IMPACT OF OFFICE SYSTEMS ON PRODUCTIVITY

INPUT

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INPUT Planning Services for Management

IMPACT OF OFFICE SYSTEMS ON PRODUCTIVITY

ABSTRACT

This report establishes a framework for understanding office productivity problems and for evaluating white-collar workers' performance. The report defines four productivity performance levels and evaluates current and advanced office systems at each level. Office work is analyzed from both a functional and a cost perspective to provide a foundation for the productivity analysis.

This report contains 117 pages, including 23 exhibits.

U-OSP-197
November 1983

INPUT

IMPACT OF OFFICE SYSTEMS ON PRODUCTIVITY

NOVEMBER 1983

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IMPACT OF OFFICE SYSTEMS ON PRODUCTIVITY

CONTENTS

EXHIBITS

I INTRODUCTION

I INTRODUCTION

- There is great concern about the productivity of white-collar workers both at a national level and among information systems managers. This concern was borne out by the topic selections for this years' Information Systems Program (ISP) reports. Both office productivity and cost justification for office systems were selected by clients as major topics.

- In structuring the research programs for the two reports, it became apparent that the two subjects were closely related since cost justification of office systems should be based upon improved productivity. However, even preliminary research demonstrated that the productivity of white-collar workers is an extremely complex subject, and current office systems have only begun to address the problem.

- It was therefore determined that the two reports logically fell into a sequence requiring separate, but related, research programs. Essentially, the foundation for this report has been ongoing INPUT research spanning a number of projects during the past several years. This has been supplemented by telephone interviews with numerous major office systems vendors in order to obtain reference sources.

- It was also determined that detailed analysis of the theoretical limitations of current measurement techniques (including mathematics itself) was required, and significant papers are cited in this regard. The referenced documents were selected not only for technical quality and pertinence but also for their ability to be understood.

- This report establishes a framework for understanding the productivity problem and for evaluating performance at four levels. Current and advanced office systems are evaluated within this framework.

- The related INPUT report is entitled Methods of Cost/Benefit Analysis for Office Systems, September, 1983. Its purpose is to extend the conclusions and recommendations of this report.

II EXECUTIVE SUMMARY

II EXECUTIVE SUMMARY

- Note: this executive summary is designed in a presentation format in order to:

  - Help the busy reader quickly review the main conclusions and recommendations.

  - Provide a useful presentation to facilitate group communications.

- The key points of the entire report are summarized in Exhibits II-1 through II-7. On the left-hand page facing each exhibit is a script explaining its contents. The underlying technical and theoretical basis for the conclusions require careful reading of the report (and perhaps of some of the references) to be fully understood.

- The complexity of the office productivity problem should not be over-simplified, or "solutions" will be accepted that may exacerbate rather than relieve the problem.

A. OFFICE SYSTEMS TARGET: PROFESSIONALS AND MANAGERS

- The emphasis in office systems has shifted away from clerical staff and toward managerial and professional workers. The reasons for this shift are readily apparent from even a rough comparison of office salary costs, as shown in Exhibit II-1.

  - Managerial and professional personnel together represent approximately 68% of total office salary costs.

  - Secretaries and typists (where current office automation products have been directed) represent only 8.7% of total office costs.

  - Vendors aim at the more lucrative target.

- Viewed by function, the product concentration is even more striking.

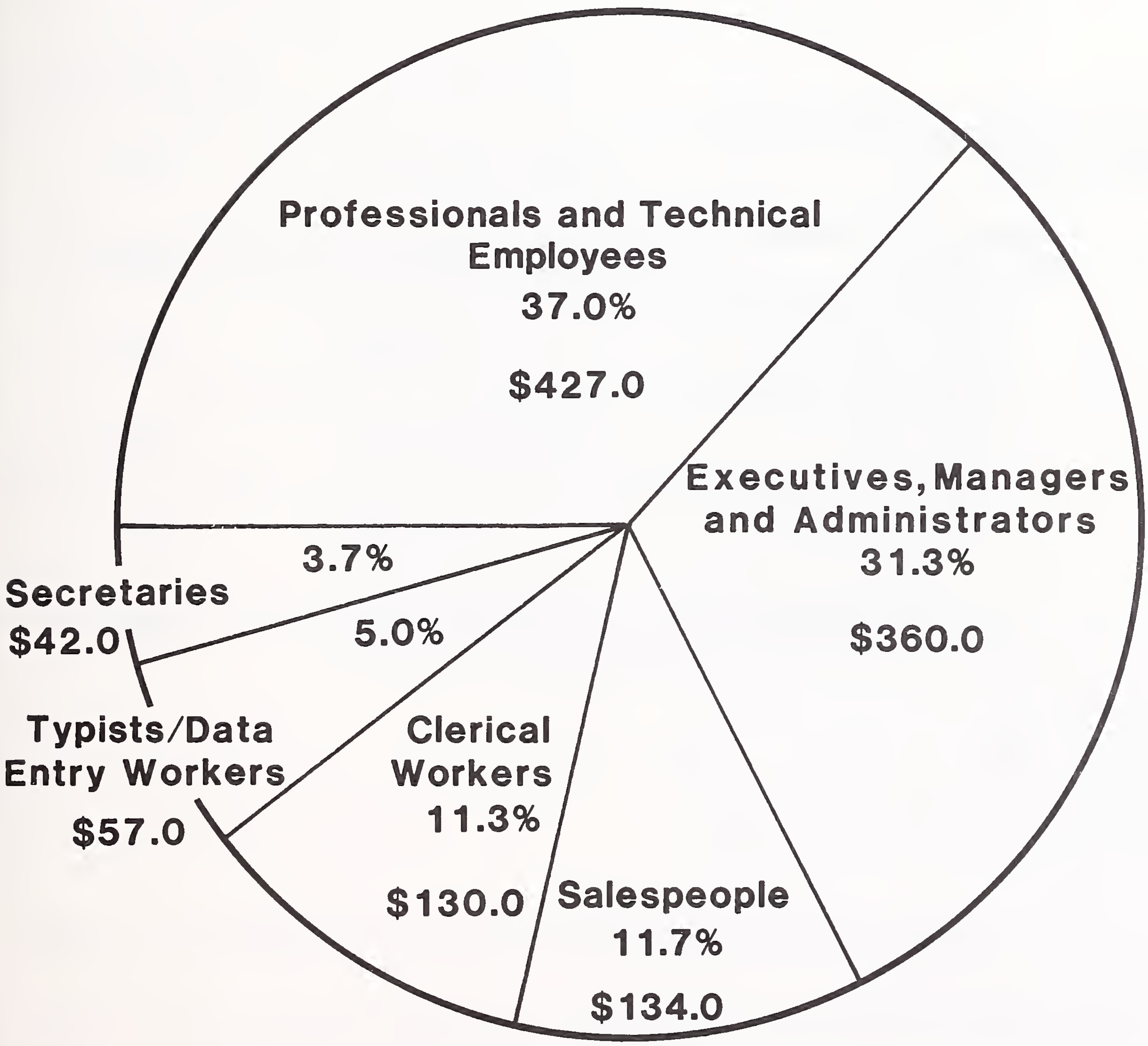
  - Word processing systems, which have been practically synonymous with office automation, could eliminate only 3.8% of office costs even if all typing were eliminated.

  - On the other hand, the relatively nebulous functions of interpersonal communications, analysis, and decision making constitute nearly half of total office expenses (47.2%), making them an important target for improved productivity.

- The reason typing functions have been targeted in the past is quite simple - their performance is easily measured because they produce a tangible product. Productivity improvement could therefore be identified, and equipment investment could be cost justified. Measuring productivity improvements of managerial and professional employees, on the other hand, has been and is more difficult because their "products" are less tangible. Nevertheless, even a modest improvement in their productivity represents a large payoff.

EXHIBIT II-1

OFFICE SYSTEMS TARGET: PROFESSIONALS AND MANAGERS



Total: $1,150 Billion

White-collar Salary Costs, 1981 ($ billions)

B. HIGHEST PRICED OFFICE SYSTEMS ACTIVITIES

- INPUT classifies office costs by six job categories with eight functions per category.

- Based on INPUT's research and years of experience, these activities can be ranked according to total salary costs across all industries and departments.

- The six highest ranked activities comprise over 50% of total white-collar salary costs.

- These six activities are evenly split between professional and technical, executive, managerial, and administrative job categories.

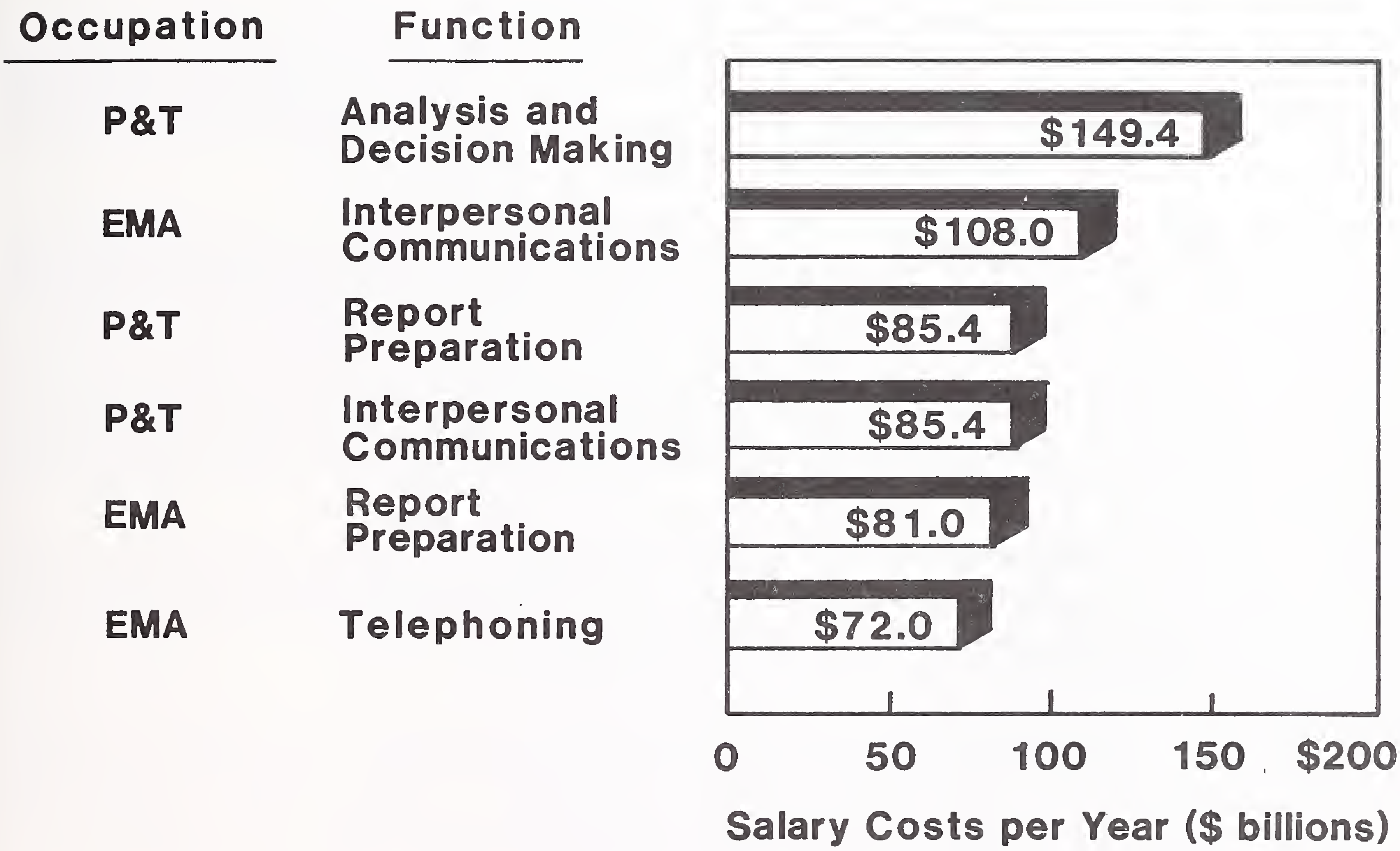
- Professional and technical account for three of the top four areas.

- Interpersonal communications and telephone functions account for 50% of the top-ranked activities.

- These are the office activities that offer significant potential for productivity improvements due to their dominance of office costs.

EXHIBIT II-2

HIGHEST PRICED OFFICE SYSTEMS ACTIVITIES



P&T = professional and technical occupations

EMA = executive, managerial, and administrative occupations

C. PERFORMANCE LEVELS IMPROVE PRODUCTIVITY ANALYSIS

1. PERFORMANCE LEVELS I AND II

- For purposes of productivity analysis, four performance levels have been established, the first two of which are shown in Exhibit II-3.

  - Performance Level I (PL-I) represents the hardware/software system that exists to support, and theoretically improve, all of the higher performance levels. The software can be viewed as establishing the interfaces (languages) to support the higher levels.

  - Performance Level II (PL-II) is used to analyze the interaction of the human-to-computer dyad, which is presently accomplished manually. Therefore, the performance at this level not only depends upon the effectiveness of the languages available to the dyad, but also upon the manual skill of the human at the terminal.

- Vendor claims to the contrary, investment in improving productivity at each performance level can be justified only insofar as it contributes to improved performance (productivity) at a higher level.

  - Hardware/software systems and technology in general cannot be justified simply because they are state of the art, even if information systems personnel feel the systems advance their career objectives.

  - Justification of a word processing system should not be based on improved efficiency of typists if the effectiveness of professionals is impaired by slow turnaround from a centralized word processing system.

  - Easy copying and distribution of paper documents may create handling problems and result in unnecessary analysis of meaningless or misdirected information.

EXHIBIT II-3

PERFORMANCE LEVELS IMPROVE PRODUCTIVITY ANALYSIS

Performance Level	Primary Functions
I. Hardware/Software (PL-I)	Support of All
II. Human-to-computer Dyad (PL-II)	Typing Copying Telephoning Dictating

2. PERFORMANCE LEVELS III AND IV

- Performance Level III (PL-III) associates performance with a work unit network (organization) that has been established to accomplish certain tasks.

  - The terminology "work unit network" is significant in that it implies formal and informal interorganizational dependencies, or relationships that are expected to increase as more employees interface with computer/communications networks.

  - Work unit networks at PL-III are characterized primarily by communications between human beings, whether face to face or by telephone, written reports, or electronic messages. Practically all such communications today are paper oriented because even oral communications must be documented if substantive action takes place. (The term "paper pushers" for office workers remains descriptive.)

- Performance Level IV (PL-IV) represents institutional performance, that is, how well the goals and objectives of the company, agency, or enterprise are being met. This performance level depends upon analysis of the communications that occur at PL-III and upon decisions that result from that analysis. It can be assumed that relatively few decisions can be directly related to institutional performance except through the complex, hierarchical, work unit networks that support the few actual decision makers.

EXHIBIT II-3 (Cont.)

PERFORMANCE LEVELS IMPROVE PRODUCTIVITY ANALYSIS

Performance Level	Primary Functions
III. WorkUnit Networks (PL-III)	Interpersonal Communications Telephoning Report Preparation Information Handling
IV. Institutional (PL-IV)	Analysis and Decision Making

D. EXTENT OF THE PERFORMANCE MEASUREMENT CHALLENGE

1. PERFORMANCE LEVELS I AND II

- In order to determine whether or not productivity is being improved, it is necessary to have some means of measurement. Exhibit III-4 presents the disciplines that can be used to measure performance levels I and II and the relative difficulty of measuring and making predictions at both levels.

- PL-I has been broken into hardware and software since the problems of the two must be viewed separately.

  - Hardware performance can be measured and predicted employing conventional mathematics of the physical sciences. However, the development of metrics that permit even simple comparisons of relative performance across architectures leaves a lot to be desired - MIPS is not the answer.

  - Once software is added, the measurement problem becomes substantially more complex and predictability practically impossible. Indeed, a good theoretical argument can be made that hardware/software systems cannot be modeled. INPUT does believe, however, that the techniques of operating research do hold promise for improvement.

- As soon as the human factor is added at PL-II, additional measurement techniques are necessary, and the task becomes more complex.

  - Industrial engineering techniques have limited applicability in the office environment because the physical product (paper) of office work is not necessarily a good measurement of productivity.

  - Artificial intelligence at this level can only help with the human-to-computer interface.

EXHIBIT II-4

EXTENT OF THE PERFORMANCE MEASUREMENT CHALLENGE

Performance Level	Measurement Instruments or Tools	Degree of Measurement/ Predictability & Difficulty*
PL-I		
Hardware	Conventional Mathematics	2-3
Software	Operations Research	4-5
PL-II	Conventional Mathematics Industrial Engineering Operations Research Artificial Intelligence	3-7

*Rating: 1-10, with 10 being most difficult.

D. EXTENT OF THE PERFORMANCE MEASUREMENT CHALLENGE (continued)

2. PERFORMANCE LEVELS III AND IV

- At PL-III significant new measurement problems arise because the social sciences do not lend themselves to the application of either conventional mathematics or industrial engineering.

  - The body of the report explains in some detail the difficulty in applying current mathematics to even simple economics problems, much less to the infinite variety and complexity of work unit networks.

  - While most operations research techniques grew out of industrial engineering, there is potential for applying some of the more advanced techniques to work unit networks. Unfortunately, mathematicians are just becoming interested in some of the problems that operations research analysts have encountered with current mathematics.

- At PL-IV the full range of human intelligence and creativity come into play, and an entirely new science is required if computer/communications technology and humans are expected to work together effectively. Regardless of its seeming lack of direction, theoretical immaturity, and obvious complexity, artificial intelligence must be considered at this level - not as the solution, but as a means of defining (measuring) problems that will only become more difficult as new technology is employed at lower performance levels.

