RESEARCH PARKS GROWTH, DEVELOPMENT AND PLANNING CONSIDERATIONS

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ABSTRACT

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By

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The past decade has witnessed the growth and development of a specialized type of land use--the research park. Many communities across the country have been "sold" on the research park concept and have made strong efforts to attract them, recognizing them as a clean, nuisance-free type of industry.

This study attempts to provide a greater understanding of this type of land use by providing some insight into the research industry--its source of financing, performance, and fields of concentration. The emergence of the research park and its significance, characteristics and necessary attraction requirements are presented to give insight into the planning of the park. Since most of the material pertaining to research park planning is found only in technical journals, and since little has been done to present composite findings that would be useful to planners and others interested in planning for this type of development, the study attempts to provide the pertinent information to adequately analyze the research park within the framework of planning.

Much of the material for this study was gathered from leading technical and professional journals, brochures received from developers and promoters of parks, personal correspondence and several personal interviews.

The study reveals that research must take place in an environment that is stimulating to the researcher. This emphasis upon the environment of the community as a proper setting for the park, together with emphasis upon personnel attraction distinguishes the planning of this type of land use from other uses. From a planning standpoint, the need for planning criteria to better assess the research park and its impact upon the community is stressed, together with the need for establishment of meaningful policies by local government which take into account public and private costs, both direct and indirect. Physical planning criteria are also developed which pertain to the actual planning of a research park site.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Research and Development (commonly referred to as R & D) has, in the last decade, spurred the communities and institutions across the country to take stock of their resources in an effort to attract research parks. These communities and institutions recognize that with the research park come certain economic and social benefits.

Since R & D expenditures have now reached $25-billion, having doubled every five to eight years, the conduct of R & D activity in suitable places of environment has been receiving considerable attention. As a result, the research park, created to provide such places of environment, has become a relatively new type of land use and has been receiving serious attention by promoters, developers, and planners across the nation.

The purpose of this thesis is to provide an insight into the planning of research parks. But in order to better understand this type of land use, the historical growth of R & D is provided with considerable information on why important research centers have already developed across the country and the reasons for their growth. The reader is provided information on who the developers of research parks are, the parks' occupants, how the parks are financed, and their success. Recognizing that all parks are not successful, an insight is provided into some of the main ingredients to consider in developing a successful research park. Sufficient material is available today to assess the trend in park location and to identify the general criteria for the success of such facilities.

Lastly, planning criteria for the physical planning of the park site and the important considerations relating to it are presented.

Much of the material for this thesis was gathered from leading technical and professional journals, brochures received from developers and promoters of parks, personal correspondence, and several personal interviews. These provided some of the key references from which planning criteria were developed.

The planner, because of his intimate involvement with the planning and development of his community, frequently becomes involved in the early stages of research park planning. It is hoped that the reader of this thesis, especially those in the planning profession, will gain a greater understanding of the research and development activity and a deeper insight in planning for the research park.

CHAPTER I

THE PROGRESSIVE GROWTH OF RESEARCH AND DEVELOPMENT

Research and development--commonly known as "R & D"--is a process which leads to discovery and innovation. Today, R & D activity plays a major role in the economy, and in many communities has become recognized for its great impact upon the growth and development of an area.

Concepts and Definitions

Definitions of research and development are provided to establish a clearer understanding of the processes involved in this field of activity. As the name itself implies, there are two stages involved in organized research and development: the research stage and the development stage. A distinction is also made within the research stage between basic research and applied research.

Although it appears that the character or stages of research and development may be readily reported, in actual practice it is difficult to do so, and statistics relating to this activity are frequently combined. Nevertheless, it may be helpful to briefly review the definitions. The definitions are those used by the National Science Foundation which has conducted countless surveys and provides respondents to the surveys with these definitions in order to obtain comparable data.

Research, as defined by the National Science Foundation, is the process of seeking and discovering previously unknown facts and principles regarding some phenomenon, process or problem. In other words, it is a search for new knowledge.

Basic Research. For the Federal colleges and universities, and other non-profit institutions sectors, the definition of basic research stresses that such activity is directed toward an increase of knowledge in science. It is research in which ". . . the primary aim of the investigator is a fuller knowledge or understanding of the subject under study rather than a practical application thereof." With particular reference to research conducted by the profit-making organizations, the following is added: "original investigation(s) for the advancement of scientific knowledge . . . which do not have specific commercial objectives, although they may be in fields of present or potential interest to the . . . company." (Note: Basic research is also termed "fundamental" or "academic" research.)

Applied Research. The core definition used by the National Science Foundation is summarized in the colleges and universities sector: "Applied research is directed toward practical application of knowledge." Again with specific reference to profit-making organizations, the following distinction is made: "Research projects which represent investigation directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either product or processes."

Development is "the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods including design and development of prototypes and processes."[1]

It can therefore be summarized, from the above definitions, that basic research essentially entails a searching of new scientific knowledge with no specific, practical application in view; applied research builds on the results of basic research and consists of scientific investigations and experimentation when a practical or commercial objective is more or less defined. Development embraces the long and expensive stages of work between developing an idea and actually translating this idea into a tangible prototype product or process.

Research and development can be considered as a collection of highly diverse and unique operations that differ fundamentally from each other in such important respects as the intended use of the results, the field of knowledge being investigated, the kind of skills, and the

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[1]U.S. National Science Foundation, "Trends in Funds and Personnel for Research and Development, 1953-1961," Review of Data on Research and Development, No. 33, April 1962, p. 8.

depth of knowledge required. The projects are conducted under varying organizational arrangements and, depending on the kind of a project, require different types and amounts of human, material, and financial resources. There are, however, important features common to all R & D projects. One such feature is that all R & D projects are concerned with either creation of new knowledge or new practical uses of knowledge. Thus, all research and development can be viewed as devoted to production of new technology. A second general trait is that the product of research activity is not known with any reasonable degree of certainty in advance. All that can be available, in effect, are judgments regarding the probabilities of various outcomes.[2]

Not all research and development activity is divided equally among the various stages (basic, applied, development). While 64 percent of R & D spending in the United States is currently devoted to the development stage, 22 percent devoted to applied research, only 14 percent is geared to basic research.[3]

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[2]Nestor E. Terleckyj, "Research and Development: Its Growth and Composition," Studies in Business Economics, No. 82, March 1965, pp. 10-11.

[3]Victor J. Danilov, "R & D Expenditures," Industrial Research, X, No. 1 (January 1968), p. 60.

The sections following in this chapter will provide a broader perspective of this activity as it has emerged through history and as it exists today.

Historical Review

Much of the scientific progress in the United States has resulted from the involvement of the Federal Government in the support of science. The Federal Government throughout most of its history has been concerned with the status and progress of science and has endeavored in a variety of ways to encourage scientific activity.

National interest in science dates from the time of Jefferson and Franklin. Our forefathers expressed eagerness to promote science, recognizing its usefulness to the development of the nation. It is notable that the Declaration of Independence appealed to "natural law" and that the Constitution empowered the Congress to "promote the Progress of Science and the useful Arts" at a time when the very word "science" has not yet become a part of the popular vocabulary.

In the field of education, the notable contribution by the Federal Government is found in the Morrill Act, passed in 1862, which provided land grants to help the states establish colleges and thus encouraged a cooperative working relationship between the Government and the universities. The establishment of experimental stations at these land grant colleges also assisted to promote agricultural research.

The Federal Government assumed positive responsibilities in other areas associated with science and technology. The Patent Office, one of the oldest Government agencies, was established in 1790--its function provided for in the Constitution. An ambitious coastal survey to promote shipping, and the construction of a national turnpike leading into the new country opening up in the West was approved by Congress in the early 19th century. The Army also surveyed the Great Lakes and lent technical assistance in the construction of canals and railroads. The Smithsonian Institute was created by an act of Congress in 1846 for the increase and diffusion of knowledge "through scientific research, exhibits and publications." The National Academy of Sciences was established in 1863 to furnish advice and technical support for the Federal Government in its dealings with scientific matters.[4] Therefore, it is clear that the Government has played an important role in research activity from the beginning of our history.

Beginning with the textile mills of New England, the wave of technological development swept the Nation. The growing economy stimulated the search for better techniques in agriculture, manufacturing, transportation and commerce.

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[4] Proceedings of a Conference on Academic and Industrial Basic Research, Princeton University, November 1960, sponsored by the National Science Foundation, from article by Richard H. Bolt, "Role of the Federal Government in Basic Research," p. 7.

The great majority of scientific work during the 19th century was devoted to the solution of practical problems--the invention of "things" and processes that would immediately become useful and profitable. Science lived in close proximity with trade and industry and material development. Science gave little time to basic research--the quest of new knowledge for its own sake and without practical application. All of the inventions and technological advances that went into building industrial America were based on an inherited body of scientific knowledge--the sum of scientific discoveries which had originated largely in Europe.

In the latter part of the 19th century, however, American universities began to engage in scientific research. Beginning in a few of the leading institutions, recognition of the importance of academic research gradually spread, until by the end of World War I, it had become traditional in all the major universities and many others. Private industry also entered the research field. In 1900, General Electric established the first American research laboratory in private industry. Some 100 such laboratories were in operation by World War I, mainly in the fields of electricity and chemistry. This number had tripled by the end of that war. This trend grew throughout the 1920's and 1930's, in spite of financial setbacks during the Great Depression. The importance of research became recognized firmly, and increasing numbers of forward-looking industries engaged in it themselves and, in some instances, supported it in universities. A few private non-profit research institutions also came into existence. Thus, by the advent of World War II, research had become a widespread enterprise, though its value had not yet been recognized by the public as a whole.[5]

During the war years, the Government turned in large measure to private industry to carry out military research and development. This method led into the peacetime era, and did not decrease once the war was over.

In the initial postwar years, support for science and its applications was largely motivated by the goals of national security, better health, and other practical ends. As the public and Congress recognized that progress in the applications of science could flourish only with a strong base in basic science, the National Science Foundation was established by Congress in 1950 as an independent agency devoted to the support of science and scientific education without regard to practical misssions. Thus, basic research, together with other research, began to be accepted as a proper objective of Federal support.

Two reasons are frequently cited for the growth of research after World War II. First, peace was not accompanied by relaxation of international tensions. It therefore became necessary to maintain the strongest possible military

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[5] U.S. National Science Foundation, Fourteenth Annual Report for the Fiscal Year Ended June 30, 1964, pp. xiii-xv.

establishment. This required the continued improvement of old weapons and development of new ones. Second, there is a growing recognition that money spent on research is an investment that brings to the nation a handsome return in the form of greater wealth, higher standards of living, and better health--as well as increased military security. Expenditures for research provide the seeds for the future growth of the national economy. In addition, the new break-throughs in electronics and atomic science have greatly accelerated the overall pace of research. The development of the transistor and electronic computer have opened up wholly new industries and have opened doors to new discoveries once thought to be years away.

Today, research and development has grown into a multibillion dollar activity, ranking in size with the chemical, electrical equipment or petroleum industries. In total dollar volume of expenditures, it actually exceeds rubber, textiles, paper, electrical power or automobiles--all major support groups in the national economy.

Research Performance and Source

Approximately $25-billion was spent on research and development in 1968 in this country. Considering that only $2.5-billion was spent in 1940, one can readily see the great upsurge that this activity has experienced in this country--ten times as much as in 1950[6] (see Figure 1).

Who are the performers of research and development and what percentage of activity does each perform? Four major sectors perform R & D work:

1. Industrial companies, within their laboratories or in other establishments.
2. Government laboratories and testing sites.
3. Colleges and universities.*
4. Other non-profit institutions.*

Table 1 presents the amounts of funding and performance of R & D activity among the four major sectors. It is quickly noted that the Federal Government furnishes most of the R & D funds while industry performs the greatest amount of R & D activity. Although not reflected in Table 1, industry is the chief performer of federally-financed R & D work, accounting for 66 percent of all that was accomplished in 1968. Industry concentrates heavily on development work for the federal government because it is best organized to handle

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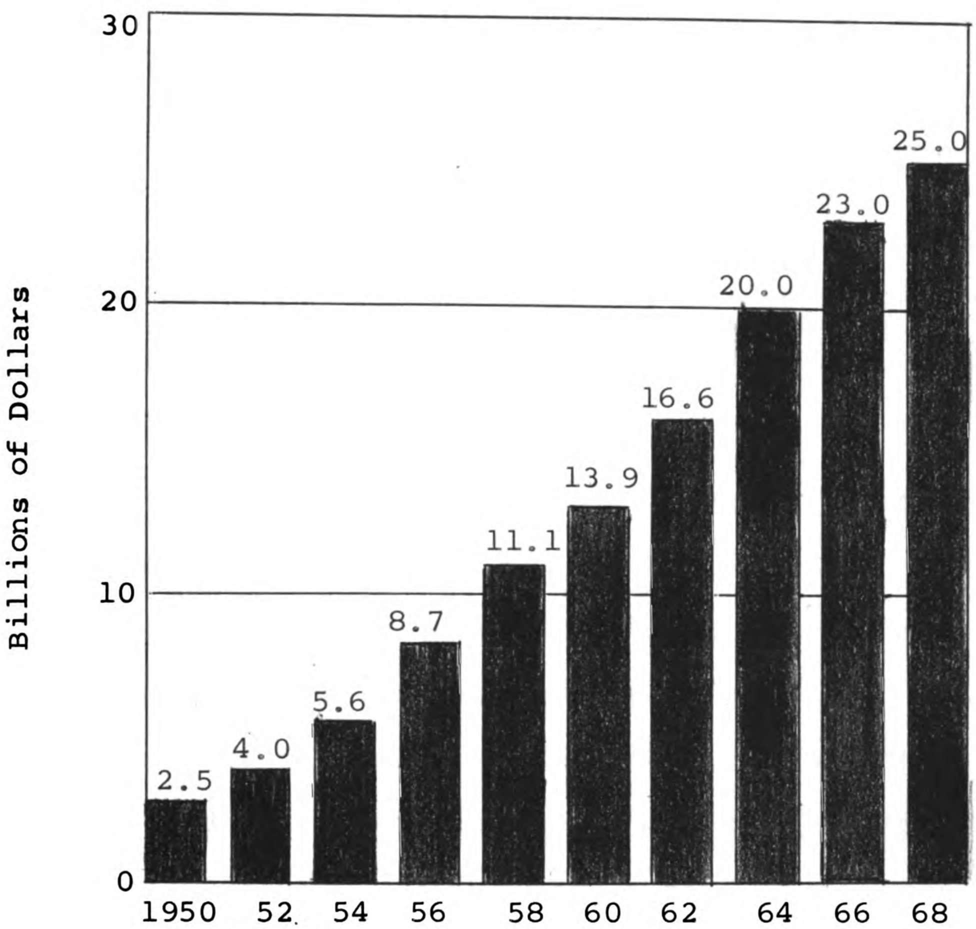
[6]Victor J. Danilov, "Research Funds," Industrial Research, VII, No. 1 (January 1965), 28.

*Colleges and universities comprise all institutions of higher learning and include professional schools such as medicine and engineering, affiliated research institutions, hospitals, and agricultural experiment stations. Other non-profit institutions consist of private philanthropic foundations, non-profit research institutes, voluntary-health agencies, professional societies, etc.



Source: Daniel R. Roman, Research and Development Management: The Economics and Administration of Technology (New York: Appleton-Century-Crofts, 1968), p. 48.

Figure 1. Level of R & D expenditures, 1950-1968.

