Computer-Aided Facilities Planning

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Preface

This book is for facilities planners and managers. It is a survey of current practice in both planning and computer aids. The ideas and computer applications contained in this book can help you "work smarter," instead of harder, on future planning projects.

I have assumed that you have some familiarity with computers and that you have seen a personal computer, a large mainframe, and probably a large minicomputer. I have also assumed that you know what a computer program is and does, that you have heard about such things as service bureaus and time-sharing networks, that you have read about or seen a demonstration of computer-aided design.

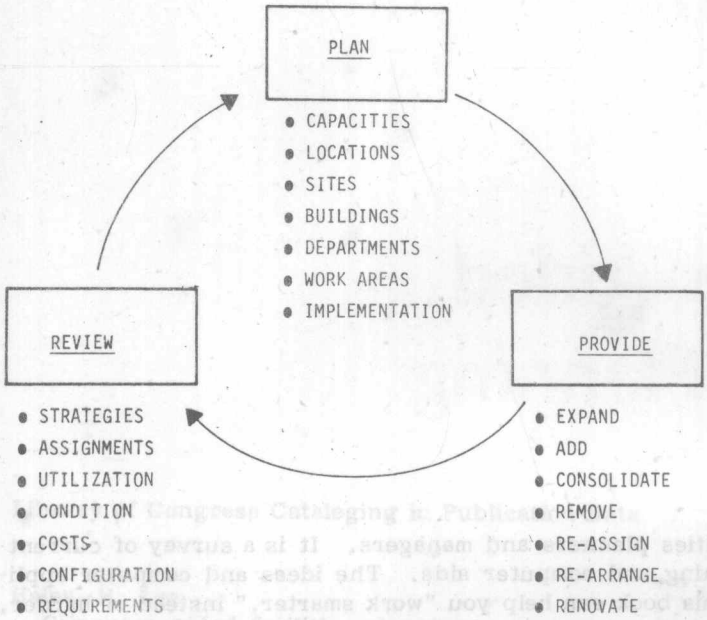
We will use a broad definition of "facilities" to include: land and its improvements; buildings and other structures; space within buildings; furniture, equipment, and machinery. In discussing industrial facilities, we will include material handling equipment.

We will view facilities planning as one stage in the facilities management cycle. This cycle, depicted in the figure, encompasses the provision or construction of facilities, as well as their ongoing review and management.

Facilities planning is a broad endeavor that cuts across other disciplines of planning, engineering, and design. To keep this book manageable, it has been necessary to limit its scope where these allied disciplines are concerned. We will not cover the use of computers for such engineering tasks as structural analysis, electrical schematics, piping design, civil engineering, and energy simulation. The planning of industrial facilities is sometimes inseparable from process and methods planning. Computer-aided process planning, however, is a subject unto itself, and will not be covered here. I have taken the same position with respect to computer simulation of materials handling and production systems. While simulation is an indispensible tool in certain facilities planning tasks, it is also a field of its own and is already the subject of many books.

The scope of this book, then, is largely confined to space projections, block and detailed layout planning, material flow analysis, plan and elevation drawings--the core activities of most facilities planners. The management of the planning project and of the facility itself are also covered.

You will be a much better planner if you systematize first, and computerize second. For this reason, Part I is about facilities planning. In it I have



The facilities management cycle.

outlined the kinds of systematic planning approaches and techniques that lend themselves well to computer support. My experience suggests that the computer will not make you systematic although it will force you in that direction. The computer will make you better and rapidly more effective if you already have good manual approaches. For this reason, I urge you to read Part I carefully and compare your present practices to the methods it describes.

Part II is about computers--describing what is available, and providing typical examples of computer-aided facilities planning. Part II is a survey. It covers a wide range of applications in layout planning, space estimating, design and drafting, inventories, etc. We will discuss the purpose and benefits of these applications. Inner workings will be covered only as required to understand the strengths and weaknesses of a particular computer aid. We will not look at code, or programming, or the inner workings of computer equipment.

I have limited Part II almost exclusively to commercially available software and systems. With dozens of proven products available there is little need today to develop one's own. Internal development efforts should generally be limited to the construction of large data bases, specialized facilities management systems, or the development of links between separately sourced systems and programs.

Part III is about implementation. Finding computer aids is easy; there are a great many around. Others are easily developed. But getting them installed and achieving good results is often another story. In Part III, I have compiled checklists and pointers from past installation efforts. If observed, you have a good chance of avoiding others' mistakes.

Finally, in Part IV, I have included two appendixes--one on information sources and a second on consultants--and a reference section. I do not claim

completeness for these materials. They have been compiled from my personal experience and my awareness of what others are doing. Because this book is a survey of a rapidly changing field, Part IV will help you keep current and gain additional depth in the areas of your primary interest.