  - To a certain degree, the application of artificial intelligence research to specific areas through knowledge engineering is merely an extension of good systems work.

  - Information systems personnel cannot afford to ignore artificial intelligence as a "blue sky" science that has no immediate, practical application. The research being done and the techniques being developed are fundamental in improving white-collar productivity.

EXHIBIT II-4 (Cont.)

EXTENT OF THE PERFORMANCE MEASUREMENT CHALLENGE

Performance Level	Measurement Instruments or Tools	Degree of Measurement/ Predictability & Difficulty *
PL-III	Operations Research Artificial Intelligence	6-9
PL-IV	Knowledge Engineering Artificial Intelligence	10

*Rating 1-10, with 10 being most difficult.

E. PERFORMANCE LEVELS REPRESENT A LOGICAL PROGRESSION

- There is a logical progression from data to information to knowledge bases as technology is applied to white-collar work. This progression can be associated with established performance levels.

- At PL-I it is obvious that the hardware deals with encoded (processable) data. Locating of these data in the storage hierarchy has been facilitated through the use of operating systems.

- At the human-to-computer dyad level (PL-II), data base systems have sufficed up to now (whether dealing with corporate data bases on large-scale systems or with personal data bases on personal computers), but many promised results have not been achieved and such systems continue to evolve.

- As integrated electronic systems incorporate data, text, and images, all information required by the work unit network (PL-III) should be readily accessible from workstations. The development of such systems is currently the focus of advanced office systems development and will receive considerable impetus with the availability of cheap mass storage.

- At PL-IV knowledge bases that lead the user through pertinent data and information bases will be required. It is INPUT's opinion that generalized decision support systems (which are currently in their infancy) will evolve into expert systems of necessity. In other words, detailed knowledge of the specific decision making process (or even style) will be required in order to improve productivity (performance and effectiveness) at PL-IV.

EXHIBIT II-5

PERFORMANCE LEVELS REPRESENT A LOGICAL PROGRESSION

Performance Level	Data/Information/ Knowledge Requirements	Systems Requirements
PL-I	Data	Operating Systems
PL-II	Data	DBMS
PL-III	Information	Integrated Electronic Office Systems
PL-IV	Knowledge	Expert Systems

F. PRODUCTIVITY ASSUMPTIONS

- Based upon difficulties in defining office productivity, limitations in measurement techniques, and rapid changes anticipated in advanced office systems, certain assumptions concerning office productivity were made in the report. These assumptions are summarized in Exhibit II-6.

- Measurement becomes increasingly difficult at higher performance levels. Measurable improvements at PL-I and II do not necessarily result in improvement at PL-III and IV. Adequate measurement tools and techniques do not currently exist at PL-III and IV. Lacking adequate measurement tools, simple intuitive measures will be required to justify installation of advanced office systems.

- Decreased paper will have a positive productivity impact. Spending time on analysis and decision making rather than on interpersonal communications is a sign of productivity improvement. Acceptance and use of competing office systems can be used as a measure of productivity improvement.

- When these assumptions are applied to both current and advanced office systems, difficulties of cost justification become apparent.

  - Most current office automation systems emphasize efficiency in paper production.

  - Improvements in ability to communicate are effective only if they decrease the time spent on communications.

  - The measurement of the effectiveness of analysis and decision making using advanced systems is virtually impossible at present.

- If these assumptions are accepted, the need to determine exactly what office workers do and how they do it becomes apparent.

EXHIBIT II-6

PRODUCTIVITY ASSUMPTIONS

- Measurement is more difficult at higher levels.
- PL-1 and PL-II improvements do not guarantee PL-III and PL-IV payoffs.
- PL-III and PL-IV measurement methods do not exist.
- Decreased paper has a positive impact on productivity.
- Having more time for analysis and decision making is positive.

G. RECOMMENDATIONS

- Exhibit II-7 presents the most significant recommendations of the report. These recommendations represent considerable additional involvement and work for information systems organizations, but they are necessary to avoid installing systems that may actually have an adverse effect on productivity in the office.

- Cost justifications that consider the interaction between the four performance levels must be made; vendor cost justifications addressing specific automation products cannot be relied upon.

- Evaluate the cost justification and results of advanced system prototypes that have been installed by others.

- Develop prototype systems before committing to complex new office systems.

- Become familiar with the developing techniques of knowledge engineering and expert systems.

- Evaluate carefully the impact of intelligent workstations (including personal computers). Their productivity impact is not readily apparent.

- INPUT's companion report, Methods of Cost/Benefit Analysis for Office Systems, elaborates upon these recommendations by evaluating current cost justification procedures and presenting case studies on prototype systems.

EXHIBIT II-7

RECOMMENDATIONS

- Cost justifications should consider performance level interactions.
- Evaluate and develop prototype systems.
- Become acquainted with knowledge engineering and expert systems.
- Carefully evaluate impact of intelligent workstations.

III OFFICE PRODUCTIVITY CONSIDERATIONS

III OFFICE PRODUCTIVITY CONSIDERATIONS

A. WHAT OFFICE WORKERS DO

- The current concerns about office productivity have been generated from two sources: businesses that recognize that white-collar salaries represent an ever-increasing percentage of total expenses, and vendors of office systems who recognize an enormous potential market.

- Efforts to improve office productivity (or even to address it as an issue) from either perspective are hindered by a lack of understanding of exactly what most white-collar workers do (much less produce). For years the most commonly used generic term for office workers was "paper pushers," and over 25 years after the introduction of computer technology into the business environment, it remains an apt description. Indeed, this study will make the point that computer systems and office automation products have substantially increased the amount of paper used in business offices and, therefore, have contributed to the current office productivity problem.

- Even before defining the office productivity problem, it is necessary to establish a general functional framework in which to consider office work and how much it costs.

I. FUNCTIONAL ANALYSIS

- White-collar workers have a myriad of occupational titles, but for purposes of this report we will assign them all to six broad categories based on general functional patterns associated with their work. These categories are as follows:

  - Executives, managers, and administrators.
  - Professional and technical workers.
  - Salespeople.
  - Secretaries/administrative assistants.
  - Typists/data entry workers.
  - Clerical workers.

- These occupational categories will be refined and described further in the analysis that follows, but they generally correspond to those used in most studies of office work. The exception is the inclusion of salespeople, which requires a few words of explanation. The reasons for including sales workers are as follows:

  - They are included under the major occupational category of white-collar workers by the Bureau of Labor Statistics.
  - As we shall see, office work is primarily communications, and sales work is almost purely communications.
  - Technology is developing that will permit salespeople to be connected to their offices (or information banks) regardless of whether they are traveling or visiting a customer site.

- INPUT believes that the overall systems that improve general office productivity also improve sales productivity.

- The general description of the functions or activities performed by white-collar workers is as follows:

  - Analysis and decision making includes reading, calculating, planning and scheduling, and just plain "think time."

  - Report preparation includes writing and proofreading regardless of whether it is done with pencil and paper or at a workstation.

  - Dictation can be to either secretaries or machines, and is included primarily because of current interest in voice recognition systems.

  - Typing/data entry includes keying previously prepared documents or data. It does not include report preparation by an author or simple data entry required for analysis by a professional using a personal computer.

  - Copying/information entry includes both convenience copying and that for publication (or mass distribution). Information entry is in anticipation of document entry through cameras or scanners regardless of whether a hard copy is made.

  - Information handling/storage includes mail handling, searching for documents, filing, retrieval of filed information, and distribution of information. While much of the information handled is paper, the same activities apply to electronic systems.

  - Telephone time includes obtaining numbers, dialing, wait time, missed connections, and actual conversations.

- Interpersonal communications includes casual, face-to-face conversations, scheduled meetings, conferences, sales calls, and travel for such purposes.

- Exhibit III-1 presents the occupational categories and general functions in matrix form. This matrix will be used throughout the report; row and column designations may be used to identify specific cells. The matrix is intended to encompass all activities of white-collar workers during normal business hours without regard for whether or not such activities are productive. In other words, coffee breaks, personal telephone calls, idle conversation, etc., will not be estimated as a separate category.

- The time distribution contained in Exhibit III-1 is obviously very general and will vary not only according to industry and company, but by individual offices performing the same functions within the same company. How white-collar workers spend their time is influenced tremendously by management style and personal work habits. This compounds problems of measuring productivity and also makes automation of such functions quite difficult.

- INPUT used such general time distribution figures for many years and always cautioned that there would be substantial variations in any specific office environment. While we still feel this to be the case, a detailed office study by IBM, reported in the IBM Systems Journal ("An Office Communication Systems"; Engel, et al; Volume Eighteen, Number Three, 1979), revealed some interesting correlations once the occupational categories and functions (activities) had been rationalized.

    - Exhibit III-2 compares INPUT's estimates of white-collar time distribution for professionals to those made in IBM's office study.

        - The weighted average of executive, managerial, and administrative (INPUT occupational category A) and professional and

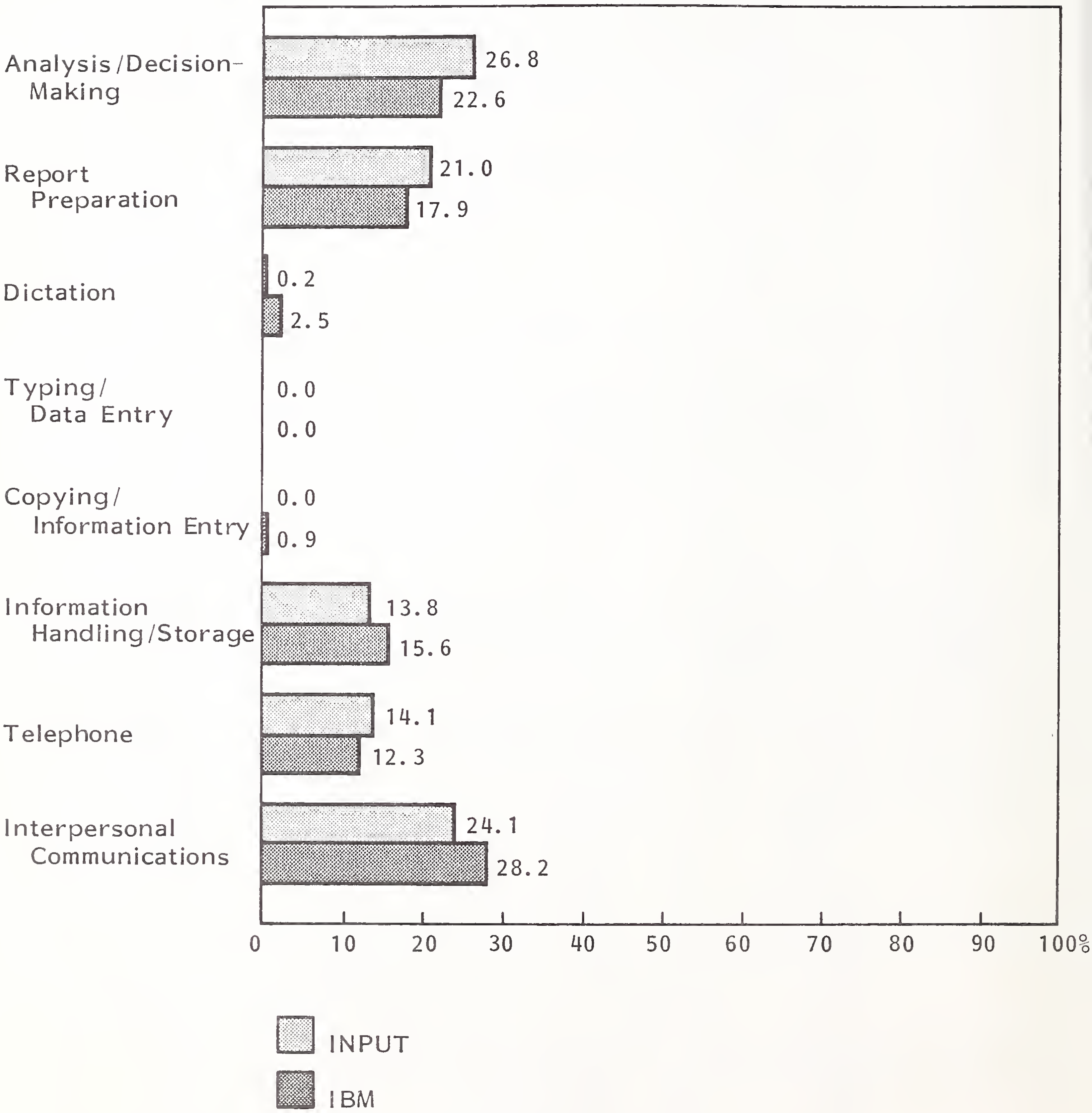
EXHIBIT III-1

WHAT WHITE-COLLAR WORKERS DO

FUNCTION / OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL
(1) Analysis & Decision-making	15.0%	35.0%	7.5%	12.0%	5.0%	25.0%
(2) Report Preparation	22.5	20.0	12.5	7.0	5.0	5.0
(3) Dictation	0.5	0.0	0.0	5.0	0.0	0.0
(4) Typing/Data Entry	0.0	0.0	0.0	20.0	40.0	10.0
(5) Copying/Information Entry	0.0	0.0	0.0	6.0	12.0	12.0
(6) Information Handling/Storage	12.0	15.0	5.0	15.0	15.0	30.0
(7) Telephone	20.0	10.0	25.0	17.5	10.0	8.0
(8) Interpersonal Communications	30.0	20.0	50.0	17.5	13.0	10.0
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

EXHIBIT III-2

COMPARISON OF TIME DISTRIBUTION - PROFESSIONAL
(INPUT ESTIMATES VERSUS IBM OFFICE STUDY)



technical (INPUT occupational category B) was used for purposes of comparison.

- IBM included more detailed activities categories (such as mail handling, filing, searching, and retrieving filed information), which were combined into the more general INPUT categories (for example all of the above were included under information handling/storage).

- IBM included an "other" category that was distributed proportionately to the functional categories being compared.

- The only IBM activity category that did not lend itself to easy distribution was reading, which for purposes of comparison was included under analysis/decision making. This activity is of concern because INPUT has concluded that a substantial amount of reading is actually nonproductive (especially for professionals) and should be allocated to information handling. This will be discussed later in the report.

- Generally speaking, there is a great deal of agreement between INPUT's general estimates and the specific IBM study.

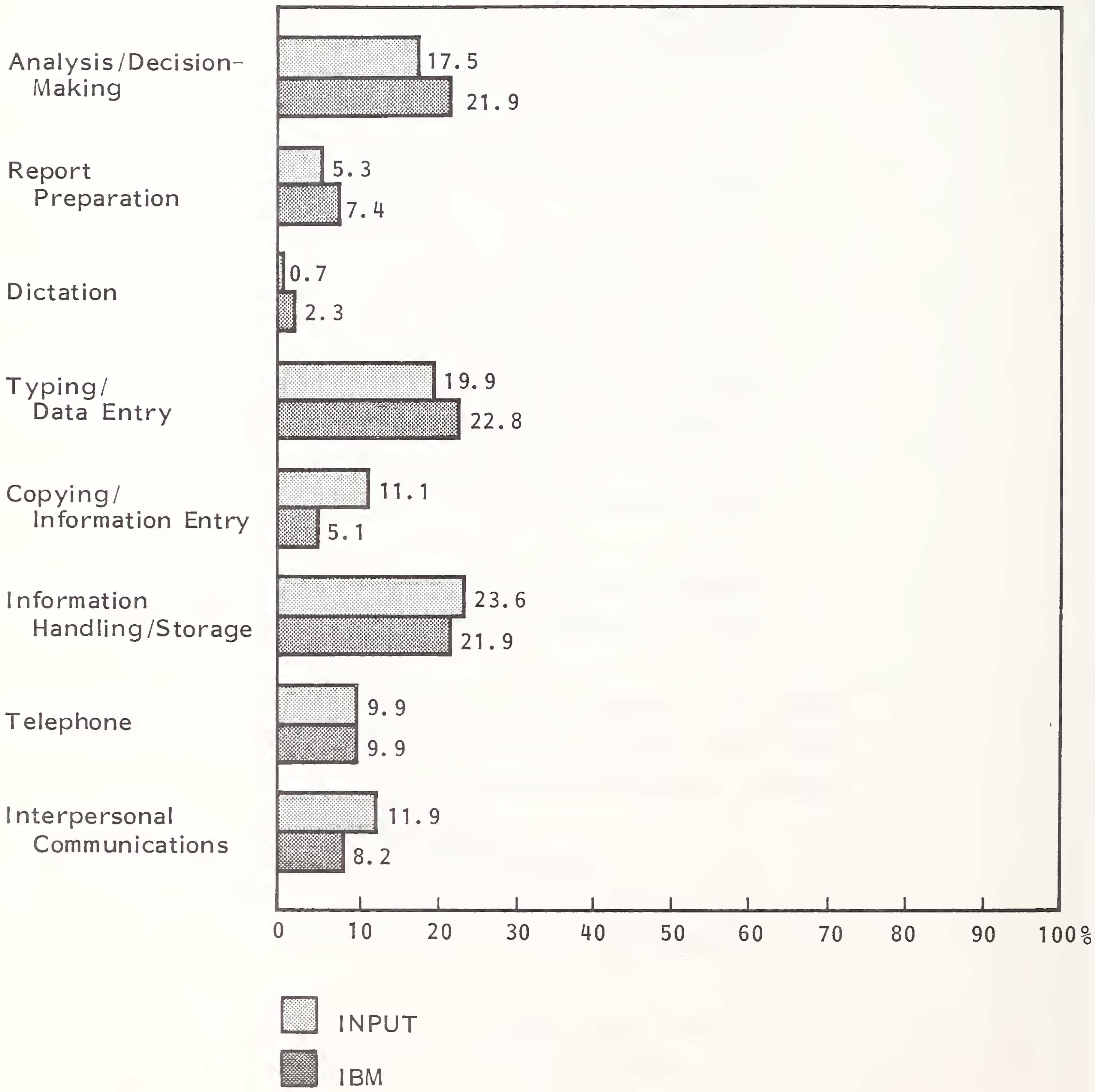
- Exhibit III-3 presents a similar comparison for all clerical employees (secretaries, typists, and clerical workers being combined on a weighted average for purposes of comparison).