Table 1. R & D funding and performance in 1968 (billions of dollars)

Sector	Funded	%	Performed	%
Federal Government	15.7	63	3.5	14
Industry	8.6	34	17.3	69
Universities	0.5	2	3.3	13
Other non-profit institutions	0.2	1	0.9	4
Total	25.0	100	25.0	100

Source: U.S. National Science Foundation, "Research and Development in Industry, 1968," Reviews of Data on Science Resources, No. 17, February 1969, p. 1.

large-scale testing, engineering, and assembly of complex machinery and instruments.[7]

It is interesting to note that the Federal Government, performing in its own establishments only 14 percent of all R & D work, financed nearly two-thirds of the national total, while industry, performing 69 percent, financed only a little over one-third. Non-profit institutions as a group, while performing about 17 percent of the national total, paid for only about 3 percent. According to the National Science Foundation, the percentage relationships have remained fairly

[7] U.S. National Science Foundation, Federal Funds for Research, Development, and other Scientific Activities, Fiscal Years 1967, 1968, and 1969, Vol. XVII (Washington, D.C.: Government Printing Office, August 1969), p. 8.

constant since the Foundation's first survey of 1953, and are anticipated to continue in a similar relationship for the remainder of the decade. An exception, however, occurred in the financing of R & D funds in the industrial sector. In 1953 total R & D funds amounted to $3,630 million, of which 39 percent was federally financed and 61 percent company financed. In 1968, however, of the $17.3 billion spent for industrial research, 66 percent was federally financed while 34 percent was company financed. This points out the increasing involvement of federally sponsored research in the industrial sector. Because of the heavy reliance by private industry on the Federal Government, the decisions of the Federal Government as to R & D programs have had a profound effect on the economic growth and composition of individual industries. In many companies, emphasis has changed in recent years from production line items to research and development, especially in the aircraft and missiles industry. Similarly, the number of scientists, engineers, and other professional personnel has increased in relation to production workers in many companies contracting with the Federal Government for R & D projects.

Fields of Concentration

Research is not evenly distributed throughout the economy but is focused upon two key areas--military, atomic energy and space research plus industrial research by private industries.

During the 1960's, the Federal R & D programs have reflected largely the national security and foreign policy objectives established since World War II. Three federal agencies (Department of Defense, National Aeronautics and Space Administration, and Atomic Energy Commission)--by magnitude in the order named--spent nearly 90 percent of Federal Government's $15.7-billion R & D budget, the remainder devoted to such programs as health, welfare and natural resources.

Since nearly two-thirds of industrial research is financed by the Federal Government, it follows that a heavy concentration of industrial research is devoted to the three federal agencies programs--military, space, and atomic energy. Whether financed by Federal funds or company funds, however, industrial R & D activities are concentrated in relatively few industries. They are aerospace (aircraft and missiles), electrical equipment and communications, and chemical and allied products. These three major industry groups accounted for approximately two-thirds of total funds for industrial R & D performance.

R & D performers in the four sectors (industry, government, colleges, universities, and other institutions) have specialized in different kinds of R & D work. According to the 1968 data, the R & D performers in industry and government have specialized relatively more in development and in applied research and relatively less in basic research. On the other hand, the universities and non-profit organizations concentrated heavily on basic research and do relatively little development work.

According to the allocation of professional manpower to projects in different fields, the National Science Foundation reported that in 1964 (the latest year for such data) industry specialized more in engineering and relatively less in physical sciences research, while its share in life sciences was low. As a whole, government research and development is somewhat more oriented toward physical sciences and engineering and less toward life sciences. Non-profit and educational institutions are highly specialized in life sciences and less toward physical sciences. See Table 2 showing the distribution of scientists and engineers which provides the basis for the above analysis.

Table 2. Distribution of R & D scientists and engineers by sector and type of work, 1964 (percent of U.S. total)[a]

Employer	R & D Scientists and Engineers in			
	All Natural Sciences (%)	Life Sciences[b] (%)	Engineering (%)	Other Physical Sciences[c] (%)
All Sectors	100	11	63	26
Federal Government	12	2	6	4
Industry	72	2	54	17
Colleges and universities	14	7	3	4
Other non-profit organizations	2	1	1	1

Source: U.S. National Science Foundation, "Salaries and Professional Characteristics of U.S. Scientists, 1964," Reviews of Data on Science Resources, No. 2, December 1964, p. 1.

[a]Numbers may not total due to rounding.

[b]Includes biological, medical, and agricultural sciences.

[c]Includes "physical sciences proper," i.e., astronomy, chemistry, earth sciences, mathematics, and physics.

Future Growth

Research and development growth in the United States has made this activity one of the largest in the economy. As indicated earlier in this chapter, research and development has grown into a multibillion dollar industry--from \$2.5-billion in 1950 to approximately \$25-billion in 1968. Similarly, while funds for research and development amounted to about 1.5 percent of the Gross National Product in 1953-54, R & D funds amounted to 3 percent of GNP in 1963-64 and have presently increased to nearly 4 percent.[8]

The continuing interest and participation by the Federal Government in R & D work and the acceleration of the aerospace program will continue to play an important role in the future. While there will continue to be a heavy concentration in federal defense and space programs, the benefits of such research will provide new ideas which will become applicable to civilian purposes. Past military research and the existence of the government market is known to have played an important part in the introduction of major new civilian products and services, such as jet travel or electronic computers, and also to have aided in developing products of higher quality whose development might have been less rapid otherwise. Some products and processes resulting from federally sponsored industrial research apparently have

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[8]Danilov, "Research Funds," op. cit., p. 32.

had civilian applications at an early stage. For example, recent space research has already led to such civilian applications as the adaptation of space suits for victims of paralytic strokes, surgical hearing-aid devices, X-ray photos with drastically reduced radiation exposure, and a wide range of electronic devices.

Although it is anticipated that the total R & D program will continue to expand, defense and space research may not continue to consume such a dominating share of the R & D budget. The United States is entering an era of gradual R & D growth in which a greater proportion of the federal funds probably will be devoted to public benefit programs such as health, transportation, pollution, education, and ocean resources.[9]

The increasing amounts spent annually for basic or fundamental research has important implications for all segments of the economy. While basic research amounted to only about 4 percent in the early 1950's, it is currently 14 percent of total R & D activity. It is inevitable that a greater reliance upon basic research for furthering scientific knowledge will result in a need for even greater R & D expenditures as man continues new discoveries.

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[9]Daniel R. Roman, Research and Development Management: The Economics and Administration of Technology (New York: Appleton-Century-Crofts, 1968), p. 63.

Planning Implications

This chapter, providing a brief review of R & D activity in this country, indicates the increasing growth of a particular segment of the economy. Together with a vast technological change being experienced within the country, the R & D effort is of great significance for possible economic and industrial development of cities and states. Certain types of research have concentrated in certain geographical regions as pointed out in the next chapter, and this has had a tremendous effect upon the social and economic aspects of those areas.

The clamor in different parts of the country, as indicated in the next chapter, indicates a strong competition to attract research-oriented industry. New types of facilities to house such research activity in suitable, complementary surroundings must be provided. Communities will need to study their potentialities in a bold effort to attract research industries. Planning for these "think" factories will necessitate a new approach from traditional industrial planning.

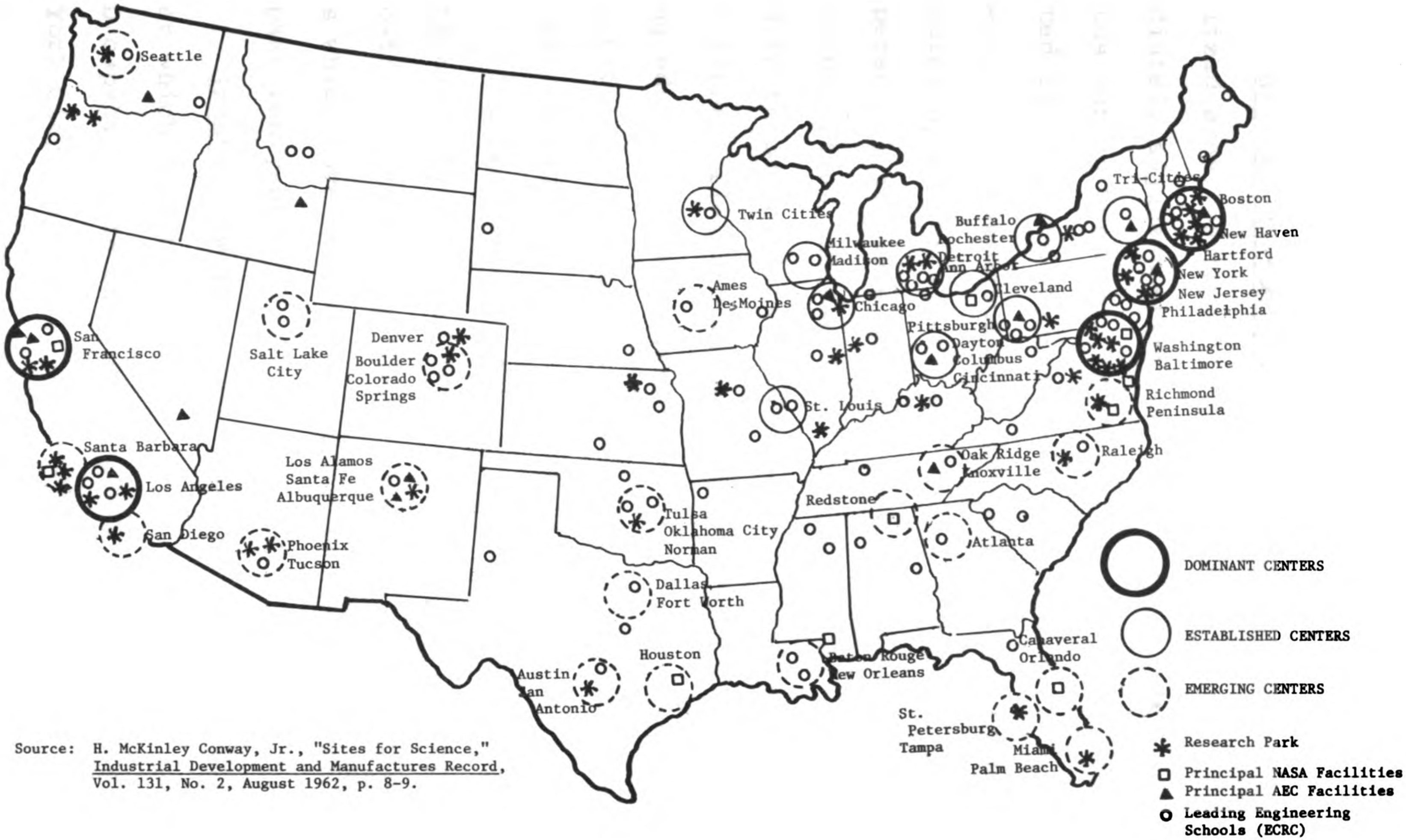
CHAPTER II

RESEARCH CENTERS AND BROAD LOCATIONAL CRITERIA

This chapter outlines the factors which have led to the locations of R & D oriented centers in the country. The information is presented from a regional rather than local level. R & D centers do not locate haphazardly but tend to gravitate to certain areas for specific reasons. The beginning of this chapter provides a broad picture of the locational patterns of research facilities and a discussion of the dominant research centers in the country--where they are located and the prime factors which have led them to locate in these areas. The remainder of the chapter describes some of the criteria which prompt a specific _type_ of R & D facility to locate where it does.

Dominant Research Centers in the United States

Several large research centers dominate the R & D scene today. The dominant centers are in the Boston area, New York-New Jersey area, Washington-Baltimore area, Los Angeles area, and the San Francisco area (see Figure 2). These locations of scientific concentration account for a heavy percentage of the nation's total R & D effort. They



Source: H. McKinley Conway, Jr., "Sites for Science," Industrial Development and Manufactures Record, Vol. 131, No. 2, August 1962, p. 8-9.

Figure 2. Dominant research centers in the United States.

exert a strong influence--almost a control--over the other scientific areas of the country.

<u>Greater Boston area</u>.--The largest complex in a localized area, perhaps, is to be found in Boston and its immediately adjacent environs. This area received its major impetus during World War II when the Federal Government located four of its key research laboratories at Harvard University and Massachusetts Institute of Technology. Attracted by the excellent teaching and research facilities and personnel at these schools and numerous smaller colleges and universities, industrial laboratories of every type have moved in to occupy locations conveniently accessible to these laboratories and institutions. Thus, an exceptionally strong educational base provided a solid foundation for R & D activity. Today there are several hundred companies in this area engaged in R & D operations.

The heaviest concentrations have developed at key points along Highway 128, which passes to the immediate west of Boston and links together a group of smaller suburban towns which have developed campus-like research parks during the past ten years.

<u>Greater New York area</u>.--Another large, dominant center which must be recognized for its sheer volume of R & D capability is that which has developed in and around New York City. Actually, the research-oriented activities spill over into Northern New Jersey and Connecticut, with

most of the laboratories shunning the central city to locate in the suburban communities.

This complex probably offers more variety than any other in the nation. R & D operations range from small one-scientist labs up to such giants as Bell Telephone Laboratories. Areas of research range from cosmetics and similar consumer products to satellite communications and rocket propulsion. The New York City area also has a monopoly on investment research in the Wall Street complex, on marketing research in the Madison Avenue area, and proximity to the pre-eminent biological center of the world.[10]

The development in and around Princeton is especially noteworthy. Since World War II, about 50 industrial research organizations have moved into the Princeton area primarily to be close to the University. Though proximity to Princeton itself is of primary importance, convenient accessibility to New York and to the headquarters offices of the research-oriented industries is a major factor also.

Washington-Baltimore area.--This complex has been experiencing accelerated growth and many R & D firms have chosen the area in order to be close to the fund-granting agencies of the Federal Government. Some of the major government research facilities located in the Washington-Baltimore area are the Atomic Energy Commission, the NASA

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[10] H. McKinley Conway, Jr., "Sites for Science," Industrial Development and Manufacturers Record, August 1962, p. 24.

Goddard Space Flight Center, the National Institute of Health, the U.S. Army Biological Laboratories, the Naval Research Laboratory, the Walter Reed Army Institute of Research, the Metallurgy Research Center, and the National Science Foundation, to name but a few.

The presence of these vital Federal activities has led to a fast growth of private R & D firms eager to maintain close liaison with program administrators. Over 500 firms are now located in the area.

Los Angeles area.--This area has maintained a dominant position in the aerospace industry and supporting industries. In Los Angeles the chief attraction has been the amenities of the area--the climate, higher educational level, emphasis on informal living, etc., plus the proximity of major aircraft manufacturers and similar defense facilities which developed on a large scale during World War II.

San Francisco area.--Most of the R & D activity in this locality are found in the San Francisco Bay Area near Stanford University. University of California and Stanford University are both noted for science education which has proven to be a big factor in attracting R & D activity in the general area. The Stanford Research Institute became one of the largest, non-profit research organizations in the country which helped to attract highly qualified teaching and research personnel.

Other Important Research Centers

Many other important centers are gaining prominence in various parts of the country and containing a large number of scientists. While Figure 2 provides the locations of many of these centers, only some of these centers are discussed below.[11]

The Milwaukee-Madison area, which ranks high nationally in terms of scientists per unit of population, is capitalizing on the resources of the University of Wisconsin and Marquette University, plus such R & D operations as those conducted by Allis Chalmers and A. O. Smith Corporation--each employing more than 100 scientists.

The Detroit-Ann Arbor-Lansing complex offers Michigan, Michigan State, and Wayne Universities. Important research activities are concentrated at these universities as well as GM Tech Center in Warren (near Detroit) and the private research firms based around Ann Arbor.

The Buffalo-Rochester-Syracuse area is particularly strong in research activities. Rochester contains the large Eastman Kodak laboratories, while Buffalo contains units of Bell Aerosystems, Du Pont, Hooker Chemical, Union Carbide and Westinghouse. Syracuse has the large General Electric plants. Cornell University, Syracuse University and University of Buffalo are located within the area.

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[11] Ibid., pp. 26-27.

Pittsburg has long been a steel research center, with laboratories of steel companies; Westinghouse, Gulf, and Alcoa. Cleveland has considerable research as a result of National Aeronautics and Space Administration (NASA) and such companies as Sohio and Republic Steel.

