	5749-010
VRNA (RSCS SNA)	IBM	5798-DMJ
VS1-BPE	IBM	5652-VS1,5662-257
VS1 IPO	IBM	5750-AAB

IBM could not be expected to provide necessary solutions to his problems; he spends considerable outside time on industry efforts to address communications problems.)

- Very little thought has been given to PC operating systems. (There seems to be the general attitude that the top down approach under the greater SNA umbrella will eventually encompass them anyway, and who cares what they are doing when they are not connected.)

- A general review of the non-IBM systems software products (see Exhibits A-3 and A-4) reveals the usual concentration of products which address performance, accounting, and security weaknesses with IBM systems. Performance and security are both recognized as major problems on the network and are scheduled for improvement within CIS's plan. Operating research personnel are assigned to CIS and used for consulting with end users and for addressing network performance problems.

- Current expenditures for license fees for systems on the MVS/SNA network is $585,000 per year. There were staff reductions in CIS during the last year because of the general problems in the semiconductor industry and personnel budget figures were not obtained.

- The focus within the company is clearly on network management and not on the operational problems within individual processors (or processor complexes) except insofar as they represent bottlenecks to information flow. Generally speaking, little attention is given to minicomputer operating systems and no improvement project is scheduled on the DEC systems. However, there is a specific plan in place to upgrade/improve MVS/SNA software. This plan states:

  - "This project involves upgrading installed software products to current levels and releases plus adding two products to provide data for network utilization and performance tuning.

- "The MVS/SNA network at. . .has reached the practical limits of the software installed. Replacing/upgrading the software will provide the safety required to avoid having the software environment restrict business expansion and growth and will keep. . .current."

- The message is simple and has been stated before--IBM operating systems were not originally designed for the communications (network) environment, and as they have evolved since the announcement of SNA over 10 years ago, they have had an endless effort to keep up with user demands. On the other hand, minicomputers do not seem to present too much of a problem, and INPUT continues to believe they have a proper place in the Processing Hierarchy.

D. CASE STUDY #4

- The fourth case study is somewhat unusual in that the interview with an aeorspace company involved with the development of embedded, on-line, real time computer systems was prompted by a published paper on productivity improvement.

- The individual who published the paper serves as assistant to the general manage of a major development laboratory and is also prominent in efforts to improve software engineering productivity. During the interview, it was discovered that he was a pioneer in the development of operating systems for the ground control complex of an early satellite program. We discussed the increased use of satellite communications and fiber optics for business communications and agreed that the volume of data and information being transferred in future business systems will present all of the performance, reliability, and general network development problems which have characterized aerospace systems in the past.

- Aerospace systems are specified in great detail and are open to competitive bidding. In many ways, they are substantially more clearly defined than many of the commercial computer/communications networks which are being considered by both business and government. (In other words, applications and loading of both distributed networks and LANs will be less predictable because of evolutionary hardware/software development over the life of the network or operating system--the ability to accommodate change becomes more significant.) The development laboratory has the opportunity to select the best hardware/software available and make the necessary "make or buy" decisions (in terms of both hardware and operating systems) to be competitive in the bidding process.

- Therefore, the systems being developed represent a variety of processors running under vendor operating systems, modified operating systems, and custom operating systems. These embedded systems are normally mini-computers, but they must in turn interface with both mainframes and micro-processors. The experience with building these systems (networks) to meet specifications in terms of performance and reliability is believed to be highly pertinent to those building hierarchical networks with high standards of reliability, availability, serviceability, and performance.

- The paper contained the following list of "what makes software development hard":

  - Incomplete or inaccuract software requirements.

  - Incomplete or inaccurate interface definition.

  - Trying to fit too much in a given memory space.

  - Trying to do too much computing in too little processing time.

  - Internal conflict for resources.

- Queuing.

- Too many types and/or numbers of interfaces with outside hardare.

- Error detection and correction.

- Documentation.