  - As in the professional comparison, there is a high degree of similarity in the overall time distribution, but there are substantial deviations in two specific categories.

  - The time spent taking and transcribing dictation is much higher in the IBM study, but this can be explained by the fact that the

EXHIBIT III-3

COMPARISON OF TIME DISTRIBUTION - CLERICAL
(GENERAL VERSUS IBM OFFICE STUDY)



IBM study site was the corporate and divisional headquarters of a multinational corporation where the concentration of senior executives would increase the amount of dictation.

. The other area of substantial deviation is copying, where INPUT's estimates are more than double those in the specific study. This is probably due to INPUT's rather broad definition of time spent on copying, which has been adopted for purposes of evaluating productivity impact, and it will be discussed in detail later in the report.

- The comparison with the IBM study was presented for two reasons:

  - The time distribution estimates in Exhibit III-1 will be used to project costs of white-collar workers by function, and confirmation of their usefulness for this purpose was desired.

  - The IBM study included the installation of a prototype computer-based office communications system, the observations of which will be useful in later analysis of office productivity.

2. COST ANALYSIS

- By applying the time distribution estimates in Exhibit III-1 to occupational employment figures and annual average salaries, it is possible to determine the approximate costs of office functions by occupational category, as shown in Exhibit III-4.

- Even simple ordering by occupational category and function demonstrates rather dramatically the reasons office systems vendors have been emphasizing a shift toward the support of principals rather than clerical employees, as shown in Exhibit III-5.

EXHIBIT III-4

COST ANALYSIS OF OFFICE FUNCTIONS

(SALARY AND BENEFITS BY OCCUPATIONAL CATEGORIES - 1981)

($ billions)

FUNCTION / OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) OTHER, CLERICAL	TOTAL
(1) Analysis & Decision-making	$54.0	$149.0	$10.1	$5.0	$2.9	$32.5	$253.9
(2) Report Preparation	81.0	85.4	16.8	2.9	2.9	6.5	195.5
(3) Dictation	1.8	0.0	0.0	2.1	0.0	0.0	3.9
(4) Typing/Data Entry	0.0	0.0	0.0	8.4	22.7	13.0	44.1
(5) Copying/Information Entry	0.0	0.0	0.0	2.5	6.8	15.6	24.9
(6) Information Handling/ Storage	43.2	64.1	6.7	6.3	8.6	39.0	167.9
(7) Telephone	72.0	42.7	33.4	7.4	5.7	10.4	171.6
(8) Interpersonal Communi-cations	108.0	85.4	67.0	7.4	7.4	13.0	288.2
Total	$360.0	$427.0	$134.0	$42.0	$57.0	$130.0	$1,150.0

EXHIBIT III-5

WHITE-COLLAR SALARY COSTS, 1981
(ORDER BY OCCUPATIONAL CATEGORY & FUNCTION)
($ billions)

COSTS BY OCCUPATIONAL CATEGORY			COST BY FUNCTION		
CATEGORY	DOLLARS	PERCENT	FUNCTION	DOLLARS	PERCENT
Professional & Technical	$427.0	37.0%	Interpersonal Communications	$288.2	25.1%
Executive, Managerial, Administration	360.0	31.3	Analysis and Decision Making	253.9	22.1
Sales Workers	134.0	11.7	Report Preparation	195.5	17.0
Clerical	130.0	11.3	Telephone	171.6	14.9
Typists/Data Entry	57.0	5.0	Information Handling/Storage	167.9	14.6
Secretaries	42.0	3.7	Typing/Data Entry	44.1	3.8
Total	$1,150.0	100.0%	Copying/Information Entry	24.9	2.2
			Dictation	3.9	0.3
			Total	$1,150.0	100.0%

- Typists and secretaries, who have been the focus of office automation product investment until recently, represent less than 10% of white-collar compensation (8.7%).

- Production costs of hard copy (typing and copying) represent less than 10% of the cost of office functions (6.0%).

- At a recent public meeting, an IBM manager of office systems made the folllowing points:

  . There are currently 50 million white-collar workers in the U.S. (52.9 million was the number used for cost distribution in Exhibit III-4), and this would increase to 60 million at the end of the decade.

  . This is approximately 60% of the workforce, and if the economy is going to grow the productivity of white-collar workers must be increased.

  . IBM is concentrating on principals that are executive, professionals, and salespeople - secretarial and clerical workers are secondary.

- It is not difficult to understand why IBM (and other vendors) have adopted this attitude, but exactly how the objective of improving the productivity of principals will be achieved represents a substantial problem.

B. PRODUCTIVITY IMPROVEMENT ASSESSMENT

1. PRODUCTIVITY MEASUREMENT

- If productivity is to be improved, there is the implication that it can be defined and it can be measured. It is not at all clear that either of these essentials for improving productivity exist in many white-collar activities (especially in the more costly functions shown in Exhibit III-5). For example:

    - Interpersonal communications are the largest cost in the office environment. Who is to say whether two people in conversation are accomplishing anything productive or merely discussing last week's tennis match, and who can determine how productive a meeting is for either the individuals or the organization involved?

    - Analysis/decision making is the second most costly function. Who can determine whether an executive staring out the window is in the final stages of reaching a major decision that will more than justify his $250,000 salary, or whether is merely wondering if he should invite a business associate out for a martini.

    - Report preparation time may be improved, but what value can be placed on the product? A report may have negative impact upon the organization's productivity if it raises unnecessary points or questions that must be evaluated or answered by others. Ability to prepare reports more rapidly does not necessarily mean either the individual or the organization is being more productive.

- In addition, there are tremendous differences in individual abilities and motivations that may raise serious questions about any general solutions to improving productivity with technology. Consider the following:

- INPUT's research on productivity in the systems development process revealed differences of 30:1 in individual ability in specific activities such as debugging. In fact, some respondents stated that individual differences in productivity were infinite since specific systems problems could never be solved by some individuals.

- Research conducted after World War II indicated that only a small percentage (approximately 15%) of combat infantrymen ever fired their weapons at the enemy, and it could not be determined that those who did were necessarily the best marksmen. (The major inhibiting factor seemed to be the vague hope that "if I don't bother them maybe they won't bother me.")

- When such variations in ability and motivation are considered, it becomes apparent that investment in technology is going to have unpredictable results. There is a difference between working efficiently and effectively, and office automation products have so far addressed the former rather than the latter. But even the knowledge-based systems currently under consideration must take these individual differences into consideration. Put another way, enabling a bad manager to supervise more people does not necessarily result in a more productive organization.

- The wide range of individual abilities to solve abstract problems, and the complexity of individual motivation to take desired (or even required) actions - such as making a decision - indicate that a high percentage of productive white-collar work is probably accomplished by an extremely small percentage of white-collar workers. Moreover, this productive work probably does not depend upon the enormous amounts of human effort and data that are generated in the office.

- If these judgments seem harsh, it is only because they are stated simply and without the benefit of an office systems vendor's promises. It is the purpose of this report to evaluate not only the current state of white-collar productivity assessment, but also the proposed solutions to the problems as they are assumed to exist. Despite the prospect of enormous investments in office systems technology, very little attention has been given to the measurement of the actual impact on productivity.

2. LEVELS OF PERFORMANCE MEASUREMENT

- In order to consider the potential impacts of proposed solutions on office productivity, it is necessary to establish a framework in which the performance of white-collar workers can be defined. Only then will it be possible to develop metrics and instruments for measurement. The necessity for this framework has been recognized by James H. Bair ("Productivity Assessment of Office Information Systems Technology," James H. Bair; Emerging Office Systems, Ablex Publishing, 1982), and the levels defined below roughly parallel those he has recommended.

- The lowest level to be considered is the hardware/software performance level, which in itself is quite broad since it can consist of a standalone piece of equipment (word processing workstation or personal computer) or an international computer/communications network complete with appropriate data/information bases. This shall be referred to as Performance Level I. The following general observations are in order:

    - Hardware/software performance measurement has presented the computer industry with problems for well over 20 years. Despite hardware and software performance monitors, software engineering, and software physics, most installation managers still struggle with fundamental problems of capacity planning, resource utilization, and expense recovery.

- Network performance (reliability and response time) has defied all but the most superficial of analysis tools, and operations research analysts have had difficulty in even interesting mathematicians in the problems of queuing networks, which may provide some insight into the performance of local area networks (LANs).

- It is extremely important to be able to predict performance at the hardware/software level because it will determine the acceptance of advanced office systems. Prediction of performance of complex hardware/software systems cannot be classified as a science at this point.

- As a side issue, it should also be pointed out that the question of actual productivity of PL-I systems is far from resolved. As soon as software is added, the question of overhead becomes significant, and mere measurement of performance can consume a substantial portion of systems resources. It cannot be assumed that a given percentage of CPU cycles engaged in executing systems software necessarily represents productive work from the point of view of either the end user or the stated objectives of the system.

• The next level of performance defined by Bair was described as "throughput performance" and later as the "human-computer dyad." The latter better describes the productivity measurement problems that are being encountered as office systems are directed more at principals in the office. The human-to-computer dyad will be used in referring to PL-II, and its important attributes are as follows:

  - On the simplest level the human-to-computer dyad can be measured in terms of computer/communications service cost plus the value of the time of the operator. If an industrial engineering approach is taken to the evaluation of office productivity, it will provide an essential measurement of relative effectiveness. In many technical areas where calculations are involved, this is all that is necessary. Can calculations be most cost-effectively performed by a human using paper and pencil, a pocket calculator, a personal computer, a timesharing service, a batch job under MVS, or a dedicated Cary I? (The applicaton of even such simple analysis to current human-to-computer dyads can reveal some embarrassing productivity combinations.)

- The productivity of typists can also be effectively measured by simple cost analysis of this type and is frequently used for equipment justification.

- The extension of PL-II analysis to decision support systems brings up a much more complicated situation because quality of output must be considered. Assuming the human-to-computer dyad produces decisions more rapidly and more cost effectively, how do those decisions compare with those produced by some other means? The evaluation of decisions is an extremely difficult business and is normally avoided or deprecated as "second guessing." However, it is essential for both partners in the human-to-computer dyad to be sensitive to the necessity for such feedback, otherwise counter-productive results are inevitable.

- At the present time, most vendors are concentrating on improving the productivity of the human-to-computer dyad through ergonomics (display resolution, keyboards, mouses, etc.) and through software interfaces. While these are necessary endeavors, the assumption has been made that the end result of the dyad is necessarily more productive - the end user cannot (or should not) make this assumption.

• One of the primary reasons this assumption cannot be made is that human-to-computer dyads become connected through communications networks into what we shall refer to as work unit networks. (Bair refers to this as "organizational performance," but we prefer work unit networks because of the increased organizational and interorganizational fluidity in problem solving that is becoming possible.) Making it easy to interface on such networks can generate a great deal of "junk mail" and idle conversation. Work unit networks are classified as PL-III, and are distinguished by the following attributes:

- There are many humans or human-to-computer dyads connected in a work unit network that is formed (or comes into being) for the following reasons:

  - It is defined by an existing organizational entity that normally has a prescribed and frequently continuing function.

  - It is formed to solve a specific problem (or problem set) or to produce a specific product (or output), and it may be interorganizational in nature (as well as intercompany, international, etc.).

  - It develops either within or without organizational bounds as an informal work unit among individuals who, for some reason, have an affinity for communicating with each other. Such an affinity may be recognized (and even encouraged), or it may exist even when specifically forbidden by management.

- Work unit networks imply communications in order to make them function, and this information interchange accounts for 77.9% of white-collar workers' salary costs (as shown in Exhibit III-5). In fact, if the office productivity problem is to be described, it must be classified as a communications problem within the work units described above.

- The bulk of the communications functions depicted in Exhibit III-5 do not lend themselves to easy analysis of their efficiency - much less their effectiveness. Only typing and copying can be easily quantified; and, as mentioned previously, quantity of paper produced is not a good measure of effectiveness. In fact, a good argument can be made that a large quantity of paper is the best indication of poor communications.

- At PL-IV, the final contribution of the previously described levels to institutional performance must be considered. It is at this level that we reach a point of conflicting paradigms with some of those who are addressing the question of office systems productivity.

  - Bair describes institutional performance as: "The economic context of the organization's performance which may cause fluctuations that must be taken into account. For example, an austerity program may decrease morale and provide inadequate resources to meet organizational goals. Lack of personnel or support services could cancel any advantages of increased processing capability."

  - We have trouble with the view that office systems productivity is influenced by institutional performance rather than the other way around. It would seem that the ultimate purpose of office systems is to improve institutional performance - whether it is a vendor planning the introduction of a personal computer or the United States government attempting to negotiate a nuclear arms agreement.

    - The effectiveness in the vendor's case can be measured in how well the personal computer does in the marketplace, both in sales and profit.

    - A work unit (international) responsible for a nuclear arms agreement cannot be deemed productive unless an agreement is reached - regardless of how much processing capability they have to support them.

    - Over a decade ago, a company destined to leave the computer business stated that they could afford to have a computer-based planning system if they had IBM's bottom line. When it was pointed out to them that the planning system might be the cause rather than the effect they could not (or would not) believe it.

. The point is that if a function is productive it is assumed to produce something of value - it should not, therefore, be eliminated under adverse circimstances. On the other hand, if it does not produce something of value it should not be established just because funds are available.

. Unfortunately, the connection between a great deal of white-collar work and institutional performance is, at best, tenuous.

- The concept that "information is a corporate asset" may possibly be true, but it is extremely difficult to place a value on that asset based on corporate performance. In fact, it is difficult at present to place a value on information in terms of improved productivity of the personnel that use such information.

- Exhibit III-6 summarizes the four performance levels at which productivity can be evaluated, designates the primary office functions associated with the levels, gives examples of current office products supporting the levels, and establishes a set of office systems categories that will be used in analyzing productivity at the various performance levels.

  - The underlying hardware/software supporting the office obviously covers all of the functional areas, products, and office systems. Performance at this level is extremely important since it will determine the viability of future office systems to support the higher performance levels. For example:

    . Processing power had to become cheap enough before it could be distributed to white-collar workstations in the form of personal computers.

EXHIBIT III-6

PERFORMANCE MEASUREMENT LEVELS

PERFORMANCE LEVEL	PRIMARY FUNCTIONAL AREAS	EXAMPLES OF CURRENT PRODUCTS AND SERVICES	OFFICE SYSTEMS CATEGORIES
I. Hardware/Software	All	All	All
II. Human-to-computer Dyad	Typing, Copying, Telephone, Dictation	Word Processing Equipment, Office Copiers, Telephones, Answering Devices, Terminals, Dictation Equipment, Personal Computers	I. Data/Information Entry and Retrieval
III. Work Unit Networks	Interpersonal Communication, Telephone, Report Preparation, Information Handling	Audiovisual Equipment, CABXs, Electronic Filing Systems, LANs, Electronic Mail, Teleconferencing	II. Data/Information Storage and Distribution III. Sensory Extension IV. Data/Information-based Systems
IV. Institutional	Analysis and Decision-making	Data Base Systems, PCs	V. Knowledge-based Systems VI. Expert Systems

- Electronic storage must have capacity to hold images of all paper documents before paper can be eliminated (or significantly diminished) from the office environment, and it must be cost competitive in order to be adopted.

- Cameras or scanners must have competitive price/performance to economically enter the documents into the storage systems.

- The local area network must be capable of distributing the information among all office workers.

- A relational data base system must have competitive price/performance if it is to be used for transaction processing.

- Supercomputers may be required in order to implement knowledge-based systems requiring inferential processing against large data/information bases and supporting natural language interfaces. (Despite the new terminology, inferential processing can be viewed as a logical extension of prompting, albeit intelligent. It is the critical factor in distinguishing a knowledge-based system from an information system.)

- The knowledge base must contain the essential elements (data) from which to make inferences and must be structured to support adequate response time.

- The performance of individual systems components will not be sufficient to project the performance of the total office system. While hardware/software performance may be the cleanest and most studied, adequate tools do not yet exist to support accurate throughput (productivity) of future systems.

- The human-to-computer dyad is receiving a great deal of attention in terms of terminal design and human/machine interface. Examples of both current products and research for future systems follow.

    - Automatic telephone dialers are economical for both business and personal use. Time savings in looking up numbers, dialing, and trying again can be substantial for anyone who uses the telephone extensively and is truly interested in improving productivity.

    - Telephone answering systems are eliminating the necessity for having a human "cover the phones."

    - Fourth (and fifth) generation computer languages continue to receive attention as the trend towards information centers and decision support systems hits full stride. IBM's making Intellect (Artificial Intelligence Corporation) available through its marketing representatives is an example of an attempt to push past fourth generation languages in certain applications areas. Fifth generation languages will not only be nonprocedural but will be more natural in that they will be tailored to the particular occupations or professions.