The Dayton-Columbus-Cincinnati triangle provide considerable R & D activity, through such institutions as Wright-Patterson Air Force Base, historic home of aviation research; Batelle Memorial Institute, one of the nation's leading consulting research organizations; and Ohio State University.

Another center is St. Louis, home of Monsanto Chemical's main laboratories, and McDonnel Aircraft, the latter produced the Mercury capsules used for global orbits.

While the listing of above centers is by no means complete, with many more research centers located across the nation, as indicated on Figure 2, the listing is sufficient enough to identify types of research-based complexes, the elements of such complexes and some of the main attractions of the areas for R & D activity.

Elements of Research Complexes

The research-based complex, sometimes referred to as a "scientific complex" can be identified as containing one or several elements.[12] They are:

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[12]James F. Mahar and Dean E. Coddington, "The Scientific Complex--Proceed with Caution," Harvard Business Review, XLIII (January-February 1965), 140-141.

1. Science-based industry composed of:

   a. Industrial research and development laboratories which may or may not be part of manufacturing facilities.

   b. Technically-oriented manufacturing plants (i.e., plants employing a high proportion of scientists and engineers, producing products embodying advanced and rapidly changing technology).

   c. Supporting suppliers and services.

2. One or more major universities which emphasize:

   a. A wide range of graduate studies in science, engineering and mathematics.

   b. Basic and applied research in science and engineering.

   c. Graduate studies in business management.

3. Federal government research facilities administered either:

   a. Directly by the government, such as the National Bureau of Standards Research Laboratories in Boulder, Colorado.

   b. By private industry or universities, such as Johns Hopkins University's Applied Physics Laboratory near Baltimore.

The full three-element complex--science-based industry, universities, and government laboratories--is the best known type of research-based complex. The Greater Boston area is the leading example of the three-element complex.

Palo Alto, California and Ann Arbor, Michigan are good examples of complexes built around strong universities and science-based industry. Stanford University has its own research park occupied by over 40 firms. Ann Arbor's complex is still in the formative stages, but since 1957 the

University of Michigan has spawned over a dozen firms and has been a key factor in attracting several other firms.

The Washington, D.C. area is a leading example of the complex composed of government facilities and related science-based firms. San Diego, with its large aerospace firms and small supporting firms, is an example of another complex--the technically oriented industry, containing research facilities in direct association with it.

Complexes which developed without the university element, such as San Diego and Orlando, usually began as an unplanned circumstance through accidental location or individual company decision. On the other hand, for an area to set out deliberately to develop a complex, the university element appears to be an essential ingredient in order to enhance the chances of success. The reasons for this are discussed in later chapters.

Scientific complexes which have two or three elements are characterized by having close interrelationships, or common bonds, which result in extensive communications among the elements. A common interest in science and technology is usually the force which binds the elements together.[13]

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[13]Denver Research Institute, University of Denver, "The Scientific Complex--Challenge to Colorado," June 1964, p. 1.

Types of Research and General Locational Criteria

The general locational pattern of research activity found in this country indicates that important factors are at play. As noted, in the discussion of elements comprising scientific complexes, the forces of government, industry and universities are involved. In addition, the important decisions of the individual research firms or agencies to locate within these complexes are based on many factors or criteria. The type or character of R & D activity is an important consideration, since it becomes oriented to certain areas which meet its broad qualifications. The listing below indicates some of the research types and one or more of the necessary "ingredients" for its conduct. This, therefore, provides some indication as to why individual research and development firms locate where they do.

1. Research oriented to production.--This type of research is usually located within the production plant or within proximity to the plant. Typical of such research is the automobile and aircraft production industry, where control tests are carried out from time to time during assembly and the finished product subject to rigorous testing in simulated conditions. Both industries, however, perform a considerable amount of other research activity which does not necessarily have to be located at the production plant. This includes research in chemical analysis, metallurgical examination of components, and research tests on plastics,

rubber plated components, oils, greases, adhesives and sealing compounds, frequently leading to the improvement in performance characteristics.

There is a great concentration of manufacturing and research facilities in the great industrial centers, primarily in the East and Midwest. Historically, a company located where the idea was conceived, and its research staff occupied the same plant where production took place, or some nearby facilities. There was little searching for other sites or organized pressure to locate in another community. This is how Eastman Kodak Company happened to locate in Rochester, New York; U.S. Steel Corporation in Pittsburg; Ford Motor Company in Detroit; Armour and Company in Chicago; and 3 M in St. Paul.[14]

2. Research oriented to processing.--Process research comprises investigations of complete processes or specific component of a process to find a better way of producing new or old products. Usually such research cannot be separated from production research (many industries conducting both types of research) and the research facility is therefore located at the production plant. An excellent example of a process research takes place in the chemical industry. Chemical research concerning the compilation of

[14]Victor J. Danilov, "Sites for Sale," Industrial Research, VI, No. 5 (May 1964), 30.

new formulas for manufacturing purposes can be, and frequently is sited some distance from the factory location. On the other hand, control research, concerned with the testing of raw materials and with quality control must necessarily be located within the factory environs.

3. Research oriented to raw materials and waste utilization.--Such research, generally a part of process research, is conducted by industry at plant locations where large amounts of raw materials are utilized with considerable waste products resulting. Research of raw materials insures a certain quality content necessary in processing, whereas research of waste products may frequently result in the production of a by-product. The oil refining and paper industry conduct large amounts of such research.

4. Research where natural geographical features are essential.--Research in oceanography, geology, marine, and wildlife, forestry, etc. necessitate natural bodies of water, ground formations, biological life in its natural environment for its conduct.

5. Research where climatic conditions are of prime importance.--The mild climate in parts of the country is favorable for certain research where testing plays an important role and economies are realized in the assembly, storage and testing of products. In the aircraft industry, for example, the majority of assembly and testing is conducted in the West where favorable weather allows open-air type storage sheds, and testing of aircraft can be conducted on

a year-round basis. Many parts and engines are shipped from the East to West for aircraft assembly for this very reason.

Other climatic conditions of an extreme nature are required, for example, in polar exploration and research, and research of this nature is naturally restricted to the cold regions of the country.

6. Research restricted to areas specializing in a major activity.--Several areas of the country contain certain types of research resulting from the establishment of facilities of a specialized nature, requiring large expenditures, in those areas. These facilities are usually government-financed. Examples include atomic research conducted at government atomic reactor sites such as Oak Ridge, Tennessee; National Aeronautics and Space Administration (NASA) research at Canaveral, Houston and Huntsville, Alabama. The Federal Government's decision to locate such facilities in particular sections of the country has resulted in the development of science-oriented communities large concentrations of scientists, engineers and technicians.

7. Research oriented to complement major industries and other economic activity.--Types of research activity are located in areas where considerable economic activity, including major industries, has already become established, frequently in large metropolitan areas. Research of this nature complement the various activity of the area, locating itself around the existing "nuclei". In the Detroit area, for instance, numerous small research firms have located to

complement the auto industry and conduct research in plastics, rubber, upholstery, metals, etc.

Similarly, many research centers have emerged in "spillover" areas near the larger, older centers. San Diego and Santa Barbara, California, are now receiving a share of the Los Angeles research growth. Phoenix, Tucson, Salt Lake City, and Seattle are considered to be "spillover" areas of California and are receiving the California-type R & D expansion.[15]

8. Research related to universities and institutions.--Research conducted at universities is generally of a pure, academic nature, and is most suitably carried out in the university environment. The university has important resources at its disposal--"brainpower, facilities and equipment, sources of information, etc." The location of medical research, dictated by the location of medical schools, hospitals, and related facilities falls within the same category.

9. Research oriented to complement university and institutional projects.--The advantages resulting from a university or institutional location have attracted many research firms to locate in their vicinity. Usually such research programs complement the university and institutions programs. Such firms have the benefit of faculty consultation and part-time employment, use of facilities such as

[15]Conway, op. cit., p. 30.

library and computers, academic courses for personnel, university programs, etc. Examples include the Research Triangle in North Carolina, established to complement the research programs at three universities in the area, and the emerging complex of industries based around Ann Arbor, Michigan.

10. Research requiring isolated conditions.--Research requiring an atmosphere free of dust, smoke and dirt, noise, vibration, electric and acoustic interference and other disturbances must be conducted in isolated areas, away from factories and cities. Vibration of buildings, for instance, cause sensitive instruments to get out of adjustment frequently and may preclude the use of such instruments as infra-red spectrometers and electron microscopes. Airborne soot and smoke from a factory may interfere with many research techniques requiring a high purity of materials and cleanliness of apparatus.

11. Market research.--Such research involves the quality testing of products for consumer use; investigation of the market for new products, including the testing of consumer reaction to such products; the investigation of marketing channels and the determination of the best distribution facilities. Being market-oriented, such research is usually conducted at the place of market rather than at the place of production.

12. Research related to administrative and organizational procedures.--Research of this nature is utilized to promote efficiency and economy in an organization. This kind of research is usually conducted either solely by or with some assistance of consulting experts in the field. While some firms have established a separate facility for the conduct of such research, generally this type of research can be conducted in offices with a minimum of equipment.

A considerable amount of research does not involve any great expenditures for equipment or space, since research is in the form of services, frequently on a contractual basis. "Thinking" rather than products are utilized. As in administrative or organizational research, this type of research is generally conducted in offices where general office equipment is about the only equipment necessary. Examples are research surveys where various statistics and data are compiled and analyzed (i.e., economic research, population growth analysis, sociology research). In some instances separate facilities are established for such research conduct. The Brookings Institution in Washington, D.C. (economic research) and the Rand Corporation in California ("brainstorming" and abstract thinking on various problems for private and governmental agencies) are examples. Location for such research is usually governed by its broad market.

13. Research oriented to the community environment.--Research may be attracted to a particular community which ranks high in regard to pleasing living environment. Such factors as mild climate, university, cultural and recreational facilities are emphasized in order to gain a prestige location and provide a stimulating professional and cultural environment for research personnel. Many research firms have purposely located in the vicinity of Princeton and Stanford Universities for this very reason.

Other Locational Factors

While the preceding section provided a review of general location needs of R & D activity based upon its particular orientation, other factors also have an important influence upon the location of a research facility.

1. Relation of research to other departments within the organization.--The place of a research division on the organizational chart of an industrial firm determines whether such activity will be located within the plant or at some distance away. This varies from one firm to another on account of different conceptions of what constitutes research and of what the proper relations should be between research and other company activities. The constant intrusion of factory problems into the research laboratory and the fear of domination of research by production have provided a

strong impulse to the present tendency to move the research laboratory away from the plant.[16]

2. Size of business.--The size of a company's business and the amount of its resources constitute a factor which controls the extent to which research can be separated from production and the main plant. A small business will usually be able to afford only a single laboratory to carry out all its technical experimental work, most of which will be directly connected with production. In somewhat larger concerns, a certain degree of separation is feasible, and two or more separate laboratories may be established, one of which is devoted mainly to research, but is still responsible for a considerable amount of development and control work in order to avoid duplicating apparatus, or for other reasons of economy. It is normally only in the really large concerns that a practically complete functional segregation of research is possible, and it is therefore only these large establishments which have to consider the possible advantages of locating the research laboratory away from the plant.

3. Type of business.--The problem of finding the best location for a research laboratory may assume different aspects according to the nature of the business or according to the products produced. There are types of business which

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[16] C. C. Furnas, Research in Industry: Its Organization and Management (New York: D. Van Nostrand Co., 1948), pp. 308-319.

have special inducements to locate their research activity away from factories and cities. Telephone and communication industries, mentioned earlier in this chapter, are examples.

Also, industrial companies having several plants have different problems from those having a single plant. The problem of which of them are to be selected for the location of the research laboratory may follow several methods:[17]

a. the research laboratory may be established away from any of the plants and preferable near the central offices.

b. the research laboratory may be organized at one of the manufacturing plants, selected in preference to the other, sometimes because it is the largest plant, sometimes because it manufactures a greater diversity of products than the other plants, and sometimes simply because it is the oldest plant, and the research work has been established there before the other plants have been built.

c. laboratories may be established at each of several plants.

d. laboratories in which research is closely allied to production may be organized at several plants, with

[17] J. F. Schwitter, "Universities as Research Park Developers," Industrial Research, VII, No. 4 (April 1965), 73.

an additional central laboratory away from the plants and devoted chiefly or entirely to basic or fundamental research.

4. Economic considerations.--Various economic considerations may overlap other factors in locating a research facility. Small firms possessing only a "one-man laboratory" will usually find it most economical to conduct research at the main plant. Large companies, too, may sometimes keep their research laboratories at the main plant for economy of service facilities and in order to avoid duplication of instruments and other equipment.

5. Psychological considerations.--Creating a favorable psychological problem for research may have an important role in locating a research facility. Aside from giving research personnel greater pride in their work, an atmosphere of freedom from various intrusions and interruption, and the possibility of the research staff to house themselves near their work adds to the morale of the staff.

Types of Research Attracted to Research Centers

A review of the types of research activity and their orientation provides some important clues as to the types of research which are most suitable for location in a research center. While some research activity (research oriented to production, processing, natural resources, etc.) is restricted in its location for the reasons outlined in the preceding sections of this chapter, other research is much more flexible in choosing its location and therefore, suitable for location in a research center. The following are generally the types of research found in research centers:

1. "thinking" rather than products are employed.
2. science-based industries where products are not emphasized. Any production of prototype products is at a small scale, necessary for testing of its merits for production elsewhere.
3. highly diverse and complex facilities are generally not required.
4. basic or applied research, rather than development is emphasized.
5. research which complements university and institutional programs.

Due to the type of research conducted in research centers, facilities are constructed with flexible interiors to meet the changing demands of the occupants. Also, the type of research conducted within the building cannot be readily identified as is generally the case in industry. Since such facilities are built in an atmosphere designed to attract scientific manpower conducive to thinking, they are a compatible type of land use for which many communities compete. Chapter III provides further discussion of the research center and its aspects.

CHAPTER III

THE RESEARCH PARK

This chapter discusses the research park as it has emerged through acceptance of the industrial park concept, and provides information about the developers, occupants and success of it. Several approaches to research park planning are outlined, and an insight is provided into the development and planning of several research parks in the country.

Differentiation between Research Park, Industrial Park, and Industrial District

Research parks may be defined as a development according to a comprehensive plan which provides park-like sites for industrial laboratories and other science-oriented activities, whose production is generally limited to prototype goods, with adequate control of the area and buildings through restrictions and zoning to protect the investments of the developer of the district as well as its occupants. Some of the terms used for these parks are "Research Parks," "Research Centers," "R & D Parks," and "Science Centers."

Industrial parks may be similarly defined as a tract of land subdivided and developed according to a comprehensive plan for the use of a community of industries with adequate control of the area and buildings through restrictions and zoning to protect the investments of the developers of the district as well as the industries occupying it.

The industrial district refers to a zoning classification which allows various types of industry such as heavy, medium, and light to locate in a certain area of a community which has been specifically zoned for such use.

While there are similarities in the developments of research and industrial parks, as noted in the definitions, the difference lies in the general setting and type of activity conducted. In the layout and general appearance of a research park, there is somewhat more attention given to landscaping, density controls, and building setbacks and design. (Research parks established in heavily built-up sections of a city, however, more closely resemble large-scale office complexes with high-rise and low-rise buildings grouped around a landscaped plaza or mall.)

In terms of activity, an industrial park's occupants may include industrial research laboratories and production facilities (generally of a small product nature and which do not produce fumes, obnoxious odors, etc.), while the research park is generally restricted to research and limited production. The latter usually consists of prototype production on a pilot scale only, essential to the research program where the product is used for testing and analysis, or light manufacturing on a rather highly selective basis to complement the research activities. This is discussed further in a later section of this chapter.