I first outlined this book in December 1980. Had I written it then, it would be hopelessly obsolete today. Such is the pace of change in computer-aided facilities planning. The past three years have brought the amazing spread of personal computers; the electronic spreadsheet, making it easy to "program" many routine tasks; integrated software combining spreadsheets, graphics, and word processing; and the 32-bit microprocessor, dropping the price of computer-aided design systems from $100,000 to as low as $25,000.

During this time we have also seen the formation and growth of new professional groups devoted to facilities planning: the International Facility Management Association, the Society of Property Administrators, the Organization of Facilities Managers and Planners. Each of these groups has provided a forum for the discussion and spread of computer aids. New journals have also appeared such as *Computers in Design and Construction*, *Facilities Design and Management*, and *Corporate Design*, each devoting space to computer aids and case studies.

I am convinced that facilities planners are just beginning to make effective use of computers. The price of dedicated devices is now within our reach. Computers are also much easier to use. And, with these new forums available, the spread of computer aids should be very rapid indeed. While this book includes current applications, I am sure some exciting new ones will come along in the future. Appendix A has been included to help you keep up with these developments yet to come.

H. Lee Hales

Acknowledgments

I had the good fortune to learn facilities planning from Richard Muther, working in his consulting firm for eight years. We also coauthored two books. The first was a brief survey of office space planning. The second was a two-volume, 600-page book, *Systematic Planning of Industrial Facilities*. One does not write a 600-page technical book without drawing on it heavily in subsequent works. So you will find that much of Part I here is written around the Richard Muther techniques as described in our joint efforts, and in his earlier well-known works on facilities planning.

In 1980, I went to the Massachusetts Institute of Technology, spending much of the year studying computers. During this time I met and learned from some true pioneers in the field of computer-aided facilities planning.

From Kreon Cyros, M.I.T.'s director of facilities management systems, I learned about large-scale information systems and data base design. Software developed by Kreon Cyros and his staff is currently used to manage millions of square feet in universities, hospitals, offices, and plants. While living in Boston, I was able to spend time with John Nilsson, an M.I.T. graduate and early pioneer in computer-aided architectural design. As president of Decision Graphics in Southboro, Massachusetts, John Nilsson shared with me his great knowledge of CAD and its evolution in architecture and facilities planning.

My research at M.I.T. led me to Howard Berger, founder of Micro-Vector, Inc., in Armonk, New York. From him I learned about the surprising power of personal and microcomputers when applied to facilities planning. Since the early 1970s, Howard Berger has written dozens of programs. He is one of the most creative and prolific software writers I know. His programs have been used by a variety of professionals to plan millions of square feet.

In New York, I also met and learned from Marshall Graham, senior vice president of Environetics International, one of the first firms to apply computer-aided design to interior layout planning. Marshall Graham and his staff have been practicing computer-aided facilities planning for more than 10 years.

Still another New Yorker, Allan Cytryn, amazed me with his algorithms for multistory and block layout planning. Currently running on an Apple IIe, they are the latest in a series of programs that originally required large mainframe computers.

I have learned the most about algorithms from James M. Moore, president

of Moore Productivity Software in Blacksburg, Virginia. As a professor and consultant, Jim Moore has developed encyclopedic knowledge of algorithms, their origins, and inner workings. He is the developer of CORELAP, one of the most widely used algorithms for plant layout. Fortunately for us all, Jim Moore shares his knowledge through prolific writings on computer-aided facilities planning.

Recently I had the good fortune to work with David Arrigoni and David Albert at Arrigoni Computer Graphics. Since the mid 1960s, David Albert has contributed to the development of several popular CAD systems. He is currently president of Vulcan Software, Inc., in Campbell, California. David Arrigoni pioneered the development of low-cost, easily used CAD systems for architectural drafting. Both of these men shared their knowledge and experience with me.

My recent consulting work led me to Dennis and Rose Erickson, president and vice president respectively of BASICOMP, Inc., in Mesa, Arizona. The Ericksons and their staff are a remarkable team. They have spent years perfecting a variety of low-cost aids to interior design and facilities planning.

Two others deserve special mention. First, Harvey Jones, Jr., friend and fellow student at M.I.T., who suffered my ignorance of bits and bytes while we wrote a thesis together on computers. Harvey brought me up to speed with patience and much repetition. He is now senior vice president, marketing, for Daisy Systems Corporation. And finally, my wife, Pamela--the real force behind this book. After two years of hearing about it, she said "Publish or perish!" And she still loved me enough to type the manuscript. No, we don't have a home computer . . . yet.