    - Extensive research continues on voice recognition, which will permit humans to talk with their computers.

    - All human-to-computer communications, whether pushing buttons, talking, or sending a computer a piece of correspondence by entering a document into an electronic storage system (with appropriate optical scanning for extraction of information required to update data bases), will be classified as a Category I Data/Information Entry and Retrieval Systems.

- Work unit networks are concerned primarily with the communication of information, and this is clearly indicated by the primary functional areas addressed, the current products (or services) in support of this level, and the office systems categories established for future office systems.

  - The primary functional areas covered are interpersonal communications, telephoning, report preparation, and information handling.

  - Products and services that currently support this performance level are limited in their general use except for audiovisual equipment (most of which is not computer based).

  - Future office systems have been classified into three categories: II - Data/Information Storage and Distribution Systems, III - Sensory Extension Systems (teleconferencing is a simple example), and IV - Data/Information-based Systems. (These categories will be described in the section on future office developments.)

  - The primary function of work unit networks is to provide data and information for analysis and decision making.

- Institutional performance is influenced by analysis and decision making, a process which is not very well understood, is weakly supported by office products, and depends upon multidisciplinary research in artificial intelligence (AI) for the development of future systems.

  - The information requirements for supporting decision making are not understood despite the current emphasis on such systems.

- For years emphasis on corporate data bases for management information systems obscured the fact that neither systems vendors nor corporate management knew what information was necessary (or desirable) for decision making. Changes of terminology attempt to indicate progress but, actually, little progress has been made.

- To prove this, it is only necessary to analyze the popularity of personal computers in corporations that have invested millions of dollars in data base systems. Either the problems of decision support are simpler than originally supposed, or there are still many problems with centralized information sources. (More on this later.)

- To really support analysis and decision making, substantial progress must be made in a number of complex areas (user interfaces, inferential analysis of information requests, data information base structuring, and decision modeling). Knowledge-based systems and expert systems have been separated because of anticipated progress (or lack thereof), and they will be discussed later in the report.

3. FUNCTIONAL/OCCUPATIONAL ANALYSIS

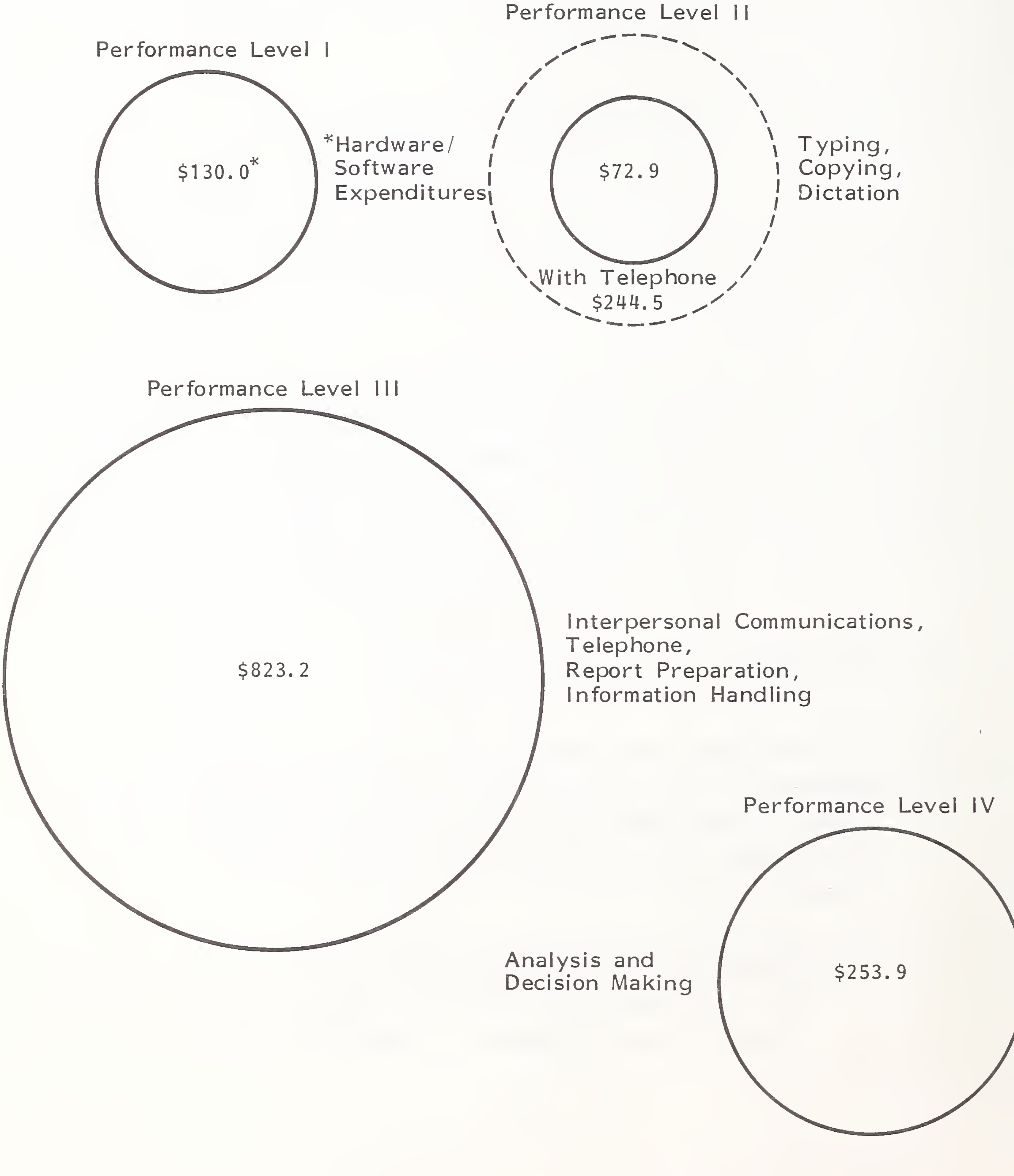
- The establishment of performance measurement levels permits a functional and occupational overview of major targets in improving white-collar productivity. Graphic representation helps to put them into perspective, and Exhibit III-7 presents the cost of the primary functional areas assigned to each performance level.

  - Performance level I is presented for comparison purposes only since it does not represent any white-collar costs but is merely the estimated amount invested in equipment to support white-collar workers.

EXHIBIT III-7

PERFORMANCE LEVEL - FUNCTIONAL SALARY COST ANALYSIS

($ billions)



- The cost estimate of $130 billion is based on a $2,500 investment per white-collar worker, which is a rough median figure within the $2,000-4,000 range that was encountered in our research.

- This figure includes the investment in all office equipment (telephone, copiers, typewriters, etc.) and not in computer-based products alone.

- The justification for these expenditures must come from improved productivity (cost savings) at the higher performance levels.

- Performance level II includes the primary functional costs for typing, copying, and dictation (as shown in Exhibits III-4 through III-6), which represent the focus of office automation products investment to this point. The total salary costs for these functional areas is $72.9 billion, but that number requires some qualification.

  - Telephone was listed as a primary functional area under both levels II and III because of emerging voice systems for store and forward, audio recognition and response, etc. However, the major expense is in person-to-person communications (as opposed to a human-to-computer dyad) and this expense was allocated to PL-III.

  - Even if the total telephone expense is allocated to PL-II, the target only expands to $244.5 billion, which is still small compared to PL-III.

- Performance Level III demonstrates graphically the importance of communications in white-collar expense. Whether face-to-face, over the telephone, or in the reparation and handling of paper documents, white-collar workers spend most of their time communicating, and the $823.2 billion represents 71.6% of total white-collar expense.

- When we consider that a great deal of analysis and decision making also occurs at this performance level, the target becomes even larger.

- It is obvious that the area of communications is extremely important; what has not been so clear is that work unit organization can play a significant role in determining the expense of communications. (This will be analyzed later in the report.)

- PL-III is the primary target for quantitative improvements; in other words, it has the greatest potential for cost reduction.

- Performance Level IV has been designated as the primary province of analysis and decision making and, as such, is the most promising target for qualitative productivity improvement.

  - It must be pointed out that a vast network of analysis and decision making underlies the relatively few fundamental decisions that actually affect institutional performance.

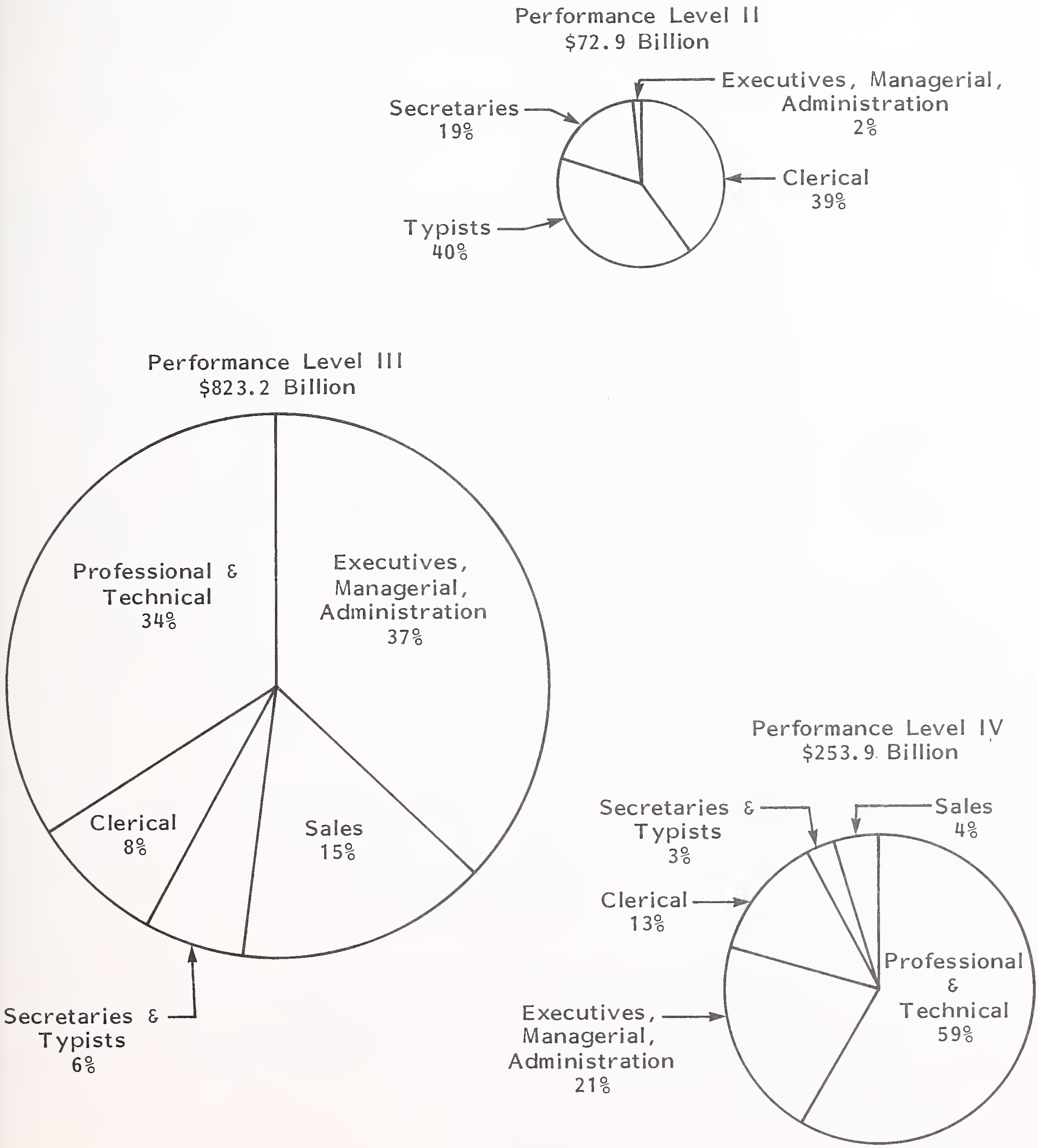
  - The point is that decisions will be made regardless of the quality of supporting information and staff work.

  - The complexity of today's business environment therefore demands a qualitative improvement in decision support systems.

- Exhibit III-8 breaks down the three personnel-related performance levels by occupational categories. The graphic representation clearly points out the importance of concentrating both quantitative and qualitative productivity

EXHIBIT III-8

PERFORMANCE LEVEL - OCCUPATIONAL COST ANALYSIS



improvement efforts in the nonclerical categories, and it is appropriate to point out the following:

- For purposes of simplification, and later amplification, the three nonclerical categories (managerial, professional, and sales) were not allocated any time for typing or copying (as shown in Exhibit III-1). Therefore, the occupational distribution of PL-II shows only dictation time spent by managerial employees.

- We are aware that nonclerical employees spend time using office copiers. (The IBM study isolated 0.1% for upper management, 0.6% for other management and management-equivalent personnel, and 1.4 for nonmanagerial personnel.) However, there is no question that copying is currently considered a clerical function, and it is difficult to obtain accurate national estimates of how much time nonclerical employees spend on that activity.

- It is also known that nonclerical employees spend a certain amount of time typing. However, the category is not even included for nonclerical employees in most studies. It has traditionally been considered bad form for a nonclerical employee to even admit having typing skills, much less to have a typewriter in the office, and this attitude continues to inhibit acceptance of computer workstations by nonclerical employees - despite the current personal computer craze.

- While office systems are changing these traditional views of what are appropriate work functions for various occupational categories, the fact remains that whether time is spent at a typewriter or a personal computer, a certain amount of typing is being done.

- It is also a fact that shifting certain functions from clerical to nonclerical employees will not increase productivity, much less will it improve cost effectiveness. Transfer of functions from PL-III and PL-

IV to PL-II will not automatically improve productivity despite the rush by vendors to put all white-collar workers on-line.

- Computer-based systems have significantly improved white-collar productivity in two areas: the ability to calculate (part of analysis and decision making) and the ability to produce paper.

  - In substantially less than one eight-hour shift, a single Cray I can perform all of the arithmetic operations mankind executed prior to Univac I. And yet the requirements for supercomputers to attack new problems are well documented.

  - On the commercial side, the ability to generate data has been increased beyond the capacity of routine accounting and statistical procedures to assimilate them in any meaningful fashion. The development of models in the social sciences has not been refined to the degree where they can be considered much more than crude tools. The result has been an enormous increase in analysis by human beings - most frequently with few tangible results.

  - Combined with the ability to produce paper documents based on these data and/or analyses, the net result has been an ever-increasing problem of evaluating (not to mention controlling) the quality of data/information that is being communicated.

- Evaluation implies measurement and, as we have seen, productivity improvement in the office environment is difficult to define and even more difficult to measure. Nevertheless, certain assumptions can and must be made if current and future office systems are to be evaluated.

4. MEASUREMENT ASSUMPTIONS

- As already stated, measurement becomes increasingly difficult from one performance level to the next. It is now necessary to comment on critical differences that exist between measurements in the physical sciences, industrial engineering, and the social sciences.

    - Despite problems encountered in quantum mechanics, mathematics provides a reasonable representation of physical phenomena. It is possible to both measure and predict hardware performance. As systems become more complex and software is added, both prediction and measurement become more difficult, but at least the measurement instrument (mathematics) is available for PL-I.

    - Industrial engineering approaches to productivity measurement in a manufacturing environment also lend themselves to relatively straightforward arithmetic except in the more complicated aspects of operations research. This is true primarily because productivity itself can be fairly simply defined (X number of widgets produced in Y amount of time, with Z rejects, etc.). There have been (and continue to be) attempts to apply industrial engineering techniques to the problem of improving office productivity, especially at PL-II. These attempts normally meet with mixed success for the following reasons:

        - Even in a manufacturing environment, measurement becomes difficult at the "therblig" level (individual motions of an operator at a machine) because of both human differences and resistance to being measured.

        - The human-to-computer dyad presents an even more complex problem because the combined output cannot be easily measured in terms of output quality, and quantity is of questionable value.

- Nevertheless, keystrokes can be measured, pages can be counted, and a "mouse" may improve the operator's system interface. These measurements will therefore frequently be made at level II with little regard for the productivity impact at higher levels.

- Most discussions of office productivity measurement ends at PL-II with the acknowledgement that measurement at higher levels is indeed complicated and must be left to the social sciences.

- At PL-III and PL-IV white-collar workers are essentially involved in processing and communicating information. As Carlos Cuadra has stated, information, by its very nature, is "amorphous, renewable, and dynamically changing in relevance and value as a function of time." The measurement tools of the social sciences are as inadequate as those of the physical sciences when quantifying the value of such information (either while being processed or as an end product).

- The second measurement assumption is that measurements indicating improvement at PL-I and PL-II do not necessarily indicate net productivity improvement when interactions with levels III and IV are considered.

- The third measurement assumption is that the measurement tools for levels I and II (physical science and industrial engineering measurement instruments) do not adequately describe productivity at the higher performance levels, and that the tools of social science are not satisfactory for levels III and IV either. The last point in this assumption is supported by an article on "Mathematics in the Social Sciences" by C.W. Kilmister (Professor of Mathematics at King's College, University of London) that appears in The Encyclopedia of Ignorance (an amusing title that disguises an elegant compendium of "the infinite region beyond the edge of present knowledge" in such diverse fields as space, mathematics, physics, and computer systems). Kilmister essentially makes the following points:

- Von Neumann and Morgenstern pointed out in the Theory of Games and Economic Behavior (1944) that the use of mathematics in economic theory had not been highly successful. (Ironically, it is the same von Neumann who shaped the architecture of the computer systems we are attempting to apply to these problems.)

