NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ALIGNING STRATEGIC AND INFORMATION SYSTEMS PLANNING:
A REVIEW OF NAVY EFFORTS

by

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March, 1990

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School — 6b OFFICE SYMBOL (If applicable) 55	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION — 8b OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS Program Element No — Project No — Task No — Work Unit Accession Number

11. TITLE (Include Security Classification)
Aligning Strategic and Information Systems Planning: A Review of Navy Efforts Unclassified

12. PERSONAL AUTHOR(S) Glenn W. Zeiders III

13a. TYPE OF REPORT	13b. TIME COVERED	14 DATE OF REPORT (year, month, day)	15 PAGE COUNT
Master's Thesis	From To	March 1990	132

16. SUPPLEMENTARY NOTATION
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17. COSATI CODES			18. SUBJECT TERMS (continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUBGROUP	Strategic Information Systems Planning, Information Systems Planning, Information Engineering, CASE, Business Systems Planning

19. ABSTRACT (continue on reverse if necessary and identify by block number)

The neccessity for well-defined, integrated information systems (IS), driven by today's dwindling human, financial, and management resources, makes it essential to plan effectively. This can only be achieved by linking IS planning to the overall strategic plan of the organization. Department of the Navy (DON) IS planning has historically missed the mark in this respect. Information Engineering, automated through Computer Aided Software Engineering (CASE) technology, offers significant benefits for improving DON IS planning. Two CASE workbenches, Information Engineering Systems Corporation's USER: Expert Systems and Texas Instruments' Information Engineering Facility, have proven highly effective in automating IE in DON applications.

Keywords: theses, (KR)

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS REPORT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL LCDR Robert L. Knight	22b TELEPHONE (Include Area code) (408) 646-2771 — 22c OFFICE SYMBOL 54kt

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

Approved for public release, distribution is unlimited

Aligning Strategic and Information Systems Planning: A Review of Navy Efforts

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March 1990

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ABSTRACT

The necessity for well-defined, integrated information systems (IS), driven by today's dwindling human, financial, and management resources, makes it essential to plan effectively. This can only be achieved by linking IS planning to the overall strategic plan of the organization. Department of the Navy (DON) IS planning has historically missed the mark in this respect. Information Engineering (IE), automated through Computer Aided Software Engineering (CASE) technology, offers significant benefits for improving DON IS planning. Two CASE workbenches, Information Engineering Systems Corporation's USER: Expert Systems and Texas Instruments' Information Engineering Facility, have proven highly effective in automating IE in DON applications.

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I. INTRODUCTION

The management of information systems (IS) development in the Department of the Navy (DON) has historically suffered from the lack of a solid planning foundation, as evidenced by the proliferation of non-integrated, redundant, application-driven systems that exist throughout the service. This is due to a variety of reasons. First, planners suffer from the fact that they deal with an uncertain and distant future, with the possibility of achieving no tangible benefits until long after the incumbent planner has departed. As such, planning is perceived by many as a significant and unnecessary resource drain. In addition, forecasting inaccuracies due to inadequate knowledge of the social, political, cultural, and economic forces at work in the environment add elements of risk and uncertainty that further complicate the planning effort. Differences in perceptions regarding organizational priorities and industry trends between top management and IS personnel also adversely affect planning. Finally, planning has often been carried out as a meaningless, mandated, ritual rather than as a highly utilized operational tool. All these factors lead to a lack of commitment from top management down, thereby undermining the overall IS planning effort of the organization.

A heavy price may be paid as a result of inadequate IS planning. Without the benefit of a solid planning foundation, information and integration requirements are often short-sighted and incomplete, and as such, represent the basis for systems that will not meet the overall information needs and mission of the organization. The result: huge software maintenance costs comprising up to eighty percent of total lifecycle costs. On the other hand, an effective planning effort will serve as a basis for systems that promote corporate strategy, improve overall performance, and facilitate communications between management and systems personnel.

Despite the unfavorable perceptions that exist regarding planning, there are considerable pressures to plan effectively. First, in today's budget climate, effective planning is vital to ensure continued funding for systems throughout their lifecycle. For FY 1990, the House of Representatives Committee on Appropriations mandated cuts of $300.75 million in the Department of the Navy ADP budget, including a $70 million cut directly attributable to Navy mismanagement of ADP programs. [Ref. 1:p. 39] As a result, there will be increased emphasis on strategic and IS planning in the future to prevent huge cost growths, redundant systems, and development of systems that do not meet strategic information needs of the organization. Secondly, rapid changes in technology emphasize the importance of planning at all levels in order to avoid the proliferation of incompatible, incomplete information systems. Finally, the necessity for efficiency, driven by dwindling human, financial, and management resources available to organizations, make it essential to plan effectively. As the vision of information as a corporate resource continues to evolve, there will be increasing motivation to develop integrated, organization-wide information systems. These systems can be successful only if the development process is based on a solid foundation of strategic information systems planning.

As the significance of information systems to fulfilling the corporate mission increases, so does the necessity to link systems planning with the strategic objectives of the organization. Aligning the strategic information systems plan to the corporate strategic plan will ensure that the organization will be in a position to exploit emerging technologies and industry trends, while continuing to develop systems that fully support its information requirements. Establishing the linkage between strategic and IS planning is essential for an organization in many ways:

> First, it is important to know how a change in the strategic planning of an organization would affect the planning of information technology because changes in the infrastructure of an organization take years to evolve. It is important to analyze these changes early and identify the cultural issues that are unique to each organization because a significant level of planning and resources is needed for cultural change to happen. Second, senior executives strongly desire to regain effective control in the aftermath of the information technology explosion. This control can be achieved through strategic planning at both organizational and technological levels in order to align development efforts with strategic business objectives, plans, and priorities. This desire is due largely to senior executives' recognition that information systems are becoming the critical path in effecting critical changes in an organization. [Ref. 2:p. 218]

Many methodologies and tools have been introduced throughout the years designed to improve the process of developing computer-based information systems. The vast majority of these methods have fallen woefully short in support of strategic systems planning. However, two methodologies have proven effective for aligning strategic and information systems planning. [Ref. 3:p. 448] The first, Business Systems Planning (BSP) was developed in the late 1960's by IBM, and was the first systems development methodology to recognize the need to link IS planning to strategic planning, and to emphasize data as a corporate resource. [Ref. 4:p. 103] The second, Information Engineering, was developed in the 1970's by James Martin and Clive Finkelstein as a strategic information systems development methodology supporting the entire lifecycle. [Ref. 3:p. 449] This thesis will examine and compare them, and discuss the suitability of using each in the context of Department of the Navy (DON) applications.

The thesis examines the efforts of the Department of the Navy in aligning strategic and information systems planning, and will present recommendations for facilitating this process. SECNAV Instruction 5230.9A, the Information Resource (IR) Program Planning guide, and SECNAV Instruction 5230.10, the Department of the Navy Strategic Plan for Managing Information and Related Resources (IRSTRATPLAN), document the Navy's commitment to a top-down approach to strategic IS planning. However, in practice, its efforts have not been particularly successful. Huge cost overruns, unnecessary duplication, the inability to integrate existing systems, and overall program mismanagement have resulted in a loss of credibility and confidence for the DON in Congress. There are several reasons for these difficulties. One of the primary reasons is the lack of understanding by top DON management of Information Resource Management (IRM) issues, and in particular, the methodologies and tools available for aligning its overall strategic planning and IS planning. Uneasiness regarding the need for IRM and IR planning, the organizational structure required to support IRM, and the relative strengths and weaknesses of the various IS planning tools and methodologies, all add to the reluctance of top management to embrace these issues. Second, the reluctance of top management to commit considerable resources to what is perceived to be an uncertain process, further complicate the IRM and IR planning process. It is important for DON management to understand that IS planning methodologies are not a panacea and do not provide an overnight payback. The large up front investment in time and capital required will yield benefits downstream, and over the long run, not overnight. A commitment to education at all levels of both the IS and line communities is required to improve the overall performance of DON system development and program management. In addition, environmental factors such as political issues, budgetary constraints, and the inefficiencies of the Life Cycle Management (LCM) process when applied to IS development and acquisition, further hinder IRM and IR planning efforts in the DON.

The thesis will address the following questions:

1. Which CASE tools are the most suitable for aligning strategic and IS planning in the Department of the Navy (DON)?

2. Why have IS planning methodologies been under-utilized in the DON?

3. Are DON organizations the size of Type Commanders (TYCOMS), such as CINCLANT, or Systems Commands (SYSCOMS), such as NAVSEA or NAVSUP, too large and complex to effectively utilize these methodologies in support of IS planning efforts?

4. Are DON activities effectively aligning their IS plans to the overall strategic objectives of their organization and the DON as a whole?

5. What are the benefits to the organization of applying IS planning methodologies to systems development projects?

6. Is Information Engineering suitable for use as a strategic planning tool outside the realm of ADP?

Chapter II will provide background information on the interrelationship and importance of strategic planning and information systems planning. In addition, it will examine the strengths and weaknesses of Information Engineering and Business Systems Planning as IS planning methodologies.

Chapter III will evaluate IR planning in the Department of the Navy, by examining the planning process, and the difficulties currently hindering the process. In addition, it will examine the potential implications of the DoD-directed Corporate Information Management (CIM) initiative.

Chapter IV will discuss the benefits of applying Information Engineering and Computer Aided Software Engineering (CASE) technology to the DON IR planning process, and will present recommendations to facilitate its use. It will then examine and compare three commonly used CASE workbenches that automate some or all of the Information Engineering process. In addition, the lifecycle coverage of these toolsets will be compared in the context of an analytical framework for comparing information engineering methodologies, developed by Hackathorn and Karimi. [Ref. 2:p. 204] The following CASE workbenches will be examined:

1. Information Engineering Systems Corporation's "User: Expert Systems",
2. Texas Instrument's "Information Engineering Facility",
3. KnowledgeWare's "Information Engineering Workbench"

Finally, Chapter V will present conclusions and recommendations for improving the IR planning efforts of the Department of the Navy.

II. ALIGNING STRATEGIC AND INFORMATION SYSTEMS PLANNING

A. STRATEGIC PLANNING

> Strategic planning is the process of deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources. Strategic planning. . . is a process having to do with the formulation of long range, strategic plans and policies that determine or change the character or direction of the organization. Robert Anthony [Ref. 4:p. 8]

From the definition, one can see that strategic planning is proactive in nature, and deals with issues, impacts, and potential strategies for accomplishing business objectives. It is a comprehensive, iterative, three-stage process for exercising favorable influence over future events. The process starts with strategic planning and continues through strategic implementation and strategic management. As a result of feedback during the implementation and management of the plan, it is continuously refined. (Figure 1) In the first stage, the organization is analyzed to determine where it stands, and where it must go. This analysis examines the organization as a dynamic and adaptable system that is affected by and interrelates with the following forces: external, social, cultural, political, economic, and competitive. [Ref. 6:p. 205] Understanding these forces, how they interrelate, and what threats and opportunities they create, is vital for

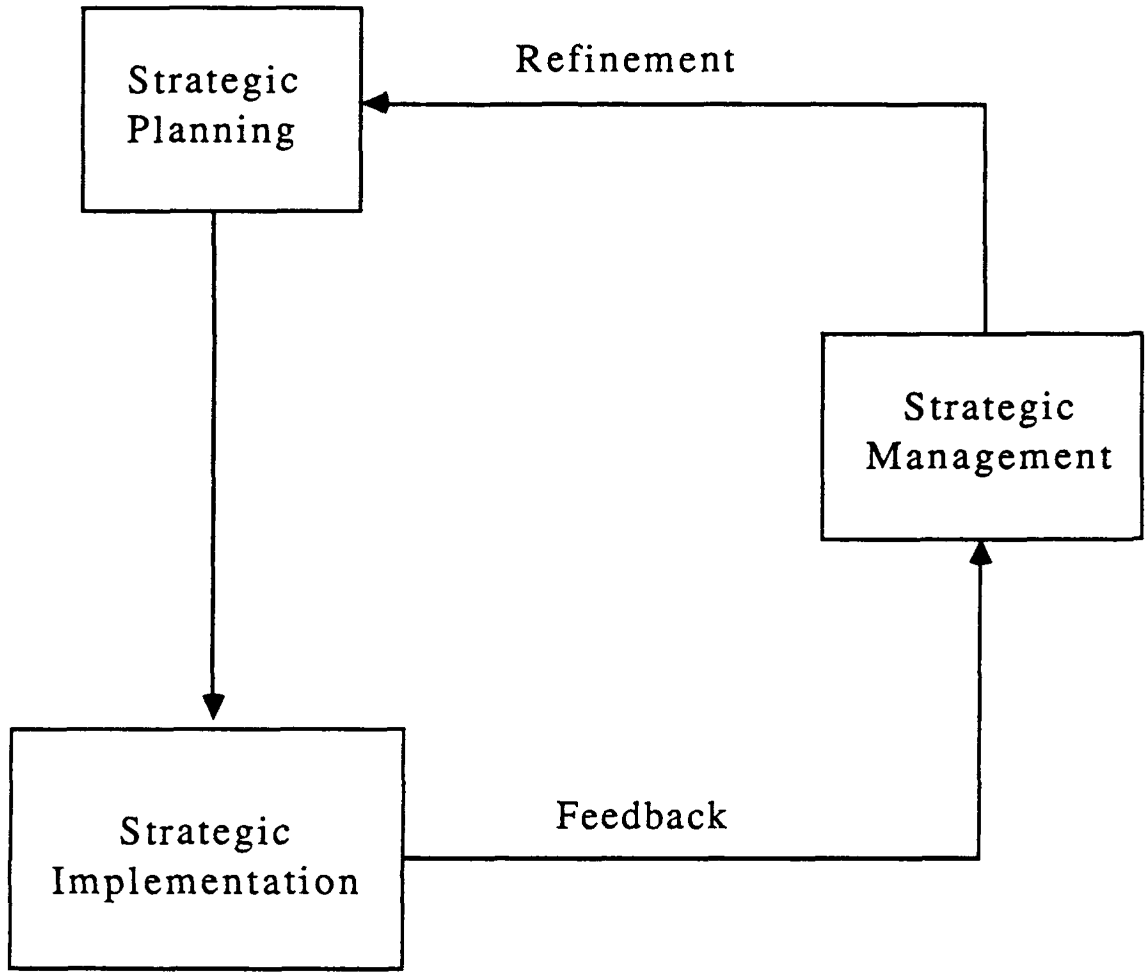

Figure 1. Strategic Planning Life Cycle [Ref. 5:p. 160]

effective strategic planning. In addition, the availability and development of corporate resources such as plant and equipment, personnel, capital, and data must be considered. From this organizational analysis, goals and objectives are set, and strategies for achieving these goals must be developed. For example, a typical strategy statement would be: "Effectively manage inventory". In stage two, these strategic directions are communicated to the organization via the setting of management objectives, and then implemented through supporting strategic, tactical, and operational plans and policies. At this point, the strategy statement has been refined and strengthened to include specific plans and policies for executing the strategy. Thus, the above strategic statement is supplemented with statements such as: "Adjust inventory levels according to demand or in accordance with policy", or "Prioritize inventory management by mission essentiality." Finally, in stage three, these plans and policies are executed and managed by the organization. During this stage, feedback and performance criteria must be monitored to ensure the success of the organization. Problems in the plan are identified, and refinements are instituted as necessary.

B. STRATEGIC INFORMATION SYSTEMS PLANNING

In organizations where information is a vital resource, such as the Department of the Navy, strategic planning and information systems planning must be closely tied. The IS planning process must be an integral part of the overall business plan of the organization in order to achieve the optimal fit between organizational requirements and IS functions. [Ref. 7:p. 4] An effective information systems plan that has been closely aligned to strategic business objectives holds significant advantages for the organization. First, it promotes commitment from top level management, as they will be more willing to provide adequate resources for systems that are strategically important, and from information systems personnel by making them stakeholders in the success of the organization. Second, it enhances both lateral and vertical communications within the organization since all components are supporting mutually agreed upon objectives. Third, an effective strategic IS plan provides focus and constraints on resource allocation by narrowing the scope of organizational objectives. Similarly, the project selection process is streamlined by the assurance that only those projects which directly support the business and IS plans will be developed. The requirement to develop systems that "put out fires" will be reduced. Finally, the strategic IS plan provides a vehicle for managing changes in technological, environmental, and organizational climate. By anticipating and planning for future requirements, the strategic IS plan facilitates the timely and orderly introduction of systems designed to ensure continued organizational success.

In general, development of an effective IS strategic plan supplements the formulation of the strategic business plan. It involves a three step process starting with strategic IS planning, then moving to tactical IS planning, and finally, to operational IS planning. Strategic IS planning links organizational needs and information resources and entails evaluating environmental and organizational factors, deciding on objectives, and formulating policies.

Strategic IS planning begins with a determination by management of where the organization stands in the evolution of its data processing function. Two IS planning models are highly effective at determining the current state of employment of information technology and information systems within an organization: McFarlan and McKenney's Strategic Grid, and Nolan's Stages of Growth model.

1. The Strategic Grid

For some organizations, IS activities play a vital and strategic role, not only in their daily operations, but also in the development of their future applications portfolio, as a way of achieving competitive success. On the other hand, IS activities may play only a minor, supporting role in the organization. Further the role of IS in the organization may be either increasing or decreasing at any given point in time. Whatever the case, it is vitally important for management, both IS and senior -level, to examine the role that IS plays in their organization. The Strategic Grid approach, developed by McFarlan and McKenney of Harvard Business School, maps the role and strategic impact of IS to the organization in an extremely simple, yet highly useful manner. [Ref. 8:p. 152] The four quadrant grid graphs the strategic impact of existing information systems, on the vertical axis, against the strategic impact of the organization's planned application development portfolio., on the horizontal axis. (Figure 2) Based on its placement on each of the two axes, an organization is mapped into one of the four quadrants: Strategic, Turnaround, Factory, and Support.

Organizations that fall into the Strategic quadrant are critically dependent on the efficient daily functioning of their existing IS activity, and have applications under development that are essential to their continued competitive success. Banking firms and airlines are excellent examples of firms that reside in the Strategic quadrant. These organizations must place a high degree of emphasis on IS planning in order to maintain a proactive stance. To do this, there should be little organizational distance between top management and IS management. In addition, clear and formal lines of communication should be established and maintained to ensure close cooperation between the two.

There are many organizations that are highly dependent on their current IS activities, but are not dependent on their future applications portfolio for continued strategic success. These organizations fall into the Factory quadrant of the Strategic Grid. Large manufacturing and distribution firms may fall into this category. Much of the day-to-day operations of these organizations is dependent on the smooth and efficient operation of their IS activity. The applications portfolio of these firms contains maintenance work and "back-room" applications that, although important, will not significantly affect the ability of the organization

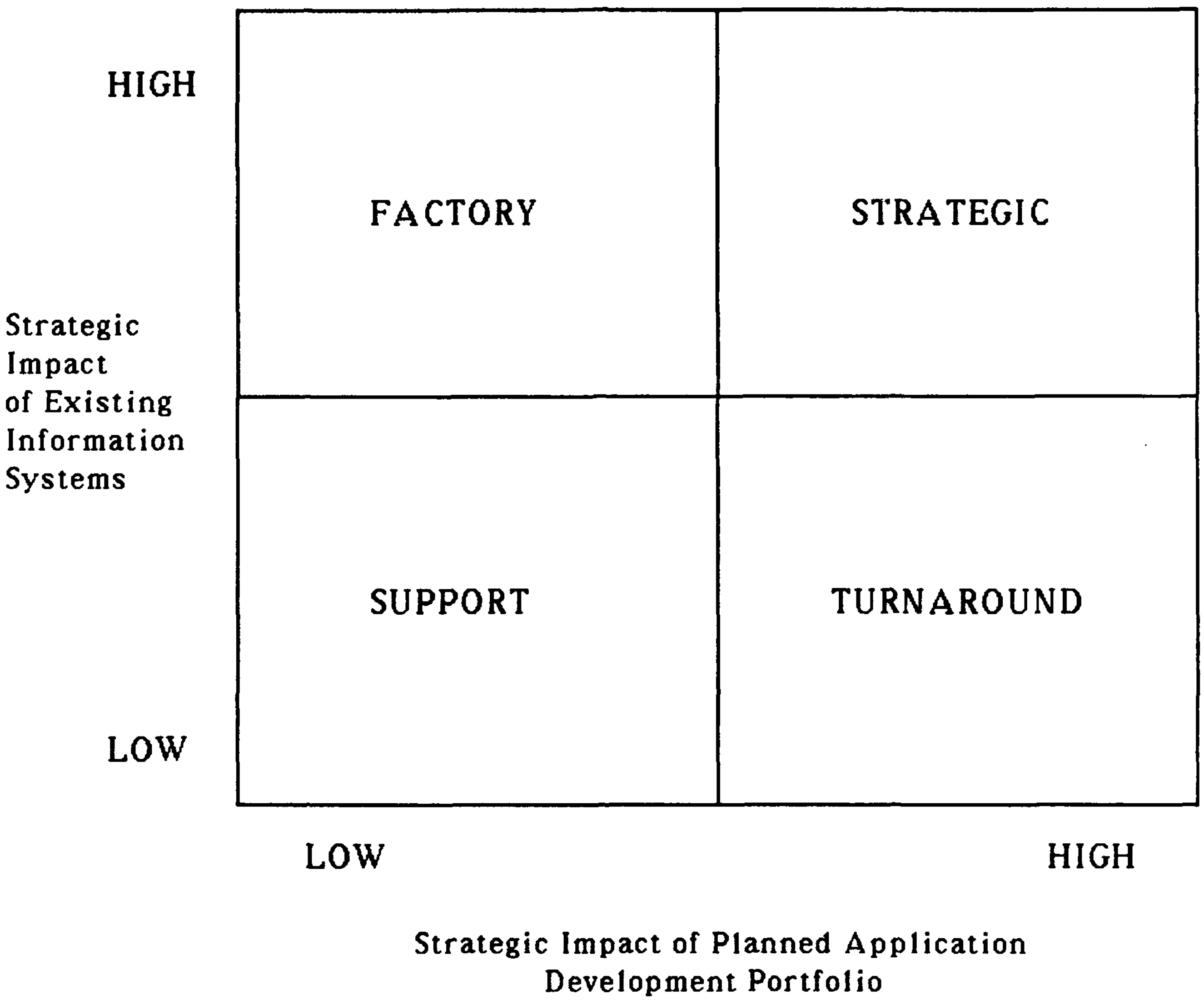

Figure 2. The Strategic Grid [Ref. 8:p. 152]

to compete. As a result, IS planning has a short term. operational management perspective, with an emphasis on cost savings and efficiency.