- Then in commenting on the items which are underlined above, the interviewee stated:

  - "These items belong in the realm of software system architecture and are all facets of the same problem. New microprocessor technology and the associated economics have made these items amenable to solution. It is now far less expensive to purchase more memory and computing capacity than to build software that timeshares or space-shares limited resources. A series of software packages that operates in a given number of time slots on a complex commutated basis is bound to be expensive to develop and will surely have severe design problems. All of the interrupted processes, intermediate storage, stoppage of external (or disk) data transfers, and the total range of internal traffic control are extremely inefficient. As the number of sharing software programs increases, and the commutated time slots thereby decrease, the bulk of computing capacity is spent on internal housekeeping.

  - The interviewee argues that the shared resource concept was developed on the basis of scarce and expensive processing power and memory and involves segmented software, elaborate internal housekeeping software, a commutating system consistent with external demands, priority handling systems, multi-leveled interrupt handling systems, and a sophisticated handler for queuing. He then points out that all of this

does no useful processing of data (it does not facilitate information flow) and only manipulates the software and resources that do the actual data processing. Pushed to the limit, he concluded all resources are dedicated to housekeeping and no useful computing throughput is performed.

- While IBM's MVS/XA and VM operating system strategy is obviously an exaggerated example of the software architecture which is being called into question, the interviewee is specifically concerned about the overhead associated with timeshared, virtual storage systems on minicomputers. He specifically pointed out that microprocessors were achieving the processing power of the VAX 11/750 at one tenth the cost, and distributed (differentiated) software architectures provided attractive alternatives in establishing and meeting the performance objectives of embedded real time systems on a cost-effective basis.

- For those who might question whether these architectural considerations apply to the "real world" of data processing, INPUT concludes that to the degree the future of data processing is associated with computer/communications networks, they do. One has only to look at all of the productivity items listed above to see that they are precisely the problems everyone is struggling with.

- The shared resource mainframe software architecture has been strained for some time and has fueled the demand for host MIPS out of all proportion for the size of networks they have been able to drive. The message in this case study is that minicomputers are going to suffer the same fate as they are expanded to handle larger data bases and heavier network traffic.

- The question now becomes whether or not micros are the key to solving the problems, and INPUT's answer is yes, but. . .

- IBM can be expected to absorb the processing power of 4381s (or 360/168s) on a chip with precisely the same old software architecture that has sold so many mainframes.

- As they begin to integrate increasingly complex operating environments and new storage devices (such as optical memories), the personal computer operating systems may fall into the shared resource "solution" and burden their processors with the same housekeeping overhead associated with their bigger brothers.

APPENDIX B: OPERATING SYSTEM FORECAST BY COMPUTER TYPE

APPENDIX B: OPERATING SYSTEM FORECAST BY COMPUTER TYPE

- Exhibits B-1 through B-11 contain INPUT's market sizes and growth rates for each year from 1985 through 1991 for MVS/XA, MVS, DOS, UNIX, and PC-DOS operating systems running on different IBM and PCM computer modes.

EXHIBIT B-1

OPERATING SYSTEMS FOR ALL
370 ARCHITECTURE COMPUTERS, 1984-1991

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
MVS/XA UNITS	879	1432	2632	4914	6079	8175	10044	11705	35%
MVS/XA %	4	6	10	16	17	18	17	17	
MVS UNITS	4668	6004	7787	9885	10573	12267	14369	14900	14%
MVS %	21	26	30	32	30	28	24	21	
VM CMS UNITS	1098	1211	1552	1929	3233	5371	12284	18158	64%
VM CMS %	5	5	6	6	9	12	21	26	
VM/MVS UNITS	1114	1265	1668	2158	2382	2924	2908	3232	14%
VM/MVS %	5	6	6	7	7	7	5	5	
VM/MVS/DOS UNITS	2100	2055	2114	1970	2170	2556	3423	3270	9%
VM/MVS/DOS %	10	9	8	6	6	6	6	5	
VM/DOS UNITS	1320	1295	1356	1336	1280	1465	1727	1529	2%
VM/DOS %	6	6	5	4	4	3	3	2	
VM/UNIX UNITS	50	126	325	753	1697	4021	6846	9267	95%
VM/UNIX %	0	1	1	2	5	9	11	13	
VM/OTHER UNITS	656	610	588	585	556	694	606	722	4%
VM/OTHER %	3	3	2	2	2	2	1	1	
DOS UNITS	9884	8556	7431	6285	6006	5791	5306	4418	-10%
DOS %	45	37	29	21	17	13	9	6	
UNIX UNITS	150	220	260	568	918	1281	2128	2890	62%
UNIX %	1	1	1	2	3	3	4	4	
OTHER UNITS	162	147	137	127	2	1	0	0	
OTHER %	1	1	1	0	0	0	0	0	
TOT. ALL TYPES OS	22080	22920	25850	30510	34895	44545	59640	70090	22%
TOTAL %	100	100	100	100	100	100	100	100	

- AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-2

OPERATING SYSTEMS FOR 370 ARCHITECTURE
COMPUTERS OVER 2 MIPS, 1984-1991

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
TOTAL MVS/XA	879	1432	2632	4914	6079	8175	10044	11705	35%
% MVS/XA	9	12	17	23	26	29	30	32	
TOTAL MVS/370	3924	5231	6963	9113	9757	11118	12767	13202	14%
% MVS/370	42	45	45	43	42	39	39	37	
TOTAL VM CMS	494	673	952	1187	1064	1132	1337	1522	10%
TOTAL VM CMS %	5	6	6	6	5	4	4	4	
TOTAL VM/MVS	846	1030	1456	1784	1923	2271	2107	2213	9%
TOTAL VM/MVS %	9	9	9	8	8	8	6	6	
TOTAL VM/MVS/DOS	683	788	920	946	910	924	1020	894	-1%
TOTAL VM/MVS/DOS %	7	7	6	5	4	3	3	2	
TOTAL VM/DOS	702	746	847	861	816	810	659	510	-10%
TOTAL VM/DOS %	7	6	5	4	3	3	2	1	
TOTAL VM/UNIX	50	126	228	569	1013	1902	3108	4175	79%
TOTAL VM/UNIX %	1	1	1	3	4	7	9	12	
TOTAL VM/OTHER	150	162	176	208	209	203	72	43	-25%
TOTAL VM/OTHER %	2	1	1	1	1	1	0	0	
TOTAL DOS	1516	1278	1082	1012	998	1030	1034	1023	-1%
% DOS	16	11	7	5	4	4	3	3	
TOTAL UNIX	150	220	260	384	576	629	793	853	27%
% UNIX	2	2	2	2	2	2	2	2	
TOTAL OTHER	35	35	34	32	0	0	0	0	
TOTAL OTHER %	0	0	0	0	0	0	0	0	
TOTAL TOTAL	9430	11720	15550	21010	23345	28195	32940	36140	18%

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-3

OPERATING SYSTEMS FOR 370 ARCHITECTURE
COMPUTERS LESS THAN 2 MIPS, 1984-1991

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
TOTAL MVS/370	745	773	824	772	816	1149	1602	1698	16%
% MVS/370	6	7	8	8	7	7	6	5	
TOTAL VM CMS	604	538	600	742	2169	4239	10947	16636	94%
TOTAL VM CMS %	5	5	6	8	19	26	41	49	
TOTAL VM/MVS	268	235	212	374	459	653	801	1019	37%
TOTAL VM/MVS %	2	2	2	4	4	4	3	3	
TOTAL VM/MVS/DOS	1417	1267	1194	1024	1260	1632	2403	2377	15%
TOTAL VM/MVS/DOS %	11	11	12	11	11	10	9	7	
TOTAL VM/DOS	618	549	509	475	464	655	1068	1019	15%
TOTAL VM/DOS %	5	5	5	5	4	4	4	3	
TOTAL VM/UNIX	0	0	97	184	684	2119	3738	5093	121%
TOTAL VM/UNIX %	0	0	1	2	6	13	14	15	
TOTAL VM/OTHER	506	448	412	377	347	491	534	679	11%
TOTAL VM/OTHER %	4	4	4	4	3	3	2	2	
TOTAL DOS	8368	7278	6349	5273	5009	4761	4272	3395	-12%
% DOS	66	65	62	56	43	29	16	10	
TOTAL UNIX	0	0	0	184	342	652	1335	2037	
% UNIX	0	0	0	2	3	4	5	6	
TOTAL OTHER	127	112	103	95	2	1	0	0	
TOTAL OTHER %	1	1	1	1	0	0	0	0	
TOTAL TOTAL	12650	11200	10300	9500	11550	16350	26700	33950	27%