The Emergence of the Research Park

The research park is a relatively new "creature" on the urban scene, responding to the locational needs of research and science-oriented firms. Its growth can be traced to several factors:[18]

1. maturity of the industrial park concept after World War II.
2. the research upsurge that began about the same time.
3. the desire of research firms to locate in more attractive settings convenient to centers of learning, research, and technical assistance.
4. increasing involvement of universities in research and industry, and the realization that the proximity of research firms can be advantageous to both the universities and firms.

Industrial parks had their beginning around the turn of the century. The majority of sites were initiated and developed by the railroads. However, it was not until the 1940's that there was substantial interest and growth in the industrial park concept. The decade could be characterized as the "take-off" period for industrial parks. Its maturity

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[18] Ibid.

was evidenced by careful planning, extensive and stringent restrictions to create the character and image of the park, and integrated services for site-seeking industrial firms.

After 1950, the parks entered a phase of accelerated growth that continued through the 1960's. The appearance of specialized facilities--of which research parks are the most outstanding--also appeared at this time. Research parks, born in the surge of research and nourished by the acceptance of industrial parks, were considered even more desirable if they could be located near a center of learning.

The first university research park was sponsored by Stanford University in 1951, but it was not until 1957 that steady park growth was established. Today, there are at least 126 research-oriented parks. More than two-thirds have been established since 1960, with 88 being found between 1960 and 1965. The greatest number (18) came into being in 1964. There has been a noticeable decline in the launching of new science parks since 1965. Five were announced in 1966 and only one in 1967.

Developers of Research Parks

In 1967, Industrial Research magazine conducted a survey of 126 research-oriented parks. Most of the parks (72) were started by realtors and land developers as a business investment. However, 27 were established by municipalities, chambers of commerce, and local industrial development groups primarily to attract new industry to the area.

Universities founded 20 research parks and cooperated with community groups in the formation of at least 10 others. In most instances, the motivation was not monetary, but rather a need to expand university facilities or a desire to interact with industry and to assist the community.

Four research parks were started by science-based companies that built new facilities and sought to induce other firms to locate on their property. This usually was done to recover some of the development costs, or to create a scientific community for the exchange of ideas or business.

Non-profit research institutes founded three parks and a utility group established another. In all four cases, the objectives were mainly regional development and business expansion.[19]

Occupants of Research Parks

The research park, as defined earlier in this chapter, contains a variety of occupants across the country. Two types of occupants predominate, however. They are (1) research and development laboratories and (2) science-based activities with prototype and related light manufacturing.

Research and development laboratories.--The types of R & D laboratories contained in research parks are:

1. research laboratories of manufacturing concerns

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[19] Victor J. Danilov, "How Successful Are Science Parks?" Industrial Research, IX, No. 5 (May 1967), 78.

2. contract research laboratories
3. United States Government laboratories
4. university research laboratories.

Research and development laboratories of manufacturing concerns have been located in research parks to utilize the services of facilities that are not available at the firm's manufacturing plant, or to provide a proper setting for research, away from the production plant. Many of these concern's research divisions engage in prototype and limited, light manufacturing that is linked with research and development.

Contract research laboratories are also found in some research parks, such as the Opinion Research Corporation in the Princeton Research Park in New Jersey.

The United States Government has located several research laboratories in research parks. Examples are the U.S. Weather Bureau Research Laboratory in the University of Oklahoma Research Park and the U.S. Forest Service Forestry Sciences Laboratory and U.S. Environmental Health Center in Research Triangle Park in North Carolina.

A number of universities have located research laboratories in the parks which they have developed.

Science-based activities with prototype and related light manufacturing.--Prototype development allows an application of research to the development of material goods. As such, it provides a transition from research and testing to production. The financial success of many research parks across the country, however, has necessitated that some light manufacturing be admitted. In fact, surveys conducted on this subject reveal that few parks contain research as the primary and exclusive activity. Also a number of parks which allow prototype manufacturing actually "stretch" the term to include some light manufacturing on a selective basis, regulated by performance standards with emphasis placed on "nuisance-free" activities.

The 1967 Industrial Research survey indicated that only 20 percent of the 126 parks conduct research as the sole activity. Appendix A provides a list of 116 of these parks, with an indication of those parks which conduct research only. Mixed uses within the park permit a firm to sell or sublease its facility for any one of several alternate uses should this become necessary. Also, lending institutions encourage such mixed uses by lending more freely in parks with a variety of permitted occupancy according to a leading developer of successful R & D parks.[20]

Careful consideration must be given to this item in planning any R & D park, as indicated in Chapter V. The author is not providing a recommendation on the type of occupants or activities which should be allowed. Instead, a very real and practical problem is presented, due to the

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[20]John R. Griefen, "A Research Park Does Not Live by Research Alone," Urban Land, XXIV, No. 3 (March 1965), 3.

financial problems being experienced today by many parks. This is very obvious in many articles researched for this thesis.

Success of Research Parks

More than half of the research-oriented parks have not been successful, as reported by the most recent 1967 "Industrial Research" survey.

It appears that most of the research park failures and disappointments occur for one or more of the several reasons:[21]

1. Lack of a specific reason for locating in the area, such as proximity to a relevant university, government facility, or industrial complex.
2. Inadequate park organization, planning, and/or developmental funds.
3. Insufficient sales promotion to acquaint prospects with the advantages of the park.
4. The high cost of leasing or purchasing property.
5. A poor site from the standpoint of available acreage, construction, highway access, utilities, services, air transportation, and/or physical layout.
6. Too restrictive zoning or covenants.

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[21] Danilov, "How Successful Are Science Parks?" op. cit., p. 81.

7. Lack of the type of living and working environment that appeals to scientists and engineers.
8. Disappointing interaction with the academic and/or scientific communities.

Some parks do not get beyond the announcement stage. These include the Panther Hollow project sponsored by the University of Pittsburg, the International Research Center initiated by the University of Miami, and the IIT Research Park proposed by the Illinois Institute of Technology.

A number of universities have announced plans to develop research parks, but have done nothing to implement them. These include Washington, Indiana, Iowa State and Tulane universities.

Some research or science parks proposed in urban renewal areas have been stymied due to various complications. Such projects have been proposed in Chicago, Detroit and Philadelphia. Many research park developers have not been able to attract any occupants even though the necessary land was available. Evidently, some of the ingredients for a successful park have been missing.

Approaches to Research Park Planning

Several approaches which have been evidenced in research park planning are as follows.

1. Research park using scientific facilities of surrounding area.--Most of the research parks planned to

date have been designed primarily to provide sites for new R & D firms which would utilize the scientific facilities in the surrounding area. This is least expensive in initial outlay and where the park is close to the supporting facilities, this is a practical approach. In large metropolitan areas where scientific resources are numerous and widespread, several research parks may rely on the same basic facilities.

2. Research park using scientific facilities of surrounding area, and providing for any missing elements.--This approach is sometimes used to provide for any deficiencies of an area. For example, specialized equipment and facilities, scientific and engineering library, etc. which may not be available in a community might be provided at the research park.

3. Self-contained science center and research park.--While there are few examples as yet, some observers believe that the self-contained science center is the plan for the future and will offer important advantages over the research park. In this approach, multimillion dollar facilities are first built at the core of the park and additional activities are located around this nucleus. While a project of this type might involve a very high initial investment, it would act as a powerful magnet to draw additional heavy investments.

Research parks show promise of becoming as much a part of the urban scene as have industrial parks. While research parks are relatively new and therefore do not provide sufficient evidence for conclusive judgments relating to their effects upon the urban area, there is evidence that research parks have been receiving serious attention and planning across the country.

Attraction and Advantages of Research Parks

Since research parks are generally located in communities containing a dynamic professional and stimulating cultural environment, they usually ensure a pleasing working environment. Also, well-planned parks that are aesthetically pleasing add to the morale of the staff.

In 1966 Industrial Research polled 1,133 research scientists and engineers as to their education and income. The poll showed that 72 percent had incomes of more than $11,000 per year and 29 percent earned more than $15,000 yearly. It was also shown that 51 percent of these people had completed graduate school.[22] The direct benefits of these higher incomes are not confined to the wage-earner and his family, but are felt throughout the community. Not only does the person employed in research spend more on medical and personal care, recreation, clothing, etc. than the typical manufacturing worker, but higher incomes will inevitably result in homes of higher quality and higher valuation. Also, such a person generally takes a more active

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[22]"Salary Survey Shows Concern Over Fringe Benefits," Industrial Research, VIII, No. 2 (February 1966), 75.

role in community affairs which in turn adds immeasurably to the total attractiveness and livability of the community.

The research park frequently spurs additional industrial and economic growth. For example, in the R & D firms, new ideas are tested and prototypes are developed and produced on a pilot scale. The application of newly invented processes and mass production of products often requires new plant facilities. In many instances, these operations--sometimes called "spin-offs"--are constructed in the vicinity of the park, since the assistance of the inventors and developers is needed to perfect the process or product. Also, research parks sometimes serve as a nucleus or starting point for a larger, science-oriented complex.

A major advantage offered by research parks established near universities is the increased consulting opportunities for faculty members and the research staff. It sometimes provides a significant force in attracting graduate students because of expanded university research potential.

Other advantages of research parks to research laboratories and research-oriented industries are similar to those commonly set forth for industries locating in an industrial park.

Many of the country's research firms as discussed in Chapter II, are located on sites of their own. Others, prefer to locate in a research park, and this is especially true of the small firm. Location in an established research park saves the tenant firm both time and money and avoids any diversion of the research effort from the problems requiring solution. Thus, the individual research firm does not have to worry about arranging or negotiating for necessary zoning, or for construction of needed utility lines or streets. These are taken care of by the park developer, and the tenant firm pays only its pro rata share, rather than the entire cost of bringing utilities to the building site.

Other opportunities for cutting costs arise where the concentration of research facilities within a localized area permits cooperative financing of specialized equipment, services, and meeting spaces required and used by all. Grouping of facilities also tends toward more efficient and effective police and fire protection and frequently results in lower costs of public services and in fire insurance rates.

Examples of Research Parks

This section provides some examples of research parks which have been developed or are in the process of development. It will be noted that research parks are being developed by local and state governmental agencies, chambers of commerce, private developers, real estate firms, or by a combination of several different agencies working together. In recent years, a number of private and state universities have taken the lead in bringing about the development of research parks--either on their own or in combination with some other individual or agency.

Research Triangle of North Carolina.--This park is being developed in a relatively undeveloped section of North Carolina, roughly equal-distant from the cities of Raleigh, Durham, and Chapel Hill. These three cities, each of which contains a major university--The University of North Carolina at Chapel Hill, Duke University at Durham, and North Carolina State College at Raleigh--mark the points of a triangular area which gives the research park its name. From a point in the center of this triangle, it is not more than 15 miles to any one of the three institutions. The Research Triangle was formed with the purpose of strengthening the graduate programs of the three surrounding universities, in recognition of the extensive research activity already under way at the three universities, and in recognition of the creative atmosphere conducive to the conduct of research that is present in the area.

The Research Triangle Foundation was formed in 1956 by a small group of North Carolina leaders, including the presidents of Duke University and the Consolidated University of North Carolina. The group began publicizing and promoting the Research Triangle concept. With voluntary contributions totaling $1.5-million, as a start, the Research Triangle

Foundation acquired the 4,600 acres of land currently contained within the Park.[23]

The focal point of the Research Triangle Park is the 200-acre campus of the Research Triangle Institute. The Institute was established as a separate, non-profit corporation to provide research services on a contract basis to industry, government agencies, educational institutions, and foundations. Though closely allied with the three schools which comprise the Research Triangle, the Institute performs research with its own full-time staff and its own facilities. It augments its capabilities, when appropriate, with consultant assistance from university faculty members.

The Institute's early development was partially financed by an allocation of $500,000 from the $1.5-million which had been contributed to the Research Triangle Foundation. In addition, North Carolina's General Assembly appropriated $200,000 as a special grant to be used for the purchase of equipment. Also, a grant of $2.5-million from the Dreyfus Foundation provides funds for the creation of a major institute laboratory and research program. This laboratory and its scientific activities will be devoted entirely to the field of polymers. Other divisions of the Institute are performing contract research in such diversified areas as: industrial use of radioisotopes, problems of

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[23] Luther C. Hodges, "The Research Triangle of North Carolina," State Government, XXXIII, No. 1 (Winter, 1960), 17.

measurement and controls, industrial operations research, military maintenance and weapons studies, anti-tumor agents in plant extracts, reliability of complex systems components, and inorganic chemistry with biochemistry orientation.

Greater Ann Arbor Research Park.--This provides an example of cooperative effort by several agencies--the University of Michigan, the City of Ann Arbor, the Ann Arbor Chamber of Commerce, and many private individuals. This development provides 209 acres of land available for the construction of research laboratories and related research facilities.

The prime mover behind the initial development efforts was the Economic Development Committee of the Ann Arbor Chamber of Commerce, which began the search for suitable land appropriate for the location of research-oriented industries. (In view of Ann Arbor's relatively small size and its special role as "college town" and home of the University of Michigan, attempts were directed to attracting industry compatible with the university atmosphere.) After examination of many potential sites, the committee decided upon a tract of land immediately adjacent to Interstate Route 94 and the Ann Arbor Municipal Airport and convenient to the University of Michigan campus and to nearby residential and commercial areas.

The development group immediately began to tackle the problem of providing sewer and water services and constructing streets in the park. While the area was serviceable from an engineering standpoint, its location outside the city limits posed a problem of utility extensions and the property was not contiguous to the city limits--a necessary prerequisite for annexation. In 1960, a petition was submitted and approved for annexation of the park and intervening area, after negotiations with the intervening property owners.

Following the successful annexation, a special committee was set up to review the proposed zoning ordinance, develop the necessary internal controls, and work with a consulting engineering firm to develop a design and layout of the research park. Arrangements were then worked out with teaching and research personnel at the University of Michigan to assist in gaining publicity and recognition for the park.

Cornell University Industry Research Park.--Cornell University has established a research park on its lands located about 3½ miles from the campus and about 4½ miles from the center of Ithaca. As in Ann Arbor, the park is located near the campus and adjacent to the airport which is served by both scheduled and chartered air services. In sponsoring the development of the park, Cornell hopes to attract a select group of research-oriented industries to join the Advanced Electronics Center of the General Electric Company, the first member of this research community.

It is noteworthy that, in drawing up the development plans for the research park, the full resources of the

University were employed. A special committee of university professionals was established, including representatives from the College of Architecture, the departments of City and Regional Planning, Sociology, and Economics, the College of Engineering, and the Graduate School of Business and Public Administration. This committee, in cooperation with the area's various planning boards, participated in the formulation of detailed plans for the industrial research park, for nearby residential areas, and for schools, churches, and shopping centers, in order to insure an orderly development of the entire area.

University of Oklahoma Research Park.--Another university-sponsored project is located at Norman, Oklahoma. Again, this park is adjacent to an airport and to Interstate Highway 35 which adjoins the research park and connects it with Oklahoma City, some 18 miles away.

In developing its program for the park, the University established three broad objectives to be accomplished:

1. to provide for industry and government agencies dedicated to research and development, a protected site and all needed facilities, where research activities might thrive in a scientific environment.
2. to aid in the control of the continual growth of Norman in a manner which will perpetuate its university atmosphere.

3. to attract to Oklahoma and the Southwest, science-based industry requiring highly skilled, intelligent labor and professional personnel.

The park is patrolled by the campus police, and a continually manned fire station is located within the park. These services are provided on a 24-hour basis, thus reducing insurance costs for facilities within the research park.

Technology Square.--In the heart of the Boston Area, Technology Square was developed under joint sponsorship of M.I.T. and a Boston real estate firm, Cabot, Cabot and Forbes Company. An "in-city" development, Technology Square was constructed on a 14-acre site in the City of Cambridge, adjacent to the campus of the Massachusetts Institute of Technology.