Other organizations depend neither on their current IS activities nor their future applications development portfolio, for their continued strategic success. These organizations fall into the Support quadrant. Large manufacturing firms may also fall into this quadrant. In these organizations, IS management is at a much lower organizational level, and the priority placed on IS planning is equally low.

Many firms, on the other band, may have a future applications development portfolio that is vital to their continued ability to compete, even though the strategic impact of existing IS activities is low. Rapidly growing organizations are often in the Turnaround position. These firms are in a transitionary period in their IS development. They have yet to develop a high dependency on IS support, yet they realize the strategic importance and future competitive benefits of information systems. As a result, the organizational position of IS management is rising to reflect its new strategic significance. Further, top management is increasing its commitment to IS planning through "a revised reporting structure, increased top-level participation in IS steering committees, and more intense user involvement in establishing priorities." [Ref. 9:p. 152] An organization must move through the Turnaround quadrant in order to move from Support to Strategic. This is implicitly obvious as a firm in the Support stage must make a commitment to increasing the strategic significance of its applications portfolio in order to move on to the Strategic quadrant.

The Strategic Grid is useful not only for characterizing the organization as a whole, but also for examining the role of IS in individual business units. This is important as individual business units in the same organization may have radically different positions on the grid. The placement of an organization or a business unit on the grid has several important implications. First, it provides management with an effective diagnostic tool for determining where they stand in terms of their IS activity, and therefore gives them an indication as to where and how best to conduct their IS planning efforts. It also provides a comprehensive picture of the degree to which IS planning efforts must be integrated into overall organizational planning. The actual position of the organization on the grid, and its position on the grid as perceived by senior line and IS management are vital inputs to the IS planning process. So to, is the desired position on the grid that the organization wishes to attain. Second, it establishes the strategic role of the IS function- its operations, the role of its management, and its future role in the organization. As such, it provides management with a toc' determining the organizational placement of IS, and suggests the required level of involvement of general management and the role of the executive steering committee. Similarly, it suggests an appropriate type of management control system for the organization and its individual business units.

It also suggests the need for a flexible, dynamic planning and control approach when the role of IS is changing over time. Finally, it serves to determine the degree of importance of the information resource to the organization, and the nature of effort that must be undertaken to develop it. As such, it is an effective starting point for any strategic IS planning effort. The main disadvantage of the approach is that it doesn't provide any tools or clear criteria for determining where an organization or business unit should be located on the grid. [Ref. 7:p. 12] This is left up to the subjective evaluation of management. Determining the location of the DON on the grid is a significant task because of its complexity, and the varying degrees of importance that information technology plays in its organizations.

2. Nolan's Stages Of Growth

Nolan's Stages of Growth is a six-stage model that examines the growth of an organization's DP function, from its inception the mature management of data resources. The model was originally conceived as a four stage model, but was modified to six stages as a result of the continued increase in complexity of the DP environment. During the first three stages, DP management is concerned with management of the computer. At approximately the middle of stage three, there is a transition to management of the data resource. (Figure 3) The model is a useful strategic IS planning tool in that it provides management with a diagnostic tool for identifying the current state of the organization's IS function,

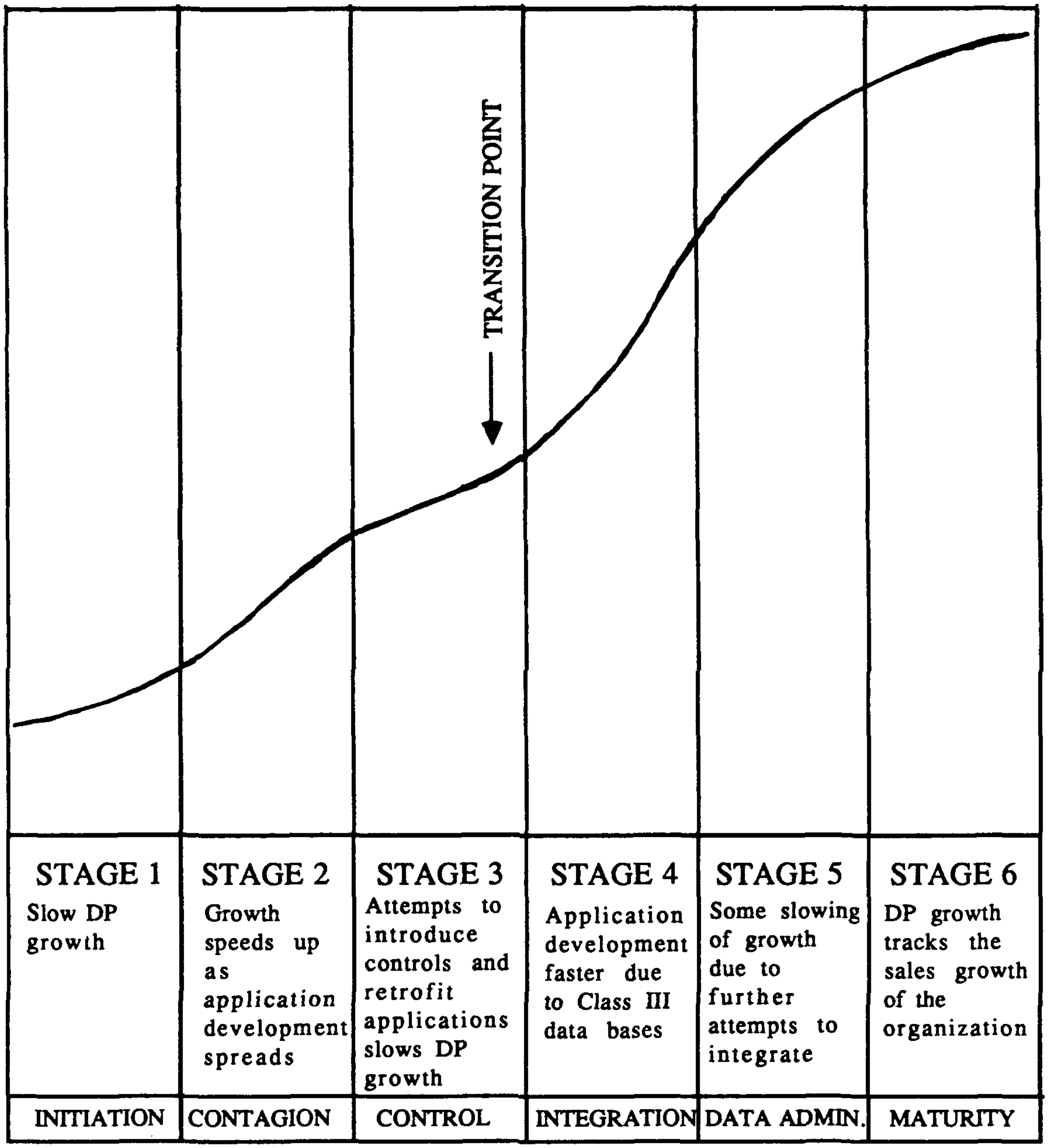

Figure 3. Nolan's Stages of Growth [Ref. 9:p. 81]

and what must be accomplished to evolve to the next stages. According to the model, an organization starts at the first stage, Initiation, and must evolve through every subsequent stage before reaching maturity in its DP function. The six stages are described below: [Ref. 9:p. 80]

1. Stage 1: Initiation: Initial development of an organization's first applications- generally "back-room", administrative and accounting applications. No overall DP control.

2. Stage 2: Contagion: Enthusiasm. Growing demand for, and proliferation of, applications. Applications developed in isolation causing incompatible and redundant data. Lack of planning and control mechanisms.

3. Stage 3: Control: Management attempting to gain control of DP function due to user frustration, high maintenance costs, and a long applications backlog. Management upgrades documentation, restructures existing applications, introduces data base management, and formalizes planning and control mechanisms. Slow application development as a result of DP rebuilding and restructuring. Perceived need for Data Administration, although little action taken.

4. Stage 4: Integration: Existing applications retrofitted to data base technology. Successful Class III data bases lead to fundamental changes in applications development process. Increase in demand for DP. Increased DP growth and expenditure. Redundancies of data and lack of enterprise-wide information analysis hinder attempts to develop planning and control applications.

5. Stage 5: Data Administration: Information Resource Management. Enterprise-based strategic planning of the data resource. Stable data models and end-user computing. Class I data bases provide flexible and valuable IS and decision support systems.

6. Stage 6: Maturity: Organization-wide information analysis and data modeling has been implemented. Applications mirror the enterprise. DP growth tracks the sales growth of the organization.

The transition point in between stages 3 and 4 represents the point at which applications development should become data base-driven rather than application-driven. Further, systems analysis and design moves from a procedure orientation to a data orientation.

Nolan's Stage model can be employed to analyze both the organization as a whole and its individual business units. An organization may have separate divisions that simultaneously reside in all six stages. Determining which stage the organization or business unit resides in can be a difficult process. Figure 4 gives a graphical representation of the benchmarks required to determine the placement of the organization. Taking a single benchmark by itself may be misleading, therefore management should examine all six benchmarks before determining their organization's stage of DP growth.

Managing the organization's evolution through each stage of growth is a key challenge for IS and senior line management. Nolan has developed five guidelines for effectively managing and taking advantage of this growth. [Ref. 10:p. 122] First, he states that management must recognize the transition of the organization from computer management to information resource management. Managers must first recognize the change and then develop data-oriented applications and planning and control systems to facilitate the transition. Second, management must recognize the importance of new technologies that enable the smooth transition to data administration. Third, management must

Exhibit V
Benchmarks of the six stages

First-level analysis	DP expenditure benchmarks.	Tracks rate of sales growth.	Exceeds rate of sales growth.	Is less than rate of sales growth.	Exceeds rate of sales growth.	Is less than rate of sales growth.	Tracks rate of sales growth.
	Technology benchmarks.	100% batch processing.	80% batch processing. 20% remote job entry processing.	70% batch processing. 15% data base processing. 10% inquiry processing. 5% time-sharing processing.	50% batch and remote job entry processing. 40% data base and data communications processing. 5% personal computing. 5% minicomputer and microcomputer processing.	20% batch and remote job entry processing. 60% data base and data communications processing. 5% personal computing. 15% minicomputer and microcomputer processing.	10% batch and remote job entry processing. 60% data base and data communications processing. 5% personal computing. 25% minicomputer and microcomputer processing.
Second-level analysis	*Applications portfolio.*	*There is a concentration on labor-intensive automation, scientific support, and clerical replacement.*		*Applications move out to user locations for data generation and data use.*		*Balance is established between centralized shared data/common system applications and decentralized user-controlled applications.*	
	DP organization.	Data processing is centralized and operates as a "closed shop."		Data processing becomes data custodian. Computer utility established and achieves reliability. ◀ Transition point		There is organizational implementation of the data resource management concept. There are layers of responsibility for data processing at appropriate organizational levels.	
	DP planning and control.	Internal planning and control is installed to manage the computer. Included are standards for programming, responsibility accounting, and project management.			External planning and control is installed to manage data resources. Included are value-added user chargeback, steering committee, and data administration.		
Level of DP expenditures ▷	User awareness.	Reactive: End user is superficially involved. The computer provides more, better, and faster information than manual techniques.		Driving force: End user is directly involved with data entry and data use. End user is accountable for data quality and for value-added end use.		Participatory: End user and data processing are jointly accountable for data quality and for effective design of value-added applications.	
		Stage 1 **Initiation**	**Stage 2** **Contagion**	**Stage 3** **Control**	**Stage 4** **Integration**	**Stage 5** **Data administration**	**Stage 6** **Maturity**

Figure 4. Benchmarks of the Six Stages [Ref. 10:p. 122]

identify the stage of DP evolution for each business unit in order to keep DP activities on track. By knowing where each unit stands in the evolution of its DP function, management can effectively plan for the future. Fourth, management should develop a multilevel IS strategy and plan. Nolan's Stage model provides the first input to the strategic planning process by providing management with a way of determining their current state. Once management knows where the organization and each business unit stands, they can utilize the model to develop an IS strategy and growth plan that is aligned with the firm's overall business strategy. Finally, top management must make the executive steering committee work. In order to effectively plan for IS, senior management must formulate a strategy, set priorities, and establish a favorable environment for IS growth.

Nolan's Stages of Growth model enables management to determine the most appropriate IS strategy for the organization, based on its current stage. It is also useful for diagnosing and understanding changes that must be made to facilitate the transition between stages. As such, it represents an easy -to - understand and powerful tool for beginning a strategic IS planning process. The major drawback to the model is that it gives a "snapshot" picture of the organization or business unit at a given time, and does not adequately show the direction of changes. Similarly, despite the benchmarks provided for determining the stage of growth, it can be extremely difficult to accurately map complex organizations such as the DON into a specific stage.

3. IS Strategy Development and Analysis

Once the current stage of IS activity is known, an analysis of the strengths and weaknesses that bear on its IS strategies must be conducted. Internal factors, such as budgetary and human constraints, and external factors, such as competition, legislation, and the prevailing technological climate, must be considered. It is important to understand that:

> . . . the extent and complexity of corporate activity make it impossible for data processing to be 'all things to all people'. Consequently, decisions will have to be made on what data processing be -its priorities and purposes; when, where, and whom it will serve; and so on. If the DP management makes these decisions without the benefit of an agreed-upon strategy and plan, the decisions are apt to be wrong, if they are right, the rationale for them will not be adequately understood by users (and management). If users do not understand the strategic direction of data processing, they are unlikely to provide support. [Ref. 10:p. 126]

Next, management must develop an IS strategic plan that fulfills the information requirements of the organization, and formulate policies with which to implement this strategy. As stated earlier, this IS strategy must be an integral part of the overall business plan to achieve the optimum match between the organization's information requirements and the functioning of its IS component.

The tactical planning phase is concerned with long and medium range (2-10 years) conceptual planning, and the development and formulation of the IS Master Plan. The IS Master Plan starts with needs, objectives, and constraints set forth in the strategic plan, and entails the following:

1. Requirements analysis;
2. Assembly of an applications portfolio;
3. Establishment of a priority scheme for the applications portfolio;
4. Development of applicable information systems architectures. [Ref. 7:p. 4]

In addition, it documents plans and policies for non-ADP support activities such as procurement or logistics. The IS architectures developed are graphical statements of flows, interfaces, and information, technical, and support requirements that illustrate how individual systems and components fit together to form an integrated comprehensive whole. Management must develop IS architectures that establish goals and strategies for each IS function in order to make them fully supportive of the overall business plan. The following architectures should be developed: data, information flow, technical, support systems, network, and any other applicable functions. Each architecture should illustrate:

1. the current or baseline situation;
2. the planned or interim situation when all currently programmed actions are implemented;
3. the target situation. [Ref. 11:p. 2]

Each architecture study will assist the planner in the refinement of the organization's IS objectives. Without a solid grasp of how the goals of the organization are translated into these architectures, application development efforts will have a short term perspective resulting in the development of isolated, fragmented systems that do not meet the overall needs of the organization. This problem is particularly evident in large, complex DON organizations, such as those at the SYSCOM and TYCOM level. (Figure 5) IS architectures serve "as a blueprint on which systems development activities can be: a) prioritized by deciding the sequencing for building the architecture; b) coordinated by relating to other systems in an efficient manner; and c) optimized by building each system with the corporate information requirements in mind." [Ref. 2:p. 204]

There is significant volatility in the IS environment due to technological innovation, competition, changes in corporate strategies, and many other factors. This volatility places a premium on the successful development of flexible Master plan and architectures that will permit orderly and consistent change to match evolving organizational requirements.

The operational IS planning phase involves the development of a detailed annual IS plan. This plan should include performance targets, resource allocation and budgetary decisions, specific tasks and schedules, and other activities required for achieving short range objectives. [Ref. 7:p. 5] The annual plan should be based on the broader objectives set forth in the Master Plan, in order to maintain a linkage between the day-to-day operation of the IS activity, and the strategic and tactical objectives of the organization.

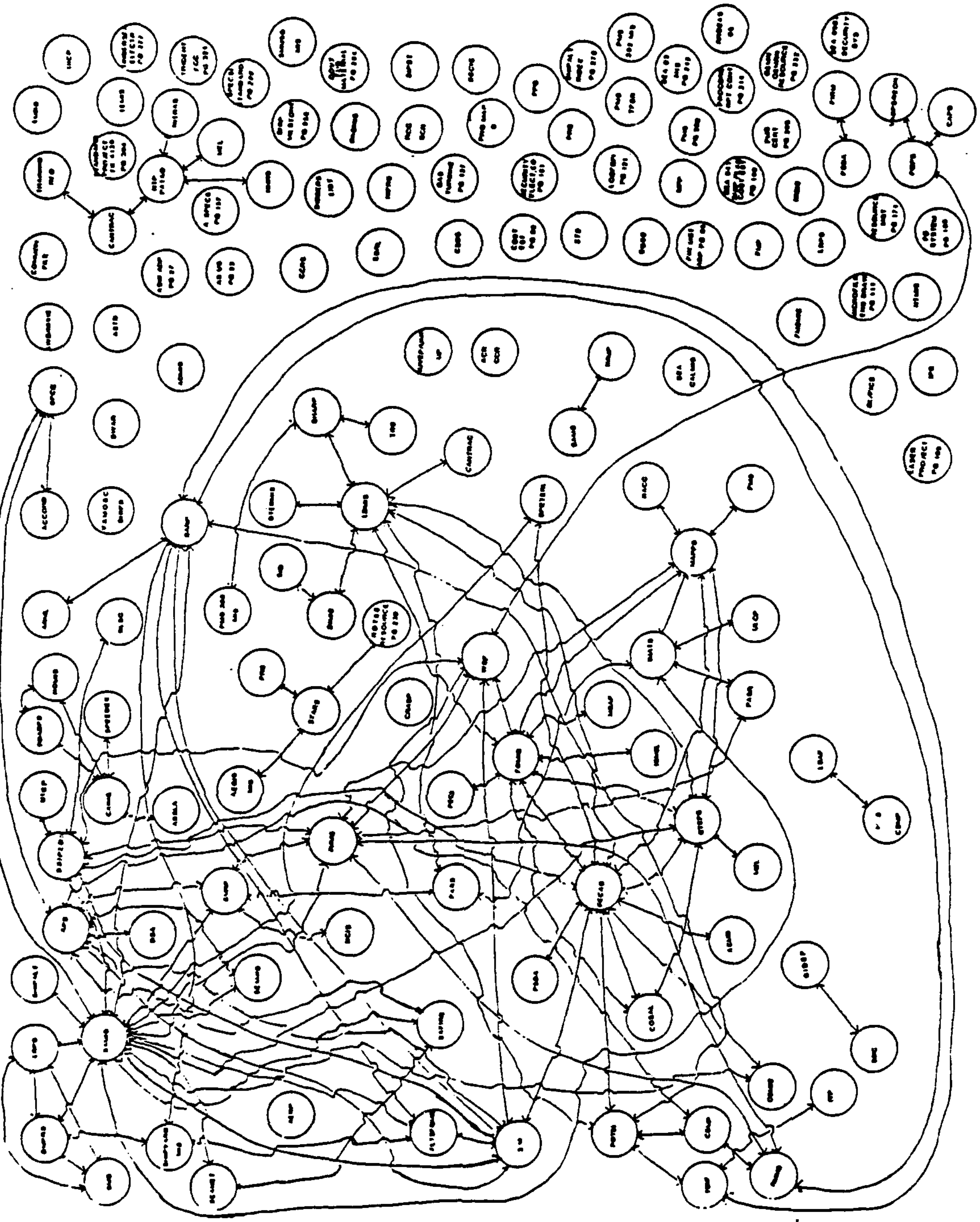

Figure 5. Complexity of Component Level Architectures [Ref. 12]

C. METHODOLOGIES FOR LINKING STRATEGIC AND IS PLANNING

1. Maintenance Hassles Drive the Need For a New Approach

The maintenance of systems developed using traditional manual approaches such as Structured Analysis and Design is extremely high. The cost of this maintenance may add up to as much as four times the development cost over the life of the project. In addition, it may absorb some 60-80 percent of analyst and programmer resources, leaving only the remainder for the development of new systems. One of the primary reasons for these maintenance problems is the fact that these systems have traditionally been developed to meet narrow management needs, without regard for the strategic objectives of the organization. In addition, since the systems were developed using process-oriented techniques, they are highly susceptible to environmental pressures, and changes in management information requirements.