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Part I

HOW FACILITIES ARE PLANNED

1

An Organized Approach to Planning

Levels of Planning Decisions

Facilities plans and decisions are made at several levels. The highest, most abstract decision level is that of capacity planning--providing enough productive capacity of all kinds to meet the needs of the organization. At some point, this capacity must be related to specific quantities and conditions of floorspace, land, buildings and equipment.

From overall capacity decisions, the planner moves "down" to locations--the geographic placement of capacity. At this level, site planning or land use decisions are made, followed by building decisions covering both the interior and the structure or shell.

Next comes the "department level," where decisions involve groups of people and equipment and their day-to-day activities. Once group or department level decisions are set, the planner looks at workplace design. Finally, plans are made to implement the foregoing decisions.

In practice, of course, there is considerable overlap. It is desirable, but not necessary, to proceed in rigorous "top-down" sequence, but the decisions made at any level must be compatible with those at other levels. Figure 1.1 illustrates the levels of planning. Note the slight variation in issues among the different types of facilities.

Facilities Planning Phases

In addition to levels, let us also introduce the concept of facilities planning phases. Each planning project can be said to move from some existing facilities or conditions to some future stage of development or desired conditions. The project is accomplished by proceeding logically through a sequence of planning phases. Each *phase* addresses a different *level* of planning and decision.

The phases overlap in recognition of the need to integrate the decisions made at different levels of planning. The concept of phases is illustrated in Figure 1.2 and defined further in Figure 1.3.

The difference between overall (Phase II) and detailed (Phase III) planning needs to be stressed. Overall planning focuses primarily on form and

LEVEL OF PLANNING	GENERAL ISSUES	SPECIFIC ISSUES		
		INDUSTRIAL SETTINGS	ADMINISTRATIVE SETTINGS	INSTITUTIONAL SETTINGS
CAPACITY	Rate of output. Amount of space. Make or buy. Subcontracting. Own or lease.	Production rates. Number of shifts. Degree of automation. Methods.	Space standards. Types of furnishings. Interior concepts.	Number, size and duration of programs and projects. Limits to growth.
LOCATIONS	Number of sites. Geographic locations. Utilities.	Transportation. Labor costs. Zoning. Taxes.	Rental rates. Convenience. Labor costs.	Acquisition of adjoining property for growth. Zoning.
SITES	Access/egress. Traffic patterns. Space allocation. Future growth.	Topography. Ratio of yard to underroof space.	Aesthetics. Solar energy.	Density. Aesthetics.
BUILDINGS	Size, orientation and placement on site. Type of structure. Possible future uses.	Bay size. Clearances. Floor strengths. Utilities. Flow patterns.	Building module. Number of floors. Size of floors. Exterior finish. Aesthetics.	Degree of specialization. Recycling and reuse of existing facilities. Aesthetics.
DEPARTMENTS	Effective use of space. Proper placement of people and activities.	Work flow. Production methods and equipment. Materials handling.	Communications patterns. Reporting relationships	Communications patterns. Reporting relationships Location of specialized equipment.
WORK AREAS	Individual workplace productivity.	Methods and standards. Materials handling. Safety. Workplace layout.	Systems and procedures. Furniture specifications. Status. Appearance.	Systems and procedures. Scheduling, placement and control of specialized equipment.
IMPLEMENTATION	Budgets. Sequencing. Timing.	Schedules. Lost production.	Schedules. Disruption.	Schedules. Disruption.

Figure 1.1. Levels of facilities planning.

the arrangement of facilities. It addresses major operating activities and key economic issues. Detailed planning focuses primarily on the position and placement of dimensioned objects to realize an overall concept or plan.

Consider the planning of a corporate office building. Deciding to use a precast concrete, multistory structure is a Phase II decision. So too is the decision to place Finance next to the Executive Offices on the top floor. Positioning the receptionist's desk to face the elevator is a detailed (Phase III) decision. So too is the placement of lighting, electrical, and telephone outlets to serve the receptionist's desk.