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-4

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
SUMMIT SERIES

TYPE	1984	1985	1986	1987	1988	1989	1990	1991
SUMMIT : UNITS	0	0	0	0	0	0	100	700
MVS/XA UNITS	0	0	0	0	0	0	45	315
MVS/XA %	0	0	0	0	0	0	45	45
MVS/370 UNITS	0	0	0	0	0	0	10	70
MVS/370 %	0	0	0	0	0	0	10	10
VM CMS UNITS	0	0	0	0	0	0	6	35
VM CMS %	0	0	0	0	0	0	6	5
VM/MVS UNITS	0	0	0	0	0	0	4	21
VM/MVS %	0	0	0	0	0	0	4	3
VM/MVS/DOS UNITS	0	0	0	0	0	0	15	105
VM/MVS/DOS %	0	0	0	0	0	0	15	15
VM/DOS UNITS	0	0	0	0	0	0	4	28
VM/DOS %	0	0	0	0	0	0	4	4
VM/UNIX UNITS	0	0	0	0	0	0	16	126
VM/UNIX %	0	0	0	0	0	0	16	18
VM/OTHER UNITS	0	0	0	0	0	0	0	0
VM/OTHER %	0	0	0	0	0	0	0	0
DOS UNITS	0	0	0	0	0	0	0	0
DOS %	0	0	0	0	0	0	0	0
UNIX UNITS	0	0	0	0	0	0	0	0
UNIX %	0	0	0	0	0	0	0	0
OTHER UNITS	0	0	0	0	0	0	0	0
OTHER %	0	0	0	0	0	0	0	0
TOTAL UNITS OS	0	0	0	0	0	0	100	700
TOTAL % OS	0	0	0	0	0	0	100	100

EXHIBIT B-5

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
309X

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
TOTAL 309X: UNITS	0	400	2050	4250	6350	8000	9250	9925	37%
MVS/XA UNITS	0	152	820	1785	2731	3520	4163	4665	42%
MVS/XA %	0	38	40	42	43	44	45	47	
MVS/370 UNITS	0	140	697	1360	2032	2320	2498	2481	29%
MVS/370 %	0	35	34	32	32	29	27	25	
VM CMS UNITS	0	28	144	255	254	320	370	397	23%
VM CMS %	0	7	7	6	4	4	4	4	
VM/MVS UNITS	0	48	226	468	635	800	648	596	21%
VM/MVS %	0	12	11	11	10	10	7	6	
VM/MVS/DOS UNITS	0	8	41	43	64	80	93	0	
VM/MVS/DOS %	0	2	2	1	1	1	1	0	
VM/DOS UNITS	0	20	82	128	127	160	93	99	4%
VM/DOS %	0	5	4	3	2	2	1	1	
VM/UNIX UNITS	0	4	41	213	508	800	1388	1687	110%
VM/UNIX %	0	1	2	5	8	10	15	17	
VM/OTHER UNITS	0	0	0	0	0	0	0	0	
VM/OTHER %	0	0	0	0	0	0	0	0	
DOS UNITS	0	0	0	0	0	0	0	0	
DOS %	0	0	0	0	0	0	0	0	
UNIX UNITS	0	0	0	0	0	0	0	0	
UNIX %	0	0	0	0	0	0	0	0	
OTHER UNITS	0	0	0	0	0	0	0	0	
OTHER %	0	0	0	0	0	0	0	0	
TOTAL UNITS OS	0	400	2050	4250	6350	8000	9250	9925	
TOTAL % OS	0	100	100	100	100	100	100	100	