IBM realized this problem, and developed Business Systems Planning (BSP) as a potential solution. [Ref. 13:p. 43] James Martin and Clive Finkelstein followed with the introduction of Information Engineering. [Ref. 9:p. 4] Both methodologies are data-oriented, and are based on a solid foundation of strategic planning. In addition, both accelerated systems development time, and had a significant positive impact on maintenance costs.

2. Information Engineering

a. Overview

Information Engineering (IE) was introduced by James Martin and Clive Finkelstein in the 1970's. [Ref. 9:p. 2] It represents the compilation of an interrelated set of disciplines required to build enterprise-based computerized information systems. In contrast to software engineering and structured analysis and design approaches, IE is specifically designed to draw on the strengths of the user, management, and DP personnel throughout the system development process. It is a data-oriented approach, and is based on the premise that data and information are two of the primary resources of an organization, and lie at the center of modern data processing. This data-oriented approach provides a solid foundation on which to build computer systems, because the structure of data does not change; the processes that use it do. IE provides the means to develop the "one and only one minimal nonredundant structure of the data," and this structure forms the foundation on which information systems can be built. [Ref. 9:p. 4] In addition, IE enables rapid response to the changing information needs of management, because procedures are able to be changed quickly because they are independent of the data. Procedure or process-oriented techniques, on the other hand, tend to produce systems that are difficult to implement in a timely manner, and which are unresponsive to changing requirements. Since they build systems based on the processes of an organization, they are subject to the inherent instability and dynamic nature of those procedures. The goal of IE is to provide the means to fulfill management's requirements for information rapidly and effectively, and to act as the primary implementation vehicle for achieving Information Resource Management (IRM).

b. Methodology

Information Engineering facilitates strategic systems development through the use of modeling. It models the organization in terms of its data resource, (data that is fundamental to the enterprise) and the policies, objectives, and strategies developed by management. The data model is based on the premise that the data used in an organization does not change significantly, while the procedures that use it will. The banking industry is an excellent example of this premise. The procedures for personal banking have changed dramatically over the years, however the data behind them (deposit, withdrawal, and balance data) have remained essentially unchanged. Data changes only as the business itself changes. With an accurate data model, the organization can represent itself- its business, its products and services, and its markets - in terms of its data. As such, the data model is the blueprint of the organization, and represents an effective tool for management to develop and evaluate different policies, objectives, and strategies.

There are nine basic building blocks defined in IE. Each of which is highly dependent on the one beneath it. (Figure 6) The first block, Strategic

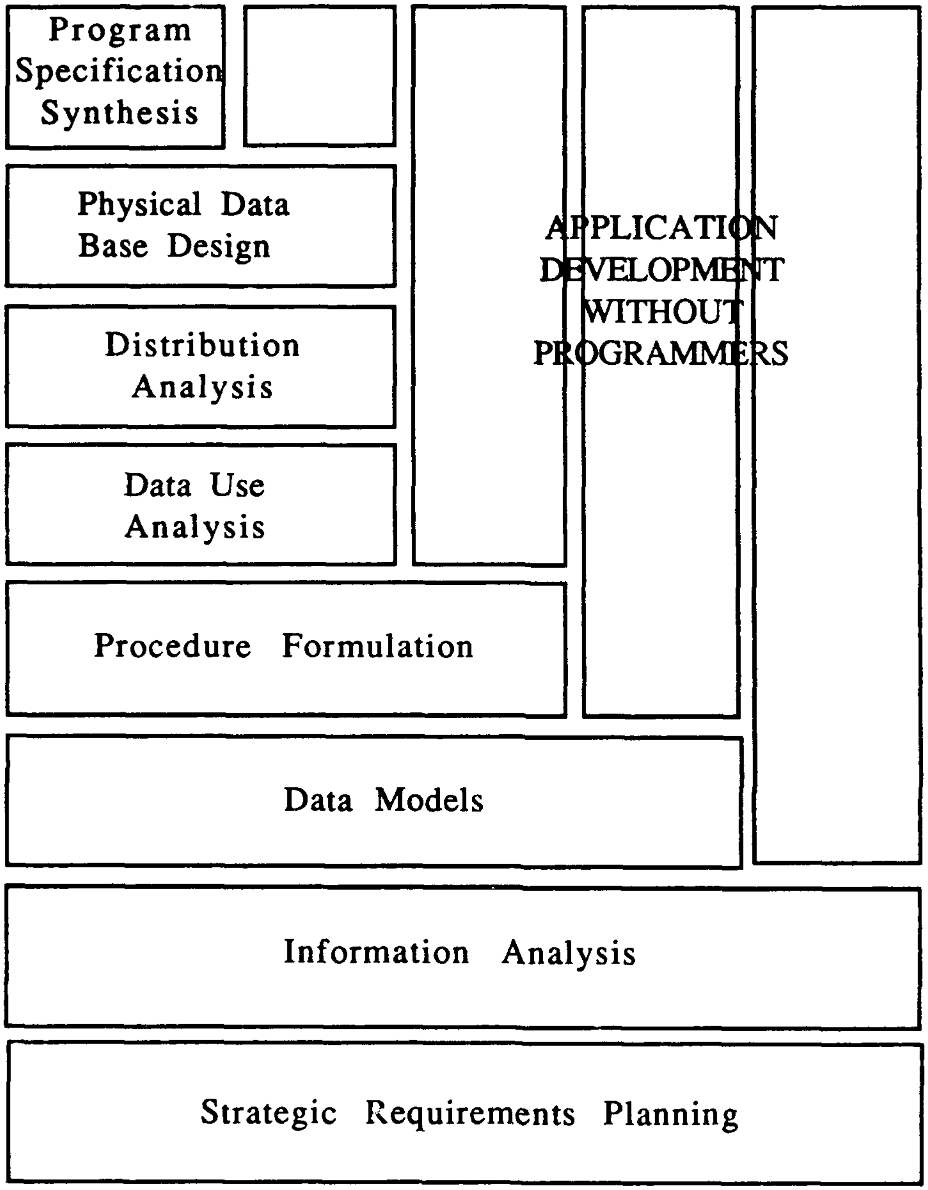

Figure 6. Information Engineering Building Blocks [Ref. 9:p. 6]

Requirements Analysis, is the foundation for the success of the methodology, but unfortunately, it is often overlooked. It attempts to identify the objectives of the organization, and what information is needed for enabling it to accomplish these objectives. The next block, Information Analysis, comprises a top-down analysis of the types of data that must be kept by the organization, and how they interrelate. Identifying these data types is critical because of the premise that data structures must remain stable. In the third stage, Data Modeling, the detailed logical data base design is created. Here, it is critical that the data be structured independent of the processes that will use it. The fourth block, Procedure Formulation, identifies events that change or use the data base. These procedures ideally should be designed by users, possibly with the aid of fourth generation languages and application generators. Block five, Data Use Analysis, and block six, Distribution Analysis, prepare the logical data model for conversion of the data models and procedures into the physical data base design accomplished in block seven. Block eight, Program Specification Synthesis, merges the different procedures, documents data changes, and produces functionally cohesive program code. Finally, block nine, Application Development Without Programmers, represents the ability of users to develop their own applications through the use of non-procedural languages and capabilities.

c. *Assessment of Information Engineering*

The stability of data models achieved through the use of IE is a major selling point, in that it allows for the creation of flexible, objectives-driven systems that meet the current and future information needs of an organization. Further, the use of modeling techniques throughout the IE lifecycle, provides for rapid feedback for strategic management. Modeling allows management to quickly consider the implications of alternative strategies. Additionally, the IE lifecycle is an evolutionary process whose formal steps progressively expand and enrich the data model and its strategies. Finally, and most important, Information Engineering is user-driven. It draws on the expertise of users throughout the organization. They design the data model; they design the system; and they identify the data and information needed by management for decision-making. The user intensity of IE is one of its primary drawbacks in real-world applications. IE requires a large up front commitment from users and management in order to provide a solid strategic and conceptual foundation for systems development. Without this commitment, the benefits of utilizing IE cannot be fully realized. Further, it assumes that users and management understand their business and the methodology; neither of which are safe assumptions. Thus, training in both areas should be a prerequisite of an IE project to ensure that the conceptualization of the data model is accurate.

3. IBM's Business Systems Planning (BSP)

a. Overview

BSP is a planning methodology that has been offered as a market support program by IBM since the early 1970's. It was developed from knowledge acquired from an internal study, the IBM Corporate Information Systems Architecture group, in the late 1960's. [Ref. 13:p. 48] BSP stresses "top-down" enterprise analysis, and an implementation strategy where information support is implemented in a modular fashion over time. This ensures that the implementation remains consistent with organizational business priorities, available funds, and other shorter-term considerations.

Several steps are involved in a BSP analysis. The first step involves establishing the study scope, selecting the study team, and defining business objectives. The next step is to define business processes and then business data. Data definition is accomplished by identifying critical business entities and the data required to manage them. Finally, an information architecture, the statement of long-term IS objectives, is defined, reviewed by top management, and released. Designer/analysts will use this information architecture in the future to build enterprise-based information systems.

b. Methodology

As with Information Engineering, the success of a BSP study is highly dependent on top management involvement. As such, an assessment of the degree of commitment of the organization to the study should be conducted prior to commencement of the study. Alter this assessment, the project team should be selected from key management personnel with expert knowledge of the enterprise and its functions. Once this is complete, the project team will attempt to identify and set objectives for the organization, and then establish a scope for the project. This project scope can target a specific area of the organization, or cover its entire span.

> Businesses whose activities span multiple functional units tend to gain more from a BSP study than those that are more simply structured since BSP deals well with complexity. It is designed to identify the requirements for data integration across multiple functions. [Ref. 14:p. 14]

Once the above issues have been dealt with, the project team must select and schedule specific personnel to be interviewed, develop a master plan for the study, and establish administrative support for the project. Finally, a start-up meeting, attended by the project team, key management, and other pertinent personnel, should be conducted to "kick-off" the study.

The first step in the actual BSP study process is the definition of business processes. Business processes are groups of logically related decisions and activities required to manage organizational resources. In order to accomplish this step, the project team must first identify the products or services output by the organization, and its supporting resources, such as raw materials, capital, personnel, and facilities. Next, business processes relating to these items are identified. There may be multiple processes for each one. This initial list of processes is then pared down, grouped, and prioritized to reduce inconsistencies and redundancies. Finally, these products must be related to organizational units. This is accomplished through the development of Process/Organization Matrix. This matrix graphically illustrates the degree of involvement of the various organizational units in each business process. (Figure 7) There are four possible degrees of involvement: major responsibility and decision maker (X), major involvement (X), some involvement (/),and no involvement (blank).

After all business processes have been defined, the project team must identify and define business entities, data classes, and the relationship between the two. A business entity can be a person, place, or thing, or any pertinent item about which data can be collected or stored. Their identification serves as a basis for determining the data needs of the organization. Each business entity should be broken down to where it can be uniquely identified, and carefully described. Next, the business entities are clarified and refined by determining data needs, their related business processes, and the relationship of both to the specific entities. Determination of the relationship of data to processes allows the project team to identify data classes: a category of information about a specific entity. Finally, each data class is refined and

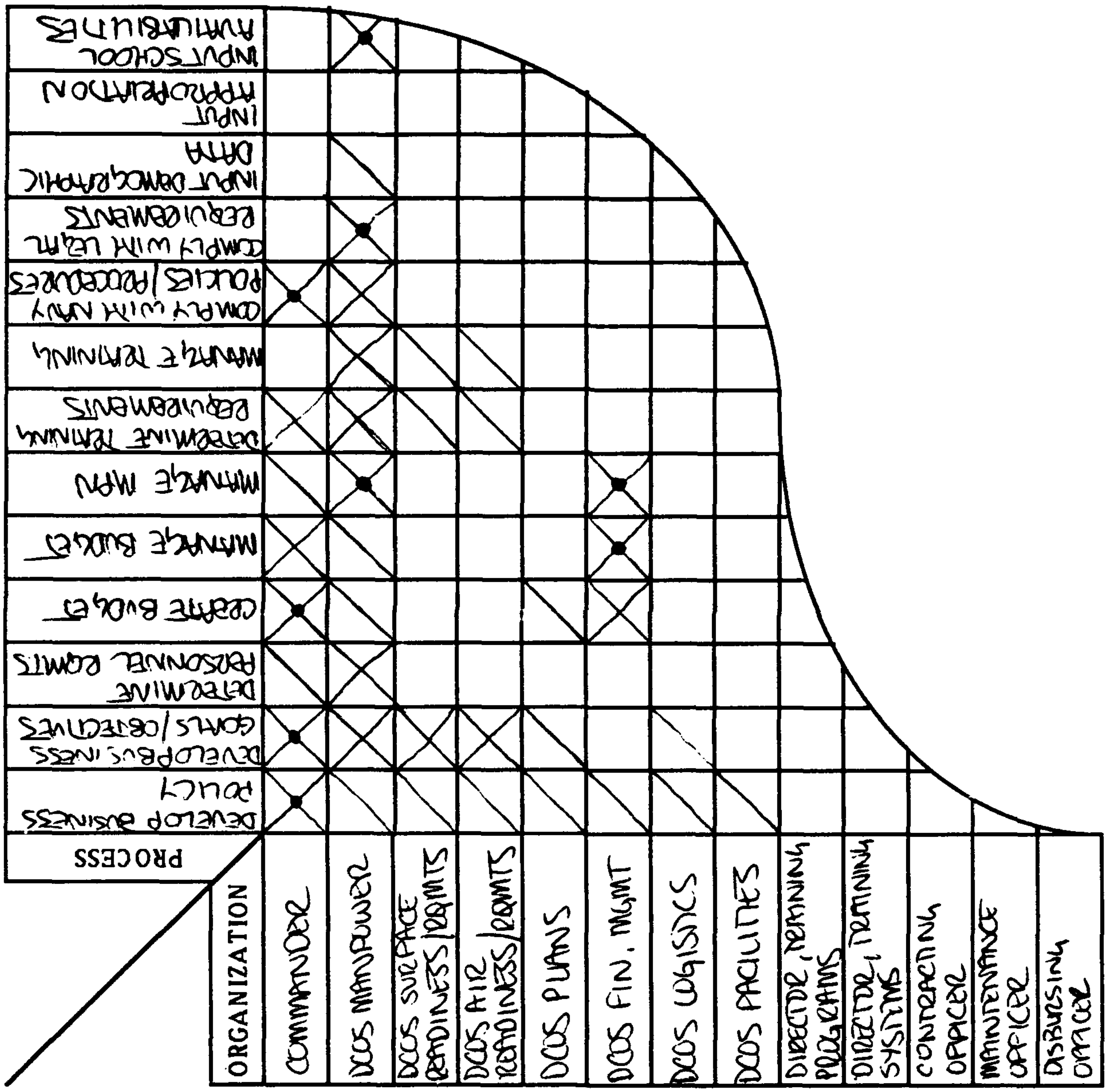

Figure 7. Process/Organization Matrix [Ref. 13:p. 45]

described completely. There must be no more than one source for each data class in order to ensure data integrity.

After all data classes are defined, the relationship between data classes and business processes is established through the formulation of the Information Architecture (Process/Data Class Matrix). (Figure 8) There are three types of relationships represented in the matrix: creation (C), where the process creates the data class; usage (U), where the process uses the data class; and no involvement (blank). The groupings resulting from this matrix can then be related to organizational personnel and structure. This gives the organization a logical view of who needs and uses specific data and information, and in what processes they use them. Finally, data flows between processes are identified, by relating processes that create data classes and those that use them. Arrows are drawn between the two to create a flow chart of data through the organization. The resulting information architecture is the key deliverable of a BSP study. It illustrates information flow throughout the organization, and relationships between processes and entities. Further, it provides management with the following pertinent information: [Ref. 14:p. 45]

1. The project team's recommendation for long range IS implementation.
2. The information systems, represented by the blocks or boxes, that form the long range plan.
3. The data controlled by each information system. (read vertically)

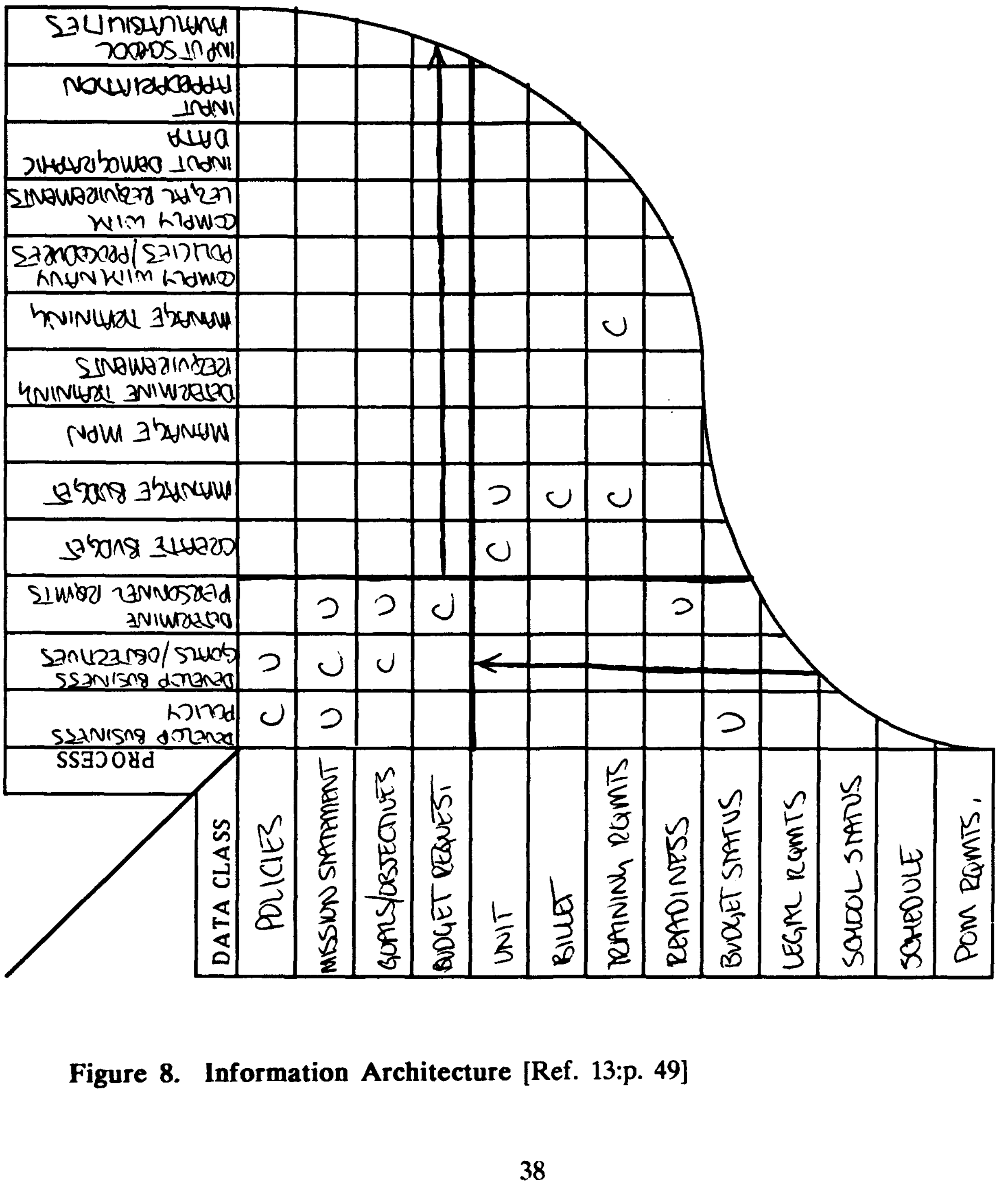

Figure 8. Information Architecture [Ref. 13:p. 49]

4. The business processes supported by each information system. (read horizontally)

5. The flow of information between the various information systems, (lines and arrows) and thus the flow of information through the business itself.