The development has over 800,000 square feet of office and laboratory space--all contained in four high-rise buildings grouped around a landscaped plaza to create a "country quiet environment." The main level of each building is an extensive lobby with shops, banks, and restaurant. Parking, adequate to meet anticipated tenant demands, is provided adjacent to the individual building or in a multi-level parking structure.

The first building was completed and occupied early in 1963. Initial tenants of the development included C-E-I-R, Inc., the Institute of Naval Studies, and IBM Corporation. C-E-I-R, Inc., will install at this location the most powerful and versatile electronic computing center in the nation.

King of Prussia Research Park.--Cabot, Cabot and Forbes are also developers of the 700-acre King of Prussia Park located on the outskirts of Philadelphia. This park is strategically located at the Pennsylvania Turnpike and the Schuylkill Expressway. Unlike the university-sponsored parks mentioned above, this park is not restricted to research laboratories but is planned for offices, and for distribution and light manufacturing facilities. Tenants include: Pennsalt Chemicals Corporation, which has built a chemical research center; General Electric Company, which has seven buildings for its Missiles and Space Vehicles Department; Western Electric Company, which has completed a major distribution center; Abbott Laboratories, Inc.; Upjohn Company; and the American Baptist Convention which has its national headquarters in the park.

Palos Verdes Research Park.--This is an excellent example of a research park sponsored and developed by private industry. Located on a scenic ocean peninsula adjacent to Los Angeles, Palos Verdes Research Park was conceived by the Great Lakes Carbon Corporation, which commissioned Stanford Research Institute to analyze over 200 land development parks and to establish the proper criteria for an ideal research center. A wholly owned subsidiary, Great Lakes Properties, Inc., supervises development of the park.

Victor Gruen Associates was engaged to draw up a land use and traffic plan for the 410-acre park. The objective was a campus-like environment free from heavily traveled thoroughfares and laid out according to highest architectural and landscaping standards. The Los Angeles County Regional Planning Commission worked with County Supervisors to create a new type of zoning classification to permit research and development compatible with the attractive residential surroundings of the Palos Verdes area. The Park's first tenant, the Northronics Division of Northrop Corporation developed its own "research campus" on a 50-acre site in the park.

While restrictive zoning limits the park to research and development, there has been some re-evaluation by the Regional Planning Commission as to whether the zoning regulations are perhaps too restrictive, to the extent that they may be unnecessarily impeding the park's development.

Mississippi's Program.--Mississippi has created a commission which, in addition to other directives involving research activities, has responsibility for selecting a location and undertaking initial development work in establishing a research park with the state. The Mississippi Industrial and Technological Research Commission has been given the responsibility of carrying out a number of assignments involving research, including: (1) offering research services to industry on a contract basis; (2) carrying out physical research as well as a study of natural resources and other economic surveys; (3) cooperating with the university in offering advanced science courses; and (4) establishing and administering a research park.

Kentucky Spindletop Research Center.--Kentucky the state government, the University of Kentucky, and private industry are cooperating in a joint effort to create a physical complex of industrial research laboratories and complementary facilities on university property. The park is being developed on a 425-acre site adjacent to the University and five miles from Lexington.

The focal point of the Research Center will be the Spindletop Research Institute, which will occupy a centrally located, 75-acre site and which will include a university-owned administration building and research laboratory. Located on a small lake, the Institute will be directly across from a planned building complex which will include future motel facilities, a library, restaurant, and auditorium. The 350 remaining acres will be made available to industrial firms for construction of new research laboratories. These new structures will be entirely separate from any of the university buildings.

A total of $1,327,000 in public money has been earmarked to cover initial costs of land development and construction of the administration building and research laboratory. Final control of the Spindletop Research Institute will rest with the University, but the managing agency will be the Kentucky Research Foundation, an independent, non-profit organization created some years ago to handle research and promotions for the University. The development of the research center itself will be directed by a special 55-man board which includes leading national and state industrial figures who will represent the private enterprise position in the overall operation.

Financing of Research Parks

Various methods of financing are employed in research park financing, ranging from outright sale of undeveloped or partially developed land within a designated area to complex leasing arrangements of fully developed sites. Several examples are provided to illustrate the various methods involved.

In the Greater Ann Arbor Research Park financing of necessary improvements within the park area was hampered by the fact that the sponsoring group had no funds available for development and the property owners felt that they could not handle the expense. The City of Ann Arbor, after thorough examination of the problem, agreed to install the streets, sewers, and water mains in advance of development and to recoup its costs by means of delayed special assessments, as the land was sold. The sponsors, in turn, agreed to sell the land at a price sufficient to meet the price of the raw land and the cost of improvements, plus an amount equal to a pro rata share of the operating costs. Under the same agreement the owners of the land agreed that the costs of the improvements would constitute a lien upon the land in the event that the land reverted to their control under the terms of an option agreement executed with the project sponsors.

By means of this unique three-way agreement, the improvements necessary for the operation of the research park were made available. Total cost of the fully improved land--including paved streets, curbs and gutters, storm drainage, sanitary sewerage, water mains and the establishment of street and lot-line trees was estimated at approximately $10,000 an acre.

The University of Oklahoma Research Park, on the other hand, was sponsored and developed by the University of Oklahoma on state-owned land adjacent to its north campus. It offers not only fully developed sites but all required services as well.

For industries which prefer to construct their own research facility, the University of Oklahoma Research Park will make land available on a long-term lease basis. For those desiring to obtain a research facility with a minimum capital investment cost and at the lowest possible rental, special financial arrangements are available through the University of Oklahoma Research Institute.

The Research Institute is empowered by Oklahoma statute to construct buildings on Research Park land to be leased to industrial and governmental agencies for the purpose of research and development. The Research Institute will build a building or buildings to house the research facility in accordance with designs and specifications approved by the lessee. These buildings and the land can be leased for a 20 to 40-year term with an option for a renewal of the lease at the end of this term at a negotiated rate. Annual rentals will be based upon an amount sufficient to amortize, maintain, and insure the property during the primary term.

Temporary structures of various sizes are available to companies and agencies needing a temporary site for a short-term research project or a site for a laboratory awaiting movement to a permanent location. Many of these buildings are equipped with laboratory utility outlets, and the Research Institute will convert the interior of the building chosen by the rentor into a functional laboratory meeting all requested requirements. These buildings are available on a three to five-year lease at low cost.

In the Cornell plan the source of capital for any building program may come either from Cornell or from the tenant firm. In the first case, suitable amortization terms will be negotiated; in the second, appropriate depreciation periods will be agreed upon. For large amounts of capital, the University prefers the second option. At the end of the amortization or depreciation period, titles to the buildings will remain with Cornell. From the outset, rent will be charged for University-owned lands.

Cornell stipulates that the establishments which will form part of its industry research park must be research laboratories and not production facilities. If development work is conducted in these laboratories it should be of a character that carries research findings through the prototype article state only.

At Purdue the Research Foundation administering the new research center will sell or lease the land to a company and will also build and lease the buildings if this should be desired.

Many states have passed legislation providing financial assistance and tax relief to new and expanding firms interested in research (but not necessarily limited to such activity). The most common form of assistance appears to be the issuance of revenue bonds by local communities to acquire land, buildings, and/or equipment for lease to private concerns. About half the states have such provisions.

More than two-thirds of the states have some form of state or local industrial development corporation for lending funds, guaranteeing loans, and/or providing a line of credit when financial assistance cannot be obtained through conventional channels. However, about a third of these authorized instruments have not been implemented or are inactive.

Only 16 of the 50 states offer any form of tax relief to new or expanding industries, with 12 applicable to scientific undertakings. Where such benefits do exist, property taxes generally are waived or reduced from five to ten years.

In some states without public industrial financing, special assistance is available through private sources. The Arizona Bankers Association, for instance, has a $5-million fund to aid new industries.[24]

This chapter provided an insight into research parks, recognizing that this type of land use requires serious planning considerations on the part of the community. Many diverse groups may be involved in the planning of the park and its sponsorship, and it frequently becomes a powerful being affecting the political, economical and social and physical climate of the community. How well the community meets its needs and responds to its character may be an important factor in its success or failure.

The chapters following pertain to the various criteria to consider at the local level, as opposed to the broad criteria pertaining to the larger, regional areas discussed earlier in the thesis. While Chapter IV will discuss the important community factors which are considered essential to the attraction of research parks, Chapter V provides the important criteria in planning the research park site for its occupants.

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[24] Danilov, "Sites for Sale," op. cit., p. 35.

CHAPTER IV

RESEARCH PARK LOCATIONS--
CONSIDERATIONS AND IMPLICATIONS

The first three chapters of this thesis outlined the historical growth of research and development in the nation; the major areas of research activity and their general locational factors; and provided some specific examples of research and development facilities in various types of settings under the sponsorship of many diverse groups.

The following two chapters will discuss the important specific factors that attract research activity into an area which a community may consider in assessing its potential to attract this specialized type of operation. Due to the significance of university-oriented research parks, a portion of Chapter IV will examine some of the motives, benefits, and problems of university-backed research parks. Physical planning considerations of the research park are outlined in Chapter V.

General Observations

Research facilities tend to be far more selective in their location since they are not greatly restricted by the location of raw materials, consumer markets, freight costs, and labor pools. Thus, the traditional locational criteria for industry, such as low taxes, surplus labor pools, cheap utilities, etc. do not usually hold true for research facilities. Instead, research facilities tend to locate in a community which has the attributes of a special order.

It appears that general geographic location, such as the far West, South or Northeast, is, in itself, of little importance in terms of locating a research facility. The research engineer and the scientist are attracted to a position primarily on the basis of the nature of the work that is involved and the overall management research policies. All other things being equal, the mobility of the technical community is such that capable personnel can be attracted to most areas of the United States. It is on the regional level that the factors most important for the effective operation of a research laboratory come into play.

Research itself is recognized as a growth "industry" and is being wooed by increasing numbers of communities and states, all seemingly competing for laboratories as a new source of payrolls, plant investments, and taxes. Many areas look upon the encouragement and stimulation of research (both academic and industrial) as basic to the long-term development of a vigorous, healthy economy. Other communities give the impression of attempting to entice laboratories as a get-rich-quick scheme, or simply as a real estate promotion.

Many of the benefits to a locality which result from an R & D complex have awakened other sections of the nation, resulting in an intensified effort by almost every major city, state and university to attract these nuisance-free, stable, and self-generating industries. As is true of any industry, however, research requires certain assets of resources and draws upon a labor pool unique to its own requirements. The basic raw materials for research are the fertile and analytical minds of highly educated scientists and engineers. The largest and most important investment in the research "industry" is in people--educated, trained and experienced researchers.[25]

Location Factors

The selection of the appropriate geographic location and the specific site for a R & D facility is a unique process. Unlike the case of locating production plants and warehouses, optimum research locations cannot be measured and projected. Competition for attracting R & D sites has become fierce, with such inducements as free land, 100 percent financing, and tax exemption for specified periods being quite common. However, investigation of material on the subject reveals that it usually takes more than such monetary attractions to land scientifically oriented enterprises in any quantity.

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[25]George R. Herbert, "The Research Center Phenomenon," Industrial Research, VI, No. 5 (May 1964), 24.

In an address by Dr. Jerome B. Ewisner, who was special assistant to the late President Kennedy for science and technology, a number of factors were listed as being most influential in creating the scientific complex encircling Boston:[26]

1. The presence of outstanding scientific schools and facilities.
2. Government-sponsored research activities.
3. A supply of skilled manpower.
4. A diversified supporting industry.
5. Readily available venture capital.
6. Good transportation.
7. Very pleasant living conditions.
8. Some very good luck.

These factors could be applied to any area that has been successful in soliciting research laboratories and scientific companies. Of the above-listed factors, the <u>key ingredient</u> appears to be a strong academic institution with highly regarded facilities, researchers, and students in science and engineering. The second most important factor is the extent of the federal government's financial commitment to an area. It is interesting to note that presently, nearly half of the Department of Defense grants to universities and other non-profit institutions for basic research

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[26]Victor J. Danilov, "Build It Here!" <u>Industrial Research</u>, V, No. 5 (May 1963), 20.

goes to Massachusetts and California; and that about 40 percent of the nation's defense research development, testing and evaluation expenditures are currently going to California. Therefore, the federal government's contribution to and the effect upon the growth of R & D in these two states alone cannot be overlooked.

Location Factors Revealed by Detailed Surveys

Some recent studies have shed further light on these location factors. One was conducted by Armour Research Foundation of Illinois Institute of Technology for the Liquid Carbonic Division of General Dynamies, and another was conducted by "Industrial Development" which had compiled its own checklist from its own experiences as well as those of the Boston Chamber of Commerce and of Dr. Jesse Hobson, former director of Stanford Research Institute. Industrial Research also surveyed 500 industrial research directors and company presidents to determine factors that enter into a research facility site.

In the Armour study, the executive management, the research director, and the scientific staff of 50 companies which had located or relocated their research facilities were interviewed.[27]

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[27]George L. Philips, "Laboratory Location," Frontier, IV, No. 2 (Summer 1964), 15.

From the corporate point of view, four factors were identified as being most important:

1. The laboratory should be neither too far nor too near corporate offices or production facilities.
2. A community where a friendly environment and political attitude have been demonstrated to similar laboratories.
3. Accessibility by normal methods of transportation.
4. The site should be generally attractive--offering opportunity for expansion, reasonable land costs, fair taxes, and desirable neighbors.

From the research director's standpoint, three requirements were paramount:

1. Easy accessibility to universities--for advanced education, library materials, and recruiting and consulting purposes.
2. Availability of outside services, such as machine shops, maintenance services, computers and supply houses.
3. Availability of non-professional labor supply.

The most important factors to the scientific staff were cited in the following order:

1. Adequate primary and secondary schools.
2. A satisfying cultural and/or intellectual environment.
3. Housing to accommodate several economic levels.

4. Recreational and religious facilities.
5. General attractiveness of the area.

The above factors need not necessarily exist within the immediate area of the laboratory location, or within the community within which the R & D facility is located. These are desirable aspects of a general area, and it can be presumed that the research staff will locate in that part of the area where his particular needs are best met. Of course, not all of the above factors are of equal importance in evaluating alternate research sites. A consensus of those who participated in the Armour study placed the greatest emphasis upon fulfilling the immediate personal desires of the professional staffman and upon allowing an opportunity for his professional development. A listing of the composite relative weights assigned to eight of the main factors is presented in Table 3.

While this composite evaluation serves only as a frame of reference for any organization considering the location or relocation of its specific facilities, its application in a general geographic area will quickly and effectively identify several promising sites. This mechanistic approach, however, will not identify the one most desirable site, nor does it consider such intangible factors as general aesthetics of the site, the ability to project the corporate's image, etc.

Table 3. Ranking of site location criteria

Order of Importance	Criteria	Value Assigned	Important to
1.	Social, cultural and general living conditions of the area	0-15	Researcher
2.	Accessibility to major universities and libraries	0-10	Researcher and Research Director
3.	General site characteristics: Site topography .. 5 Neighborhood 4	0-9	Management
4.	Community attitude toward research labs.	0-8	Management
5.	General accessibility: Highway .... 3 Public transportation . 3 Major airport 1	0-7	Management
6.	Proximity to division headquarters	0-6	Management
7.	Availability of non-professional labor supply	0-6	Research Director
8.	Availability of special services	0-2	Research Director
	Total	63	

Source: George L. Philips, "Laboratory Location," Frontier, IV, No. 2 (Summer 1961), 15.