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-6

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
308X

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
308X HARDWARE BASE	3900	3900	3940	3965	3880	3545	3105	1950	-13%
MVS/XA UNITS	624	702	788	952	1086	1134	1025	702	-2%
MVS/XA %	16	18	20	24	28	32	33	36	
MVS UNITS	2145	2106	2049	1983	1940	1702	1459	878	-16%
MVS %	55	54	52	50	50	48	47	45	
VM CMS UNITS	117	156	158	159	116	71	62	20	-34%
VM CMS %	3	4	4	4	3	2	2	1	
VM/MVS UNITS	429	390	394	357	310	213	186	98	-24%
VM/MVS %	11	10	10	9	8	6	6	5	
VM/MVS/DOS UNITS	312	273	276	238	194	142	93	39	-32%
VM/MVS/DOS %	8	7	7	6	5	4	3	2	
VM/DOS UNITS	117	117	118	119	78	71	31	20	-30%
VM/DOS %	3	3	3	3	2	2	1	1	
VM/UNIX UNITS	0	39	39	40	78	142	186	176	35%
VM/UNIX %	0	1	1	1	2	4	6	9	
VM/OTHER UNITS	39	39	39	40	39	35	31	0	
VM/OTHER %	1	1	1	1	1	1	1	0	
DOS UNITS	117	78	79	79	39	35	31	20	-24%
DOS %	3	2	2	2	1	1	1	1	
UNIX UNITS	0	0	0	0	0	0	0	0	
UNIX %	0	0	0	0	0	0	0	0	
OTHER UNITS	0	0	0	0	0	0	0	0	
OTHER %	0	0	0	0	0	0	0	0	
TOTAL UNITS OS	3900	3900	3940	3965	3880	3545	3105	1950	
TOTAL % OS	100	100	100	100	100	100	100	100	

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-7

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
303X

TYPE	1984	1985	1986	1987	1988	1989	1990	1991
303X: UNITS	2030	1320	760	295	115	50	20	0
MVS/XA UNITS	0	0	0	0	0	0	0	0
MVS/XA %	0	0	0	0	0	0	0	0
MVS/370 UNITS	244	251	167	71	33	17	7	0
MVS/370 %	12	19	22	24	29	33	37	0
VM CMS UNITS	162	106	61	24	8	4	1	0
VM CMS %	8	8	8	8	7	7	7	0
VM/MVS UNITS	142	92	61	24	9	4	2	0
VM/MVS %	7	7	8	8	8	8	8	0
VM/MVS/DOS UNITS	81	53	23	9	2	1	0	0
VM/MVS/DOS %	4	4	3	3	2	2	2	0
VM/DOS UNITS	365	238	129	50	20	8	3	0
VM/DOS %	18	18	17	17	17	15	14	0
VM/UNIX UNITS	0	0	8	3	1	1	0	0
VM/UNIX %	0	0	1	1	1	2	2	0
VM/OTHER UNITS	61	40	23	12	5	2	1	0
VM/OTHER %	3	3	3	4	4	4	4	0
DOS UNITS	954	528	281	103	37	15	5	0
DOS %	47	40	37	35	32	29	26	0
UNIX UNITS	0	0	0	0	0	0	0	0
UNIX %	0	0	0	0	0	0	0	0
OTHER UNITS	20	13	8	0	0	0	0	0
OTHER %	1	1	1	0	0	0	0	0
TOTAL UNITS OS	2030	1320	760	295	115	50	20	0
TOTAL % OS	100	100	100	100	100	100	100	0