The Process of Planning Facilities

Putting together our levels and phases, we arrive at the process of planning shown in Figure 1.4. This basic process can be followed for any facility,

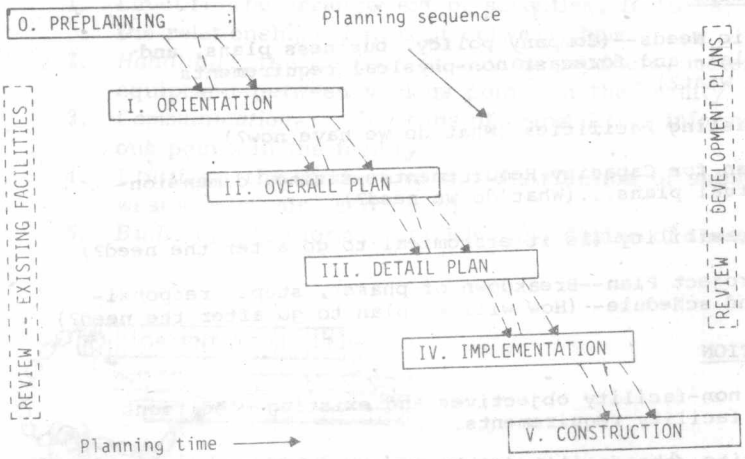

Figure 1.2. Facilities planning phases defined by Richard Muther. Phases I through IV represent pure, facilities planning activities. Phase O represents the on-going interface with business or corporate planning. Phase V is actual construction, renovation or installation. These phases are "framed" by the on going review of existing facilities, future requirements and standing facilities plans.

PHASE	SPIF NAME	ACTION	RESULT/OUTPUT	GENERAL TERMINOLOGY
0	Preplanning	Preplan	Stated Needs of the Business	Business Planning
I	Orientation	Localize	Determined Location and External Considerations	Physical Facilities Planning
II	Overall Plan	Plan the Whole	Overall Plan (Solution in Principle)	
III	Detail Plans	Plan the Parts	Detail Plans (Solution in Detail)	
IV	Implementation Planning	Plan the Action	The Plan for Implementation	
V	Execution of Plans	Act/Do	The Facility Completed, Ready to Operate	Constructing, Rehabilitating, &/or Installing

Figure 1.3. Extended framework of phases summary with planning phases defined. (From Ref. 8, Vol. 1. Copyright 1979, Richard Muther.)

regardless of type. Only the specific techniques and decisions within each phase will vary, depanding upon the type of facility--industrial, administrative, institutional, or other.

Phase O - PREPLANNING

- Compile Basic Needs--(Company policy, business plans, and general goals)--and forecast non-physical requirements (What do we want?)
- Evaluate Existing Facilities (What do we have now?)
- Forecast Plan for Capacity Requirements--sizing, dimensioning, conceptual plans...(What do we need?)
- Check for Feasibility (Is it economical to go after the need?)
- Develop a Project Plan--Breakdown of phases, steps, responsibilities, and schedule--(How will we plan to go after the need?)

Phase I - ORIENTATION

- Convert the non-facility objectives and existing conditions to physical facility requirements.
- Locate the site, the facility(ies) on the site, or the department in the plant, and identify its external opportunities and constraints.

Phase II - OVERALL PLAN

- Convert the physical requirements into overall plan of physical facilities--that is, plan the overall facility.
- Establish a solution in principle.

Phase III- DETAIL PLANS

- Convert the physical requirements and physical constraints for subdivided areas or components of the overall plan into more detailed facilities.
- Establish solutions in detail--details of major features.

Phase IV - IMPLEMENTATION

- Convert the plans of physical facilities into a program of action; planning the "Do".
- Plan the construction, renovation, and/or installation.

Phase V - CONSTRUCTION, RENOVATION AND/OR INSTALLATION

Follow-up or carrying out of the planning

Figure 1.4. The process of planning. (Courtesy of Richard Muther & Associates, Inc., Kansas City, Missouri.)

The Five Components of a Facility

One final concept is necessary to completely organize our approach. Within each planning phase, it is very useful to distinguish the different parts of the facility that must be planned or designed.

We can do this very easily with Richard Muther's five components. These are:

1. *Layout*: the arrangement of activities, features, and spaces around the relationships that exist between them
2. *Handling*: the methods of moving products, materials, people and equipment between various points in the facility
3. *Communications*: the means of transmitting information between various points in the facility
4. *Utilities*: the conductors and distribution of substances like water, waste, gas, air, and power
5. *Building*: the form, materials, and design of the structure itself.