From these results, management can determine their current level of IS support, determine organizational IS priorities, and decide on current and future information resource strategy.

c. *Assessment of Business Systems Planning*

BSP was the first methodology to recognize and emphasize data as a corporate resource. As such, it emphasizes the fundamental need for top management involvement in the IS planning process. It helps establish lines of communication between users, top management, and data processing personnel, and confronts management with the importance of dealing with DP issues on an organizational level. Further, it develops an enterprise-level information architecture, and "objectively deals with the priority issue, identifying areas in which the information system resource can best be invested for the overall interest of the business at a given point in time." [Ref. 13:p. 49] Finally, it is a well documented methodology, it is widely used, and it is widely understood. [Ref. 13:p. 49] There are several key weaknesses apparent in the BSP approach. First, since the entire process is based on creative analysis and individual interviews by the project team, it's quality is highly dependent on the team's understanding of what they are looking for, where they will find it, and how to document it. Second, the structure developed is highly customized, with limited transferability or comparability to other study's structures. Third, the BSP study process is a time-consuming and cumbersome process, that really only encompasses the planning, organizational analysis, and requirements analysis phases of the systems lifecycle. In addition, it is extremely difficult to bridge between the planning activity of the study and systems implementation. The deliverables of the process, the matrices and displays, are difficult to update, and provide no basis for the system's design. As such, systems developers must take the product of a BSP study and then revert back to traditional system development techniques. This just adds more unnecessary time constraints to the development process. Recently, CASE tools such as KnowledgeWare's IEW have automated portions of the BSP process, speeding it up, but many of the weaknesses discussed remain.

4. Comparison of Information Engineering and BSP

Both Information Engineering and Business Systems Planning are data-oriented, and both recognize the importance of linking information systems planning to the strategic objectives of the organization. In addition, both methodologies are widely used and well documented. However, Information Engineering provides significant benefits to the organization relative to BSP. First, IE provides a set of interrelated systems development techniques that span the entire systems lifecycle, from strategic planning to full systems implementation. On the other hand, BSP only provides techniques for organizational analysis and strategy-to-requirements transformation. It does not provide full lifecycle support. Second, IE is a user-driven methodology, whereas BSP is essentially analyst-driven. In an IE project, users are fully involved in the development of the data models, and throughout subsequent phases of development. BSP studies utilize personal interviews to glean information requirements; construction of the Information Architecture is accomplished by analysts. Third, whereas IE supports systems development through implementation, the deliverables of the BSP process are difficult to update, and provide no basis for system design. As a result, the IE process is considerably faster over the same lifecycle phases than BSP; a vital consideration in today's IS climate.

III. INFORMATION RESOURCE PLANNING IN THE DEPARTMENT OF THE NAVY

A. THE DEPARTMENT OF THE NAVY'S IR PLANNING PROCESS

The IS planning program in the Department of the Navy is a multi-level program that seeks to develop an integrated approach and overall framework for meeting its overall information requirements. It attempts to align IS planning at all levels to the overall strategic objectives of the organization. SECNAV Instruction 5230.10, the DON Strategic Plan for Managing Information and Related Resources (IRSTRATPLAN), provides a top-down perspective of DON information resources as they relate to both tactical and administrative functions. In addition, it provides strategies, policies, and guidance, on which DON commands can base their IR planning and management efforts. SECNAV Instruction 5230.9A, the Information Resources (IR) Program Planning guide, provides top-down IR planning guidance to DON organizations at the departmental, functional sponsor, and component levels. Both documents provide a broad foundation on which to structure DON IR planning efforts.

The DON IR planning program is a continuous process that includes both strategic IR planning and IR requirements planning. Strategic IR planning requires an analysis of the information support environment internal to the DON and an assessment of the impact of external factors such as technology trends, competition, and politics. Top management derives high level IS policies and strategies from this analysis, and these provide the basis for IR planning at all subordinate levels. Results of the strategic IR planning process are documented in the DON Strategic Plan For Information Systems Management. [Ref. 11:p. 5]

The objective of DON IR requirements planning is to analyze major organizational functions, derive their information requirements, and coordinate the requirements with the strategic directions and policies promulgated in the strategic plan. Both current and future information requirements are assessed, and any shortfalls in satisfying those requirements are identified. The information requirements derived form the basis for project selection downstream at the activity level.

The DON IR requirements planning process begins in January at the Departmental level, and continues through April. (Figure 9) In January, departmental level functional sponsors document DON-wide requirements for IR support needed in major functional areas such as Manpower, Supply, or Safety. These requirements are documented in Functional Area Strategic Plans (FASP). FASP's were previously called Functional Sponsor Plans. In February, the FASP's are reviewed by the IR Planning Committee to ensure "appropriate interfaces and integration between functional area planning." [Ref. 11:p. 6] The IR Planning

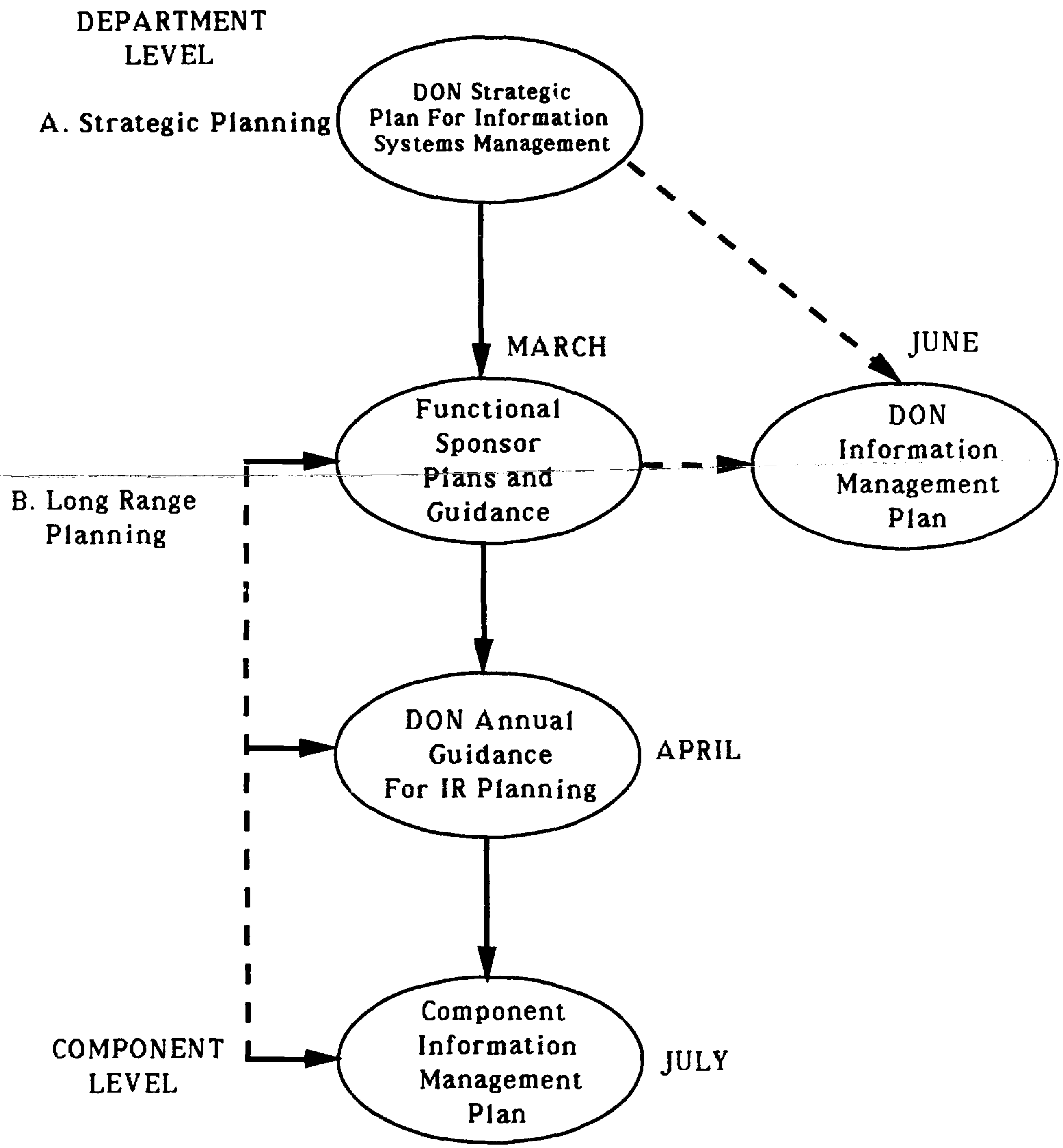

Figure 9. DON IR Planning Process [Ref. 11:p. 4]

Committee should consist of high-level members from commands at the departmental and component level, such as the Director, Naval Supply Systems Command, or the various Deputy Chiefs of Naval Operation. The FASP's are submitted to the Director, DON Information Resource Management (DIRDONIRM) in March. They are presented at the Functional Area strategic planning conference, also in March, and are distributed to the cognizant component commands. The results of IR planning at this level are documented In the DON Information Management Plan (IMP) released in June.

IR planning occurs at the component level from April until July. Component level IR planning "develops a framework for IR support within the component headquarters and all subordinate organizations. Emphasis is on supporting the component's mission and functions within the context established by departmental strategic and long-range plans." [Ref. 11:p. 6] The results of the component level IR planning process are documented in Component Information Management Plans (CIMP). In mid-August, the CIMP's are presented to the IR Planning Committee at the annual IR Planning Conference. Each CIMP is then distributed to all organizations having a funding or other management responsibility for planned actions.

Throughout the rest of the year, IR planning and management occurs at the cognizant activity level in accordance with the Planning, Programming and Budgeting System (PPBS) and Life Cycle Management (LCM) processes. The objectives promulgated in the CIMP or FASP will, if approved for development or acquisition, be further refined in project plans, which in turn, form the basis for initiating the LCM process.

B. ASSESSMENT OF DON IR PLANNING PROCESS

On paper, the DON IR planning program appears to be comprehensive and effective. On the other hand, several habitual internal management problems continue to hinder these efforts. First, top DON management, including IS management, suffers from an insufficient level of expertise on key computer-related issues. Misperceptions as to what Information Resource Management is, why it is required, and what organizational structure is required to accomplish it, cause a lack of direction concerning IR planning at top DON IS management levels. This manifests itself in a deficiency of specific top-down guidance from DIRDONIRM and NAVDAC, which hampers the annual planning efforts of subordinate levels. The key to successful IR planning at all levels is for top management to "clearly define at any point in time exactly those factors that are crucial to the success of his particular organization in the period for which he is planning." [Ref. 15:p. 127] Similarly, NAVDAC and the DONIRM staff have been unable to provide the assistance and training required by component and subordinate activities to build their own IR planning staffs. Their lack of expertise on IRM-related issues prevents them from providing the proactive leadership required for effective IR planning, and limits them to a review role in the planning process. The ability to provide detailed critiques of the CIMP's and FASP's, and to ask hard, probing questions of both components and resource sponsors, is vital to effectively manage the DON IR planning effort. In order to reach the knowledge level required for effective management of the IR planning process, a comprehensive education program on IRM and IR planning issues should be established. The training program should reach all personnel with management and funding responsibility in this arena, and cover all facets of Information Resource Management including planning and Data Administration issues, and strategic development methodologies such as Information Engineering. A related issue which has adversely affected the effectiveness of IR planning and IRM, is the shortage of computer-literate officers at all levels, resulting from the failure to create a competitive career path in this area. The failure to effectively utilize officers with Masters-level education in Computer Systems Management, Telecommunications, and Computer Science, has created a significant management void in these fields, and an important barrier to effective IR planning. A second internal factor hindering the IR planning process has been the lack of commitment to the process by top management at the resource sponsor and component levels. This is evidenced by their attendance record at the annual planning conferences, and their level of participation at the meetings. Generally, the senior managers attend the conferences for their briefs only, and then turn over responsibility for attendance to second tier management. Second tier management is usually only interested in what DIRDONIRM has to say, and not on broader issues that may influence planning at their organization. In addition, they are generally unprepared, and are incapable of asking or answering important questions. As a result, integration issues are not discussed, and therefore not planned for at subordinate levels. This lack of top management commitment is partially due to their lack of ease regarding IRM issues, but also to misperceptions as to the strategic importance of the information or data resource to the organization. They see no immediate benefits from their efforts, and as such, view the IR planning process as a significant resource drain and paperwork hassle. Further, due to the current budget climate, top management commitment is driven by cost considerations, and therefore, is not focused on long range planning issues.

Other internal factors affecting IR planning in the Department of the Navy are the result of deficiencies in the process or the documentation that governs it. First, the IRSTRATPLAN has been updated three times since its inception in 1987. The document has developed into a forum for top DON management to react to changing information requirements, and therefore is contradictory to what the document should be accomplishing. The IRSTRATPLAN should serve as an IS Master plan with a five to ten year planning horizon. It should be a forward thinking and proactive document that serves as the foundation for IR planning, and should not be updated or modified on an annual basis. It should only be updated as major changes in technology or in the various missions and objectives of the Navy occur. Second, the functional sponsor planning process has been yielding information requirements and policies that fail to provide an integrated view of what must be accomplished at the component level to meet their needs. This is due to two reasons. First, in most cases, the Functional Area Strategic Plans are being written by the Systems Commands (SYSCOM) or components acting as Central Design Agencies (CDA), that are to use them as a basis for their own planning process. As a result, they don't correlate plans and budgets well, and worse, they fail to address broad issues such as standardization and integration. Second, the SYSCOM's and CDA's tend to write the FASP's and CIMP's in a manner that justifies their own existence. Since they are writing their own planning guidance, there is no top-down pressure to streamline or improve the planning and development processes in their organizations. Finally, the DON IR planning process is hindered by significant time constraints. Requirements planning at the functional sponsor level is constrained to three months, while the more comprehensive component planning process is limited to two months. These are highly unrealistic constraints for effective planning and policy making. However, since the FASP's are written in large part by component level organizations, and since the requirements and policies they document are relatively static, it is recommended that the functional area strategic planning process be limited or done away with. By doing so, the importance of the IRSTRATPLAN as a strategic and tactical planning document would be increased, as would the length of time devoted to IR planning at the component level. IR Planning in the Department of the Navy has been hindered by two external factors as well: today's unstable budget climate, and inefficiencies in the life Cycle Management (LCM) process. As a result of today's highly unstable budget climate, and the significant cuts in funding for ADP that have been incurred by the Department of Defense, IR planning currently involves running from budget issues. Planning has become resource-driven in that it is aimed at protecting what resources and funding assets that have already been accumulated. In addition, vertical cuts and temporary scalebacks in programs have made it impossible for management to develop systems in accordance with their plans. Finally, budget constraints have adversely affected DON efforts to establish standards. The inability to establish DON-wide standards will hinder any efforts to implement Administration, or to move towards an integrated overall IS architecture.

The second external factor hindering DON IR planning efforts is the inefficiency of the Life Cycle Management process when applied to ADP acquisition and development. The process affects IR planning and management by significantly slowing down the process of procurement and development of IS resources. Continual budget justification at each milestone of the process make the IS plan difficult to execute as envisioned, and mires the project manager in a continuous paperwork nightmare. Each LCM milestone should signal the transition to the next stage in the development of the program, but due to continual budgetary second guessing, the process has become a continuous string of milestones, none of which move the project ahead. The only ways to solve this problem are to grant the project manager with increased authority, accountability, and time in position to allow himself to make procurement decisions, to significantly accelerate the development process through the employment of CASE technology, or to alter the LCM process.

In its present configuration, the LCM process is geared towards multiple year systems development processes. The availability and desirability of progressive systems development methodologies such as Information Engineering make the requirement for a modified LCM process for ADP vital. The ability of Information Engineering to accelerate the entire systems lifecycle will be defeated by the continual budget justifications required by the current LCM process. Total lifecycle approval should be given up front for a program utilizing Information Engineering, as this would facilitate a total commitment, with all required resources, to the IE process. Deferring reevaluation of the program until System Decision Paper (SDP) IV at approximately the two year point would be optimal.

C. CORPORATE INFORMATION MANAGEMENT (CIM)

The Corporate Information Management (CIM) initiative was launched by DoD Comptroller Atwood on 4 OCT 89 in response to problems found in the recent Defense Management Review (DMR). The initiative represents a move to consolidate and standardize DoD information systems development and management. Specifically, the CIM initiative calls for the following:

1. Implementation of DoD-standard information systems in six functional areas: Civilian Personnel, Pay, Inventory Management, Warehousing, Accounting, and Contracting by 1995.

2. Immediate freeze on new systems, and spending on systems under development in the above functional areas.

A separate but related issue, prompted also by the DMR, is the consolidation of Central Design Agencies (CDA) and Data Processing Installations (DPI) into tri-service organizations called Information Technology Facilities (ITF). The impetus for these changes is the need to reduce redundant systems in these functional areas. As an example, it was stated that there are twenty-six separate payroll systems throughout the DoD. In addition, it was stated that DoD organizations spend upwards of $4 billion annually on development, maintenance, and modernization of information systems. The DoD comptroller estimates that this initiative should result in total savings of $4.3 billion from FY '91 to FY '95. As a result of this initiative, the DoD has line item reduced DON ADP budgets, to take into account the anticipated cost savings from CIM. This equates to $327 million annually over the next five years.

The CIM initiative holds significant implications for DON IRM and IR planning efforts. Most importantly, the directed spending freeze has made the interim and target architectures on systems currently under development unattainable. Second, it has superceded, although not officially, the DON IR planning process, as a result of the spending freeze, and the pending consolidation of CDA's and DPI's. Planning for new systems will continue, although existing systems must suffice.

The initiative calls for the formation of two CIM study groups to study the issue, and to develop recommendations for DoD-standard systems. The first, the Executive-level group, will report directly to the DoD Comptroller, and will be comprised of senior DoD and industry officials. The second group, at the Functional-level, will report to the Executive level, and will be made up from experts in the six functional areas listed above. The groups have been given a six month to two year window in which to develop functional descriptions (FD) for systems in these areas. From there, they will choose the existing system that most closely matches the FD, and then will re-engineer the system to meet tri-service needs. The current plan is to utilize a "structured approach" such as BSP as the front-end planning tool, and KnowledgeWare's Information Engineering Workbench (IEW) as the back-end tool. The prospect of using an Information

Engineering-based CASE tool for the study was proposed, and is under consideration. Its use would definitely facilitate the process, because of its strong data orientation, and its ability to facilitate rapid development of a prototype system. Before a tri-service system can be developed, data structures must be standardized to meet the needs of all three services. The use of functional descriptions to determine requirements would base systems development on a process-oriented foundation. Since all three services have substantially different processes and needs, this would create a highly unstable basis for a standard system. In addition, the development of functional descriptions, supplemented by BSP, would be a slow, tedious process in comparison to utilizing automated IE. Finally, the user involvement inherent in the IE development process is highly desirable when building a standardized system such as those proposed, because it would facilitate communication between the services, and would promote a sense of commitment to the process.

IV. COMPARING THE INFORMATION ENGINEERING CASE TOOLS

A. USE OF INFORMATION ENGINEERING AND CASE IN THE DON

It is imperative that DON management employ Information Engineering to facilitate its IR planning efforts. "Information Engineering provides the discipline to ensure that...(the DON)...avoids multiple, incompatible, non-integrated systems that meet short term needs, but which result in significant data integration problems and costs over the long run." [Ref. 16:p. 78] It is an effective implementation vehicle for IRM, and represents a formidable weapon for dealing with the IR planning problems currently encountered by the DON. IE provides, as one of its major deliverables, a highly stable data model. This data model provides management with some important advantages. First, it facilitates management's ability to adapt and update the system to meet changing functional requirements, because it is data-oriented. Second, it provides DON management with a flexible framework upon which one development effort can be based on another. Finally, it provides a rigorous logical design which provides increased control and integrity, and decreased redundancy, in the physical design.

IE serves as an effective tool on which to base DON standardization efforts, because the data model has the ability to incorporate diverse and complex functions under an integrated architecture. Top DON management has the perception that the development of an overall Navy-wide IS architecture, and the planning and analysis tasks that must accompany it, are too complex for the application of IE. This is unfortunate, because Information Engineering is ideally suited for strategic and IR planning and systems development in complex organizations, because it models the organization independent of its multiple, diverse functions and procedures. As a result, it is capable of integrating disparate management issues and information requirements into a single consolidated architecture. The use of Information Engineering in the Department of the Navy would significantly reduce the time required to design and field information systems, and would ensure the most efficient use of management's time in planning for and managing the development process. By providing a rigid structure on which to base IR planning, analysis, and design, IE provides the discipline necessary to significantly accelerate the development process. It allows this acceleration, while improving the consistency and completeness of the design relative to traditional methods. Top DON management would experience the results of their efforts through faster systems implementation, reduced maintenance costs, improved project management, and an overall reduction in the applications backlog currently plaguing the organization.