The "Industrial Development" survey identifies the following as important R & D location factors:[28]

1. Intellectual Base--This includes educational programs extending through the graduate level, with special emphasis on science and engineering curricula.
2. Nucleus of Scientific Activity--There should exist a sufficient amount of scientific activity--both in volume and variety--to be attractive to other professionals. A sizeable labor pool should be available which can be drawn upon for building and operating prototype plants.
3. Accessibility--A successful scientist today is an organization man who must travel frequently to company headquarters and to various science centers. This requires good airline connections and puts a premium on good transportation of other types. Expressway locations have a special attraction for research-oriented industry seeking to project its corporate image to the motoring public. Some of the new research parks are being built around airstrips to appeal to executives who fly their own airplanes.
4. Aesthetic Appeal--This includes a variety of intangible assets which appeal to the scientist. The level of home life most favored by engineers and

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[28]Conway, op. cit., p. 20.

scientists is highly significant. It is most compatible with lawyers, doctors, teachers, and managers. Included are climate, residential areas, quality of schools, cultural environment, recreational facilities, prestige of an area, political climate, and other items under the general heading of "living conditions."

5. Supporting Services--A large industrial research laboratory needs a great many special services: compressed gasses, instrument repair, photo processing, computers, etc. The availability of such services within a convenient range is a vital factor in the location decision.

6. Sites--An increasing number of managers of R & D firms are insisting on special sites which provide the atmosphere of a college campus.

In the "Industrial Research" survey the following location factors were ranked in order of importance.[29] Only those factors receiving more than 20 percent of the vote are reported.

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[29] Victor J. Danilov, "The Seduction of Science," Industrial Research, VII, No. 5 (May 1965), 46.

Factors	Percent
Proximity to a university	75.8
Cultural advantages	67.7
Professional manpower available	56.6
Cost of property and construction . . .	41.4
Proximity to other research-oriented facilities	34.3
Transportation	27.3
Labor force	24.2

The "Industrial Research" survey further recognized the industrial research buildup around leading institutions of higher education, the concentration of federal R & D contract awards, and the concentration of defense and space industries in the Northeast and Far West. At the same time, the findings tend to minimize the role of climate, markets, utilities, and state financial assistance in industrial research site decisions.

Survey Conclusions and Implications

The surveys reported in this chapter, as well as other surveys reported in leading technical journals, disclose that corporate management, when faced with the selection of a site for a new research facility, rate proximity to a major university, the strength and attitude of the university, the cultural, social, and educational environment of the community among the top factors affecting the decision. This is not surprising, for the greatest problem of research management is simply the recruitment and retention of outstanding scientific and engineering personnel.

The most valuable and saleable asset for any community interested in the creation of a research park or attraction of research-based industry, therefore, is a total environment attractive to professional personnel, in which the university plays an important function.

If the development of a major concentration of laboratories is to be expected, the only substitute for a strong university appears to be the presence of a major government research and development facility, but this usually depends upon the nature of government activity. The importance of these alternative assets is measured in quite different terms, however.

Universities, by providing opportunity for continued graduate work, by their effect on the cultural and educational level of the surrounding community, and by providing a core of professional personnel from academic and research ranks, create an attractive research environment. On the other hand, certain types of large government facilities will draw a cluster of R & D facilities designed to provide supporting activities. Examples of the latter are two U.S. Government science complexes, the George C. Marshall Space Flight Center in Huntsville, Alabama and the Manned Spacecraft Center in Houston, Texas which have attracted research and development operations directly related to the complex. Similarly, nearly 500 R & D plants have clustered around the

Washington, D.C. area to be close to major government R & D laboratories.[30]

The importance of the strong university or a large government facility is such that it becomes difficult to name an important research center which is not in the shadow of either of the two.

To evaluate the strength of a university as a potential attractor of research and development operations, the quality of the graduate school (especially the physical sciences), the library, personnel, research equipment and research already underway at the university should be considered.

A comprehensive study on university quality was conducted by the American Council on Education in 1966. The Council asked over 4,008 scholars to rank 106 United States schools offering doctoral degrees.[31] The schools were ranked in two ways: (1) rated quality of graduate faculty, and (2) rated effectiveness of the graduate program. The findings of the survey can be of value in determining the strength of a university as a potential attractor of research and development.

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[30]"Research Labs Swarm to Capital," Business Week, April 23, 1966, p. 144.

[31]American Council on Education, "An Assessment of Quality in Graduate Education" (Washington, D.C.: The Council, 1966), p. 10.

The research and engineering strength of a university has also been studied by Industrial Research by examining the dollar volume of research for the 1963-1964 academic year.[32] The study revealed that 39 universities fell in the more than $10-million class, 29 ranged from $5- to $10-million, and 33 had a research volume of from $1- to $5-million. Twenty-three fell below $1-million. While not a true measure of excellence, particularly with regard to the smaller, highly specialized institutions, the selection of the over $10-million group, when related to research park location, provided some interesting results.

In a study conducted by Robert G. Snider, Executive Director of the Commonwealth Industrial Research Corporation, to evaluate research parks as a way of stimulating the industrial utilization of Pennsylvania State University's scientific and engineering skills, 78 research parks were listed as to their success and occupancy, using certain selected criteria.

When those major universities conducting over $10-million research were related to research park location, three times as many successful parks as low-occupancy parks (21 vs. 7) were located within 20 miles of one or more of these major universities. Of 17 successful research parks, developed prior to 1962, all but three were so located.[33]

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[32] Robert G. Snider, "How Successful Are Research Parks?" Industrial Research, VII, No. 1 (January 1965), 16.

[33] Ibid., p. 18.

This reveals the strong relationship between volume (and type) of university research conducted and the "attraction" this holds to the location of a successful research park. Certainly it indicates that this element cannot be overlooked.

This presents a major problem for the "have not" states--how to attract research facilities and science-oriented industry? The ability to change the allocation of government research and development contracts based on competence may prove to be very difficult. Also, the boasting of the climate or central location, or even flooding the nation with promotional advertising and literature (although all of these factors have a role) cannot be a solution.

Instead, state funds would be better spent in developing one or more distinguishing universities in science and engineering; building a reservoir of scientific and technical manpower and services; encouraging the development of suitable sites for science-oriented facilities and improving the overall business and living climate.

If new research centers are to be created, then the enlightened self-interest of the universities as well as that of the local community and the state point to the advantages of assisting universities to develop their research capacities and competencies to the highest possible level. At the same time, efforts should be made to relate as effectively as possible the resources of universities to the creation of research centers.

Many communities exist today which contain many of the basic ingredients necessary for successful research parks, including that of an important university. However, the full potentialities of the university and community simply have not been exploited--its resources have not been promoted. Such promotion can be assisted appreciably if the respective resources of the following four entities are effectively related: (1) universities, (2) industries, (3) promotional and development agencies and (4) government.

Universities can assist importantly by expressing their own relevant resources and competencies, as well as the social and cultural values and advantages of the community. Promotional and development agencies can provide for the articulation of conditions necessary to attract and to develop research centers or parks. Such agencies can be helpful in relating university assets to programs of industrial growth.

Leading industry can assist in maintaining its "avant-garde" position by utilizing and maintaining close ties with the academic community. It has been noted, particularly on the East and West Coasts, that relations between industries and universities can be mutually advantageous.[34]

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[34]Office of Research Development and School for Advanced Graduate Studies, Michigan State University," Relating University Resources to Development of Industrial Research Centers," 1962, pp. 18-19.

Advice to communities interested in industrial development was well summarized by Dr. J. Herbert Holloman, Assistant Secretary of Commerce for Science and Technology, when he stated, "I would advise any community to exploit the excellence that it already has, to build upon it, to concentrate on it, and to have an appreciation of the interacting roles of the university, the technical community, the industry, and the government with respect to that excellence."[35]

Recent Locational Trends

Recent survey results have revealed that three trends have evolved in the locating of research and other scientific facilities:

1. There is a definite movement away from traditional manufacturing centers.
2. Scientifically oriented industries tend to attract like industries.
3. The clustering effect is greatest around the nation's leading scientific and technological institutions.

These trends are the result of industry's increasing efforts to obtain the best possible environment for science-based operations. It appears that part of this is due to the scarcity and competition for qualified personnel, and

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[35] Theodore B. Brown, "The Changing Research Parks," <u>Industrial Research</u>, VIII, No. 5 (May 1966), 44.

part can be traced to the sincere belief that scientists and engineers are more creative and productive when associating with their colleagues in a stimulating park-like atmosphere.

<u>The Role of the Community</u>

The character and environment of the community is obviously a very important consideration in attracting a research park. As indicated in Table 3 of this chapter, together with other surveys which deal with locational criteria for research parks, the social, cultural and general living conditions or environment of a community are given careful study by organizers and developers of research parks. The fact that a community may contain a number of these important location criteria causes it to play an important role in attracting research parks.

Research parks can be considered a specialized type of activity which prefer a community containing factors in its environment which could be labelled as "high quality." Due to the importance of these "high quality" communities in becoming attractors for research parks, this section provides some insight into those community-wide factors which the author considers to be most significant.

1. <u>A college or university within 30 minutes driving time</u>.--Science-based organizations ordinarily place considerable importance on the availability of college and graduate-level courses for their employees. Advances in many areas of science and technology are occurring so

rapidly that scientists and engineers are of limited value to their employers unless they keep current on the advances in their particular fields. Attending day or evening classes at a nearby education institution is one of the most widely used methods of staying abreast of new knowledge.

In addition to courses available to employees, many transplanted companies are interested in hiring local university graduates. One of the major reasons cited by Lockheed in choosing a location near Stanford University was to have access to Stanford graduates who have come to Palo Alto for an education, but who do not want to leave the area after graduation.

According to Dr. Terman, Vice-President and Provost of Stanford University:

> A really first rate university does even more than give an opportunity to attend classes and provide potential employees. Through a quality faculty, it provides a panel of experts with diverse skills available on a consulting basis that even small industry can afford. Its faculty provides intellectual leadership for the entire scientific complex.[36]

2. Better than average living conditions.--Living conditions in an area must be better than in the average metropolitan area. Living conditions, as used here, include quality secondary schools, aesthetics of the area, climate, cost of living, personal taxes, prestige of the area,

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[36] Denver Research Institute, The Scientific Complex--Challenge to Colorado, University of Denver, June 1964, p. 6.

recreational opportunities and a host of less important factors.

Of these items, the quality of primary and secondary schools is probably the most important. Most scientists and engineers are well educated themselves and are extremely interested in the educational facilities available to their children.

Communities which contain above average living conditions frequently become prestigious areas which may serve as an important attractor for scientific personnel. Obviously, if a community is to contain the advantages of a pleasant environment, it must be of a sufficient size in order to provide the necessary services and facilities which create such an environment. In a study by Mr. G. David Hughes, Associate Professor at Cornell University, firms located in research parks responded to their choice of a community size. The study found that firms engaged in research to any degree prefer the medium-sized communities whose population is from about 50,000 to 300,000 persons. Based on the response of the firms surveyed, the findings suggest that the small community (under 50,000 persons) is at a disadvantage in attracting research firms.[37]

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[37] David G. Hughes, Research Parks from the Community Viewpoint, Graduate School of Business and Public Administration, Cornell University, 1966, p. 22.

3. A well-developed professional environment and a thriving cultural environment.--One of the chief concerns of a good scientist or engineer is if he is continuing to grow professionally. This depends, to a large extent, upon the type of work that he is doing. It also depends on his opportunities to associate with other individuals who are working in his field or related fields, especially those who are ahead of him professionally. It depends on his opportunities to hear lectures, attend seminars and participate in activities of professional societies.

As to the need for a wide range of cultural activities, one top scientist puts it this way, "In terms of value to a scientific complex, a symphony orchestra is worth two top engineers on the faculty."[38] This rather unusual comparison points out the importance many scientists and engineers place on the cultural environment of the area in which they live. This environment also includes special musical programs, opera, theatre, art galleries, museums, libraries, and lectures.

4. High-quality industrial space.--Research firms, especially national science-based firms, normally do not want to be bothered worrying about the availability of water, power, sewage, roads, or zoning. They take these things for granted and are willing to pay a fair price to get them.

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[38] Mahar and Coddington, op. cit., p. 148.

They also want to be assured that their neighbors will be compatible, and this requires well-thought-out planning and the necessary restrictions to assure compatibility.

5. Reasonable operating costs and supporting services.--The cost and ease of doing business in a community must compare favorably with other competing areas. The factors which affect the cost and ease of operations include labor relations, labor productivity, taxes, local government policies, quality of supporting services and availability of airline transportation. The latter is especially important and, if completely lacking, may exclude an area which otherwise meets the attraction requirements.

Taxes on business must bear some relationship to the services rendered. It is obvious that if tax costs were the sole consideration, research parks and facilities would not have developed in such high tax states as Massachusetts and California. However, both states support high-quality education institutions at all levels thus making the tax burden more palatable. How tax revenues are spent is usually given as much weight in location decisions as the level of taxation.

6. A conducive legal, political and financial atmosphere.--The research park developer prefers a community where a friendly environment and political attitude have been demonstrated. Otherwise, expensive education and public relations programs may be necessary in dealing with the community. The developer is very much interested in zoning,

tax and assessment policies, the local governmental structure, and the business vitality of the community.

It is readily recognized that a number of the items emphasized in this section as being important in attracting research parks are generally important planning goals in any "planning conscious" community. Obviously, communities containing better than average living conditions and a stimulating environment seldom are a result of haphazard, unplanned growth. Therefore, those communities which taking planning seriously, are guided in their growth in an orderly manner, and provide many community amenities to its residents serve as starting points in the search for research park locations.

Similarly, several new towns and communities which have begun to develop in this country in recent years provide many of the amenities in which the research park developer is specially interested.

The author by no means wishes to imply that communities which measure up to the many qualities cited in this section should necessarily promote a research park. Other considerations play an important role in the decision-making process, and a community should take a comprehensive approach in determining the suitability of the research park facility. Not only must the private costs of the park developer be considered, but the public costs and the welfare of the community as a whole. Chapter V provides an insight into this latter consideration.

The Role of the University

The earlier section of this chapter places heavy emphasis upon the proximity of a major university in attracting R & D facilities. Because of this emphasis, a portion of this chapter will deal with this important factor.

Today, universities are becoming increasingly aware of the importance of industrial research parks or centers and are helping initiate programs to assist in the establishment and sponsoring of such development. About one-third of the research parks involve universities.

The rise of organized research has brought about more formal mechanisms for the administration and conduct of R & D activities on the university campus. Prior to World War II, nearly all of the research, except for the activities of the agricultural experiment stations at land-grant institutions, was carried out through the academic departments. There was little need for coordinating agencies, separate research facilities, or full-time research personnel. The faculty members who did the teaching also performed or supervised the research in the departmental laboratories.

As the volume of research increased and universities undertook the operation of government-owned research centers, research coordinators, councils, and institutes became a permanent part of the academic scene. Full-time researchers, generally known as "research associates," were added to the academic staffs; affiliated non-profit research organizations, such as Armour Research Foundation and Stanford Research

Institute, were created to handle "applied" research projects; and a hierarchy of research offices--vice presidents, directors, division heads, contract officers, etc.--was added to the campus administrative structure.

More than 20 universities have elected to develop research parks in the last 15 years either alone or in cooperation with community or private groups. Although the development of research parks is new to the academic field, the management of real property by institution of higher learning is not. Many public colleges and universities, for instance, were founded through "land grants" from the government, while numerous private institutions were the result of bequests and gifts of land from individuals.

The mere size of many universities also frequently involves extensive property management, especially when there is more than one campus or agricultural experimentation exists at scattered locations.

Another form of university property involvement is concerned with the management of property for investment purposes. A number of the major private universities depend, to a considerable extent, upon the income from property left to the institutions by alumni and other interested parties.

Research parks, of course, are quite different from any of these earlier property dealings by colleges and universities. They provide a new dimension to higher education--and industrial site location. The increasing involvement of universities in research and industry, and the realization that the proximity of science-based industries can be advantageous to both the institutions and the companies can be attributed to the growth of university-related research parks.

The first university research park was sponsored by Stanford University in 1951. About 125 research parks have been established, more than half having been established since 1962. The number of parks located near major academic centers totals almost 30. Most of the others are situated near large government centers.

In a survey conducted in 1965 by Dr. J. P. Schwitter of Kent State University, 53 industrial research parks were surveyed. Of these, 17 were associated with 20 universities.