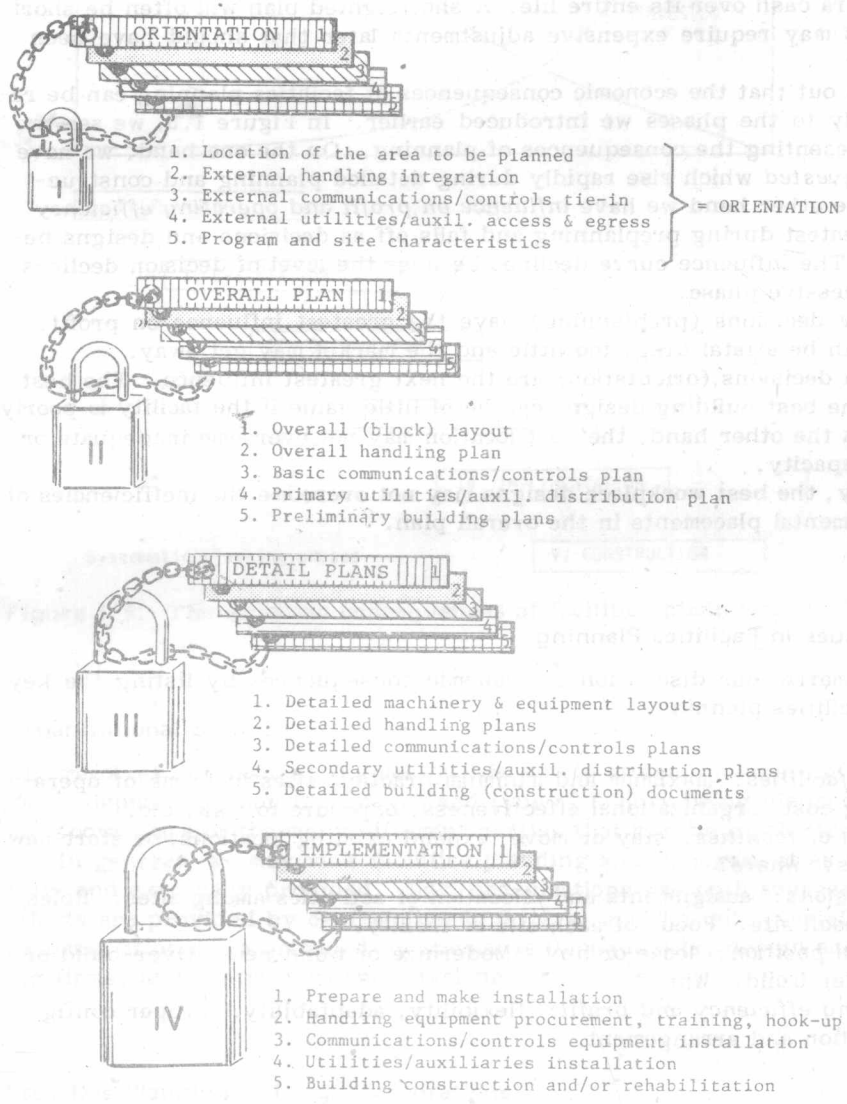

Figure 1.5. All five components are coordinated and approved (locked) at each planning phase. (From Ref. 8, Vol. 1. Copyright 1979, Richard Muther.)

These components are often planned by different parties in a project team, representing the different professional points of view. By recognizing the need to make "component decisions," we can "lock together" our planning efforts by phase and level, as shown in Figure 1.5.

The Economic Consequences of Facilities Planning

Facilities decisions can have a direct and lasting impact on financial resources and operating efficiency. An expensive plan or design will consume extra cash or incur extra debt during its construction. An inefficient plan or design will consume extra cash over its entire life. A shortsighted plan will often be short-lived. This may require expensive adjustments later that should have been avoided.

It turns out that the economic consequences of facilities planning can be related directly to the phases we introduced earlier. In Figure 1.6, we see two curves representing the consequences of planning. On the one hand, we have *resources invested* which rise rapidly during detailed planning and construction. On the other hand we have *influence on profit and operating efficiency* which is greatest during preplanning and falls off as decisions and designs become firm. The influence curve declines because the level of decision declines in each successive phase.

Capacity decisions (preplanning) have the greatest influence on profit. Too much can be a fatal drag, too little and the market may get away.

Location decisions (orientation) are the next greatest influence. The best site plan, the best building design, can be of little value if the facility is poorly located. On the other hand, the best location may not overcome inadequate or excessive capacity.

Similarly, the best workplace designs may not overcome the inefficiencies of poor departmental placements in the overall plan.

The Key Issues in Facilities Planning

We can summarize our discussion of economic consequences by listing the key issues in facilities planning.

Size of facilities: maximum and minimum practical sizes in terms of operating cost, organizational effectiveness, exposure to risk, etc.

Location of facilities: stay or move; expand existing locations, or start new ones. Where?

Site missions: assignments and allocation of activities among sites. Roles of each site. Focus of each site or facility.

Financial position: lease or buy. Modernize or build new. Over-build or under-build. When?

Operating efficiency and profit: flexibility, adaptability. Proper configuration and arrangement.

Clearly, the issues above are economic in nature and impact. The manner in which they are resolved is important and requires a sound approach.