Finally, the utilization of IE for IR planning and development would protect current investments and funding by helping management clearly and accurately determine and prioritize its information needs. A clearly defined, well integrated, and proactive IS plan would go far in improving the credibility of the Navy's IRM efforts in the eyes of Congress. The result could be a significant improvement in the funding climate.

B. CASE TOOLS SUPPORTING INFORMATION ENGINEERING

The Department of the Navy has utilized multiple tools for automating various phases of the systems lifecycle. Three tools, in particular, have enjoyed widespread use: Information Engineering Systems Corporation's (IESC) USER: Expert Systems; Texas Instruments' Information Engineering Facility (IEF); and KnowledgeWare's Information Engineering Workbench (IEW). These products were selected for review in this thesis because they are the most widely used in Department of the Navy applications, and because they have associated themselves with the Information Engineering methodology, either as a whole, or in part. In addition, IESC holds an umbrella contract with the Naval Data Automation Command (NAVDAC) for IE methodology training, technical support, and automated support tools usage.

1. IESC's USER: Expert Systems

a. Overview

Information Engineering Systems Corporation was founded by Mr. Clive Finkelstein, co-developer of IE, in the early 1980's. In 1984, IESC released USER: Expert Systems, an expert system and CASE product, which automates the Information Engineering methodology. Its support extends from strategic planning to the generation of computer applications that support those plans. Mainframe, mini, and micro computer applications are supported by the product. The integrated software package supporting the product provides a class 4 expert design dictionary, Level 2 expert modeling support, and Level 2 active documentation. Appendix A describes each of these software support tools in more detail.

USER: Expert systems provides expert systems support to strategic development of information in five phases, using IE:

1. Analysis Phase
2. Design Phase
3. Build Phase
4. Prototype Phase
5. Implement Phase

IESC maintains that significant cost savings and dramatic gains in productivity can be achieved using USER: Expert Systems to automate these phases. Further, since the resultant systems were designed extensively by users, their ability to meet all information requirements will be enhanced, and they will be more closely aligned to the strategic requirements of the organization.

b. Methodology

Information Engineering, as practiced by IESC, is composed of three major stages: Analysis, Design, and Generation. (Formerly called Discovery, Integration, and Implementation, respectively) Each phase is made up of a number of stages. (Figure 10)

(1) Analysis Phase. In the Analysis phase, users, with the aid of the project team, use strategic and tactical statements derived early in the phase to identify and define data and the information derived from the data required at the strategic and tactical management levels of the organization. It is composed of the following stages and steps: [Ref. 5:p. 230]

1. Project Scope Stage:
   -Identifies the project area
   -Identifies pertinent personnel, including a project leader, and obtains management authorization and sponsorship
   -Establishes plans, tasks, milestones, and funding
   -Identifies strategic and tactical statements to be used as input. These statements are derived through either formal strategic planning involving top management, or through informal planning sessions with lower level management. Top management input is received through review of the input of the lower levels.

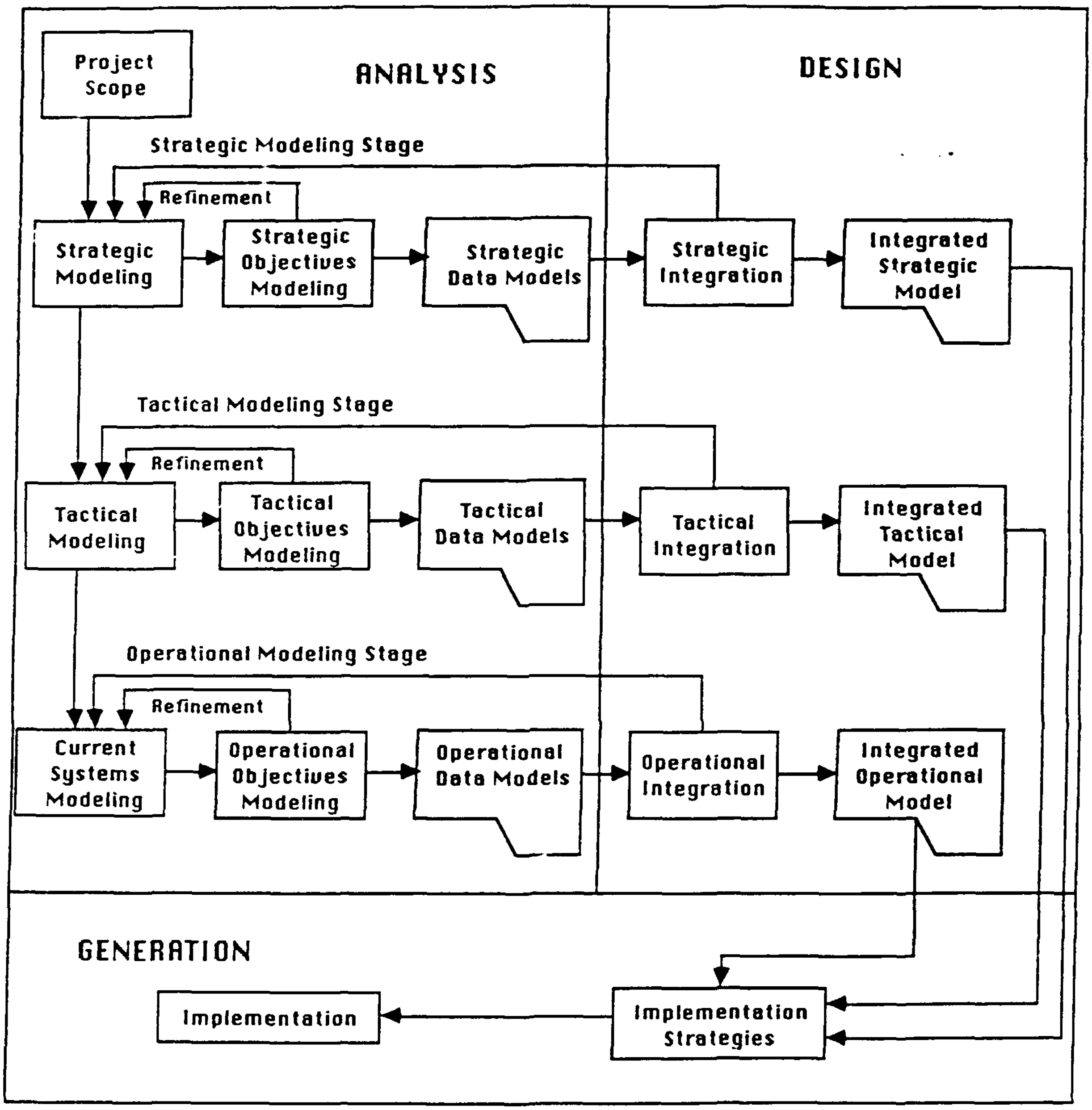

Figure 10. IESC's Information Engineering [Ref. 5:p. 222]

-Trains project personnel in strategic modeling (for top management) and tactical modeling (for operational management)

2. Strategic Modeling Stage:
-Identifies and clarifies the mission and purpose of the organization
-Sets strategic directions with appropriate management
-Analyzes the strategic statements and directions for the future derived in the Project Scope phase
-Broadly identifies strategic data and operational segments that generate tactical data on which the strategic data is based

3. Strategic Objectives Modeling:
-Reviews goals and objectives, concerns and issues, and policies implementing those goals, objectives, and issues
-Determines performance criteria
-Identifies strategic data for measurement of performance criteria
-Establishes performance ranges and controls for decision early warning

4. Strategic Refinement:
-Progressively refines strategic data using a formal approach
-Establishes standard terminology and expert rules at the strategic level
-Produces strategic data models representing a strategic blueprint for management and a basis for tactical modeling
The strategic modeling stages are carried out by responsible senior management in the project area. Goals and objectives, concerns and issues, and relevant policies identified above are used to classify strategic data for input into the strategic data model. This model is used to plan the detailed tactical modeling stage.

5. Tactical Modeling Stage:
-Identifies the tactical environment with middle and operational managers
-Expands the strategic data models through analysis of markets, services, products, and channels
-Identifies detailed tactical data of interest to middle and operational management, and data used to derive strategic data of interest to top management

6. Tactical Objectives Modeling:
-Examines management objectives at various levels in the project area
-Progressively refines objectives, strategies, and tactics
-Further refines strategies for later definition of expert rules
-Identifies data neck to manage achievement of objectives
-Identifies exception reports and decision triggers at the tactical level

7. Tactical Refinement:
   -Progressively refines tactical data using a formal approach applied against each functional area separately
   -Establishes standard terminology and expert rules at the tactical level
   -Produces tactical data models which are a detailed blueprint of the organization
   Much detail of the project area's data resource is identified and refined in the tactical modeling stage. The functions of the stage are analogous to the strategic stage, except on a more detailed level. In most, but not all cases, the tactical data model is used as input for operational modeling.

8. Current Systems Modeling:
   -Used with tactical modeling for current manual or automated systems, or packages, needed for the future
   -Formally cross checks data presently used in existing source documents, reports, ledgers, comPuter files etc. against tactical data models
   -Discards current data not needed for the future
   -Includes data for the future that was overlooked in previous stages

9. Operational Objectives Modeling:
   -Examines operational objectives in the project area
   -Identifies data neck to manage achievement of objectives
   -Identifies exception reports and decision triggers at the operational level

10. Operational Refinement:
   -Progressively refines operational data for each functional area defined
   -Establishes standard terminology and expert rules for the operational level
   -Produces operational data models for day-to-day operation of the organization

Current systems modeling does not require the same level of expertise about the operation of the business as the previous stages. It serves as a formal cross check of the strategic and tactical data models to ensure that all fundamental data is identified. It can generally be carried out by IS personnel or systems analysts using existing source documentation.

(2) Design Phase. The design phase is an automated phase using the Expert Design Dictionary. Although it can be applied after the analysis phase, it is most effective if it is applied concurrently with strategic and tactical modeling and refinement. In strategic design, the strategic data identified in the Analysis phase is entered into the Expert Design Dictionary; a tool that fully automates the Information Engineering process, and checks for data consistency, consistency across data models. It automatically combines common data into an integrated strategic model. The process is analogous for tactical and operational design. Tactical and operational data are entered into the Expert Design Dictionary concurrently with derivation of the models. The models are analyzed, and common data is then combined into integrated tactical and operational models.

c. *Generation Phase*

The integrated strategic, tactical, and operational data models output from the design phase are utilized as the design blueprint for the final phase: Generation. The Generation phase defines detailed implementation strategies for each part of the integrated data models. These models may represent the conceptual basis for both manual and automated systems. Expert design software automatically restructures the integrated data models in the dictionary into submodels specific to each application, for implementation. Software, hardware, and communications facilities, and the physical design of the application are determined. Reports, and procedures are defined as well. The resultant submodels provide a language-independent interface to information systems, and provide a direct input to the automatic generation of information systems.

d. Training and Workshops

The success of an Information Engineering project is directly related to the commitment and training of users. IESC provides a comprehensive training and quality assurance program to supplement its CASE product. This program is composed of six major workshops, plus executive and top management overview presentations. The education program is designed to enable the project team to be self-supporting as soon as possible, ensuring maximum project concurrency and high productivity. Periodic quality assurance consulting ensures a consistently acceptable product. The six workshops are described below:

1. Introductory Workshop:
   -Definition of project boundaries and scope
   -Development of preliminary strategic and tactical data models
   -Completion of management questionnaires (2 weeks prior)
   -Review and prioritization of preliminary models by top management
   -Identification of personnel for later stages

2. Strategic Modeling Workshop:
   -Strategic data model developed from preliminary models
   -Review of strategic data model by top management to identify priority tactical areas

3. Strategic Management Workshop:
   -Development and refinement of relevant policies, objectives, and strategies
   -Identification of critical success face and measures of effectiveness
   -Strategic gap analysis
   -Management review of refined strategic model and strategic plans

4. Tactical Modeling Workshop:
   -Extension of strategic data model into several tactical data models
   -Management review of tactical data model to identify priority areas
   -Identification of personnel for involvement in later phases

5. Operations Modeling Workshop:
   -Extension of tactical models of priority areas into operational models
   -Detailed definition of the specific operational system
   -Management review

6. Implementation Workshop:
   -Operations modeling and refinement of priority operational systems
   -Design and implementation of applications with aid of PROLOG Design Knowledge Base.

Figure 11 illustrates a typical project plan, with scheduling of education, modeling, refinement, and implementation. Note that the entire process lasts approximately six months on average. Modeling and refinement of models and applications is an iterative process throughout the project schedule.

e. *USER: Expert Systems Software Product Description*

The USER: Expert Systems software package represents an array of expert systems that automate the Information Engineering methodology. This software assumes that the user has knowledge of the business, but no significant computer experience. The software was designed primarily for use on

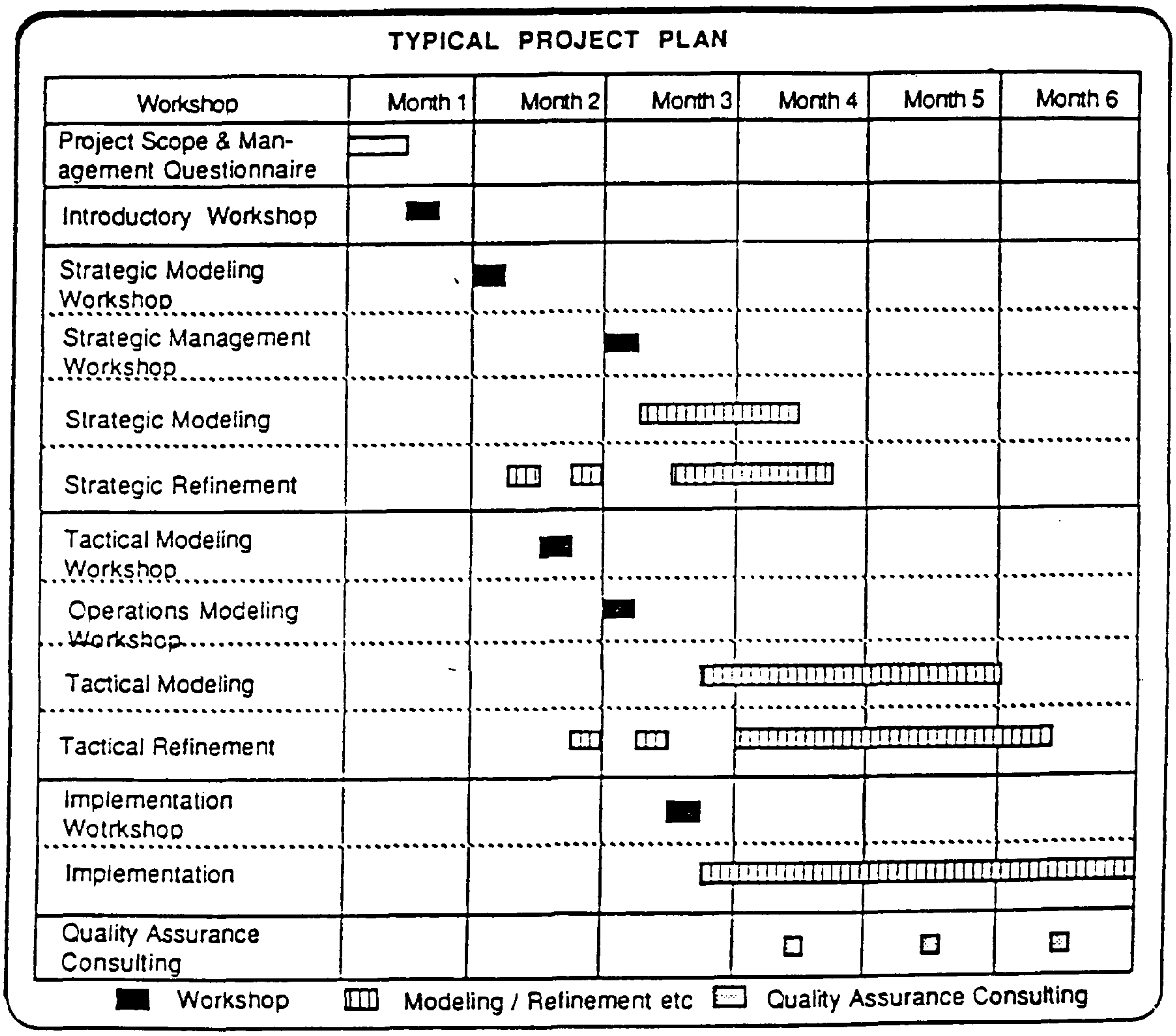

Figure 11. IESC Typical Project Plan [Ref. 17:p. 12]

microcomputers since they are the most accessible to the business user. Hardware requirements such as memory, performance, and output specifications, for USER: Expert Systems are listed in Appendix B. The software package comprises the following expert systems:[1]

1. USER: DATA is an Expert Design Dictionary that is composed of a Class 4 Expert Design Dictionary and a Strategic Planning Dictionary. It provides support to both users and analysts, and automates the Analysis and Design phases of IE. It allows clear definition of the strategic data resource, and the automatic integration of common data throughout the organization.

2. USER: PROJECT is an Expert Project Management System that supports the Generation phase of IE. It supports the identification and progressive implementation of subject data bases, and automatically derives an implementation plan from the data defined in the Expert Design Dictionary. Finally, based on the defined business strategies, it prioritizes the subject data bases for future development efforts.

3. USER: GENERATOR is an Expert Development System that supports the Generation phase of IE. It automatically generates a PROLOG knowledge base of the strategic and tactical data models, and supports the design of screen forms and reports. Further, it automatically generates the data base creation statements required for automatic installation of the subject data bases on micros, minis, or mainframes using a target data base management system (DBMS). These data bases and applications can be prototyped on a microcomputer using USER: SQL, a full implementation of DB2 SQL packaged as a part of USER: GENERATION.

4. USER: PROCEDURES is an Expert Logic Refinement System supporting the Generation phase. It automates procedure modeling, and automatically derives procedures and programs for processing the data defined in the models. A detailed representation of this processing logic is generated automatically using graphical procedure maps and structured English statements.

[1] Information for this section was drawn from Ref. 16:pp. 16-19.

5. USER: IMPLEMENTATION provides a series of Expert Systems Migration products that are designed to translate systems developed with USER: GENERATOR and USER: PROCEDURES for migration to minicomputer and mainframe hardware, operating systems, DBMS products, and languages independent of the USER: Expert Systems software environment.

The following expert systems facilities support the software products described above, in order to provide full capability to automate the Information Engineering process:

1. USER: ADMIN is an Expert Systems Administration Facility supporting all USER: Expert Systems products. It automatically verifies the integrity of the Expert Design Dictionary, and provides automatic repair when applicable. It supports multiple Design Dictionaries for multiple projects, and provides a menu-driven DOS shell for access to MS-DOS/PC DOS facilities.

2. USER: PLOTMASTER is an Expert Data Mapping Facility offering a Level 2 expert data modeling capability which is fully integrated with the Expert Design Dictionary.

3. USER:UEF is an Expert Design Dictionary Expert Facility that automatically generates the PROLOG knowledge base with USER: GENERATOR, and acts as an open architecture export facility.

These software tools and facilities provide comprehensive support for strategic planning, data modeling, and system design activities, and represent a highly effective front-end CASE tool.

f. *Assessment of USER: Expert Systems*

USER: Expert Systems provides the most comprehensive front-end support of the IE process of the three CASE workbenches discussed. It is fully data-oriented; relationships and restrictions between data are used to group data into potential information systems. Further, it is the only product on the market today that normalizes data to Fifth Normal Form (5NF). No other product normalizes data past Third Normal Form. "An entity is in fifth normal form if it is dependent on other occurrences of the same entity or entity type". [Ref. 18:p. 9.13] In other words, 5NF is indicated by the presence of a recursive relationship. Normalization to 5NF is particularly important to the design of expert business systems because it enables intelligence to be built into the data model. Further, it permits the representation of logic intrinsic to the data model, based on the structure that exists between related occurrences of a specific data entity. [Ref. 5:p. 141] Thus, it allows the representation of highly detailed, intricate interrelationships between data elements, such as the ability to define technical substitutes in an inventory management system, or to optimize routing of deliveries in a distribution system.