- While von Neumann and Morgenstern dismissed the argument that mathematics is inappropriate for sciences involving the "human element"; they did go on to argue that, because social phenomena are at least as complex as those of physics, it might "be expected - or feared - that mathematical discoveries of a stature comparable to that of calculus will be needed in order to progress in the field."

- Kilmister goes on to point out that little attention has been paid to this warning, and precious little progress has been made during the last 40 years. He uses a simple supply-and-demand diagram to demonstrate the inadequacy of a model using current mathematics. Then, after pointing out promising theoretical work, he concludes that "much remains to be done in tackling unanswered questions" and that "the reason for the lack of success to date will be seen to be the lack of mathematical tools specifically designed for the purpose . . . ."

- INPUT has gone to some length to point out this problem because some of the work in advanced, knowledge-based systems may defy measurement (evaluation); and, what is more important, may incorporate "decision support models" that produce unpredictable results and go unnoticed.

- Lacking adequate measurement tools to describe (measure) white-collar productivity at PL-III and PL-IV, INPUT assumes that simple, intuitive measurements will be necessary (and probably desirable as well).

- INPUT will assume that fewer rather than more paper documents will enhance productivity at PL-III and PL-IV and that the amount of paper will therefore provide a rough measurement of productivity at those levels. In announcing its plans for the fifth generation, a group of Japanese scientists observed, "In Japan as elsewhere the recent rapid progress in word processing techniques will no doubt increase the volume of text data and documents that have to be handled by computer to an intractable level." It is INPUT's position that central computer and word processing techniques are already producing paper documents in quantities that not only have reached an unmanageable level in the U.S. (where word processing is more advanced than in Japan), but that the documents in themselves are a major contributing factor to the white-collar productivity problem. Volume of paper becomes a problem in that it requires analysis (or at least handling).

- Even recognizing that interpersonal communications and telephoning are necessary, they are not an especially productive way to spend time. Current levels of these activities are generally too high, and time saved on them could be more effectively spent on analysis and decison making. Therefore, if less time is spent on these functions, the savings could indicate improved productivity (at least in the foreseeable future). The following are general comments concerning the productivity of oral communications.

  - The percentage of telephone time spent on meaningful business communications is quite small (something less than 25%) when calling overhead, looking up numbers, missed calls, leaving messages, idle conversation, and personal business are considered.

  - Meetings become increasingly expensive as more people are involved and suffer from poor planning of content, poor attendance by the right people, unnecessary attendance by others, and a general tendency to stray from the subject. Although the amount of meaningful information conveyed may vary, it is usually quite low.

- Travel suffers from all of the problems of meetings plus the actual travel time involved and the impact of having the individual away from the office.

- In addition, oral communications of all kinds are subject to misunderstandings and must be documented in some form.

• Lastly, it is assumed that use of office systems (where optional) in levels III and IV is an indication that the user feels more productive. In other words, a widely used system contributes more to productivity than an underused one.

  - The classic tactic of mailing computer reports with a notice of discontinuance unless positive confirmation of use is received is a reasonable measure of usefulness.

  - Whether the problem is the human-to-computer interface, adequate training, or ignorance, an unused system cannot improve productivity.

  - Given alternatives (telephone, electronic messages, travel to a meeting, etc.), it must be assumed that most white-collar workers will select the alternative that makes the most productive use of their time.

• The seven productivity measurement assumptions that will be used in this report are summarized in Exhibit III-9.

C. PRIORITIES FOR IMPROVEMENT

• Office costs have been analyzed both by function and by occupation earlier in this chapter (see Exhibits III-4 and III-5). Even a simple ranking of these cell costs serves to establish a rough prioritization for improvement, as shown in Exhibit III-10.

EXHIBIT III-9

SUMMARY OF ASSUMPTIONS CONCERNING PRODUCTIVITY MEASUREMENT

Assumption No. 1:	Measurement of white-collar productivity (performance) becomes increasingly difficult at higher performance levels (as defined in this report: levels I through IV).
Assumption No. 2:	The same results, e.g., amount of paper produced, do not necessarily indicate the same increase in productivity for levels I and II as they do for levels III and IV.
Assumption No. 3	Measurement tools from the physical sciences and industrial engineering that can be used with some effectiveness at performance levels I and II are not adequate for levels III and IV; moreover, the social sciences do not have adequate tools (mathematics) to solve the problems of measuring productivity at the higher levels.
Assumption No. 4:	Lacking adequate measurement tools to describe (measure) productivity of white-collar workers at performance levels III and IV (regardless of mathematical complexity), simple intuitive measurements are both necessary and desirable.
Assumption No. 5:	Decreases in the volume of paper documentation can be used as a rough measurement of productivity improvement at performance levels III and IV.
Assumption No. 6:	When the time spent on interpersonal communications (including telephoning) is used instead for analysis and decision making, it may indicate productivity improvement.
Assumption No. 7:	Relative use of competing office systems can be used to measure productivity improvement.

EXHIBIT III-10

RANKING OF OFFICE COSTS BY OCCUPATIONAL CELL

FUNCTIONAL/ OCCUPATIONAL CELL *	DOLLARS (billions)	PERCENT TOTAL EXPENSE	CUMULATIVE PERCENT	RANK	CELL DESCRIPTION (Occupation Code and Function Category)**
1. B.	$149.4	13.0%	13.0%	1	P & T — Analysis and Decision Making
8. A.	108.0	9.4	22.4	2	EMA — Interpersonal Communications
2. B.	85.4	7.4	29.8	3	P & T — Report Preparation
8. B.	85.4	7.4	37.2	4	P & T — Interpersonal Communications
2. A.	81.0	7.0	44.2	5	EMA — Report Preparation
7. A.	72.0	6.3	50.5	6	EMA — Telephone
8. C.	67.0	5.8	56.3	7	Sales — Interpersonal Communications
6. B.	64.1	5.6	61.9	8	P & T — Information Handling
1. A.	54.0	4.7	66.6	9	EMA — Analysis and Decision Making
6. A.	43.2	3.8	70.4	10	EMA — Information Handling
7. B.	42.7	3.7	74.1	11	P & T — Telephone
6. F.	39.0	3.4	77.5	12	OC — Information Handling
7. C.	33.4	2.9	80.4	13	Sales — Telephone
1. F.	32.5	2.8	83.2	14	OC — Analysis and Decision Making
4. E.	22.7	2.0	85.2	15	T/DE — Typing/Data Entry
2. C.	16.8	1.5	86.7	16	Sales — Report Preparation
5. F.	15.6	1.4	88.1	17	OC — Copying
4. F.	13.0	1.1	89.2	18	OC — Typing/Data Entry
8. F.	13.0	1.1	90.3	19	OC — Interpersonal Communications
7. F.	10.4	0.9	91.2	20	OC — Telephone
1. C.	10.1	0.9	92.1	21	Sales — Analysis and Decision Making
6. E.	8.6	0.7	92.8	22	T/DE — Information Handling
4. D.	8.4	0.7	93.5	23	S/AA — Typing/Data Entry
7. D.	7.4	0.6	94.2	24	S/AA — Telephone
8. D.	7.4	0.6	94.9	25	S/AA — Interpersonal Communications
8. E.	7.4	0.6	95.5	26	T/DE — Interpersonal Communications
5. E.	6.8	0.6	96.1	27	T/DE — Copying
6. C.	6.7	0.6	96.7	28	Sales — Information Handling
2. F.	6.5	0.6	97.3	29	OC — Report Preparation
6. D.	6.3	0.5	97.8	30	S/AA — Information Handling
7. E.	5.7	0.5	98.3	31	T/DE — Telephone
1. D.	5.0	0.4	98.7	32	S/AA — Analysis and Decision Making
1. E.	2.9	0.2	98.9	33	T/DE — Analysis and Decision Making
2. E.	2.9	0.2	99.1	34	T/DE — Report Preparation
2. D.	2.9	0.2	99.3	35	S/AA — Report Preparation
5. D.	2.5	0.2	99.5	36	S/AA — Copying
3. D.	2.1	0.2	99.7	37	S/AA — Dictation
3. A.	1.8	0.2	99.9	38	EMA — Dictation

Total: $1,150.0

* Cell designation from Exhibit III-2

** EMA = executives, managers, and administrators, OC = clerical workers, P&T = professionals and technical workers, S/AA = secretaries and administrative assistants, T/DE = typists and data enterers

- The highest ranked six of the thirty-eight cells represent over 50% of white-collar expenses.

  - Those six cells are split equally between Professional and Technical (P&T), and Executive, Managerial, and Administrative (EMA).

  - P&T accounts for three of the top four cells with the following functional areas: analysis and decision making (13%), report preparation (7.4%) and interpersonal communications (7.45).

  - The three EMA functional cells are interpersonal communications (9.4%), report preparation (7.0%), and telephoning (6.3%).

- The next five cells raise the cumulative percentage of white-collar salary expenses to over 74% with P&T and EMA continuing to dominate.

  - Only sales interrupts the dominance with interpersonal communications (5.8%) being the seventh ranked cell.

  - The other P&T functional cells are information handling (5.6%) and telephoning (3.7%).

  - EMA is represented by analysis and decision making (4.7%) and information handling (3.8%).

- It is not until the twelfth ranked cell that a clerical category appears (other clerical information handling - 3.4%).

- Only three cells involving typing and copying (the predominant PL-II functions) appear before the 90% cumulative expense level is reached at the 19th ranked cell (the midpoint of the cells being ranked). These three cells (T/DE-typing, OC-copying, and OC-typing) represent a total of only 4.5% of total white-collar salary expense.

- It is obvious which cells should have priority for users, because of potential cost savings through improved productivity, and for vendors because of the potential market. This enables us to evaluate both current products and advanced systems that may be developed to address office productivity.

IV OFFICE SYSTEMS EVALUATION

IV OFFICE SYSTEMS EVALUATION

A. BACKGROUND AND METHODOLOGY

1. BACKGROUND

- It is important to recognize that office systems remain essentially paper oriented. Despite the fact that office workers spend most of their time communicating orally, paper is still the life blood of offices. The end product of office work is a paper document whether that document is the company's strategic plan, advertising copy for a new product, a memorandum documenting a meeting, a processed insurance claim, or the cost justification for a new word processing system.

- Paperwork management, systems and procedures, and organization and methods analysis received much more attention before computers were used in office work. There are several reasons for this change of emphasis.

  - Computer technology promised to solve many office problems - especially those involving routine calculations such as accounting.

  - The fascination with the new technology diverted attention from the more mundane aspects of office systems, and new career opportunities attracted the most promising systems analysts.

- Much more money was invested in new computer systems than in improvements of existing paper-based systems. In fact, managers who proposed solutions that did not involve computers were considered backward.

- Computer systems analysts began to feel traditional systems work was beneath them, and became so involved in the complexities of computer hardware and software that they did not have time to do a thorough analysis of office systems and procedures.

• The result was a split between the data processing department and users - which continues despite emphasis on information centers, decision support systems, and user friendly systems.

• Parallel to the development of the central data processing function, new technology began to find its way into the office. Office copiers, micrographics systems, word processing systems, timesharing systems, minicomputers, and then personal computers were installed without the benefit of much assistance from the central DP function. The possibility of providing integrated, computer-based office systems becomes more real with advancing technology both in cost and ease of use.

• As central data processing facilities gradually distributed computer processing power to users, and as user-installed office systems acquired the ability to perform more data processing functions, contention became inevitable. Perhaps nowhere is this more apparent than at IBM where, despite a major reorganization in order to present a single face to the marketplace, those who sell office products directly to end users offer different solutions than those who sell mainframes to corporate management or the data processing department. (And this disparity is within the world's most disciplined sales force.)

2. METHODOLOGY

- Chapter IV will analyze the impact of current office products and potential advanced office systems on overall office productivity. Due to the difficulties in defining and measuring white-collar productivity, which were described in the preceding chapter, and also due to the complexity of the areas to be covered, the evaluations will be made in the following manner:

  - Generic products and systems will be established and evaluated based on the performance levels established in Chapter III.

    - These generic products and systems may provide alternative solutions to the same problems.

    - Specific products and systems will be mentioned as references and illustrations only.

  - The generic products and systems will be analyzed against the occupational/functional cost matrix developed in Exhibit III-4. This will be done in terms of the primary target cells for the product or system being analyzed and for the potential impacts (positive or negative) on other cells.

  - The performance assumptions established in Chapter III (Exhibit III-9) will be applied in making the evaluations.

- Generic products and systems will be classified in six major categories.

  - Data/information entry and retrieval systems will include:

    - Manual systems (paper based).

    - Word processing systems.

- Copiers.

- Workstations (including personal computers and portable terminals).

- Pattern recognition systems (OCR-MICR).

- Text/document storage and distribution systems.

  - Paper-filing systems.

  - Micrographics systems.

  - Multifunction copiers (such as IBM's 6670 Information Distributor) and facsimile systems.

  - Image processing systems (such as IBM Scanmaster I).

  - Electronic filing systems.

  - Electronic mail and messaging systems.

- Sensory extension systems.

  - Phone systems.

  - Land mobile radios.

  - Video conferencing (including high resolution TV monitors).

  - Audio recognition/response systems.

  - Robotics.

- Data/information-based computer systems.

  - Batch systems.

  - Interactive systems.

  - Data base management systems.

  - Integrated information-based systems (DBMS and document storage).

- Knowledge-based systems.

  - Decision support systems (DSS).

  - Information centers.

  - Integrated data/information-based systems with DSS (modeling and simulation).

  - Personal computers/personal data bases (assumed to be a personalized DSS).

  - Computer conferencing for problem solving.

  - Inference-oriented systems (artificial data bases).

- Expert systems.

  - Knowledge-based systems/specialized models (Medical, VLSI Design, etc.).

- Business planning systems (if a generalized system can be created).

- It should be obvious that the wide range of systems listed above cannot be evaluated or even described in great detail in this report. Fortunately, the computer industry has always abounded in terms to describe relatively few (not to say simple) concepts; therefore, the task is not nearly so imposing as it may seem. The purpose of our analysis will be to demonstrate that these many systems are closely related and should not be evaluated without considering these very relationships.

B. GENERAL EVALUATION OF PRODUCTIVITY BY PERFORMANCE LEVELS

1. HARDWARE/SOFTWARE (PL-I)

- Twenty years ago IBM surveyed all of its major customers in an effort to determine the programming systems support required for its new product line (System/360, which was to be announced in 1964). When asked to rate the importance of various systems software attributes, customers overwhelmingly selected "ease of use" (as opposed to operational speed, documentation, compile speed, etc.). The message was clear: it was more important to improve user (human) productivity than it was hardware performance.

- With this information in hand, IBM proceeded to develop OS/360, which was the most complex operating system that had ever been developed. In addition to communicating with the computer (programming), an entirely new language (JCL) was required in order to communicate with the operating system itself. Programmers found they made more errors with JCL than they did in writing code; JCL specialists became necessary in some organizations; an elite corps of systems programmers were required for the care and feeding of the operating system; and the mysteries of computing were effectively shielded from the outside world. All of this was in the pursuit of "ease of use," which obviously has different meanings to different people.

- As IBM systems software has evolved over the last 20 years, it has achieved a life of its own, and the shift to MVS/XA can be greeted with as much fanfare as a major hardware announcement. Indeed, there is good reason for this since a preponderance of hardware CPU cycles are used to execute systems software, the productivity of which is not clearly understood except that, on large IBM mainframes, systems software requirements are driving hardware development and not visa versa. There is the assumption that something so complex and so expensive must be doing something wonderful - which is not necessarily true.

- Large-scale operating systems were originally developed to make effective use of a scarce and expensive resource - computer processing power. By giving more users access (either through applications programs in a multiprogramming batch environment or through terminals in a timesharing environment), the central mainframe could avoid idle time and be more productive. In fact, a busy CPU is still being used as a measurement of productivity. A new release of an operating system, for example, will be tested at keeping the CPU busier than its predecessor - without regard for whether the work is productive or merely overhead.

- However, properly configured large-scale mainframes were the most cost-effective solution as long as processing power remained relatively expensive. Due to economics of scale, large central processors were more productive (had better price/performance) than many smaller systems. However, it soon became apparent that minicomputers with operating systems designed for an interactive environment have substantially better price/performance for support of terminals (Economics of Computer/Communication Networks and Their Future Impact, INPUT, 1976).

- It is now even more apparent that microprocessor-based systems (intelligent terminals, word processors, or personal computers) can have substantially better price/performance when used for some functions. This is true with only minimal use of such systems (in other words, they do not have to be kept busy 100% of the time in order to be more cost effective than a highly productive mainframe operating at over 90% of capacity).

- INPUT still believes that there is a proper distribution of processing power from large-scale mainframes to minicomputers to microprocessors. However, this proper distribution is primarily hardware oriented and can become vastly distorted when systems software is considered. Such software trades off processor performance against improved ease of use (productivity) at the human-to-computer dyad (PL-II). As pointed out previously, measuring performance becomes much more complicated when software is combined with hardware, but there has been a disturbing propensity for many hardware/software systems designers to assume that processing power will always be available for every frivolous use on the software side. In other words, hardware processing power has been considered a virtually unlimited resource at all high-productivity performance levels.

- Before proceeding to higher preformance levels, it is desirable to establish that there are "serious limitations on the ability of computers to carry out enough computations to solve certain mathematical and logical problems." This conclusion has been reached by Hans J. Bremerman, professor of mathematics and biophysics at the University of California at Berkeley, and is succinctly documented in his essay "Complexity and Transcomputability," which appeared in <u>The Encyclopedia of Ignorance</u>. Briefly (and simply) stated, Bremerman makes the following points:

    - Travel time of signals between different parts of a computer should not exceed switching time. Since travel time has a finite limit determined by the speed of light and distance, the entire computer must be small. (Therefore, the necessity for larger scale integration).