EXHIBIT B-8

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
4381 SERIES

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
TOTAL 4381: UNITS	2000	3900	6200	9300	9400	12900	16500	19300	25%
MVS/XA UNITS	180	468	868	1953	1974	3225	4455	5597	45%
MVS/XA %	9	12	14	21	21	25	27	29	
MVS/370 UNITS	1160	2184	3348	4836	4888	6192	7920	8878	22%
MVS/370 %	58	56	54	52	52	48	48	46	
VM CMS UNITS	140	273	434	558	470	516	660	772	12%
VM CMS %	7	7	7	6	5	4	4	4	
VM/MVS UNITS	200	390	620	744	752	1032	990	1158	13%
VM/MVS %	10	10	10	8	8	8	6	6	
VM/MVS/DOS UNITS	140	234	372	465	470	516	660	579	9%
VM/MVS/DOS %	7	6	6	5	5	4	4	3	
VM/DOS UNITS	100	195	310	372	376	387	330	193	-9%
VM/DOS %	5	5	5	4	4	3	2	1	
VM/UNIX UNITS	20	39	62	186	282	774	1320	1930	99%
VM/UNIX %	1	1	1	2	3	6	8	10	
VM/OTHER UNITS	20	39	62	93	94	129	0	0	
VM/OTHER %	1	1	1	1	1	1	0	0	
DOS UNITS	40	78	124	93	94	129	165	193	9%
DOS %	2	2	2	1	1	1	1	1	
UNIX UNITS	0	0	0	0	0	0	0	0	
UNIX %	0	0	0	0	0	0	0	0	
OTHER UNITS	0	0	0	0	0	0	0	0	
OTHER %	0	0	0	0	0	0	0	0	
TOTAL UNITS OS	2000	3900	6200	9300	9400	12900	16500	19300	
TOTAL % OS	100	100	100	100	100	100	100	100	

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-9

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
4331/4361 AND NEW CMOS 4300

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
4361 AND BELOW UNITS:	11200	10100	9700	9200	11400	16300	26700	33950	28%
MVS UNITS	672	707	776	736	798	1141	1602	1698	17%
MVS %	6	7	8	8	7	7	6	5	
VM CMS UNITS	560	505	582	736	2166	4238	10947	16636	96%
VM CMS %	5	5	6	8	19	26	41	49	
VM/MVS UNITS	224	202	194	368	456	652	801	1019	39%
VM/MVS %	2	2	2	4	4	4	3	3	
VM/MVS/DOS UNITS	1344	1212	1164	1012	1254	1630	2403	2377	15%
VM/MVS/DOS %	12	12	12	11	11	10	9	7	
VM/DOS UNITS	560	505	485	460	456	652	1068	1019	16%
VM/DOS %	5	5	5	5	4	4	4	3	
VM/UNIX UNITS	0	0	97	184	684	2119	3738	5093	121%
VM/UNIX %	0	0	1	2	6	13	14	15	
VM/OTHER UNITS	448	404	388	368	342	489	534	679	12%
VM/OTHER %	4	4	4	4	3	3	2	2	
DOS UNITS	7280	6464	5917	5060	4902	4727	4272	3395	-11%
DOS %	65	64	61	55	43	29	16	10	
UNIX UNITS	0	0	0	184	342	652	1335	2037	
UNIX %	0	0	0	2	3	4	5	6	
OTHER UNITS	112	101	97	92	0	0	0	0	
OTHER %	1	1	1	1	0	0	0	0	
TOTAL OS UNITS	11200	10100	9700	9200	11400	16300	26700	33950	

* - AVERAGE ANNUAL GROWTH RATE

EXHIBIT B-10

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
SYSTEM 360/370

TYPE	1984	1985	1986	1987	1988	1989	1990	1991
360/370: UNITS	1450	1100	600	300	150	50	0	0
MVS UNITS	73	66	48	36	18	8	0	0
MVS %	5	6	8	12	12	15	0	0
VM CMS UNITS	44	33	18	6	3	1	0	0
VM CMS %	3	3	3	2	2	2	0	0
VM/MVS UNITS	44	33	18	6	3	1	0	0
VM/MVS %	3	3	3	2	2	2	0	0
VM/MVS/DOS UNITS	73	55	30	12	6	2	0	0
VM/MVS/DOS %	5	5	5	4	4	4	0	0
VM/DOS UNITS	58	44	24	15	8	3	0	0
VM/DOS %	4	4	4	5	5	5	0	0
VM/UNIX UNITS	0	0	0	0	0	0	0	0
VM/UNIX %	0	0	0	0	0	0	0	0
VM/OTHER UNITS	58	44	24	9	5	2	0	0
VM/OTHER %	4	4	4	3	3	3	0	0
DOS UNITS	1088	814	432	213	107	34	0	0
DOS %	75	74	72	71	71	68	0	0
UNIX UNITS	0	0	0	0	0	0	0	0
UNIX %	0	0	0	0	0	0	0	0
OTHER UNITS	15	11	6	3	2	1	0	0
OTHER %	1	1	1	1	1	1	0	0
TOTAL OS UNITS	1450	1100	600	300	150	50	0	0
TOTAL OS %	100	100	100	100	100	100	0	0