Whereas most CASE products seek to improve the productivity of programmers and the software development process as a whole, USER: Expert Systems is oriented towards management and users. IESC is essentially a training and technical support organization using its CASE tool for support. As such, it provides an outstanding training tool for understanding the business and its functions. The product itself is highly user-driven; modeling and normalization are performed by the user under the guidance of IESC representatives. Further, IESC conducts a series of workshops which supplement both training and systems development efforts. This user-oriented approach has the advantage of promoting user acceptance, as well as helping to identify strengths and weaknesses in the organization. Interviews, questionnaires, and observation often only identifies problem areas in an organization. Using IESC's user-driven process, users are able to identify and assess not only problem areas, but what the organization is doing right. One drawback of the product is that the success of any project using IESC support is directly related to the amount of user involvement and management support received. In addition, a commitment by management to take advantage of the training support provided by IESC is vital. IESC's first U.S. Navy project, providing Information Engineering support to NAVSEA's Comptroller Directorate [SEA 01), failed due to inadequate training of users and a lack of top management commitment to the project. [Ref. 16:p. 96]

USER: Expert Systems is a highly effective "front-end" tool, providing comprehensive support for strategic planning, methodology and business training, strategic data modeling, and tactical data modeling. It falls short however, in support of "back-end" processes such as process modeling and code generation. Further, it does not support a centralized data dictionary, capable of fully and automatically integrating data structures from multiple workstations. Both of these items are "in the works", with the most likely solution being the integration of USER: Expert Systems with an established back-end tool such as MAGEC, and CASE integrator such as ASYST. Finally, the software is not always "user-friendly", as much of it is still immature.

2. Texas Instruments' Information Engineering Facility (IEF)

a. Overview

Texas Instruments (TI) began automating Information Engineering for internal use in 1983. As TI continued to develop the process, it recognized the practicality, and potential marketability, of using automated IE for applications development. The Information Engineering Facility (IEF) was the result. IEF consists of four integrated toolsets which together, automate the entire Information Engineering process, from planning, through analysis, design, and code generation. IEF implements the major IE diagrams, passes information automatically between diagrams, performs consistency checks and transformations between stages, and finally, writes the source code. Three of the four toolsets, Planning, Analysis, and Design, are PC-based, and work from information residing in local encyclopedias. The fourth toolset, a Code and Data Base Generator, resides on a mainframe, as does the heart of the system, the Central Encyclopedia. The Central Encyclopedia, a sophisticated DBMS and control system, acts as a central repository for business models under construction, and as a project management system. Figure 12 illustrates the IEF environment.

b. Methodology

The IEF is based on James Martin's variant of Information Engineering. It models the business rather than isolated systems, and views the development of information systems in terms of three components: business Data, business Activities, and Interaction between the two. Information Engineering incrementally refines each of these three components, and then integrates them to form executing applications. This refinement takes place in seven stages, with each of the three components becoming more detailed than in the preceding stage. The seven stages and their associated objectives are: [Ref. 19:pp. 35-39]

1. Information Strategy Planning (ISP):
   -Assess the information requirements of the organization
   -Construct an Information Architecture to meet those requirements
   -Construct a Business System Architecture to support implementation of the Information Architecture
   -Identify the Technical Architecture required to support the Business System Architecture
   -Develop a Mission Statement, and identify pertinent environmental factors
   -Present findings to top management for evaluation and action

2. Business Area Analysis (BAA):
   -Fully identify and define the data needed by the business area
   -Identify and define the business activities of each business function
   -Define the data required for each business activity
   -Identify the necessary sequence of business activities
   -Define how each business activity affects the data
   -Produce an implementation plan for the Business System Design (BSD) stage by prioritizing and integrating defined business systems
   -Develop data, activity, and interaction models for each business area

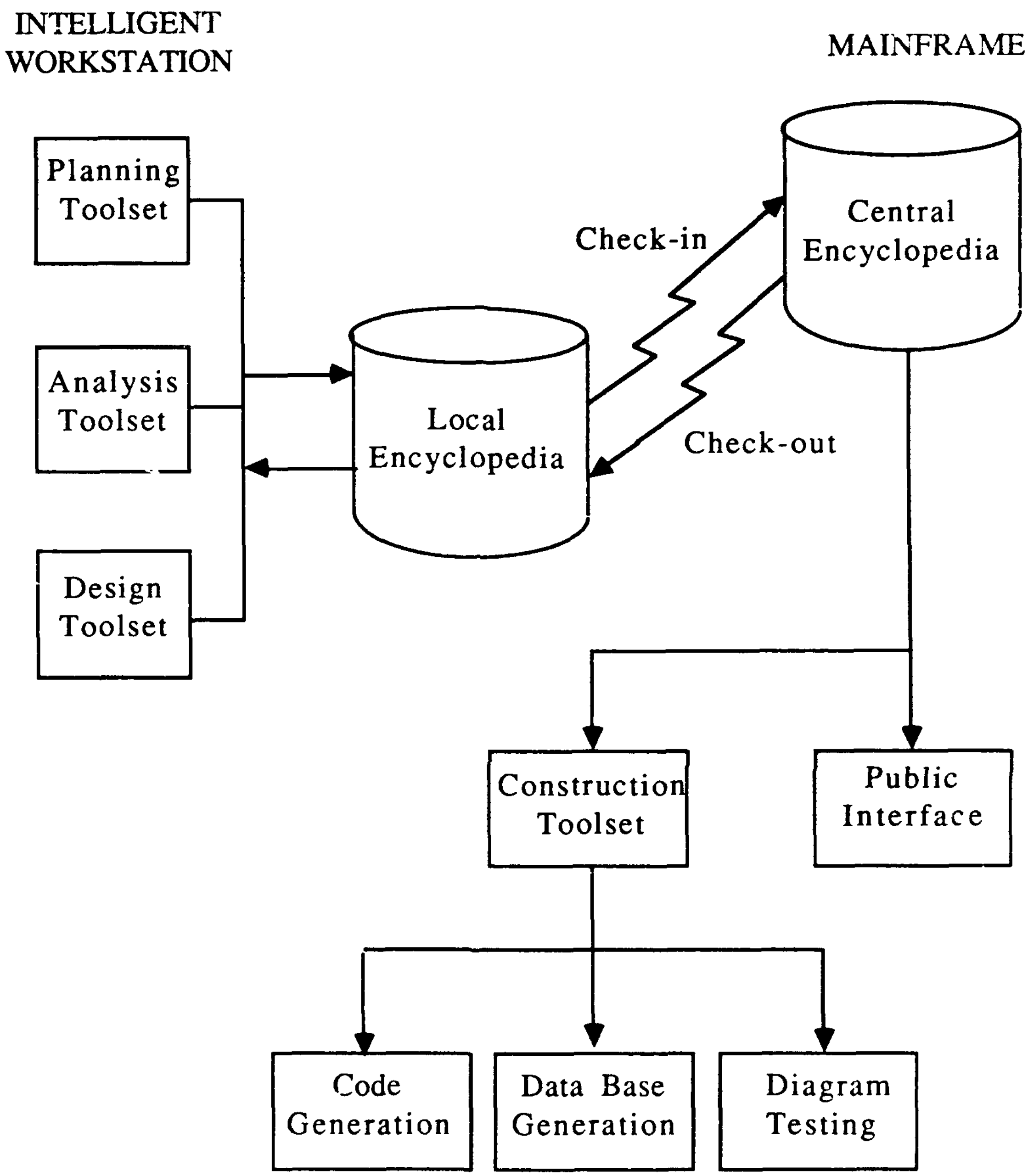

Figure 12. The IEF Environment [Ref. 19:p. 27]

3. Business System Design (BSD):
   -Define human-to-computer interactions required to carry out the previously defined business activities
   -Refine and describe the business system required by the organization
   -Develop procedure and data views of each business system
   -Develop screen and report layouts

4. Technical Design (TD):
   -Tailor the business model to a specific DBMS
   -Determine environment-specific implementation details

5. Construction:
   -Build application programs from the integrated model prepared previously
   -Build application data bases
   -Build additional environment-specific constructs required for program execution
   -Develop screen definitions based on layouts produced earlier

6. Transition:
   -Develop a Transition Plan to include the following issues: training, installation, final acceptance testing, cut-over, and post-implementation review
   -Install the application system and data structures in a production environment, based on Transition Plan

7. Production:
   -Quality monitoring and performance measurement

c. *Workshops and Training*

Texas Instruments provides training workshops that are recommended prerequisites to using the toolsets they support. These workshops are oriented more towards establishing user proficiency with the tools, than towards methodology training. An ISP workshop is provided to train members of an "Information Strategy Planning Team," made up of management personnel, in the operation of the Planning toolset. Prior to utilizing the Analysis toolset, a BAA workshop is recommended to provide the education necessary to effectively conduct the Business Area Analysis phase and use the toolset. Finally, TI provides a BSD workshop and a Data Structure Diagram workshop as prerequisites for using the design toolset. It is highly recommended that cognizant personnel attend the workshops in order to ensure that they are fully versed in the operation of the toolsets, processes, and diagrams they will be utilizing.

d. IEF Software Product Description

The Information Strategy Planning stage is supported by the Planning toolset, and to a lesser extent, by the Analysis toolset. During the ISP stage, these toolsets assist the ISP team in developing a framework on which to base the subsequent analysis and design of the potential application. They provide support for ISP through the use of the following set of diagramming tools and editors:[2]

1. Indented List Editor: specifies organizational hierarchies and business activity hierarchies.
2. Matrix Processor: automatically performs matrix clustering and affinity analysis to help segment the business into business areas and business systems.
3. Entity Relationship Diagramming tool: represents the information used in the business, including high-level entity types. Produces a high-level Entity Relationship Diagram.

[2]Software product descriptions in this section drawn from Ref. 18:pp. 39-41.

4. Process Hierarchy Diagramming tool: records business activities in a tree structure. Produces a high-level Function Hierarchy Diagram.

5. Process Dependency Diagramming tool: records interdependencies between business activities. Produces a high-level Function Dependency Diagram.

During the Business Area Analysis stage, analysts utilize the Analysis toolset to work with business functions and entity types grouped into business areas. The IEF will automatically check the resultant Business Area model for completeness and consistency throughout this stage. The following IEF tools support the BAA phase:

1. Entity Relationship Diagraming tool: represents facts about business data, depicts relationships between entity types, and details attributes of entity types.

2. Entity Hierarchy Diagramming tool: partitions entity types into entity subtypes.

3. Process Hierarchy Diagramming tool: records business activities in a hierarchical fashion, subdivides functions into processes, and defines process information views of entity types.

4. Process Dependency Diagramming tool: records the interdependencies between processes, identifies events that trigger processes, and depicts information flows from objects outside the business area.

5. Process Action Diagramming tool: specifies the detailed logic of processes, and performs process stereotyping on entity types.

In the Business System Design phase, the IEF automatically transforms BAA-level processes, dependencies, and information views into BSD-level procedures, dialog flows, and data views. During this phase, the IEF automatically checks the business system model for consistency and completeness, and transforms BSD-level entity types, attributes, and relationships into Technical Design (TD)- level records, linkages, and fields. The following tools support the BSD phase:

1. Dialog Flow Diagramming tool: defines procedure boundaries and dialog flows, binds processes to procedures, specifies linkages, and defines the commands and states that trigger these linkages.

2. Screen Design tool: designs screen layouts associated with procedures.

3. Procedure Action Diagramming tool: specifies the detailed logic of procedures, and automatically transforms and synthesizes BAA action diagrams into more highly detailed BSD action diagrams.

The Technical Design phase requires little human intervention, as the IEF automatically transforms previously defined data diagrams into Data Structure Diagrams. Both the Design and Construction toolsets support this phase. During the TD phase, the IEF automatically checks the business system model for consistency and completeness, and prepares the TD-level records, fields, and linkages for transformation into data bases during Construction. The following tools, residing on the mainframe, support the this phase:

1. Data Structure Diagramming tool: optimizes data base transformation. Pictorial representation of the physical data base layout.

2. Load Module Packaging Panels: details packaging of procedures into execution units, and specifies interfaces to external programs and data bases.

Finally, in the Construction phase, the IEF writes 100 percent of the source code in the target programming language. The IEF can generate applications to run under IMS DC/DB2, CICS/DB2, or TS0/DB2 in the IBM MVS environment. The following mainframe-resident tools support the Construction phase:

1. Data Base Generation Panels: start the automatic generation of data definition language (DDL) statements.
2. System Generation Panels: initiate COBOL source code generation and compilation, and link/edit.
3. Interactive Diagram Testing Panels: test application screens, run consistency checks, and ensure system logic runs correctly.

The IEF Central Encyclopedia is the heart of the product, and serves as an information repository and project management system for all systems currently under development. Data structures, diagrams, structured specifications, and report and screen layouts all reside in the encyclopedia. The following features of the Central Encyclopedia support the coordination of large IS development projects:

1. Model sharing and distribution
2. Actual and trial model merging
3. Administrative and statistical reports
4. Multiple level security access
5. Support of multiple projects or workstations simultaneously.

Figure 13 presents a summary of IEF automated support of the Information Engineering process. Appendix C provides further product specifications and hardware requirements.

e. Assessment of the Information Engineering Facility

Texas Instruments' Information Engineering Facility (IEF) provides full support of the entire IE process from planning through code generation. It uses sophisticated diagramming techniques to supplement planning, designing, and implementing application systems. These diagrams are fully integrated between each other and the business model through the mainframe-based Central Encyclopedia. The Central Encyclopedia is the heart of the system, and is a major advantage of the IEF. It provides for project coordination, consistency checking, and model sharing, as well as providing artificial intelligence-based inferencing rules that enforce synchronization between stages.

Each IEF toolset uses a local encyclopedia, which serves as a subset of the Central Encyclopedia, and is fully integrated with it. In addition, the IEF provides full transformation between toolsets and stages to ensure the consistency and completeness of the business model. With the exception of

	Data	Activities	Interaction	Confirmation
Information Strategy Planning	Data Oriented Matrices High Level Entity Relationship Diagram	Activity Oriented Matrices Indented List Editor Function Hierarchy Diagram Function Depend-Ency Diagram	Business Function/ Entity Type Matrix	
Business Area Analysis	Entity Relationship Diagram Entity Hierarchy Diagram	Process Hierarchy Diagram Process Dependency Diagram	Process Action Diagram	Consistency Check
Business System Design	Entity Relationship Diagram Entity Hierarchy Diagram	Dialog Flow *Diagram*	Procedure Action Diagram Screen Design	Consistency *Check*
Technical Design	Data Structure Diagram	Load Module Packaging		Consistency Check
Construction	Data Base Definitions	Transaction Controller	Application Programs Screen Definitions	Interactive Design Testing

Figure 13. IEF Automated Support [Ref. 19:p. 40]

Planning , these toolsets can be used as stand alone CASE tools as well, although thIs would undermine the IE process.

The IEF supports process modeling and data modeling in all phases, a feature not present in IESC's product. Process modeling supplements the IE process by representing activities, procedures, and procedure steps in diagrammatical form. This allows analyst to view the business from both views: data and activities. Further, it allows partitioning of models based on an organization's procedures and the processes that make up these procedures.

The IEF bases the Planning phase on user involvement, however, all toolsets rely heavily on systems analysts and programmers for guidance on use of the methodology and for operation of the system. This is contrary to IESC's product, which is highly user-driven. With the IEF, users tend to distance themselves from the systems development process after Information Strategy Planning, leaving the process to ADP-types. User involvement is a vital prerequisite to the success of an IE project, and therefore, the organization must stress continued involvement from non-ADP personnel after the Planning phase is complete. Another drawback of the IEF is that it doesn't support the rigorous data analysis and normalization that the IESC product does. It normalizes to third normal form (3NF), as opposed to IESC, which fully normalizes data to fifth normal form. As a result, the IEF-produced business model will not be as rigorous and stable as the IESC data model. Further, IESC's data analysis and planning process is much more comprehensive, with a stronger foundation of methodology training. On the other hand, IEF provides full back-end support through code generation, and a centrally managed information repository at the mainframe level; two features not supported by the IESC product. NAVSUP-0482, project manager for SUADPS, identified the tradeoffs between the IEF and USER: Expert Systems, and developed an automated bridge between the two. This bridge allows them to take advantage of the strong front-end features of the IESC product, combined with the back-end features and Central Encyclopedia of the IEF.

3. KnowledgeWare's Information Engineering Workbench (IEW)

a. Overview

KnowledgeWare was founded as Database Design, Inc. in 1979 by James Martin, as a research, development, and consulting firm. In 1985, it became KnowledgeWare, Inc., and in 1986, merged with Tarkenton Software, in order to add application generation to its product portfolio. Today, KnowledgeWare is the world's largest vendor of CASE tools. The company's strategic product line, the *Information Engineering Workbench* (IEW), is a CASE toolset consisting of three PC-based diagramming tools for planning, analysis, and design, a PC-based COBOL generator, and a mainframe-based COBOL generator. All of these products revolve around, and are integrated with, a central encyclopedia. The IEW utilizes an open architecture approach that allows for ready interface with other company's software products. On the other hand, KnowledgeWare has entered into a fully cooperative marketing agreement with IBM, and as such, IEW has been designed and updated to maintain full compatibility with IBM hardware and software products.

b. Methodology

The Information Engineering Workbench is not aligned to a specific methodology. KnowledgeWare's reasoning for this is that their tool is built around general software principles, and as a result, provides the developer with more flexibility to tailor the tool to their needs. They state that:

> Few development shops can apply a strict methodology to every development or maintenance project. Many employ multiple methodologies or 'home grown' hybrids. And everyone is faced with the 'quick and dirty' applications that don't warrant a comprehensive formal technique. [Ref. 20:p. 2]

KnowledgeWare states that users of the IEW are free to employ Martin's Information Engineering, Yourdon, DeMarco, Arthur Young, Constantine, Rockart's CSF's, BSP, SSP, JAD, Prototyping, and many other methodologies. They maintain that their product maintains the necessary engineering discipline over the systems development process, without "constraining" it to a specific methodology.

c. *IEW Software Product Overview*

The IEW workstation tools provide easy-to-use, mouse- driven applications for creating, revising, and maintaining most common systems development diagrams. All the tools are fully integrated with the central Encyclopedia, and use the expert system Knowledge Coordinator. The Knowledge Coordinator ensures the consistency, correctness, and completeness of all diagrams on a real time basis. There are six workstations that comprise the full IEW product: (Figure 14)

1. Planning workstation
2. Analysis workstation
3. Design workstation
4. Mainframe Knowledge Coordinator and Encyclopedia
5. PC-based Construction Workstation
6. Mainframe-based GAMMA workstation.

Appendix D provides hardware requirements for IEW. Product descriptions are listed below:[3]

The Planning Workstation (IEW/PWS) is a tool for managing and analyzing planning data. It helps the systems analyst define an information architecture by grouping and prioritizing activities and data into subject data

[3] Software product descriptions in this section drawn from Ref. 19:pp. 6-9.

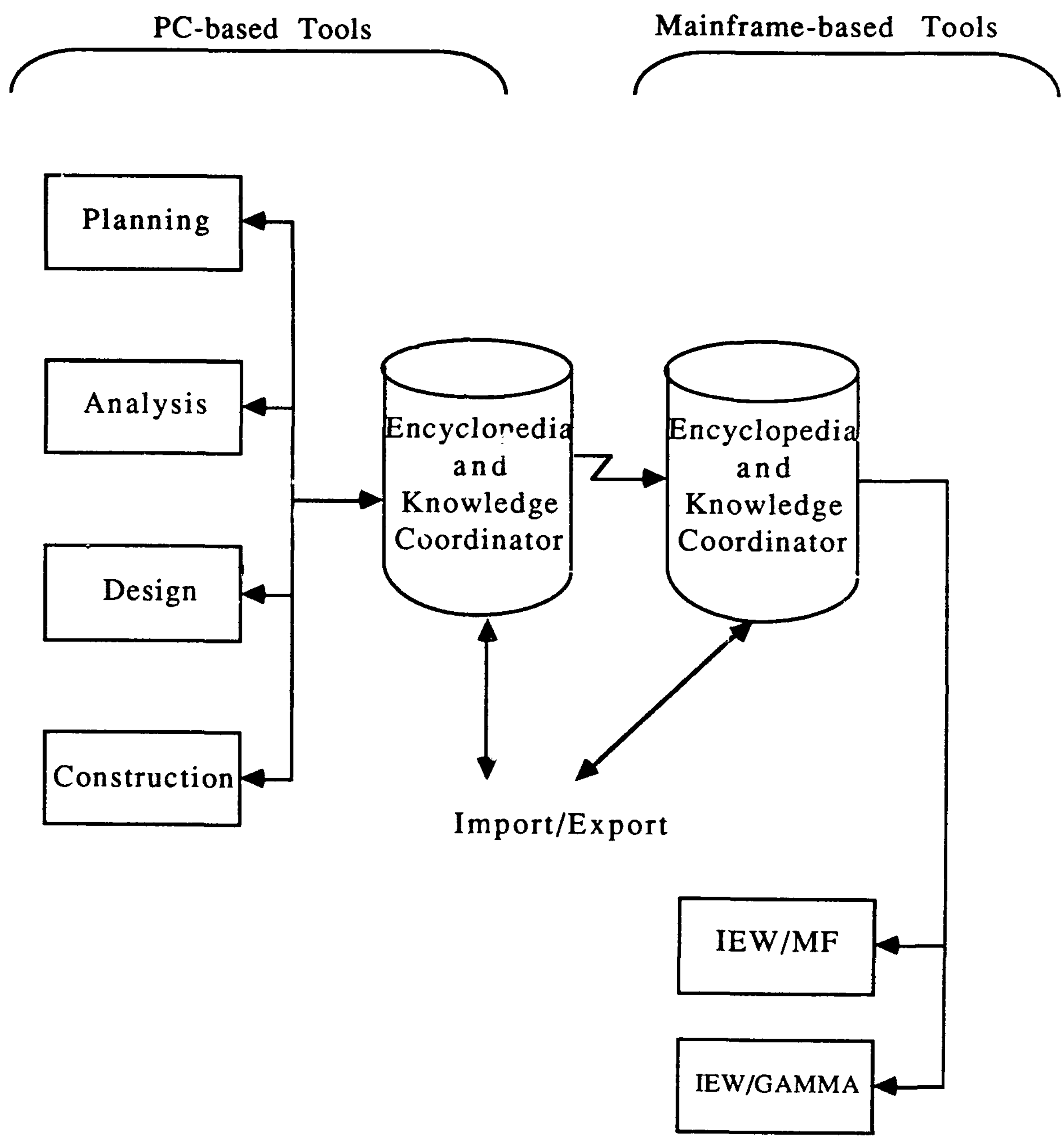

Figure 14. IEW Environment [Ref. 20]

bases. Further, it helps the analyst organize, model, and evaluate knowledge about the enterprise-its processes, functions, and data, and its organizational information needs. All diagrams are integrated using the Knowledge Coordinator to ensure consistency between diagrams. The following diagrams support the Planning Workstation:

1. Association Matrix Diagrammer: performs cross-analysis between any two objects of a strategic plan, providing a means to document and modify the information requirements of the business and the interrelationships between them.