- In addition, the signals themselves must be received and interpreted, and this implies physical measurement. These measurements are governed by the uncertainty principle of quantum mechanics, which means that "the faster the measurement, the larger is the energy that is required to make the signal readable with sufficiently small error probability."

- "The amount of signal flow (in bits/sec) in a computer is thus limited by E/L, where E is the energy available for signaling" (L is Planck's constant).

- "This fundamental limit of data processing applies to computers, irrespective of the details of their construction. It can even be extended to computers other than digital machines (and thus becomes applicable to data processing by nerve nets)." In other words, the limit applies to all architectural solutions, and getting away from von Neumann architecture only buys a reprieve. (It is interesting that Bremermann programmed and operated von Neumann's pioneering computer at Princeton in 1955.)

- Bremermann points out numerous mathematical examples, including those of operations research, which have computational costs that exceed the capacity of any computing resource on earth. Some of these can appear quite simple, such as solving the "traveling salesman problem" for 100 cities. (The traveling salesman problem is to find the route with the lowest total mileage if each city is visited only once.)

- In discussing transcomputable algorithms, the following is pertinent: "We call an algorithm transcomputable if its computational cost exceeds all bounds that govern the physical implementation of algorithms. It can be shown that the exhaustive search algorithm for chess is transcomputable. The same is true for many algorithms of artificial intelligence and operations research. In fact, any algorithm whose computational cost grows exponentially with a size parameter n is transcomputational for all except the first few integers n. This is a rather disturbing thought, and many people have chosen to ignore it."

- It is necessary to consider these limitations because the fields of artificial intelligence and operations research are important in developing computer systems designed to improve the productivity of white-collar workers. In evaluating such systems, the algorithms do not literally have to be transcomputable; they may merely be impractical in terms of performance for the commercial marketplace.

2. HUMAN-TO-COMPUTER DYAD (PL-II)

- In the 1950s it was decided that a computer could be used to compute mileage for individual railroad car movements among various stations on a major railway system. (Considering the limitations of the hardware, the problem nearly proved to be transcomputable, but a method was devised.) The system's analyst worked closely with the personnel responsible for accounting for car movements (mileage recording, key punching, tabulating, and listing off reports for billing and historical records, etc.), and it was agreed that the system was finally ready to go into production. The following then occurred:

  - When the first production run was completed the manager of the mileage section approached the analyst and said, "You tell that computer that we didn't put those mileages in there."

  - When informed that the computer had computed the mileage the only response was, "Oh, my God!"

  - The initial response was one of confidence from one who thought he understood that you gave a computer something routine to do, and it would add up a bunch of numbers and print out a report.

- The second response was similar to that of the navigator on the plane that dropped the first atomic bomb: awe - and the realization that life is never going to be the same again. If a computer has enough knowledge to understand a railway system's status and mileage as well as its specific car movements, its operator will not need either paper mileage tables or mileage clerks.

- Not only did the manager not understand how the computer worked, he could not conceive that it could do what he did. The manager did not even recognize the end result of the system he was developing.

• The actual case study presented above says much about the human-to-computer dyad.

  - General uneasiness about computers has been assuaged by the realization that they only do what you tell them to do.

  - It has generally been felt that the computer is not necessarily friendly and that it speaks a foreign language. For decades users found it necessary to go through human interpreters if they wanted to tell the computer what to do.

  - As mileage clerks are reassigned it becomes apparent that computers are decidedly unfriendly: they can even replace the person who feeds them information. With this awareness, humans have often been reluctant to get to close to a computer.

    . There is wariness that they may be replaced.

    . The analyst might think the person is dumb or his work is simple.

- Even at a terminal many people still fear the computer will catch them in a mistake.

  The attitude remains that a computer may be "friendly," but it is out to get me.

- Analysts, on the other hand, have a feeling of importance that they cannot be replaced because they can talk with the computer and that users are too dumb ever to learn how.

- A friendly user-to-computer interface may turn the dyad into a love affair with some unfortunate consequences.

  - The analyst/programmer will only help users if the computer can be involved also.

  - Newly initiated users may become more interested in working with computers than in doing their regular jobs.

  - The computer may be so friendly it permits itself to do a lot of favors (meaningless work) for its friends and then be unable to do its normally scheduled work (production) because it doesn't have time (capacity).

  - Then there are those humans who don't want to share a computer with others but insist on having a monogamous relationship.

- Human-to-computer dyads are much like marriages - they can be good or bad for one or both of the participants, and the fact that they exist does not necessarily indicate they are working effectively.

- The trend today is to bring humans and computers closer together, assuming that the human will become more productive. This is an extremely difficult hypothesis to prove, especially when impacts on higher performance levels are considered.

3. WORK UNIT NETWORKS (PL-III)

- Office work units are formed primarily to facilitate and control communications, not to produce a product. White-collar workers are organized into work units in order to establish reporting structures and, it is hoped, authority and responsibility. While a great deal has been written about the impact of office automation on organizations, those writings have normally emphasized controllable changes. INPUT believes that the changes in information flow that will result from many advanced office systems will establish electronic organizations that are more real than those depicted on formal organization charts.

- To a certain degree, sub rosa work units exist today through interpersonal communications and the telephone, but substitution of electronic media for paper flow will literally destroy the current hierarchical structure of most organizations. This will make performance measurement of work units difficult, and organizational productivity will become even more difficult to define.

- The primary functional areas associated with PL-III (Exhibit III-6) vary considerably in complexity of evaluation.

    - Information handling is the simplest since travel time of documents, volume of documents handled, time to retrieve, etc., are all measurable. However, the limitations on computer computational capacity also apply:

        - Travel time of signals (information) should not exceed switching time (the ability to receive, interpret, and take action) or queuing problems can develop that seriously inhibit performance.

- If the signal (information) is to be measured (analyzed, evaluated) rapidly, more energy (effort in information preparation) is required to make the signal readable with sufficiently small error probability (quality information is easier to handle). In other words, volume is not a good measure of productivity in information handling when useless information (errors) must be discarded in the waste basket.

- Telephoning has always been considered cheap, and therefore productive, when compared with paper communications or traveling, which is in fact true in many instances. A complete evaluation, however, requires consideration of a number of other factors:

  - Telephoning costs are often considered to be the phone bill, which is relatively insignificant compared to the personnel costs we have identified.

  - Preparation time for a phone call must be considered, and that not only includes finding the phone number, but also preparing the information to be conveyed.

  - Written confirmations of telephone conversations are frequently necessary.

  - Busy signals and inability to reach the desired party are uncontrollable wastes of time.

  - There is a natural tendency to exchange pleasantries and to discuss subjects tangential or completely unrelated to the purpose of the call or to business.

  - Speech is a relatively slow way to convey information (as compared to the written word).

- All in all, a relatively small percentage of telephone time (expense) is spent exchanging meaningful business information.

- Interpersonal communications suffer from most of the problems associated with telephone conversations, and have other disadvantages in addition.

  - Travel time is normally involved whether it is to the next desk, to the conference room, or halfway around the world.

  - Meetings and conferences compound the problems of interpersonal communications because only one person can (or should) talk at one time, and the people who participate in meetings are not necessarily the ones who can contribute the most.

  - While detailed agendas can be prepared, assembling the right people, picking the right subjects, and keeping on the subject are extremely difficult.

  - Individual evaluations of meetings vary considerably, and even if all participants agree it was a good meeting, there is no assurance that it was productive from the point of view of the work unit - it may have been popular because it was entertaining.

- Report preparation is the product of analyzing and documenting communications (information-gathering activities) and may also result in conclusions, recommendations, and even decisions. Nevertheless, reports (documents) are extremely difficult to evaluate.

  - Recording meaningless or misleading data/information can not only be worthless but actually misleading.

- Volume is not a good measure of quality or usefulness. The purpose of analysis is to create information out of data with enough explanation to be convincing. Lengthy reports tend to obscure meaningful information.

- Improving the mechanics of producing reports (whether with paper and pencil, by dictation, or at a personal computer) may produce a report faster with fewer typographical errors without misspelled words, but it can never compensate for problems associated with language and terminology, much less the conclusions reached as a result of analysis.

- In addition, it is doubtful that very many reports are carefully read under any circumstances. There just isn't enough time for human beings to scan, much less comprehend, the volumes of paper documents being produced.

- It should also be understood that a great deal of the time spent on report preparation is optional. Some people like to prepare reports and others do not. The classic "memo to the file" or "protect your reputation report" are seldom read at all.

4. INSTITUTIONAL PERFORMANCE (PL-IV)

- With the much-heralded dawning of the information age (created mostly by the theoreticians of high technology), it is important to remember that white-collar workers exist only to facilitate the delivery of products and/or services to those who need or want them. Business enterprises do not exist for the sole purpose of providing accountants with score keeping opportunities, or as workshops for business school graduates. Government agencies do not exist solely to provide work for budget examiners and position classifiers.

- As pointed out previously, it is extremely difficult to relate individual analysis and decision making to institutional performance. As analysis and decision making becomes more dependent upon data/information bases and knowledge-based systems, it is obvious that such evaluation will not become any easier. However, unless continuing measurements are made, the situation will never improve and management will lose all control - which is not an encouraging prospect.

- There is one critical weakness in institutional performance evaluation that should be understood and corrected. There is a tendency to assume that analysis and decision making are good only if specific goals and objectives are achieved. This is not necessarily so. It may simply be a case of having inadequate goals and objectives. From the point of view of institutional performance, it can be just as important to identify failures to achieve maximum performance as it is to meet minimal standards. A brief example from the IBM planning process will illustrate the point.

    - IBM has traditionally exceeded product forecasts on a high percentage of announced products. In the case of products that did not come up to forecast, the failure of product managers was recognized and corrected. When products were more successful than forecast, however (in fact, when the discrepancy between forecast and actual was greater than in the case of a product failure), the reaction was normally as follows:

        - While the forecaster might be chided by his contemporaries, his performance evaluation would seldom suffer.

        - Pride would be taken in the great institutional performance (especially by the sales force that had happily exceeded quota).

        - The product manager would probably be promoted.

- Institutional success as measured by the bottom line may distort the quality of analysis and decision making and even obscure poor performance. While it is doubtful whether the reward system for forecaster, salesman, and product manager will ever change, it is important to recognize that the quality of performance must also be evaluated independently.

- In IBM's case, a major success in personal computers has obscured some rather ineffective analysis that may have been disastrous for another company.

  . A low long-range forecast of the personal computer market delayed IBM's entry until the competitive threat to other IBM products became obvious.

  . The forecast at time of entry was so low that serious delivery problems developed almost immediately.

  . The analysis behind both forecasts was poor, and the initial decision not to enter market was probably wrong.

- The fact that IBM had the resources to make a spectacular recovery should not obscure the quality of performance in the planning process.

• To understand, much less evaluate, the various components of this decision making process is obviously impossible whether we talk about productivity, performance, or effectiveness. To evaluate the impact of individual office products or systems on the process is more difficult.

• The important thing to recognize is that decisions at the institutional level are the result of a complex human-to-computer network (as opposed to dyad), and that the individual who makes the decision may have the best decision support system in the world or use a crystal ball, but he will be held accountable and judged on institutional performance regardless.

C. PRODUCT AND SYSTEMS EVALUATION

I. DATA/INFORMATION ENTRY AND RETRIEVAL SYSTEMS

- This section analyzes specific categories of office systems and identifies the total white-collar costs of activities toward which these systems are targeted. Thus a framework of potential savings is presented upon which the reader may allocate the expected percentage of total costs that would be appropriate for the specific system and office being analyzed.

- For a number of years, word processing was synonymous with office automation, and even today many information systems managers do not make a distinction. Word processing products and systems have been widely accepted, and there is little doubt that they have improved the productivity of those who type.

  - Exhibit IV-1 presents INPUT's estimate of the potential positive and negative impacts of word processing systems on the functional/occupational cost cells developed in Exhibit III-4.

    - The primary cost reductions (positive impacts) must be in the typing function, which accounts for $44.1 billion or 3.8% of total office personnel costs.

    - There should also be secondary positive impacts on report preparation ($195.5 billion, 17%), although the actual implementation of word processing sometimes minimizes this benefit. (This will be discussed later.)

    - However, word processing systems normally increase the amount of paper that requires handling and therefore has a negative

EXHIBIT IV-1

WORD PROCESSING EVALUATION

($ billions)

FUNCTION / OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL	(G) TOTAL
(1) Analysis & Decision-making							
(2) Report Preparation	-$81.0	-$85.4	-$16.8	-$2.9	-$2.9	-$6.5	-$195.5
(3) Dictation							
(4) Typing/Data Entry				-8.4	-22.7	-13.0	-$ 44.1
(5) Copying/Information Entry							
(6) Information Handling/Storage	+43.2	+64.1	+6.7	+6.3	+8.6	+39.0	+167.9
(7) Telephone							
(8) Interpersonal Communications							
Total							

+ = Decreased costs (positive impact), − = Increased costs (negative impact)

impact in that functional area ($167.9 billion, 14.6%). (While physical handling may be eliminated, electronic documents must also be handled in the sense that they must be read, screened, routed, etc.)

- While acceptance of word processing systems indicates a positive impact on productivity (assumption #7, Exhibit III-9), it should be noted that this could depend upon improvements in report preparation.

  - Increased paper-handling costs based on increased volumes may actually lower overall productivity (assumption #5, Exhibit III-9) since paper-handling costs are greater than typing costs.

  - The improvement in report preparation productivity depends upon improved efficiency of the typists or effectiveness of the report preparers.

  - Centralized word processing functions frequently result in bottlenecks comparable to those in centralized computer installations and may actually decrease report preparation productivity unless carefully analyzed.

  - This is really a measurement problem since typing falls in PL-II and is easier to evaluate than report preparation, which falls in PL-III (assumption #1, Exhibit III-9).

  - There is a natural propensity to improve efficiency of easily measured functions at the expense of those that are difficult to measure.

- In addition, some disturbing results were reported concerning head-to-head competition between computer-based document preparation and manual preparation. Both XEROX and Stanford (SRI International) reported specific (unpublished) studies that indicated computer-based systems were actually more expensive when cost of equipment was considered and the actual labor time was equal. These problems were primarily those associated with the human-to-computer dyad.

. Complex procedures were required for locating files, logging on, etc.

. Text formatting was complex.

. Response time or systems problems caused delays.

- While the above problems are not necessarily inherent in standalone word processing systems, the trend towards complex text processing systems and local aarea networks will complicate performance measurement at PL-II. As pointed out previously, ease of use means different things to different people, and computer hardware/software systems (PL-I) have not been noted for user-friendly interfaces.

- While there are open questions about the overall impact of word and text processing systems, there is no doubt that the office copier has changed the office environment and is part of the paper-handling problem. The acceptance of office copiers has been spectacular, and the result has been a dramatic change in the information flow in the last 20 years: the primary change being an increase in the volume of paper that is flowing.

  - Exhibit IV-2 presents a curious picture since the copier has literally created much of today's office environment.

    . While the primary cost savings can be represented in the typing function (virtual elimination of the carbon copy problem) and retyping for additional distributing, it would be impossible for typists to create the volume of paper documents that copiers produce.

EXHIBIT IV-2

OFFICE COPIER EVALUATION

($ billions)

FUNCTION / OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL	(G) TOTAL
(1) Analysis & Decision-making							
(2) Report Preparation							
(3) Dictation							
(4) Typing/Data Entry				-$8.4	-$22.7	-$13.0	-$ 44.1
(5) Copying/Information Entry				+2.5	+6.8	+15.6	+$ 24.9
(6) Information Handling/Storage	+43.2	+64.1	+6.7	+6.3	+8.6	+39.0	+$167.9
(7) Telephone							
(8) Interpersonal Communications							
Total							

+ = Decreased costs (positive impact), − = Increased costs (negative impact)

- Copiers have also reduced printing costs since every office can now publish reports, but this cost savings is not included in the matrix since it cannot be quantified.

- Of course, the cost of copying itself must be represented as additional expense, and at $24.9 billion (2.2% of office expense), it is more than half of the cost of typing.

- The impact on information handling costs ($167.9 billion, 14.6%) is difficult to estimate, but it is a safe assumption that at least 50% of the documents being circulated in offices today would not exist if it were not for office copiers.

- The $83.9 billion (50% of the total) in additional paper handling costs does not include the cost of either paper or storage (file cabinets and office space).

- The enormous increased cost must be justified by improved office communications (information flow), but it is doubtful whether all of these copies are either necessary or desirable. In fact, the availability and acceptance of unlimited copying has many undesirable effects in addition to increased volume:

  - Uncontrolled distribution of copies causes additional (and frequently unnecessary) analysis by people who do not need to receive the information.

  - This, in turn, elicits unnecessary responses from these recipients since information copies are difficult to distinguish from action copies. The net result is an enormous increase in the amount of white-collar work.

- Office copiers have made the flow of paper documents practically uncontrollable. This has caused security and privacy problems that are enormous when compared to those of the electronic systems that are creating such a furor.

- The significant fact about the combination of word processing and copiers is that the systems to date have merely produced increased volumes of paper that must be processed through manual systems. They seldom capture information in processable (and controllable) form.

- Intelligent workstations (including personal computers) hold promise for establishing human-to-computer dyads that will facilitate not only the entry and retrieval of documents but also the work unit networks characteristic of PL-III. The use of the personal (professional) computers by principals is a temporary phenomenon that has not yet shed much light on the productivity impact of intelligent terminals once they are interconnected in work unit networks.