In 11 of these, the academic institution was the originator, organizer, developer, and manager of the facility. Two research parks were the result of cooperative efforts. In one case, two private metropolitan institutions developed a park, and in the other, one private and two state universities joined forces in an urban industrial area. In both instances, government agencies and business firms co-sponsored the efforts. The remaining four (of the 17) facilities were sponsored by metropolitan universities with the aid of local governments and business firms.

None of the parks were developed by church-related or liberal arts colleges. All the sponsors offered graduate training and were either technological institutions or had schools of engineering.

The park initiator in five of the 11 institutions was a campus administrator; and in five others an outsider-business firm, chamber of commerce, or government organization. In only one case was a park started by a faculty member. At most institutions, vice-presidents and coordinator of research were the driving forces behind the research park.

Benefits to Occupants of University-Related Parks

For occupants of university-related parks, campus facilities become complementary benefits of the developer. The university atmosphere seems an appropriate location for concentrating most research and development activities. Science-oriented industries, operating at the forefront of knowledge, look to the university as generators, storehouses, and transmitters of new knowledge.

Research firms often place considerable importance on the availability of undergraduate and graduate level courses for their employees. In addition, many companies are interested in the availability of local university graduates. Lockheed, for example, located near Stanford University to have access to graduates who desired to stay in the Bay area after graduation.

Library services are mentioned frequently by university park sponsors as a benefit to the occupant. Gathering, storing and retrieval of research material is becoming increasingly complicated and costly. Most universities have excellent library facilities and cooperating firms may draw from extensive documentation.

The survey revealed that special research and other facilities of the sponsor, such as nuclear reactors, computers, auditoriums, and conference rooms, generally may be used by the park occupants. Of particular benefit is the possibility of academic appointments for senior researchers. The majority of sponsoring institutions offer such privileges, including occasional teaching or lecturing.

Among the more intangible benefits are close associations and intellectual exchanges between industrial personnel and scholars of the university. The growth of university research has been accompanied by closer industrial ties as more and more companies are taking their problems to institutions of higher education.

Benefits to the University and the Community

Neither profit nor revenue for supporting faculty research was cited in the survey as the primary motivation for park development. Instead, universities like to point to the industrial research complex as a demonstration of the institutions service to community, area industry and economy. Academic-sponsored research parks are considered a logical extension of traditional service functions, such as agricultural experiment stations, laboratories for state agencies, and extension courses.

A number of concrete benefits have been indicated by universities. Ranked as highest were the increased consulting opportunities for faculty members, a greater ability to attract first-rate scientists and engineers to the faculty, and the attraction to graduate students. Only a small minority considered employment at research parks an attraction for faculty members. R & D facilities near the university are considered a significant force in attracting graduate students because of expanded university research potential. Possibilities of specialized thesis research are broadened and scientists among the park occupants can help in lecturing graduate students in special subjects.

CHAPTER V

PLANNING CRITERIA FOR RESEARCH PARKS

The planning process requires that a comprehensive approach be employed in determining the future plans of any community. The same approach should be applied in determining the feasibility of a particular type of development, such as the research park. This chapter discusses the need for public policy formulation and provides some important general criteria and considerations which the community must consider if it is to formuate meaningful policies towards the research park. This chapter does not outline criteria pertaining to community-wide qualities, as these are discussed in Chapter IV.

Assuming that the community does become involved in promoting and attracting a research park, considerable attention must be given to physical planning criteria which apply to the selection and planning of a site for the park. This chapter also provides some of the key considerations in the physical planning of any research park site or complex. Because research parks vary considerably in size, design, objectives, purpose, etc. it is not possible to assemble any standard checklists of criteria. Nevertheless, a general pattern is obvious.

The Need for Public Policy Formulation Relating to Research Parks

A policy is a course of action adopted and pursued in attaining goals or achieving objectives. The policies plan has been advanced as the mechanism to make technical planning, which is the process of translating policy into specific plans and proposals, more effective.

"Policies planning" is essentially a process of establishing ends, and determining the means by which ends will be established. The "policies plan" is a statement of the general intentions of the community and thereby serves as a guide to day-to-day decision-making on the part of public officials, administrators and citizens. Through "policies planning" the various policies of the community are brought together, conflicts are resolved, and new policies are added where appropriate. By bringing these policies together, there is a greater assurance that all the individuals and agencies who make decisions affecting community development will be operating within the same framework.

It is within this framework that research parks as well as other land uses be studied in order that policies reflect the desired objectives of the community. And, through the comprehensive approach, all aspects of a proposed development should be analyzed and adequately reflected in the public policies.

General Criteria and Considerations for Determining Public Policies Relating to Research Parks

Communities across the country are competing to attract research firms and/or assist in the development of research parks. Promotional literature cites the benefits of research parks as being clean, nuisance-free developments, which ultimately increase the tax base and, in general, improve the economy of the locality. Consequently, many communities are making a bold effort to attract this type of land use without recognizing the total community (public) benefits measured against total community (public) costs. As indicated in Chapter III, more than half of the research-oriented parks have not been successful. Recognizing that the community has an investment in the research park in terms of utilities, transportation routes, and a host of other costs, it becomes imperative that a thorough, comprehensive study and analysis be made by the community before public and private funds are committed to the research park facility. Such a study and analysis serves to affect realistic planning policies to guide the community in making a realistic and meaningful appraisal of the research park and determining whether such a facility ultimately becomes a burden or an asset. This is most important since seldom are negative aspects of the research park explored or considered.

It is not the purpose of this thesis to present detailed planning criteria relating to research parks from which the community may formulate its policies. Rather, the author wishes to present some of the important considerations and criteria which will affect policy decisions. Because of the close interrelationships of economic, physical and social forces, no attempt is made to categorize the items under consideration. Through a careful analysis of these forces, the community is better equipped to develop a meaningful policy plan rather than using a haphazard approach supplemented with wishful thinking.

The following considerations and criteria are presented in an effort to "spur" the thinking of local community leaders, governmental personnel, planners and citizens who may be involved in the decision-making process:

1. How well does the community measure up to the general requirements and location factors outlined in Chapter IV? While these are general in nature, they provide sufficient information to emphasize that a particular type of environment is necessary in order to attract research personnel into the area.
2. Does a favorable public and governmental attitude exist to encourage the research park facility to expand and prosper?
3. What type of research park is under study, and what type of activity will be conducted at the park?

Will "research only" be the sole activity, or will research plus prototype and/or light manufacturing be permitted.

The demands from "research only" activities will differ appreciably from those activities which permit a degree of manufacturing in terms of labor, utilities, transportation and other requirements. Also, the policy of permitting "research only" activities may not generate as large an amount of wages and salaries as activities permitting prototype manufacturing, which may employ more technicians and skilled labor and thus ease a critical employment problem within the community.

4. Is the research park, with its proposed activities, a compatible type of land use, or will zoning changes and possible public furor result to the detriment of the community and to the promoter of the park? Also, might the park location change appreciably the character of the surrounding area in a manner which might bring strong pressures for rezoning? Might the final result be a shift in a development pattern which might cause large expenditures to service such areas, especially if these areas were not conceived as logical growth areas in the community plan?

5. Can the community, or adjacent communities, meet the requirements of the supporting services, especially the clerical and technical personnel who generally prefer to work within a reasonably close traveling distance? What will be the impact upon the local labor supply? As noted in Item 3, a policy decision regarding the type of activity permitted within the park will have a decided effect upon the park's employment needs.

6. What will be the demands of the research park in terms of <u>physical</u> facilities such as housing, schools, utilities, streets and highways, social services, shopping facilities, etc.? For example:

    a. Will the research park be planned in stages over a long period of time or will it be developed as a completed "package"? If expensive utility provisions, street widening (on routes leading into the park) and new street construction can be staged over a period of time, it may become more palatable from the community cost standpoint.

    b. What will the influx of personnel (if any) have upon the housing needs? What type and quality of housing will be in demand? Is there a likelihood that an adjacent community may attract some of the personnel.

c. What will be the effect upon schools in terms of classroom needs? If schools are already overcrowded, how does the community intend to solve the problem?

d. What will be the effect upon other community services such as police and fire protection, libraries, social services, etc.?

e. What will be the utility requirements of the park? The community must recognize that the type of park occupants permitted within the park will vary the utility requirements.

   Textile research, for instance, many require huge quantities of water which the community cannot readily supply. Can the community afford to create an additional water supply to meet the park's demands?

   Chemical research firms may discharge chemicals which cannot be treated properly by the municipality's treatment plants. Will a new treatment plant be required, and who shall bear the cost?

f. Do the community's existing and proposed thoroughfares accommodate the anticipated traffic volumes of the park, or must the thoroughfare plan be restudied and revised?

If a park is of a relatively small size, its effects upon the community may be small, and the park may be viewed as a part of normal community growth. However, where the planned park may comprise large acreage and employ several thousand personnel, the community will be faced with many demands for physical facilities together with costs for providing such facilities (see Item 7) which are not discernible until after the facility is well established.

In order that the community fully assess the impact of the park upon the community's resources, it is important that the demands for physical facilities be carefully analyzed and projected to the satisfaction of the community and the park developer and promoter.

7. What will be the total costs and benefits to the community resulting from the research park?

The determination of costs and benefits is especially difficult because there is not a clear understanding of the interrelationship of physical, social, and economic forces within the community. Nevertheless, many factors do exist which should be considered, and as complete a picture as possible should be presented in order to guide policy makers.

Generally there has only been concern for the _direct_ municipal costs and revenues, whereas indirect costs and revenues may be equally or more significant to local governments. Also, private as well as public costs demand consideration. Expensive public improvements may be warranted without direct tax return if the total economic well-being of the community is promoted. Social as well as money costs are also important considerations. The provision of recreational and health facilities to meet the demands of increased population which may result from a large research park must not be overlooked.

Similarly, the benefits to the community, many of which cannot be measured in monetary terms and many of which may not begin to occur until later years, must receive consideration. Economic benefits to the community should take into account the park's contribution to the private sector through its local purchase of goods and services, and to the public sector of the economy through property taxes, expenditures for public utilities and services, sales and income taxes, etc.

Table 4, reproduced from a University of Maryland study, suggests the scope of direct and indirect local government costs and revenues associated with industrialization. Its application and expansion would be a helpful guide in determining the costs and benefits of the research park.

Table 4. Community benefits and costs from industrialization (schematic outline)

Benefits	Costs
A. DIRECT	A. DIRECT
1. Revenues from new business firms a. property taxes b. income or earnings taxes c. other business taxes, fees, and special assessments	1. Outlay for services to new firm: capital outlay and upkeep a. water supply and sewage disposal b. streets and highways traffic control expenditures c. police and fire protection d. air pollution and noise control
2. Revenues from new employees a. property taxes b. income taxes c. sales taxes d. other personal or household taxes, fees or special assessments	2. Personal and household services a. water supply and sewage disposal b. streets and highways c. police and fire protection d. air pollution and noise control e. educational facilities f. public health, hospital, and welfare services
B. INDIRECT	B. INDIRECT
1. Additional revenues from old businesses resulting from new activities attributable to relations with new firms; categories as in (1) above.	1. Added services to business already established resulting from activities with new concerns a. increased per unit-cost and additional capital investments for water, sewage, road network, police and fire protection b. higher cost of general government administration c. drain on natural resources d. tax losses from displaced firms
2. Additional revenues from present households as result of expanded activities: real property taxes increased as result of rise in values, and taxes from other unearned increments.	2. Added services to new employees, as in (1) above a. added health, justice and security costs b. tax losses from displaced residents and changes in land uses

Source: University of Maryland, Bureau of Business and Economic Research, "Industry as a Local Tax Base." Studies in Business and Economics, XIV, No. 2 (College Park, Maryland, 1960), 18.

Cost--revenue analysis is an approach which is receiving careful consideration by many governmental bodies today. As the technique becomes refined through use of the computer to intelligently correlate more and more information, the cost-revenue approach can assist greatly in the formulation of improved governmental policies relating to community development.

8. Assuming that a determination is made that the research park is a feasible development for the community, has an assessment of the research potential been made within the community? Rather than attempting an expensive promotional effort to attract research firms, a policy which commits the community to assist local firms in expanding its research efforts to apply to local resources, including expansion of research which may already be taking place in the locality, may receive strong approval on the part of the community, industry and university.

9. Can the research park be accommodated within the framework of the policies and general plan adopted by the community? A determination whether the research park is a logical type of land use for the community (after a careful assessment of the items indicated in this section) will also raise the issue of complementary surrounding uses, thus, the community may require a reassessment of its policies and

plan, thereby resulting in a thorough review of the plan and a new set of policies to reflect changing attitudes and aspirations on the part of the community.

While the list of criteria and considerations is by no means complete, a sufficient number are presented to serve as a guide in establishing a comprehensive analysis which should be applied when considering a major land use such as a research park, and the effect that such a facility may have upon the community. The establishment of policies relating to the research park should reflect the comprehensive analysis in which many questions become answered and in which an equitable policies plan is developed.

General Criteria and Considerations Relating to Site

In selecting a research park site, many of the same basic requirements that apply to industrial parks also apply to research parks; namely, a site that is:

1. Reasonable level topography, flood-free, and well-drained. If the park is to contain prototype manufacturing, a slope of more than 10 percent is not advised. If the park is planned for research and development operations only, a slope of more than

10 percent is acceptable, and may even contribute to attractive landscaping.[39]

2. Sufficient in size to meet the anticipated needs and allow for reasonable growth. Planned R & D parks vary greatly in size, from the 9-acre University Research Center in Cleveland, Ohio, to the 5,000-acre Research Triangle Park in North Carolina. The majority of R & D parks surveyed, however, range from 100 to 500 acres. Those parks which allow prototype manufacturing tend to be larger than those which admit only R & D operations.

3. Accessible to transportation facilities. This receives special consideration not only in the initial selection of the park site but in the design and layout of the park and the access roads. Important is the need for reasonably easy movement of personnel from home to work and back again, as well as movement out of the local area to other, more distant centers of research activity, technical information, or company activity. For top scientists and technicians this is primarily a method of travel by air or by car--preferably on the new express highway facilities of the interstate system.

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[39]Hill and Adley Associates, Selection Factors for an Industrial Park, Atlanta, Georgia, April 1962, p. 3.

4. Free of encumberances and conflicting easements. Usually, structures are not permitted over easements. Existing easements which are not related to the park can seriously affect the building plans.
5. Protected by zoning from residential encroachment and incompatible industrial uses.
6. Served by, or capable of being served by, all necessary utilities.
7. Preferably under single ownership or relatively few owners. Where multiple ownership is involved there is frequently excessive time and expense encountered in assembling the land.

Planning and Land Use Controls

This phase of R & D park planning usually requires the planner to become intimately involved with the developer of the park. The professional planner in the local Planning Department frequently provides assistance and advice in developing the park to conform to the locality's adopted ordinances, or may be required to design new ordinances (when applicable ordinances are not available) to assure that the park is (1) designed according to high standards, (2) compatible to surrounding land uses, and (3) compatible with the general land use plan and zoning ordinance. It is most important that the developer of the R & D park consult with the local Planning Department and check the local zoning ordinance, subdivision regulations and official map or thoroughfare plan before proceeding with site planning.

Plan design.--Some of the principal considerations in planning the design of the R & D park are:

1. Flexibility--It is important that as much flexibility as possible is allowed in the design plan. This is generally achieved through block planning and phase development.

   In block planning the overall size of the block is determined, but side lot lines within the block are established later to meet the purchaser's exact requirements. Streets within the plan may be designed in such fashion that a variety of block sizes are created as well as alternative plant size depths and frontage distances.

   Directly related to block planning is phase development, wherein the entire park is planned as a comprehensive unit but is developed in economically feasible stages. This approach saves capital and allows for future layout and development alternatives.