2. Property Matrix Diagrammer: assigns characteristics, properties, and priorities to individual planning objects.

3. Entity Diagrammer: graphic method for describing the information needs of the enterprise. It allows the identification of principal entity types and the relationships between them.

4. Decomposition Diagrammer: Creates and maintains hierarchy diagrams and hierarchical relationships, and alerts the analysts to circular relationships.

The Analysis Workstation (IEW/AWS) provides diagramming tools for both process and data modeling, and the definition of system specifications. It is integrated with the Planning Workstation through the Encyclopedia, and provides diagramming techniques that support many structured analysis techniques. The following tools support the Analysis Workstation:

1. Decomposition Diagrammer: refines high level business activities into lower levels of detail.

2. Data Flow Diagrammer: describes the processes of the system and how data flows between these processes.

3. Entity-Relationship Diagrammer: defines data requirements for the processes, subject area data bases, and the system as a whole.

4. Action Diagrammer: describes the procedural logic for the lowest level processes in the organization.

The Design Workstation (IEW /DWS) supports the transformation of logical representation of the system to the physical design. It supports both process and data-oriented design, and helps the designer capture knowledge about screen layouts, edit rules, program structures, procedural logic, and data base and file structures. All diagrams, and the movement between those diagrams, are stored in the Encyclopedia, and are managed by the Knowledge Coordinator. The following diagrams support the Design Workstation:

1. Structure Chart Diagrammer: describes the hierarchy between modules, along with the data that is passed between those modules.

2. Action Diagrammer for Modules: describe detailed program logic and refer to other design objects like screens, subordinate modules, segments, relations, and records.

3. Presentation Diagrammer for Screens: speeds screen design using mouse and graphics capabilities.

4. Data Structure Diagrammer: creates and maintains record, relation, segment, and screen data structures graphically.

5. Database Diagrammer: represents the physical data base design for relational, hierarchical, and flat file data base implementations.

The Mainframe Knowledge Coordinator and Encyclopedia (IEW/MF) provides the analyst and designer with project management, security, reporting, and shared access capabilities. It facilitates the sharing of information between multiple IEW workstation users, and consolidates their work into a mainframe resident central encyclopedia.

There are two application generators available as part of the IEW toolset: the PC-based IEW Construction Workstation (IEW/CWS), and the mainframe-based IEW/GAMMA. Both provide full COBOL source code generation and documentation from the previously defined design specifications. From the design specifications, both tools generate 100 percent of the application including full COBOL source code, screen maps, data base access routines, DDL, and full documentation.

d. *Assessment of the Information Engineering Workbench*

The Information Engineering Workbench's open architecture approach is a significant selling point for the product. Every toolset has import and export capabilities that allow them to take advantage of other tools in the IEW package, or be used in conjunction with other firm's software products. The tool provides capability to interface with 4GL products, DBMS', desktop publishers, code generators, data dictionaries, and spread sheets.

The IEW workstations can be used as one integrated toolset or as separate tools to meet a specific stage of the development lifecycle. As such, the

IEW offers the integration of a single-vendor solution, or the flexibility of modularity. On the other hand, since the product can be used either way, it does not provide the rigid discipline necessary for an effective, engineered, systems development process. This is due to the fact that the IEW is not based on a specific methodology. KnowledgeWare states that this approach leads to more flexibility for the system developer, and makes it possible to use the tool to create "quick and dirty" applications. "Quick and dirty" applications are exactly what organizations should steer away from. An integrated toolset based on a specific, rigid methodology is necessary in order to provide the organization with the rigorous data analysis and validation necessary to create strategic information systems. KnowledgeWare does not provide training workshops or technical support as part of their package.

4. Comparison of CASE Toolsets

Both the TI and IESC tools support Information Engineering exclusively, as opposed to IEW, which professes to support both data and process orientations through a combination of methodologies. As a result of its "open" methodology, IEW lacks the rigorous data analysis, validation capabilities, and discipline needed for the development of strategic information systems. The IESC product has the strongest data analysis capabilities, in that it is capable of normalization to 5NF. It does not, however, support any process-oriented analysis.

Both IEF and IEW provide strong back-end support as well as a central encyclopedia for integrating diagrams and stages. The IESC product, on the other hand, does not provide a fully developed back-end, nor does it provide a centralized data repository. Both issues are currently being rectified by IESC.

The IESC product provides the most comprehensive training and technical support program of the three. It is oriented towards training in both the Information Engineering methodology, and towards proficiency in using the product. IEF training workshops are specifically designed to train users on how to run the package. IEW provides no technical support with its package. The training programs available reflect the policies of each firm. Whereas IESC bases the use of its product on full participation of the user and management throughout the process, IEF is geared towards IS personnel after the initial planning phase. IEW represents a CASE tool specifically developed for use by systems analysts and designers.

IEW is the least expensive of the three products, however it provides the least benefits as well. The TI and IESC tools cost approximately the same for providing the same coverage. The addition of back-end support must be figured into the cost of the IESC product, while the cost of mainframe support must be figured into the price of the TI product. The IESC product is fully microcomputer-based, whereas the TI product requires both PC and mainframe support. IEW offers either PC or mainframe support.

The next section will compare the lifecycle coverage of the three CASE workbenches in the context of an analytical framework for comparing IE methods, proposed by Hackathorn and Karimi. TABLE 1 provides a graphical comparison of the three products.

5. A Framework for Comparing Information Engineering Methods

a. Description

The analytical framework for comparing information engineering (IE) methods presented here was developed by Dr. Jahangir Karimi and Dr. Richard Hackathorn of the University of Colorado at Denver. It encompasses two dimensions, depth and breadth, which form the axes of a graph (called the DB-space) that compares the IE methods. The framework suggests roles for developers and planners, and two processes, align and exploit, that ensure that organizational goals and the information systems architecture are properly aligned. [Ref. 2:p. 205]

The breadth dimension of the framework is composed of five phases, and represents an extension of the traditional systems development lifecycle. It is extended in that it includes strategic considerations not covered in the systems lifecycle. The breadth dimension describes both what is being done, an activity, and what will result, the deliverable. Each activity and its associated deliverable is referred to as a phase. (Figure 15) Note that the first four phases

TABLE I

CASE TOOL COMPARISON

	IESC	IEF	IEW
Methodology	data	data	open
PC/mainframe	PC	must use both	either
Normalization	5NF	3NF plus	3NF
Interface	good	excellent	excellent
Availability	NAVDAC contract	GSA	GSA
PC Toolset	$135K	$89K	$107K
Mainframe Tool	N/A	$207K	$164K
Technical Support	$275K	$200K	not provided
Total Cost	~$500K	$495K	$271K (tools only)

[Ref. 21]

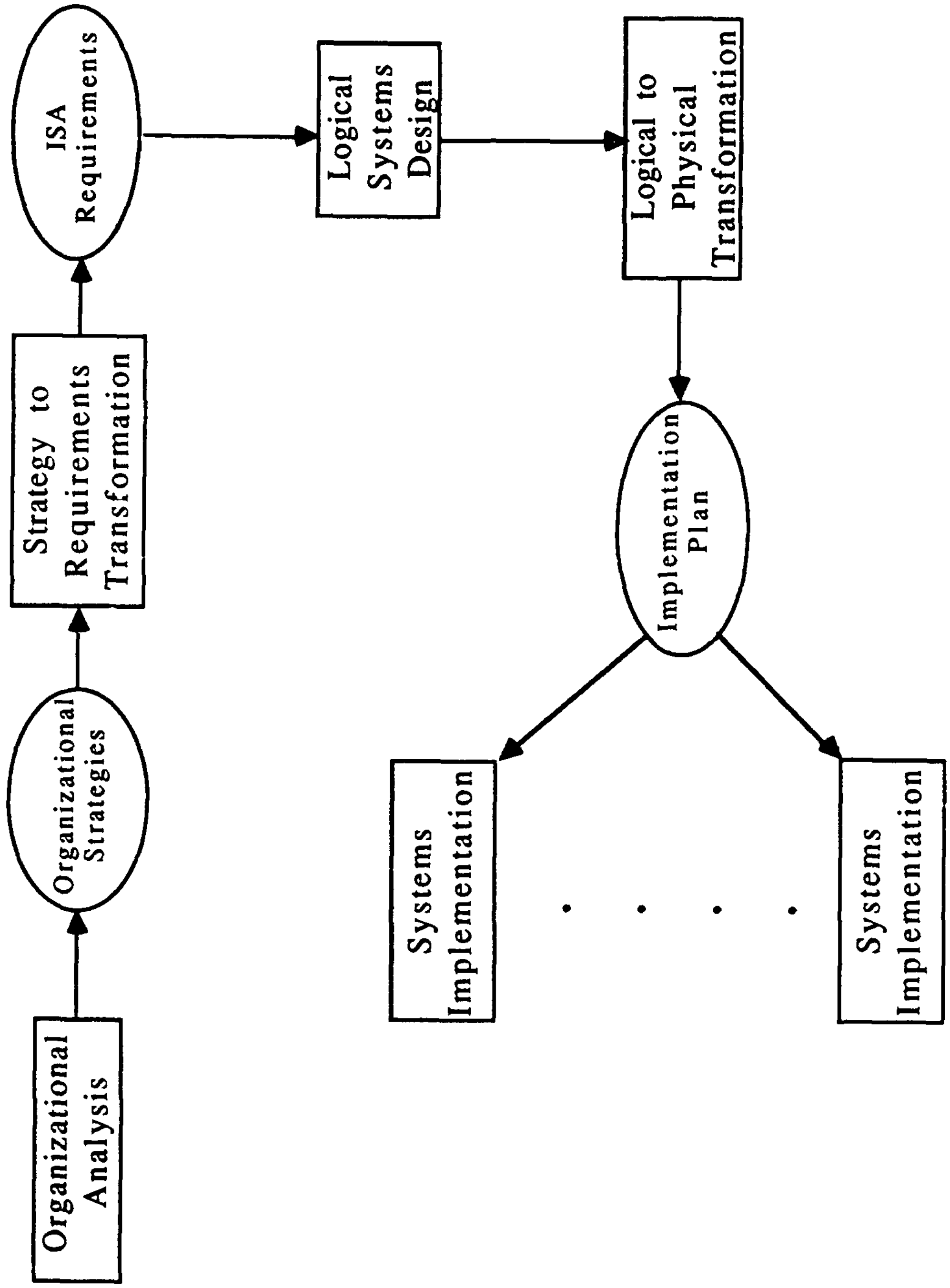

Figure 15. The Breadth Dimension [Ref. 2:p. 206]

are global to the organization, and closely parallel the phases of information engineering. The last phase of the dimension is local to a specific application, and is software engineering oriented.

The five activities of the breadth dimension are: Organizational Analysis, Strategy to Requirements Transformation, Logical Systems Design, Logical to Physical Transformation, and Systems Implementation. The first phase, Organizational Analysis, is the most vital, and in most cases, the most overlooked. The purpose of the phase is to conduct an analysis of the mission and nature of the organization and its environment, and to translate this into a formal statement of organizational goals and strategies. Phase two, Strategy to Requirements Transformation, entails modeling of the information systems architecture (ISA) which represents the information flow requirements of the entire organization. Data, applications, geographic, and communications architectures are also defined in phase two. "Planning for ISA should specifically include the implications of the business objectives and the organizational strategic plan on the strategic direction setting of information systems technology. It requires primarily business-oriented people who understand the information requirements of the organization." [Ref. 22:p. 11] The third phase of the Breadth dimension is Logical Systems Design. Its purpose is to conduct the design of the data, application, and geographic architectures using the logical model of the ISA. Phase four, Logical to Physical Transformation, consists of the decomposition of the architectures discussed above, the formulation of an applications portfolio, and decision making regarding detailed design and implementation. The final phase, Systems Implementation, occurs for each application designed in the previous phases. The result is an operational application that supports a business function of the organization.

The Depth dimension of the framework allows review of information engineering methods as they relate to both their conceptual foundation and practical results. It is composed of three stages: methodology, technique, and tool. The first stage, methodology, defines the conceptual basis of an IE activity. The second stage, technique, specifies the steps in performing a specific IE activity, including the required inputs to and results from each step. The final stage, tool, represents a tangible aid for performing a specific IE activity for example, a CASE tool. The purpose of using a tool is to produce a deliverable.

The two dimensions are used together to produce the framework, called the DB-space, for comparing IE methods. (Figure 16) The breadth dimension is used as the horizontal axis, with the depth dimension as the vertical axis.

Considering the nature of the four quadrants in Figure 15, one can characterize organizational roles to support the development process. Counterclockwise from the upper left, these roles are: [Ref. 22:p. 15]

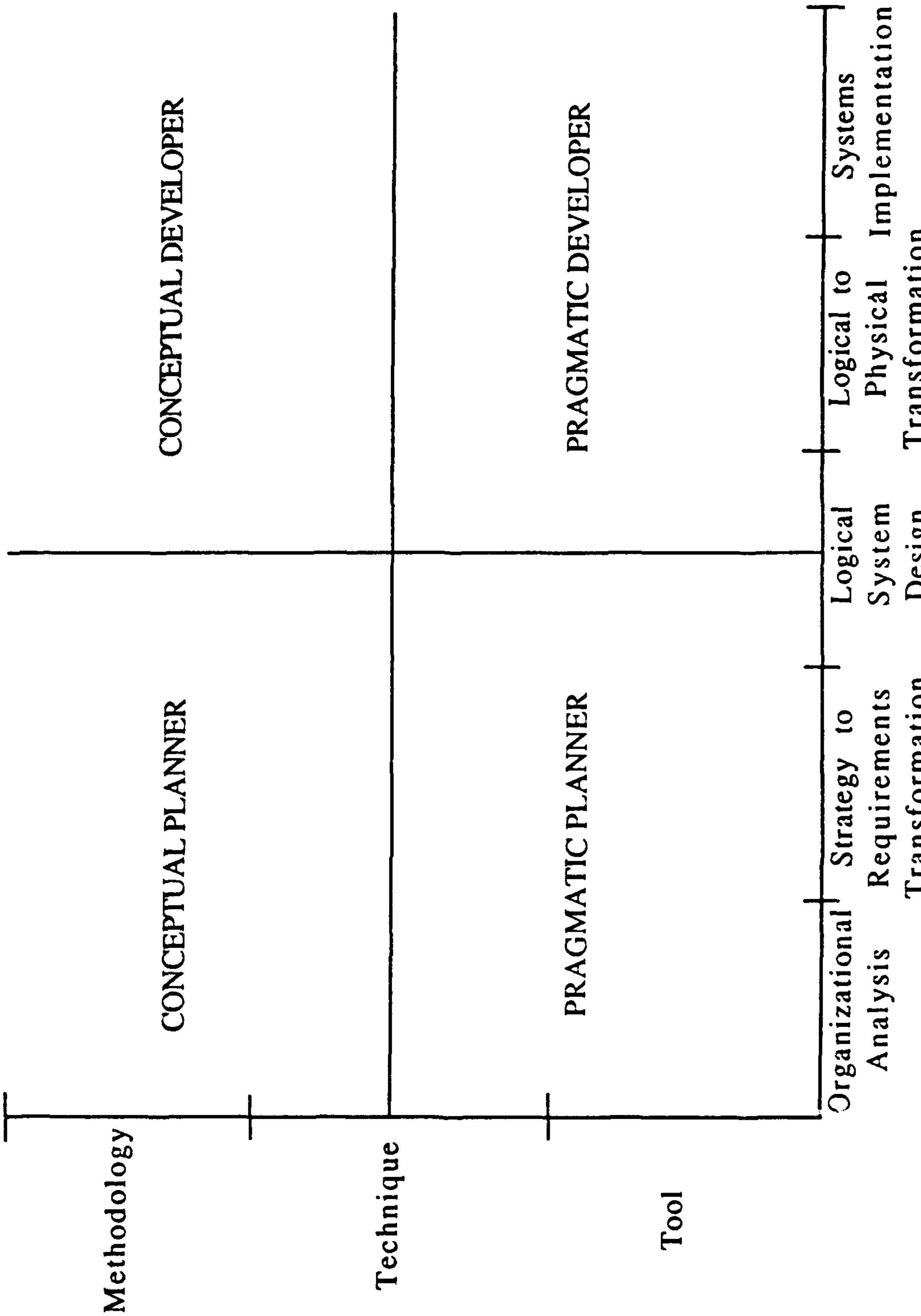

Figure 16. The DB-Space [Ref. 2:p. 209]

1. Conceptual Planner: concerned with organizational strategic planning and direction setting, and the establishment of corporate IS strategy.

2. Pragmatic Planner: concerned with modeling organizational structure, plans, policies, procedures, and investment strategies to derive the IS architecture (ISA).

3. Pragmatic Developer: concerned with implementing the ISA.

4. Conceptual Developer: concerned with conceptual basis for employing technology to meet organizational goals and needs.