  - Exhibit IV-3 shows that the use of personal computers by principals is definitely aimed at the proper function/occupational cells. The total of those subject to positive productivity impact is $412.9 billion or 35.9% of total office costs.

    - The acceptance of personal computers indicates either that they provide some productive improvement or that they are status symbols.

    - To offset the potential productivity improvement associated with analysis and decision making, report preparation, and dictation is an as yet unquantifiable expense of having non-clerical employees type and enter data. Regardless of proficiency, they must be more expensive than having clerical employees perform the function.

EXHIBIT IV-3

INTELLIGENT WORKSTATION EVALUATION

($ billions)

FUNCTION \ OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL	(G) TOTAL
(1) Analysis & Decision-making	-$54.0	-$149.4	-$10.1				-$213.5
(2) Report Preparation	-81.0	-85.4	-16.8	-2.9	-2.9	-6.5	-$195.5
(3) Dictation	-1.8			-2.1			-$ 3.9
(4) Typing/Data Entry	+ ?	+ ?	+ ?	-			+ ?
(5) Copying/Information Entry							
(6) Information Handling/Storage							
(7) Telephone							
(8) Interpersonal Communications							
Total							

+ = Decreased costs (positive impact), – = Increased costs (negative impact)

- While we will accept assumption #7 (Exhibit III-9), which states that acceptance and use of competing office systems can be used as a measure of productivity improvement, the explosive growth of personal computers does raise some questions concerning the competing systems:

  . Are personal computers being used as a substitute for poor (or expensive) service from the central information systems facility?

  . Are personal computers being used as a substitute for lack of adequate secretarial help?

  . If personal data bases can be built, used, and analyzed using desktop computers and spreadsheet software, are they really all white-collar workers need to improve their productivity?

- Most information systems departments admit they do not know what most of these people are doing with their PCs, but they assume they will eventually be forced back into the fold. It is suggested that it would be wise to determine what the users of PCs are doing and why.

- There is some indication that cost is the driving factor in PC use, and that many PCs are being employed as extensions of the handheld calculator. This is suggested by the following:

  . Professional workstations such as the Xerox Star, which provide excellent functional capability and user interfaces (at a premium price), have not been especially successful.

  . The more expensive offerings of both DEC and Apple (LISA) have not received enthusiastic acceptance. (LISA, in particular, seems to fascinate most people, but they do not feel they can justify its use.)

- It is possible that IBM will expand the market as it begins to view the PC as a stepping stone to promote computer use. (The recent IBM reorganization that incorporates PCs into entry level systems under an experienced PC executive is certainly directed toward classic IBM growth patterns.)

- The projections that intelligent workstations will constitute a $30 billion market by the early 1990s may be correct based on the targeted cells in the productivity matrix, but success in work unit networks will be essential. Establishment of such networks will require quality software for operating systems, networking, data bases, and applications. Most of this software is just beginning to develop.

- While alternative data entry systems incorporating pattern recognitions have not had appreciable impact on this systems category, microprocessor developments should soon make the technology more attractive in both capability and cost. Their availability will relieve some of the keyboard dependency of current data entry systems.

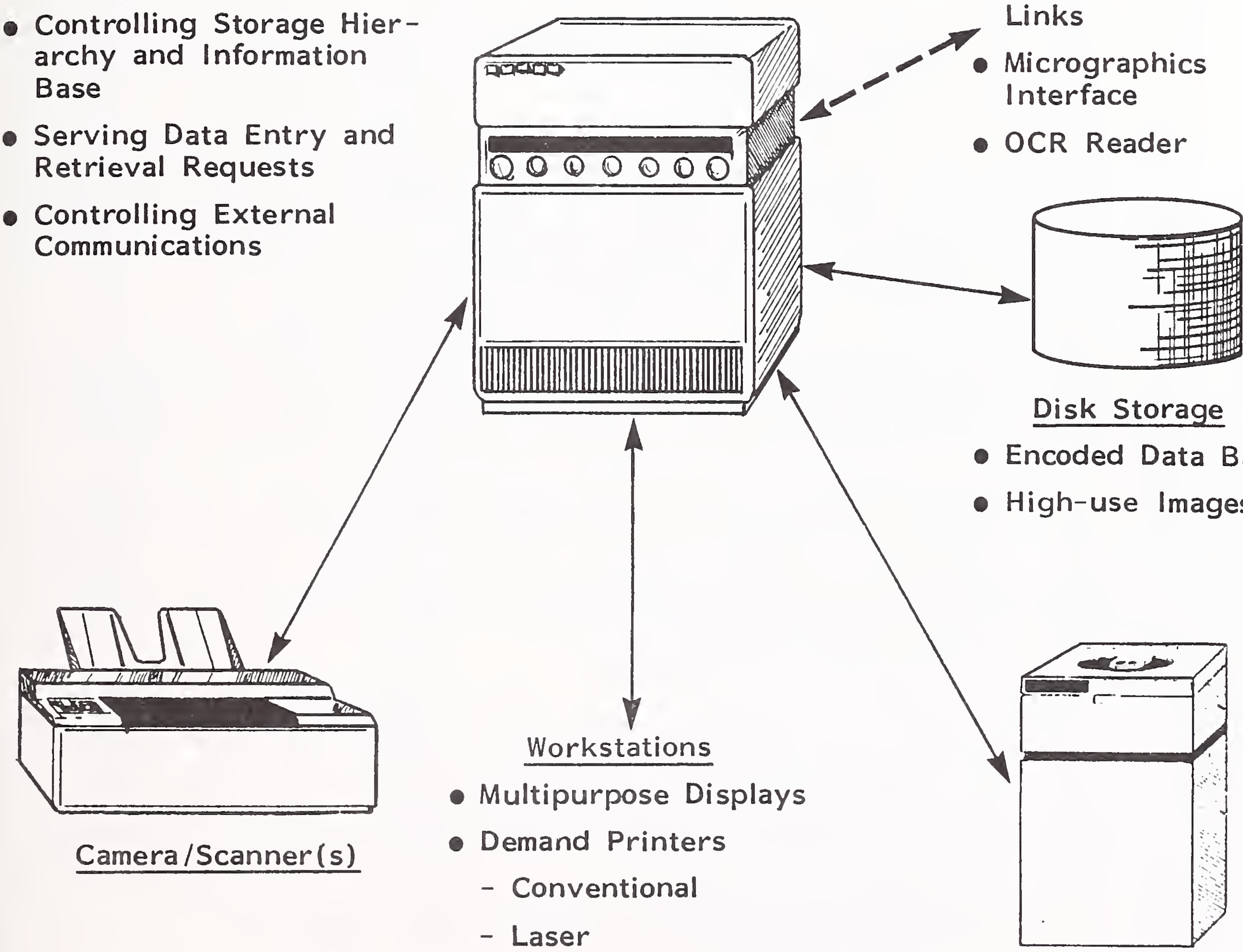
2. TEXT/DOCUMENT STORAGE AND DISTRIBUTION SYSTEMS

- The key to reducing paper in the office is the availability of cheap, high-performance, mass storage. INPUT believes that optical memories will provide such storage during the 1980s (<u>Impact of Upcoming Optical Memory Systems</u>, April 1983), and therefore defined a hierarchy of systems that would lead to electronic offices. One such system is depicted in Exhibit IV-4.

- The system could theoretically bring the paper avalanche under control by almost eliminating paper from the office. It would have a positive impact on productivity cells of $690.2 billion, or 60% of total office personal costs, as

EXHIBIT IV-4

INTEGRATED IMAGE PROCESSING SYSTEM



shown in Exhibit IV-5. The impact of such a system on productivity could be substantial and is more readily identifiable than most other office automation systems.

- Office copiers contributed to the paper processing problem and would be eliminated in the electronic office. (Some information entry at the scanner would remain.)

- All information handling would be from the workstations with substantial reductions in cost.

- Ready access to data bases, graphics, handwritten notes, and correspondence from a single workstation should significantly improve analysis by integrating information sources.

- In addition, electronic mail and message service is implicit in such a system (including signature and introduction of handwritten messages).

- Even though the impact is not shown in Exhibit IV-5, it is also felt that electronic message service will also probably reduce telephone expenses. The integrated image processing system would also improve interpersonal communications.

- There are no negative impacts once an electronic office is installed, but there are problems of implementation and cost, which were discussed in detail in Image Processing Systems - Concepts and Status, April 1980. For INPUT's most recent projections of availability, see Impact of Upcoming Optical Memory Systems, April 1983.

• Electronic filing systems have not yet been widely accepted because of both cost and limited capacity. The Burroughs OFIS I system is a good example, and the fact that Burroughs dropped optical memory development (which INPUT considers to be key) may prove to be a strategic error. It is probable

EXHIBIT IV-5

INTEGRATED IMAGE PROCESSING SYSTEM EVALUATION

($ billions)

FUNCTION \ OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL	(G) TOTAL
(1) Analysis & Decision-making	-$54.0	-$149.4	-$10.1	-$5.0	-$2.9	-$32.5	-$253.9
(2) Report Preparation	-81.0	-85.4	-16.8	-2.9	-2.9	-6.5	-$195.5
(3) Dictation	-1.8			-2.1			-$ 3.9
(4) Typing/Data Entry				-8.4	122.7	-13.0	-$ 44.1
(5) Copying/Information Entry				-2.5	-6.8	-15.6	-$ 24.9
(6) Information Handling/Storage	-43.2	-64.1	-6.7	-6.3	-8.6	-39.0	-$167.9
(7) Telephone							
(8) Interpersonal Communications							
Total							

+ = Decreased costs (positive impact), − = Increased costs (negative impact)

that Scanmaster I from IBM will also meet with only limited success (see INPUT's Executive Bulletin/Hardware, Vol. I, No. I, 1983, which cautioned clients on its use). However, INPUT remains convinced that integrated electronic offices are the ultimate solution to the office productivity problem.

- In the late 1970s IBM conducted extensive research by developing a prototype of an office communications system that was really an electronic text and document storage and distribution. The office study, which was done to specify the requirements for the prototype, and the conclusions reached after the prototype was installed were presented in "An Office Communications System," IBM Systems Journal, Volume Eighteen, Number Three, 1979. Essentially, the conclusions were as follow.

  - "The prototype empirically demonstrated that soft copy, in the vast majority of cases, would satisfy not only the informational needs of most persons but also their personal security feelings."

  - "Of note for future planning were requests for additional functions that were not included in the prototype. Among them was the request to allow access to data electronically. Such requests indicate that introduction of the workstation in the principal's office will create greater demand for interactive information and will have far-reaching impacts on system architecture at the host, distributed node, and workstation."

  - "Secretaries readily accepted the prototype. They saw its potential for easing their workload and providing them with an extended career path."

  - In analyzing the mail-processing function it was determined that the prototype (which could not handle images) was unable to handle a significant portion (40%) of the volume. It was concluded that, "These items will be difficult to include in electronic form until there is widespread availability of image scanners, displays, and printers, and total use of an electronic office by all employees."

- INPUT agrees with these assessments, and the integrated electronic office depicted in Exhibit IV-4 addresses the limitations of access to data and image processing. It should be noted a production prototype of such an integrated system (employing videotape for archival storage) was installed in the Central Bank of Belgium at the time IBM published the results of its research. The significance of optical memory in the availability of such systems is again emphasized and INPUT's research in these areas (cited above) is again recommended.

- In evaluating improved production as a result of the prototype system, IBM relied on time savings as estimated by the users of the system. In adopting this measure, the researchers assumed: "A principal will only use a function repeatedly over a period of time if some benefit is perceived," and "Time is of value and time savings represent potential benefits to a company." Both of these assumptions support assumption #7 of this study. The estimated time savings obtained for an "enhanced" version of the prototype were as follow:

  - Principals estimated that 5-25% of their time would be saved.

  - Secretaries estimated 15-35% of their time would be saved.

  - These savings are deemed conservative by INPUT for the following reasons:

    - The prototype system was relatively crude compared to the integrated systems that will be available in the mid-1980s.

    - The potential savings in telephone and interpersonal communications were probably underestimated due to the limited scope of the prototype.

- It should be noted that computer-aided micrographics retrieval systems have offered an attractive alternative to paper filing systems for a number of years without significant success except for very large archival files. This has been true for a number of reasons.

  - The systems have a clumsy human interface requiring both a conventional CRT and an image display unit.

  - Media conversion is required for development of the information base.

  - Information systems personnel have normally ignored the micrographics alternative either because they have not become involved or because they prefer conventional computer solutions (even if they are not currently economically justified).

  - It is probable that optical memories will be viewed as unconventional until IBM endorses the technology. This does not mean that such systems will not provide attractive alternatives to paper and magnetic storage of data and information.

- Electronic mail and messaging systems are currently being installed regardless of the fact that they expedite the flow of paper documents but do not significantly reduce the volume of paper produced because they do not make adequate provisions for cheap storage of documents. It is our opinion that these systems do have a favorable impact on both telephoning and interpersonal communications. However, they are considered a subset of the IBM prototype system that is, in turn, a subset of the integrated image processing system. An extensive system installed at Stanford University revealed the following:

  - Most administrative personnel enthusiastically accepted the system.

- An extensive independent evaluation of the project resulted in a recommendation for continuation and extension of the system both inside and outside the Stanford community.

- It appeared that there were reductions in both paper and telephone traffic, but there was no measurement of improved productivity other than the fact that the service was estimated to constitute 15% of total communications time. (Stanford was selected as a case study in INPUT's report Methods of Cost/Benefit Analysis for Office Systems, September 1983, in which additional analysis is included.)

3. SENSORY EXTENSION SYSTEMS

- While INPUT believes that integrated electronic information systems will reduce telephoning and interpersonal communications requirements, the primary reductions in such expense may eventually come from a group of systems that we will refer to as sensory extension systems. Taken as a group, they could have positive productivity impact on a total of $459.8 billion or 40% of office personnel costs, as shown in Exhibit IV-6. Such systems cover a wide range of complexity and acceptance.

    - The telephone is the most widely accepted sensory extension system, but some people are even reluctant to accept the telephone's simple technological advances.

        - Some do not like talking to answering machines, but as use of such machines becomes commonplace, aversions should abate.

        - Not everyone is using automatic dialers yet either, but this reluctance should also be temporary, subsiding once the positive impact on nonproductive telephone time is understood.

EXHIBIT IV-6

SENSORY EXTENSION SYSTEMS

($ billions)

FUNCTION \ OCCUPATIONAL CATEGORY	(A) EXECUTIVE, MANAGERIAL, ADMINISTRATIVE	(B) PROFESSIONAL & TECHNICAL	(C) SALES WORKERS	(D) SECRETARIES, ADMINISTRATIVE ASSISTANTS	(E) TYPISTS, DATA ENTRY	(F) CLERICAL	(G) TOTAL
(1) Analysis & Decision-making							
(2) Report Preparation							
(3) Dictation							
(4) Typing/Data Entry							
(5) Copying/Information Entry							
(6) Information Handling/Storage							
(7) Telephone	-$72.0	-$42.7	-$33.4	-$7.4	-$5.7	-$10.4	-$171.6
(8) Interpersonal Communications	-108.0	-85.4	-67.0	-7.4	-7.4	-13.0	-$288.2
Total							

+ = Decreased costs (positive impact), − = Increased costs (negative impact)

- The Bell System's experience with picture phone has probably done a great deal to delay the development of sensory extension systems. Early enthusiasm resulted in expenditure of enormous resources only to find that the product was not accepted. Among the reasons advanced for rejection in pilot projects were the following:

  - The screen size was too small.

  - Executives did not like to appear small on the screen and frequently would not stay on camera when conversing with subordinates.

  - Subordinates, on the other hand, did not like to be frozen on the camera while on the telephone (they were afraid to doodle or do other work while talking with the boss).

  - A full keyboard was not available for messages, and the screen was not large enough to show diagrams clearly.

  - Modern technology might correct many of the hardware problems, but the human considerations may still exist for audiovisual systems.

- However, advances in technology are definitely on the way for telephone systems. Cellular radio systems will soon permit mobile phones in cars and briefcases to be justified economically, and this should improve productivity by reducing the "dead time" associated with local travel (and eventually any travel).

- Reducing travel through the use of video-conferencing is very promising, but is difficult to evaluate for the following reasons:

- It is possible that a simple edict to cut travel by a certain percentage would accomplish the same purpose by eliminating unnecessary meetings, with or without video-conferencing.

- There are still those who are not satisfied unless they can actually "press the flesh," insisting that more is accomplished outside the meetings than in them. (How much business is actually transacted in bars or at dinner is an interesting question to both corporate controllers and the Internal Revenue Service, but it is beyond the scope of this study.)

- There is no question that interactive, high-resolution video can effect substantial cost savings in particular situations, such as in remote medical clinics where they would eliminate moving some patients. It has been demonstrated that para-professionals in prisons and nursing homes can be teamed with doctors to provide satisfactory care in a cost-effective manner, but implementation awaits cheap, broadband communications such as those that may be provided by advanced CATV or fiber optics systems.

- There are already a number of economical "electronic blackboards" and "frame grabbers" available on CATV systems that can be used immediately.

- Audio recognition/response systems are receiving a substantial boost from microprocessor technology and increased attention from those involved with artificial intelligence. It is INPUT's opinion that such systems will primarily find use in areas outside the office (such as warehouses, operating rooms, airplane cockpits, and other environments where it is more likely that the user will be using his hands in a critical activity). Given the choice, most people would rather push a computer's buttons than hold a conversation with it. And, even if dictation were more popular, voice recognition would only eliminate (or reduce) the transcription costs of secretaries. These costs amount to only $2.1 billion or less than .2% of office expense.