EXHIBIT B-11

OPERATING SYSTEM FORECAST BY COMPUTER TYPE
PLUG COMPATIBLE MANUFACTURERS (PCM)

TYPE	1984	1985	1986	1987	1988	1989	1990	1991	AAGR* '86-'91
PCM UNITS	1500	2200	2600	3200	3600	3700	3965	4265	10%
MVS/XA UNITS	75	110	156	224	288	296	357	427	22%
MVS/XA %	5	5	6	7	8	8	9	10	
MVS/370 UNITS	375	550	702	864	864	888	872	896	5%
MVS/370 %	25	25	27	27	24	24	22	21	
VM CMS UNITS	75	110	156	192	216	222	238	299	14%
VM CMS %	5	5	6	6	6	6	6	7	
VM/MVS UNITS	75	110	156	192	216	222	278	341	17%
VM/MVS %	5	5	6	6	6	6	7	8	
VM/MVS/DOS UNITS	150	220	208	192	180	185	159	171	-4%
VM/MVS/DOS %	10	10	8	6	5	5	4	4	
VM/DOS UNITS	120	176	208	192	216	185	198	171	-4%
VM/DOS %	8	8	8	6	6	5	5	4	
VM/UNIX UNITS	30	44	78	128	144	185	198	256	27%
VM/UNIX %	2	2	3	4	4	5	5	6	
VM/OTHER UNITS	30	44	52	64	72	37	40	43	-4%
VM/OTHER %	2	2	2	2	2	1	1	1	
DOS UNITS	405	594	598	736	828	851	833	810	6%
DOS %	27	27	23	23	23	23	21	19	
UNIX UNITS	150	220	260	384	576	629	793	853	27%
UNIX %	10	10	10	12	16	17	20	20	
OTHER UNITS	15	22	26	32	0	0	0	0	
OTHER %	1	1	1	1	0	0	0	0	
TOTAL UNITS OS	1500	2200	2600	3200	3600	3700	3965	4265	
TOTAL % OS	100	100	100	100	100	100	100	100	

* - AVERAGE ANNUAL GROWTH RATE

APPENDIX C: RECONCILIATION

APPENDIX C: RECONCILIATION

- Many of the market forecast numbers in this study differ in varying degrees from the data INPUT presented in the client seminar held in late April 1986. As was mentioned during the seminars, the information presented was preliminary and subject to more in-depth analysis.

- Since that time, additional data was gathered that caused us to reassess our assumptions in the computer marketplace which consequently affected our operating systems forecasts.

- The major factor that impacted our findings was the downward migration of the 43XX primarily via a low-end CMOS family of products for mid-range processing.

  - Since the product family will not incur major shipments until 1988, the base line forecasts were only altered marginally while the 1991 forecasts reflected significant changes.

  - By 1991, this family is expected to have over 23,000 units of the 370 architecture installed base, most of which will be running VM alone or with guests, thus altering the VM and VM/UNIX forecasts.

- In our seminar we also projected the introduction of the Summit series of mainframes in 1988 and another mainframe family in 1990. After additional analysis, we concluded that IBM would not introduce new families so close to

the introduction of the Sierra series in 1985. This move we concluded would cut off potential sales of 3090 products before their time. Consequently, INPUT projects that the Summit series will be announced in 1989 and begin shipments in 1990. This change has caused a lowering of the MVS/XA forecast since that will be the primary OS of these computers.

- In the mid-range area, INPUT originally underestimated the number of Series I in the installed base of 1986. This new installed base for Series I of 70,000 units increased our 1986 mid-range installed base found within this study.

- Overestimated for the seminar in April 1, 1986, was the retirement rate of System 36/38 and Series 1. Decreasing the retirement rate of these products increased their share of the forecast installed base of mid-range systems in 1991.