A continual dialogue or process should occur between the Conceptual Planner and the Pragmatic Developer to ensure that the organization's IS is fully aligned to organizational goals while being able to exploit emerging technologies. These processes are referred to respectively, as Align and Exploit. The Align process seeks to force IS management to conform to the mission and policies of the organization. The Exploit process seeks to identify and exploit opportunities that are feasible given the current state of the organization and technology. [Ref. 2:p. 216] Since these two roles are on separate conceptual levels, the Align process should involve the Pragmatic Planner, and the Exploit process should involve the Conceptual Developer. They will act as intermediaries to ensure clear lines of communication over the two processes. (Figure 17) A clear linkage between the Conceptual Planner and the Pragmatic Developer will ensure that the IS architecture is fully aligned to the overall business plan of the organization. (Figure 18)

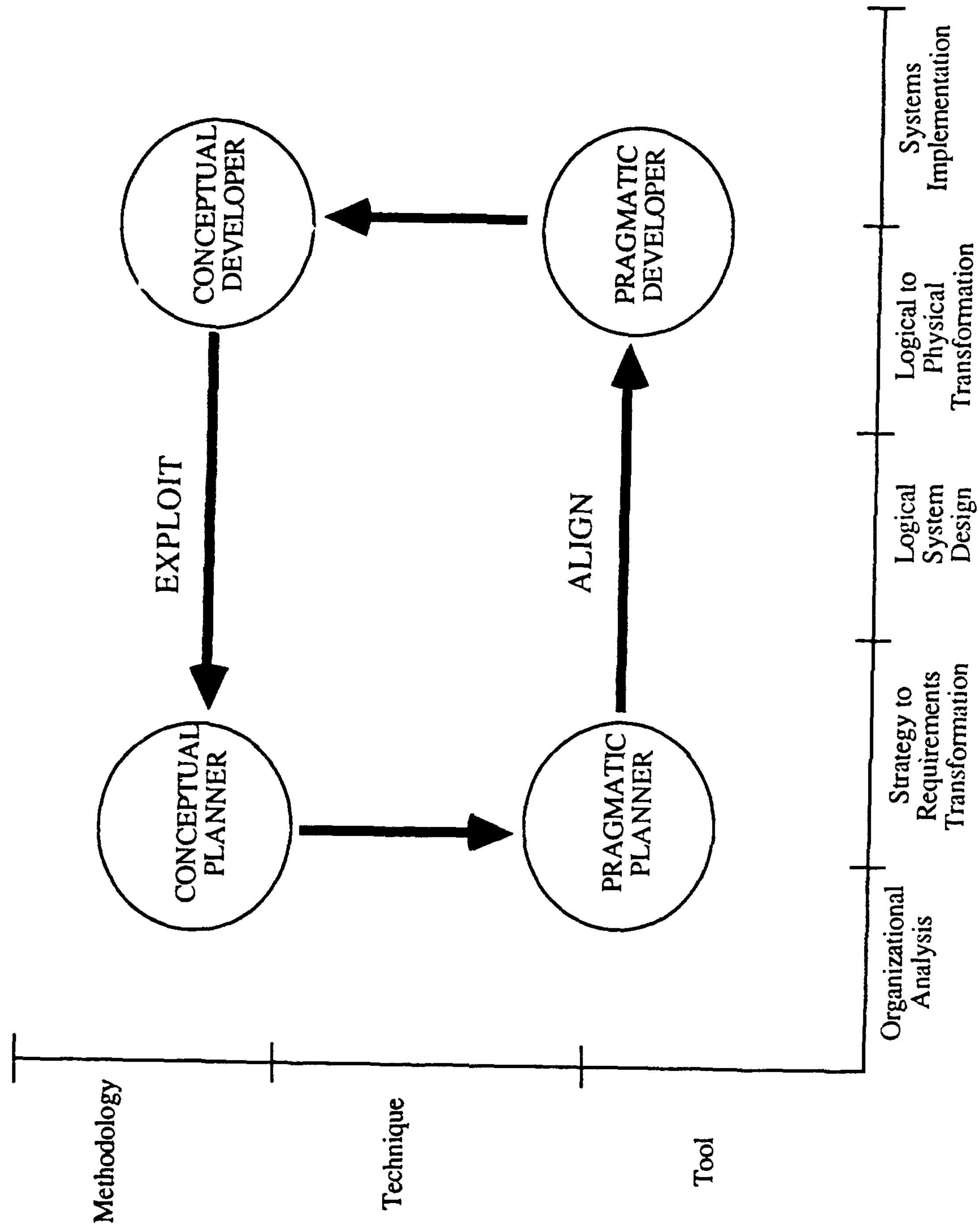

Figure 17. Align and Exploit Processes [Ref. 22:p. 16]

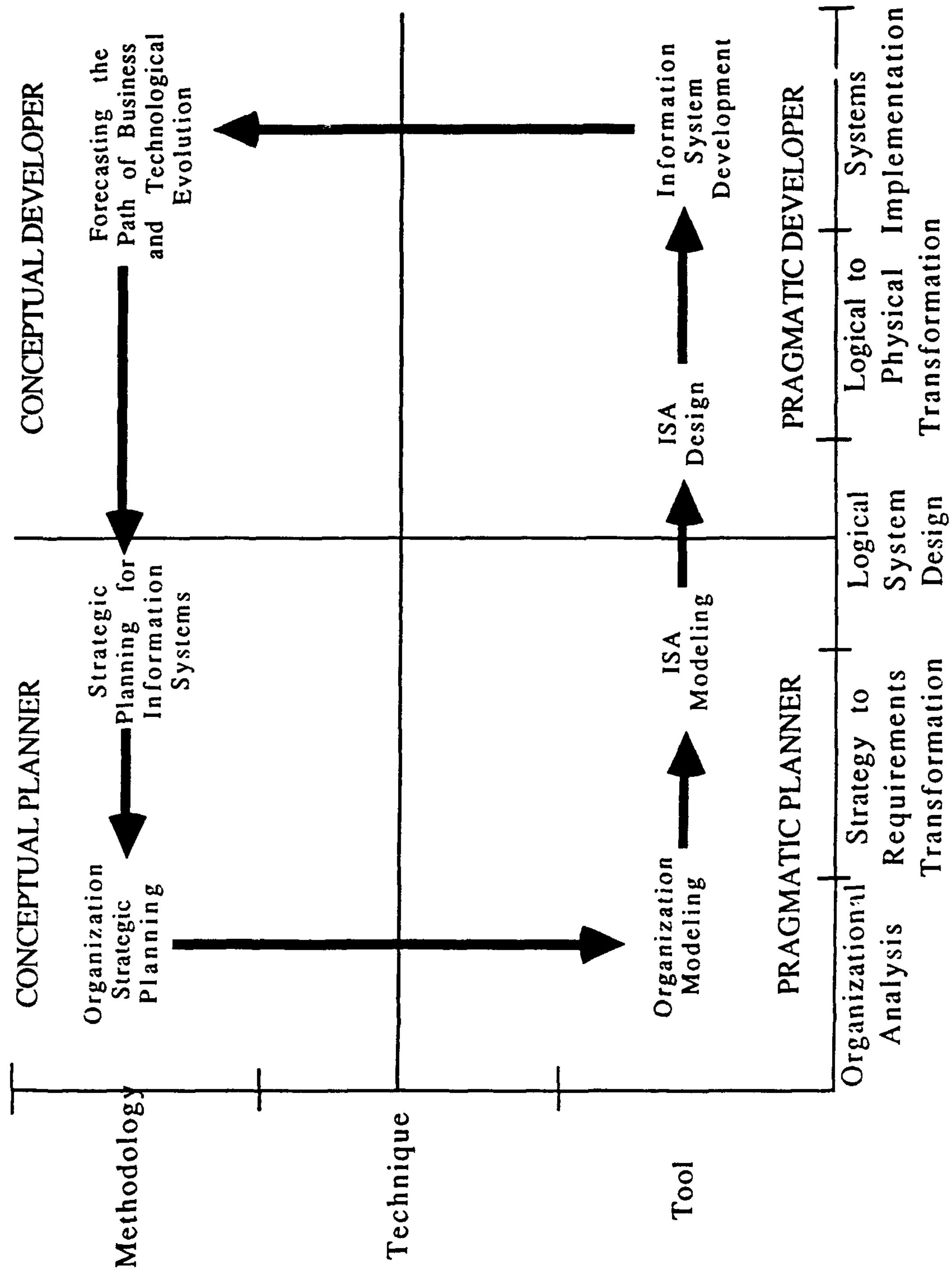

Figure 18. Aligning Strategic and IS Planning [Ref. 22:p. 14]

The parameters used for comparing IE methods are based on two major characteristics: the extent of coverage over the depth dimension, and the extent of coverage over the breadth dimension. Extent of coverage over the depth dimension details the following: the knowledge threshold of the input or analysis employed, from conceptual to machine processable (tool); the extent of knowledge provided by the output, from conceptual to machine processable; and the extent of coverage of each, from no coverage, to partial, to extensive. Extent of coverage over the breadth dimension examines the extent to which an IE method covers the lifecycle. It looks at where inputs are generated, where outputs are produced, and the coverage of each method over the applicable part of the lifecycle. Based on the results of the elimination of theses parameters, the IE method will be mapped onto the DB-space. The size and placement of the boxes representing each method indicates the relative coverage of the method over the breadth and depth dimensions of the framework. The framework does not subjectively rate one method over another, but simply gives the planner an indication of which methods provide the necessary coverage over the dimensions of the framework for the application in question. It also provides an excellent mechanism for comparison and integration of the methods, in order to gain the most complete coverage of the systems lifecycle as is practicable.

b. Using the Framework to Determine Coverage of Toolsets

Hackathorn and Karimi's framework represents an easy-to-understand graphical method of comparing the coverage of various CASE tools using common criteria. As stated earlier, it does not subjectively rate one tool over another, but it does provide the planner with an effective diagnostic method for determining the combination of tools needed to ensure full coverage over the development lifecycle. In this section, each CASE workbench discussed earlier will be rated in accordance with the evaluation criteria of the framework, and then mapped on to the DB-space to graphically illustrate the results. These ratings will be performed subjectively, based on contacts with vendors and users, supporting literature, and some personal experience. Figure 19 illustrates the coverage ratings given; Figure 20 compares the CASE workbenches in the context of the framework.

One can see from Figure 20 that no single CASE tool provides full coverage over the breadth and depth dimensions. Note however, that using a combination of tools, full coverage can be accomplished. Ideally, the combination of tools selected should provide full coverage over all fifteen sectors of the DB-space. Integration of IEF and USER: Expert Systems would accomplish this, and would fully exploit the advantages of each product.

	OA	S-RT	LSD	L-PT	SI	METH	TECH	TOOL
	I O	I O	I O	I O	I O	I O	I O	I O
IESC	E	P E	P P	P P		E E	E E	P P
IEF	P	P P	E E	E E	E E	P P	E E	E E
IEW		E P	E P	E E	E E		E E	E E

LEGEND:	
I	Input
O	Output
E	Extensive
P	Partial

Figure 19. Comparison of CASE Tools

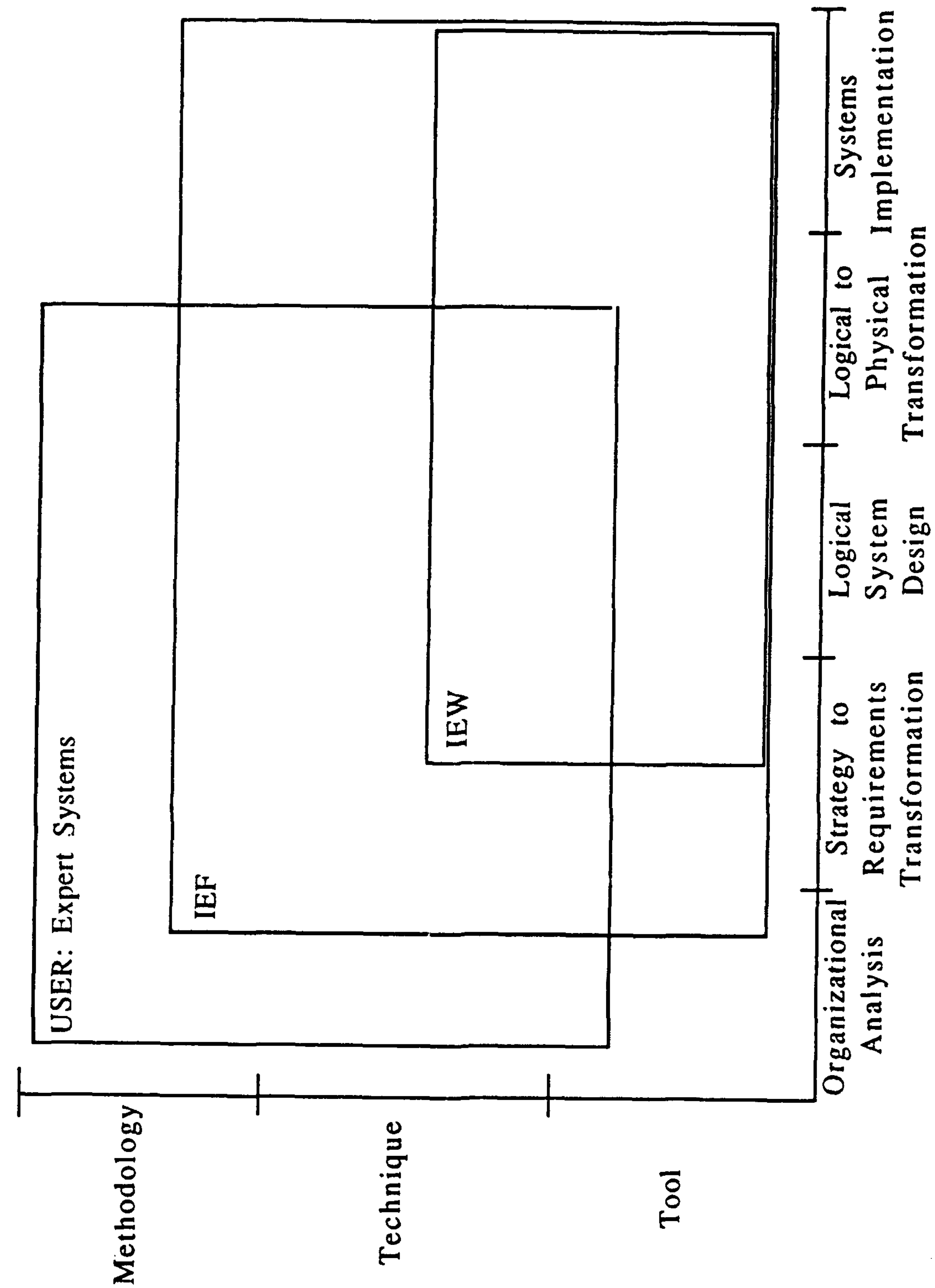

Figure 20. Coverage of CASE Tools

V. CONCLUSION

SECNAV Instruction 5230.9A, the Information Resource (IR) Program Planning guide, and SECNAV Instruction 5230.10, the Department of the Navy Strategic Plan for Managing Information and Related Resources (IRSTRATPLAN), document the Navy's commitment to a top-down approach to strategic IS planning. However, in practice, its efforts have not been particularly successful. Huge cost overruns, unnecessary duplication, the inability to integrate existing systems, and overall program mismanagement have resulted in a loss of credibility and confidence for the DON in Congress. There are several reasons for these difficulties. One of the primary reasons is the lack of understanding by top DON management of Information Resource Management (IRM) issues, and in particular, the methodologies and tools available for aligning strategic and information systems planning. Uneasiness regarding the need for IRM and IR planning, the organizational structure required to support IRM, and the relative strengths and weaknesses of the various IS planning tools and methodologies, all add to the reluctance of top management to embrace these issues. Second, the reluctance of top management to commit considerable resources to what is perceived to be an uncertain process, further complicate the IRM and IR planning process. This problem has been further complicated by the recent CIM initiative, which has essentially put a hold on the Navy's efforts to pursue effective IR planning and management. It is important for DON management to understand that IS planning methodologies are not a panacea and do not provide an overnight payback. The large up front investment in time and capital required will yield benefits downstream, and over the long run, not overnight. A commitment to education at all levels of both the IS and line communities is required to improve the overall performance of DON system development and program management.

The impact of information technology varies widely between DON organizations, and these differences influence greatly how IS planning can best be accomplished. Four factors influence how the DON should structure its IR planning in order to succeed. First, the organizational placement of IS management must suit the role that the information system plays in the competitive strategy of the business. In many organizations, including the Department of the Navy, IS management is relegated to the departmental level despite the strategic significance of both existing IS, and its applications development portfolio. As a result, IS is perceived by top management, not as a corporate resource, but in a supporting role. Thus, the IR planning process was relegated to the same position. The location of IS management in the organizational structure must be high enough for the manager to have the political strength essential to positively plan and implement IS strategy, plans, and policies.

Second, information systems and general management must be in close proximity, both physically and logically, in order to facilitate the IS planning process. Face to face interaction is vital to ensure that all information requirements are identified, communicated, and met. Third, as the formality of the organization's management style and corporate culture increases, so must the formality of the IS planning process. In a formal organizational environment such as in the Department of the Navy, there is no room for informal planning processes that are incapable of fulfilling all requirements. Finally, as the size and complexity of the organization increases, the need for formal IS planning processes increases accordingly. This is necessary to ensure the "broad based dialogue that is essential to the development of an integrated vision of IS." [Ref. 8:p. 156] If these factors are taken into account, and are handled properly, IS planning can establish the required structural linkage between the business plan and the IS plan, and between IS management and senior line management.

Information Engineering provides an excellent opportunity to solve many of the problems plaguing IR planning, development, and management in the DON. It is the most capable methodology available for integrating the diverse information needs of Navy organizations, and represents a significant improvement over BSP or process-oriented methodologies. The following are some of the more important benefits of IE when used in DON applications:

1. **Objectives-driven** approach ensures that the resulting information systems are fully supportive of the overall corporate strategy.

2. **Data-oriented** approach identifies data fundamental to the organization, and provides a stable foundation on which to base systems development. Further, it provides for standardization of data across diverse organizational boundaries, allowing for integration.

3. **Technology-independence** allows for upgrades and changes in procedures, hardware, DBMS', etc. without affecting the stability of the data model.

4. It provides for **rapid feedback** to users and management, reducing systems development time, and increasing confidence in the system.

5. It is capable of being **fully automated** through the use of CASE workbenches, speeding up development considerably.

6. It drastically **improves the quality** of the resultant information systems, thereby significantly reducing maintenance costs.

7. It facilitates **standardization and Data Administration** by providing consistent standards for defining, accessing, processing, and changing data.

8. It **improves user and management satisfaction** because they receive the system that meets their needs quickly.

9. It significantly **reduces total lifecycle costs.**

Three CASE workbenches that support IE either in part or exclusively were discussed. Two, Texas Instruments' IEF and IESC's USER: Expert Systems were shown to be effective tools for automating the IE process. IESC's product was determined to be the best "front-end" tool, as a result of its rigorous data analysis and modeling capabilities, allowing data normalization to 5NF. In addition, it provided the most comprehensive training and technical support of the three. TI's tool was determined to provide the most effective "back-end" support, with the added advantage of a centrally managed data repository. KnowledgeWare's IEW was not recommended due to its open methodology approach, which doesn't provide the rigorous structure, or the data analysis and validation required for building strategic information systems. In addition, it does not provide methodology training or technical support to supplement its product. None of the three workbenches provided full coverage over the depth and breadth of Hackathorn and Karimi's framework. As a result, the combination of using the IESC tool for front-end support, and the TI tool for back-end support and code generation, would be the optimal combination. NAVSUP 0482, project manager for the SUADPS project, has developed an automated bridge between the two products to facilitate integration.

APPENDIX A

[Ref. 23]

Software Support Tools:

A. Automated Data Dictionaries:

There are four levels of automated data dictionaries:

1. CLASS 1: Passive data dictionaries
2. CLASS 2: Active, integrated data dictionaries
3. CLASS 3: DP-driven design dictionaries
4. User-driven expert systems design dictionaries

Classes 1 and 2 do not provide support for automated analysis and design of information systems; most products on the market are one of these two. Classes 3 and 4 are both data and design dictionaries. All three CASE products discussed provide Class 4 support.

B. Automated Data Modeling:

There are two levels of automated data modeling available in CASE tools:

1. LEVEL 1: Passive data modeling
2. LEVEL 2: Expert data modeling

Level 1 tools provide a passive capability for the development and maintenance of data models. They must be manually entered and maintained. Level 2 tools provide expert data modeling that is fully integrated with a Class 3 or 4 data dictionary.

C. Automated Documentation:

There are two levels of documentation support:

1. LEVEL 1: Manual documentation
2. LEVEL 2: Active documentation

In Level 1 documentation, changes must be input manually, and there is little support for consistency checking. Level 2 documentation is fully integrated with a class 3 or 4 data dictionary. Updates and changes occur automatically as design changes are made.

APPENDIX B

[Ref. 17:pp. 3-4]

USER: Expert Systems Hardware Requirements:

A. Personal Computers:

1. Any fully compatible XT/AT/386 machine
2. XT/AT compatible hard disk (20 Mb min., 40 Mb recommended)

B. Plotters:

1. PH7475A six pen plotter
2. Any fully compatible HP7475 plotter
3. GRAPHTEK 23000 graphics plotter

C. Printers:

1. IBM graphics printer or fully compatible

D. Monitors:

1. Coior preferable due to use of colors in software.

E. Memory Requirements:

1. Software requires almost all available RAM, and cannot operate concurrently with memory resident programs.

APPENDIX C

[Ref. 19]

IEF Hardware Requirements:

A. IEF Mainframe Operating Environment:

1. IBM MVS operating system:

   a. DB2

   2. TSO/E

   3. ISPF Version 2.2

   4. VS COBOL II

B. IEF PC Operating Environment:

1. PC-DOS, MS-DOS 3.0 or higher

2. Workstation-mainframe communications using IRMA and FORTE PJ (3278/79) boards

3. Plotters/printers

4. IBM AT, PS/2 Models 50, 60, 80, and compatibles

5. EGA graphics

6. Mouse

APPENDIX D

[Ref. 20]

IEW Hardware Requirements:

A. IEW PC-based Tools:

1. IBM PS/2 Model 50 or higher w/ DOS 3.3, or IBM PC/AT w/ DOS 3.1:

    a. 20 Mb hard disk

    b. High density disk drive

    3. 5 Mb RAM

    4. Mouse

    5. VGA/EGA/CGA graphics

    6. Laser or high resolution graphics printer

2. IBM 3270/AT (monochrome only for high resolution)

    1. 5273 System unit, model 062

    2. IBM 5272 color display

    3. 20 Mb hard disk

    4. High density disk drive

    5. 5 Mb RAM

    6. Mouse

    7. Laser or high resolution graphics printer.

B. IEW Mainframe Tools:

1. IEW/GAMMA Application Generator:

   1. IBM mainframe or plug compatible under MVS supporting ANSI standard COBOL and VSAM

   2. TSO/ISPF and ISPF/PDF version 2.0 or later and TSO/E

2. IEW/MF Mainframe Knowledge Coordinator and Encyclopedia:

   1. IBM mainframe or plug compatible under MVS/SP with TSO/E release 2, ISPF/PDF V 2 R2, and MVS PROLOG, 5798-DYL

   2. 4 Mb region size minimum, 6 Mb recommended

   3. IBM file transfer software for host-PC link

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