- White-collar robots (or electronic surrogates) have not been given much consideration since it has been assumed that only manual tasks lend themselves to the technology of robotics. (Robotic file clerks for remaining paper files are a decided possibility.) However, it is now appropriate to apply a variation on the classic Turing test to define whether or not a white-collar robot is possible. To answer this question, the following criteria will be applied:

  - If human beings can call a person on the telephone, ask a question, receive an answer (decision), and if they do not care whether they have talked with a person or a machine, a robot may have answered the phone and made the decision.

  - Is this likely? Advances in audio recognition and response, and simple application of artificial intelligence would indicate it can be accomplished now. Consider the simple scenario of dealing with one's stock broker.

    - A robot could be constructed that would recognize the client's voice and answer in the broker's voice. This is within the bounds of current technology.

    - It is obvious that such a robot could execute simple buy and sell orders and report the results.

    - In addition, it is possible to envision recommended actions based on the broker's best judgment on that particular day. For example, it would not be difficult for the robot to reply, "If you have $10,000 you want to invest today, I recommend you put it into XYZ, Inc."

- In fact, the robot could even give the usual unsolicited advice. Imagine this conversation: "Judy, as long as I have you on the phone, why don't you consider selling all of your IBM stock to buy controlling interest in Rinky Dink Software Unlimited. Those kids really have something with their remote robot brain transplant software."

- This brief discussion of white-collar robots is an intentional lead into the next section of this report, which will address the required role of artificial intelligence in addressing the problems associated with PL-IV systems to support institutional performance.

4. FROM DATA BASE TO EXPERT SYSTEMS

- The journey from current data base technology to expert systems is going to be long and arduous regardless of the amount of resources that are expected or how well the effort is planned. A discussion of artificial intelligence (AI) is necessary at this point since AI progress is both obvious and necessary if the productivity of nonclerical employees is to be improved. The logic behind this discussion is as follows:

  - While the hardware for development of an integrated electronic office (Exhibit IV-4) will be available, the mere integration of encoded data and images requires data/information-based compiler systems if they are to improve the productivity in the important functional category of analysis and decision making. (Remember, principals involved in the IBM study specifically requested access to data. Specifically this means that analysis will be expedited giving direct access to data that support the information (charts, graphs, and written analysis in the form of either reports or correspondence) at PL-III.

  - For analysis to support decision making at PL-IV, it is assumed that the system must provide knowledge to the individuals interacting with it.

Essentially this knowledge base will be built on inferential capabilities built into the system by the work unit network professionals at PL-III in anticipation of the data and information that will be required at the executive levels. If this is not done, such executives will never be able to navigate through the data/information bases created by the work unit networks.

- In a richly supported knowledge base (built on an underlying data/information base), it is assumed that the decision support systems using the knowledge base would require analytical tools ranging from simple statistical and accounting procedures through relatively complex macro-economic and geopolitical models. Otherwise the user would find it impossible to deal with the wealth of knowledge, information, and data available. Therefore, some form of expert systems would seem to be mandatory if performance at PL-IV is to be improved. (In fact, analysis paralysis could take over with the result that decision making could be delayed, or even avoided, by human attempts to analyze extremely complex and interrelated events.)

- While this progression may seem both logical and even required, there is no assurance progress can be made rapidly in these areas.

- Data/information-based computer systems assume that both quality data/information will be available and that the human-to-computer dyad will facilitate access, management, and analysis. The past track record in this regard has been far from impressive:

    - Conventional data base systems have proved inflexible, expensive, and incapable of providing a user friendly environment.

    - Relational data base systems, while improving flexibility and user-friendliness, have yet to demonstrate acceptable performance against large-production data bases. (See INPUT's report, Relational Data Base Developments," August 1983.)

- Regardless of data model or system, both suffer from the inability of many organizations (or individuals) to define their data requirements.

- The additional requirement of providing ready access to electronic files of documents (text & graphics) adds complexity that may require new data models and new concepts in data/information management.

- Knowledge-based management systems include:

  - The knowledge base, which consists of everything from facts, assumptions, beliefs, and heuristics as well as methods of dealing with the data base to archival desired results such as a diagnoses, an interpretation, or a solution to a problem.

  - The subsystems, which automatically organize, control, and update stored knowledge, initiate searches based on assumed reasoning from the subsystems. Several conclusions can be reached concerning such systems.

    - Except for specialized areas, few knowledge bases exist today.

    - They are extremely difficult to build and maintain.

    - They assume an adequate supporting data base, and represent a substantial advance in complexity above data/information base technology (which still has problems in its own right).

- Expert systems are built on top of a knowledge base management system and perform a specialized professional task. Even strong advocates of expert systems caution that such systems should only be built for carefully selected tasks. It is doubtful that such systems can be constructed for general business management since the decision rules are far from clear cut. This implies the following:

- While some general expert systems may be constructed, they will usually have to be heavily tailored for the individual organization or institution.

- There is little assurance that such systems will be accepted by many executives (or professionals).

- Even more important, there is little assurance that such systems will work even if they are accepted.

- The development of expert systems to improve productivity at the PL-IV decision support level should be approached with caution even though they seem to be dictated by current trends.

- At this point, an analysis of artificial-intelligence-based systems such as the Japanese fifth generations would seem to be in order since the entire plan is specifically addressed to the improvement of the productivity of white-collar or knowledge workers. While a detailed analysis of the fifth generation effort is beyond the scope of this study, it is fair to comment that the effort at least provides for a comprehensive exploration of the potential for such systems, and this is a noteworthy (and even noble) objective. However, there are strong arguments that such artificial systems may not work because it will be impossible to predict their behavior.

D. PROBLEMS WITH THE "SCIENCES OF THE ARTIFICIAL"

- An extremely interesting and thought-provoking analysis of systems created by man (artificial systems) is provided by M.M. Lehman (Professor on Computing Science at the Department of Computing and Control, Imperial College, London) in "Human Thought and Action as an Ingredient in System Behavior," which appears in The Encyclopedia of Ignorance. It says much about the problems we have attempted to isolate in this discussion of office worker productivity and should be required reading for everyone involved with artificial intelligence.

- Lehman's analysis goes right to the heart of the problem and concentrates on system measurement and system models for hardware/software systems (PL-I) and the problems with establishing appropriate measures when people are involved (PL-II through PL-IV). He essentially concludes that systems performance models are impossible because human beings will change the system (encouraged in knowledge-based systems) in order to optimize performance and, in fact, systems must be modified as a result of observed behavior or they will die.

- In attempting to construct and improve system models, the following observation is made: "...Implementation of these proposals immediately invalidates the models of system behavior since the system, the process, has changed, and since it has changed in response to deductions that were made from these very models. Similarly, applications of the forecasting and planning data derived from a set of models to modify the output of the system invalidate these same models as representative of the programming organization (work unit), its tools and its activities that together constitute the system. If the output of the models is accepted as essentially correct, activities are reoriented and adjusted to conform to the model-based forecasts. The outputs from the models become a self-fulfilling prophecy of the behavior of a new system."

- Lehman then goes on to point out that creating a new model of the new system will include the system model as an element of itself and raises the question of whether this iterative procedure will converge. His conclusions: "Therein lies the problem, a problem that will force an ultimate admission of ignorance. And we shall see that this ignorance is not due to insufficient knowledge, understanding, or wisdom. We have here an area of uncertainty and indeterminancy that has its roots in the freedom of thought, of interpretation, of choice, and of action of mankind, individually and collectively. As such it appears to be absolute and unbreakable." (So much for improving computer-based decision support systems.)

- He then goes on to prove his contention of systems' behavior (convergence) as a continuous area of ignorance by using Godel's theory, which states that one cannot prove the consistency and completeness of an axiomatic system using the axioms and the rules of inference of that system. He proceeds beyond that by formulating an uncertainty principle analogous to that of quantum physics. Essentially it concludes:

  - By measuring and modeling an artificial system, we increase the extent and precision of our knowledge and understanding of its mode of operation.

  - This causes the system, the environment, and/or the interaction between them to be changed.

  - Thus the more accurately we measure, the less we know about its future status (provided the tendency to change exists - as it does in PL-III and PL-IV.

  - Then Heisenberg's principle arises with the mere act of observation, affecting the position and momentum of the object (system) being observed.

  - Lehman observes: "Hence, exact system science is not knowable, is meaningless, does not exist."

- In fact, Lehman goes on to state that artificial systems do not even lend themselves to certainty by applying the probabilistic judgments used in game theory because "each situation, each sequence of events will occur only once," unlike the exact sciences where paired indeterminancies are observed).

- While all of this may seem terribly technical, consider a business environment where a successful model for playing the stock market is developed and then becomes available for general use.

    - By observing the model and how it works, a modification is made that disrupts the original model (which could not have achieved positive results for everyone using it under any circimstances since it disrupted the system by its very introduction).

    - The results of this change create additional changes with unpredictable results.

    - Merely observing the results of the model will also effect subtle changes of the operation of the stock market based on individual reactions to the observed success (or failure) of the model.

- On that happy note, we will review our conclusions concerning the measurement of productivity improvement associated with various office systems, and will make recommendations as to their applicability and possible cost justification.

V CONCLUSIONS AND RECOMMENDATIONS

V CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- It is difficult to define and measure productivity of upper level office employees because what they do, how they do it, and what the end product of their labors should be are all little known.

- Even simple cost analysis of overall office personnel costs reveals that productivity improvements should be directed at management and professional employees rather than at clerical workers (see Exhibit III-10). This fact seems to be generally understood in the industry, but exactly how productivity of nonclerical employees will be improved (other than providing them all with workstations or personal computers) does not seem to be clearly understood by either vendors or information systems personnel.

- Automated office systems have heretofore focused on producing paper documents more efficiently. But paper handling, analysis of voluminous data, and meaningless information affect productivity adversely, and the net effect of word processing systems and office copiers may be the very productivity crisis we are addressing (see Exhibits IV-1 and IV-2).

- Office workers spend a great deal of their time talking with each other (telephone, interpersonal communications), and this represents 40% of office costs (see Exhibit III-5). The effectiveness of these communications is extremely difficult to measure, especially since the results must be documented in order to be of any value in today's paper-oriented office systems.

- Indeed, the measurement of performance of office systems at all levels (hardware/software, human-to-computer dyad, work unit networks, or institutional) is extremely difficult (if not impossible) to measure. This is true for the following reasons:

  - The basic mathematics used for measurement of physical systems do not apply to the social sciences or to artificial systems.

  - In complex systems human behavior not only defies prediction but also analysis of its impact on systems performance.

- Lacking precise tools for measurement of the performance of office systems, relatively simple, intuitive measures will have to be used. Our assumptions are that decreased paper volume, transfer of time spent communicating to analysis and decision making, and acceptance of new office systems can be used as measures of productivity improvement. Unfortunately, such measures are difficult to use as cost justification for the installation of new office systems.

- It is INPUT's conclusion that cost justification at one performance level must consider the potential impacts on other performance levels. In order to do that, the general characteristics and interrelationships of the performance levels must be understood.

  - PL-I, the hardware/software level, has the following general attributes:

    - While the mathematics of the physical sciences can be applied to measuring hardware performance, constantly changing software makes the whole PL-I performance unpredictable.

- PL-I performance is affected by the higher performance levels since they all make demands upon hardware/software systems.

- Threrfore, performance at PL-I may not be satisfactory to support the demands of the higher performance levels, even if the vendor is honest in his representation of its capacity.

- As artificial systems become more complex, demands will be made that will be impossible to meet (impractical systems will be developed), and at the very least, additional costs for hardware and software should be anticipated in any cost justification.

- PL-II, the human-to-computer dyad, has the following characteristics:

  - While industrial engineering techniques may be used to measure and tune certain aspects of human-to-machine (computer) interactions (time spent at terminal, key strokes, files accessed, documents produced, etc.), these measurements are extremely difficult to relate to productivity at the higher levels.

  - Different individuals will have different desires and requirements at the human-to-computer level (what is easy for one person is not for another), and even individuals will have different requirements at different times (various modes will be required depending both upon the specific task and the experience of the individual).

  - It cannot be assumed that all white-collar workers will benefit from a closer human-to-computer relationship - in some cases productivity may be affected severely.

- Some resistance to using workstations will therefore be legitimate and should be treated as such.

- Human beings will vary in their impact on performance at PL-I even if they are performing the same tasks (either through use or misuse of the hardware/software resources).

- Individuals will also have unpredictable impacts on productivity at the higher performance levels based on their interaction with the system.

- Therefore, the costs of supporting individuals will vary substantially without direct relation to their individual productivity, and one individual may affect the productivity of others (through use or misuse of the system).

- Variations in human reactions, performance, and interdependence must be considered in evaluating alternative systems solutions. (This includes everything from selective restriction of systems use to the variety of languages supported.)

- PL-III work unit networks have the potential for extending beyond the confines of the physical office and permitting complex interorganizational dependencies. Such networks have the following ramifications:

  - Advanced concepts in operations research may apply to certain aspects of work unit network performance, but there are currently serious communications problems among operations research analysts, mathematicians, computer scientists, and information system analysts.

  - Even establishing productivity measures (or objectives) becomes a function of the individual networks. The application of any generalized measures (or cost justification) is worse than meaningless - it can be extremely misleading.

- Specific analysis of current work unit networks (most of which are paper based) is essential before any alternative system can even be evaluated - much less cost justified. (In other words, generalized hardware/software systems cannot be applied with any confidence that productivity will be improved unless a thorough systems and procedures analysis is done.)

- One thing is known, however: current data base and information management cannot support the great majority of users who will be encouraged (or required) to have direct interaction with computer-based electronic data/information bases.

- It is INPUT's opinion that knowledge-based systems will not only be desirable but necessary if managers, professionals, and technical personnel are to significantly improve productivity.

- The knowledge engineering required to build these knowledge bases will be a service challenge to information systems management, which has frequently failed to recognize the importance even of data base management.

- Unless the requirements for improved management of the data/information/knowledge base is recognized, unpleasant consequences in cost/benefit ratios will be inevitable.

- PL-IV institutional performance can not be expected to be improved just because a lot of money is invested in building a complex data/information/knowledge resource. The assumption that better business decisions automatically follow investment in supporting the lower performance levels is the popular theme of both vendors and most experts who follow hardware/software systems developments. This assumption is especially risky for IS managers to embrace based on both past experience and this analysis of white-collar productivity.

- The availability of vast reservoirs of data/information/knowledge (of widely varied quality in most cases) defies human assimilation and analysis.

- It is INPUT's opinion that past concepts of data reduction will have to be extended to include information/knowledge-evaluating selection and analysis by the computer side of the human-to-computer dyad.

- In other words, significant computer modeling and simulation will be required in order improve decision making.

- Today's decision support systems are a long way from the expert systems that may be required in many areas if decision makers are to take advantage of the increased volumes of data/information/knowledge that will become available.

- The difficulties in creating expert systems are compounded by the limitations of conventional mathematics in the social sciences and the impact of human behavior in artificial systems.

- While these limitations must be recognized and understood, they should not be used as an excuse for inaction in attempting to understand the specific decision-making process that is being supported.

- In summary, we conclude that significant improvement in white-collar productivity depends upon a complex hierarchy of interrelated systems, all of which are approaching the current limitations of mathematical science and knowledge in a number of technical fields. Information systems organizations are going to have to deal with questions of artificial intelligence whether or not the questions can be answered or the problems solved.

- Rather than being "blue sky," the development of a knowledge-based, expert system requires an in-depth analysis of knowledge and user requirements, which has too often been lacking in conventional information systems design. Responsible AI practices are not promising magic solutions, they have recognized the need for thorough systems analysis in order to develop flexible systems that accommodate change. (That is what it is all about and has been from the beginning.)

B. RECOMMENDATIONS

- Do not rely on general cost justification for any type of office system. Insist on doing your own, and be sure that the hierarchy of performance levels is included in considering overall impact on productivity.

- Since the types of systems with the highest potential for productivity improvement are the most difficult to cost justify, obtain and evaluate the results of prototype systems that have been developed by others. (INPUT's Methods of Cost/Benefit Analysis for Office Systems addresses this type of analysis by presenting case studies and cost analysis methodologies used by others.)

- There is nothing wrong with an intuitive approach to the development of a prototype system, provided thorough cost analysis has been done and the probability of positive results can be demonstrated. The development of a comprehensive (and integrated) prototype system is much more desirable than adopting a canned total solution from a vendor or installing multiple solutions with the hope that one will work out.

- Examine the techniques of knowledge engineering with the view of understanding and adapting those techniques to conventional systems design. In parallel, give specific attention to data/information management functions (regardless of how much attention is already being focused on that area).

- Make a thorough and objective evaluation of the use of personal computers and intelligent workstations before they appear on every desk. The impact on white-collar productivity is going to be significant, but whether it is positive or negative will depend on the specific situation.

- Assume office automation is an extension of distributed processing and develop a comprehensive plan to address it on that basis.

- Concentrate on understanding and controlling the data/information/knowledge flow at PL-III and the decision-making process at PL-IV rather than getting bogged down with the considerations at PL-I and PL-II. Those who understand performance levels III and IV will control levels I and II.

APPENDIX: RELATED INPUT REPORTS

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- Impact of the Office of the Future, December 1980.
- Managing the Integration of Office Automation in the EPD Environment, November 1983.
- Methods of Cost/Benefit Analysis for Office Systems, September 1983.
- New Directions in Local Networking, December 1981.
- Personal Computer Versus Word Processor: Resolving the Selection Dilemma, June 1983.
- Resolving the Selection Dilemma, June 1983.