2. Lot Sizes--Lots in most planned R & D parks have been platted in various sizes to meet the needs of prospective tenants, ranging usually from one acre upwards. The Stanford Industrial Park is designed to provide minimum one-acre lots (one firm occupies a 70-acre site), while in the Research Triangle Park in North Carolina the minimum site size is six acres (two

sites are 400 acres and 500 acres each). The latter was determined to be the least acreage required for any lot in order to create the campus-like atmosphere of the Park.

In the Bohannon Industrial Park, designated as a research-oriented park and located in Menlo Park, California, sites range from one acre (200 feet by 200 feet in size) through medium-sized parcels of 2½ acres with varying widths and depths, up to parcels of 20 acres or more, depending on the requirements of the particular plant or industry. In general, the portions of the park allocated to small and medium size parcels have been platted to provide lot depths of 200 feet, 300 feet, and 370 feet; it having been determined that these depths are the requirements of most of the industries for which the Park was designed. One area has been set aside to provide sites of greater depth where parcels of 10 or more acres are required. Individual site widths are varied to provide building sites and areas required for off-street parking and loading.

In reviewing the site plans of numerous research parks, it was noted that a variety of lot sizes and parcels are provided from which an individual firm may select to meet its particular needs. Some parks also followed the practice of leaving a vacant site between existing units, wherever feasible, to permit later expansion of an existing firm by acquiring the adjoining area.

3. Streets--Consideration must be given to traffic circulation throughout the park site, access to surrounding thoroughfares, access to individual lots, width of rights-of-way and pavements, load-bearing capacity of the street, paving materials, grade, storm drainage, curbs and sidewalks (where necessary), location of utility easements, corner radii at intersections and curves, and proper tie-in to the surrounding development. Parking and loading should be prohibited on all park streets.

   Most plans call for streets of 60-foot right-of-way with 36- to 40-foot pavement widths, since they are basically industrial-type streets. In many instances, park developers maintain control of the street until the park is well established, at which time the streets are then dedicated to the political jurisdiction in which they are located. Therefore, it is important that streets be designed and constructed to meet local community specifications.

4. Utilities--Provision for water, sanitary sewers, storm drainage, electric power, gas, telephone service and the required easements for such utilities is an important aspect of the park plan.

Utility capacities for research parks will be larger than required for residential and commercial uses; therefore, the developer should work closely with the utility companies and governmental bodies involved.

Easements for utilities should be located within street rights-of-way or to the rear of lots, whenever possible, and all service lines should be buried for aesthetic reasons.

Utilities to the park are generally extended from the existing utility systems serving the general area of the park. In most instances, utility services are extended by the local jurisdiction to the property line of the park. Within the park, the costs are absorbed by the developer. Generally, the developer and the utility company and governmental body furnishing the utilities enter into a contract for the services, for the protection of all parties involved.

Planning for each of the required utilities will be discussed.

a. <u>Water</u>--An adequate water supply is essential for the operation of an R & D facility, and a survey of the available water sources must be made to determine the best source of supply. Water requirements vary considerably, depending on the type of operations permitted in the park. The

Research Triangle Park in North Carolina, for example, has contracted with the City of Durham for two million gallons of water daily, with a total of five million gallons to be provided when the Park is developed ultimately. Generally, the park which allows some light or prototype manufacturing will require more water than the pure research park.

Water mains under 8 inches in diameter are not recommended. Many parks contain water mains ranging up to 12 inches in diameter. The main should have two connections with the water system in order to form a loop. This will prevent dead-end lines and insure adequate pressure to all users in the district. Water pressure must be high and steady enough to operate sprinkler systems, air-conditioning units, and to maintain favorable fire insurance ratings. Generally, 40 lbs. pressure per square inch is sufficient for fire-fighting purposes.[40]

It is important that where a contract exists between the developer and the supplier of water, that the quality, analysis, pressure, and rates

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[40]Interview with Wade H. Brown, Director of Water Resources, City of Durham, North Carolina, and Water and Sewer Consultant to Research Triangle Park, November 14, 1968.

be specified. A knowledge of pressure readings to the developer is important because it will determine whether the special pressure needs of certain firms or occupants may be accommodated.

The park developer is usually responsible for the design of the water (and sewerage) system and must receive approval of the governmental body or authority supplying the water.

b. Sewers--Sanitary sewers must be of sufficient size to handle the anticipated needs of the park's operations. Sanitary mains of at least 8 inches are recommended and storm sewers should be of sufficient size to handle the park's particular drainage problems and the storm run-off within the park.

It is recommended that the developer consult the utilities department of the local jurisdiction (usually a municipality) to determine the types of wastes which can be treated before plans for the district are completed. Some R & D firms emit wastes which cannot be treated by the municipality's existing treatment plants. For example, some laboratories emit acid wastes and solvents, while atomic laboratories are likely to have radioactive wastes.[41] In such cases, it may be necessary to give these wastes special treatment before they can be discharged into the municipal system.

Research parks which are not located within the municipality's drainage areas that are serviced by the sewerage treatment plants might be faced with the extremely high cost of pumping sewage into the existing system by a series of pump stations. Or, the alternative is to build its own treatment plant and contract with the local governing body for the operation and maintenance of the plant, as was the case with the Research Triangle Park in North Carolina. In this instance, the park's engineering consultants designed the treatment plant and mains to conform to the City of Durham's specifications, since the City operates and maintains the plant. Prospective firms must submit an estimate of future requirements for sewage treatment, and if locating within the park, must adhere to the City of Durham's "Sewer Use Ordinance" so that a check can be made by the City on the type of sewage to be emitted.[42]

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[41]Frank L. Whitney, "Design for Research Facilities," Industrial Research, IV, No. 8 (September 1962), 44.

[42]Wade H. Brown, op. cit.

c. Electricity--The electrical needs of an R & D park can best be determined through consultation with electrical engineers and the power company serving the local area. While specifying electrical needs is beyond the scope of this report, it is important to consider the types of R & D activities likely to be attracted and the influence such activities have on the electrical requirements. For example, chemical research and development laboratories do not require the electrical capacities and flexibility of other types. Pharmaceutical laboratories require greater electrical capacity and a variety of secondary voltages. Electronic and atomic power laboratories have high electrical requirements and need great flexibility in voltages and frequencies of the electricity supplied.[43]

While details of the electrical systems of many R & D parks were not available, it is recommended that underground wiring be installed for aesthetic purposes. Several parks did indicate that overhead wiring or poles are used; however, all connections from the poles to the buildings are by underground leads. Transformers

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[43]Whitney, *op. cit.*, p. 44.

are located on enclosed pads adjacent to the buildings. This system eliminates the unsightly cross-wires running from the poles to the various structures.

d. Gas--Most R & D parks are served by gas mains of four or six inches; therefore, these size mains are recommended. Pressure should be at least 25 pounds per square inch in the main and as required in the lines serving the individual facilities.

Land use controls.--Nearly all of the R & D parks surveyed have regulatory controls to protect the research environment and create an atmosphere within which prospective tenants can carry out their research and development functions with minimum friction from other park tenants and from residents of areas beyond the boundaries of the R & D park itself. In order that the park's environment be protected, controls are exercised over the land use, land coverage, building setbacks, lot size and coverage, off-street parking and loading, building design, landscaping, etc. The instruments of regulation most commonly used are zoning ordinances, restrictive covenants and deed restrictions, and subdivision regulations. Each of these instruments will be discussed.

1. Zoning Ordinance--Zoning is the division of a municipality or other governmental unit into districts and the regulation within those districts of:

- the height and bulk of buildings and other structures.
- the percentage of a lot that may be occupied and the size of required yards and other open spaces.
- the density of population.
- the use of buildings and land for trade, industry, residences, and other purposes.

The zoning ordinance stipulates provisions for certain items. Provisions in each of the items vary according to the zoning district. Planners are frequently involved in drafting provisions regulating research parks when such provisions are not a part of the existing zoning ordinance.

The usual items considered in the zoning ordinance are discussed. Wherever possible, acceptable standards or considerations which may apply in regulating R & D parks are provided. Once again, provisions among various zoning ordinances pertaining to such parks vary widely. Provisions must be drafted which will necessarily relate to the objectives of the park development.

a. <u>Zoning District or Classification</u>--Research and development parks are located in special (purpose) zoning districts established to provide greater land use control and development standards than afforded by the usual commercial and industrial zoning districts. R & D parks are usually located in two types of special zoning districts: (1) those specifically designed for R & D uses, and (2) other special zoning districts within the district. In the latter instance research and development laboratories, light manufacturing and assembly operation, offices, etc. are frequently designated as permitted uses in an industrial zoning district, with the intent that industry could operate in park-like development.

b. Uses Permitted--This section spells out the intent of the zoning district and lists the various uses permitted. The type of uses or activities permitted in the R & D park must be decided upon, and frequently is a difficult policy question. Normally, the degree of manufacturing to be permitted, if any, is a major issue.[44] As indicated earlier in this thesis, few parks conduct only "pure research"; some of the most successful research parks permit, in addition to research, experimental or testing laboratories, light manufacturing, prototype production and offices. Therefore, the careful consideration of permitted uses will, to a large

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[44] David G. Hughes, Research Parks from the Community Viewpoint, Graduate School of Business and Public Administration, Cornell University, May 1966, p. 3.

extent, relate to the type of park that is desired.

c. Required Lot Area--The minimum lot sizes are generally stipulated in this section, as discussed earlier in this chapter. Consideration must be given to the anticipated requirements of future park occupants. Minimum dimensions of lots, such as average widths or depths, are frequently specified in this section.

d. Lot Coverage--Frequently the maximum percent of the total area of any individual site that may be covered by structures is specified--generally 20 to 30 percent. Developers desiring to maintain a very open, campus-like atmosphere for the R & D park prefer even a smaller percentage of lot coverage, from 5 to 10 percent.

e. Required Yards or Setbacks--Most developments of R & D parks require that buildings be set back a certain distance from existing and proposed streets and from interior lot lines. These setbacks help assure ample landscaping areas and space for off-street parking and loading. They also provide for fire safety, permit easier building identification and encourage better and safer traffic flow.

It is recommended that the setback from any street be at least 40 feet, while those parks with emphasis on considerable open space and campus-like atmosphere should consider 75 feet to 100 feet as a minimum. Consideration should also be given to the setbacks from streets for sites of varying size. Increasing the setbacks proportionately to the size of site appears to be a sound approach (i.e., the larger the site, the greater the setback).

Setbacks from interior lot lines should be developed in proportion to the setback requirements from streets. In many parks where 40-foot setback from streets are required, a 15-foot setback from interior lots is specified. Where greater street setbacks are required, setbacks from interior lot lines are also greater. For example 100-foot street setbacks may require 30-foot interior lot setbacks. As with street setbacks, those parks maintaining considerable "openness" should require even greater setbacks from interior lots. The Research Triangle Park in North Carolina specifies 150-feet minimum for interior lot setbacks, with the street setback ranging from 150 feet to 250 feet, depending on the size of the tract.

f. <u>Parking and Loading</u>--All of the R & D parks surveyed require that all parking and loading be off-street and paved. Provisions in most ordinances range from a general requirement that all employee and visitor parking as well as truck loading be accommodated entirely on the occupant's plant site, to regulations which base the number of car parking spaces required either on the number of employees and visitors or on the number of square feet of floor space in the building.

Generally, parking in most parks is not permitted in front yards (between building and frontage street) except for limited visitor parking, and then only when properly screened. It is recommended that employee parking and truck loading be confined to the rear or sides of the building (but not within required yards) on paved, dust free and all-weather surface.

g. Signs--It is recommended that billboards or other outdoor advertising signs, other than those identifying the name, business, products of the person or firm of a principal use located on the premises, not be permitted.

Where a Board of Design is created, approval of signs by the Board should be mandatory. Details of signs should be furnished, such as location, design, size, color and lighting. This eliminates the need of spelling out lengthy and detailed sign provisions in the zoning ordinance.

h. Performance Standards--This section of an ordinance should provide that occupants of the park establish and maintain the proper appearance from streets and adjoining properties, also to provide that each permitted use shall be a good neighbor to adjoining properties by the control of emission of noise, odor, glare, vibration, smoke, dust, liquid wastes, radiation, radioactivity, etc. This section should further state the conditions of construction and operation with which research and other permitted uses shall be expected to comply. Landscape provisions are frequently included under performance standards.

Since performance standards may become rather detailed and complex, standards for consideration will not be furnished.

2. Restrictive Covenants--Restrictive covenants, sometimes called deed restrictions, permit enforcement of agreements between the park developer and the occupant and subjects the real property to certain conditions, covenants, restrictions, and reservations. These run with the land and bind the owner and tenant and any successors and assigns to conform to and observe the restrictions as to the use of

building sites and the construction of any improvements upon the site.

For purposes of giving the occupants some voice in the enforcement of restrictive covenants, some park developers have made provisions for owners and tenants associations and boards of design in their restrictive covenants.

a. Owners and Tenants Associations--Several R & D parks have provisions for owners and tenants associations in their restrictive covenants. The principal function of these associations is to appoint members to the boards of design. Generally, the owner and tenant has one vote per acre.

b. Boards of Design--All of the boards of design for which information was received consisted of five members. These members are usually appointed as follows: so long as 20 percent or more of the park is held by the owner of the park, he appoints three members and the Association appoints two members. At such time as less than 20 percent of the park is held by the park owner he appoints two members and the Association appoints three members.

By retaining majority membership on the Board until the park is at least 80 percent occupied, the park owner can control development in a manner that will protect his investment.

All of the Boards of Design surveyed required the following information for approval of any plans of the prospective occupant:

1) preliminary architectural plans
2) site plan of parking and loading areas and the maneuvering areas
3) grading and planting plan
4) plan of utilities and easements
5) estimate of maximum number employees
6) plans for all signs
7) description of proposed operations in sufficient detail to determine if the use is permitted under the zoning ordinance and if in conformity to the performance standards
8) any other information to ensure compliance with requirements.

Restrictive covenants, therefore, serve to supplement the zoning ordinance and provide greater control to assure the development of a high-quality R & D park.

3. Subdivision Regulations--The subdivision regulations are an instrument to guide the land subdivision development, enforced through the power to withhold the privilege of public record from plats that do

not meet established requirements and standards. If a plat is not recorded, a building permit is usually not issued for the erection of a building upon the site. Through these regulations, the local governmental body is assured that the park developer will provide for streets, intersections, easements, lot signs and widths, etc. to conform to at least the minimum standards required within the governmental jurisdiction.

Summary

This chapter provides an insight into the need for the establishment of a policies plan which effectively expresses the community's desires as they relate to the research park. Some of the key considerations which a community must give attention to, in dealing with the research park, are outlined and listed. The list is, by no means complete. If the policies are to be meaningful and represent a comprehensive, coordinate approach to analyzing the research park facility and its impact upon the area, then it is imperative that careful study be made of the many facets of the problem which the community will eventually have to face.

Site planning criteria are also outlined together with the necessary controls which should be considered in governing the research park. The regulations must be geared to the objectives of the park. Development in which research and development are the principal uses will, in all probability, require more stringent regulations to provide the proper environment than will development in which research and development is only part of the total permitted uses in an industrial or manufacturing district. As indicated earlier in the chapter, the basic policy decision about the research and development activity must be agreed upon by the community and the developer and, in turn, be reflected in the regulations.

CHAPTER VI

CONCLUSIONS

Today's $25-billion expenditure for research and development in the United States plays an important role in the economy. There is a clamor among universities, cities and states to attract research-oriented industry in order to reap the social and economic benefits of this noiseless, nuisance-free kind of industrial facility.

Due to the R & D movement, which has increased ten times since 1950, the research park is being promoted in community after community. This movement, therefore, has a direct relationship to planning. Research-based industries and research parks generally devote an attractive, clean-type of industry which local governments are eager to attract, without fully assessing the total effect upon the community in physical, economic, and social terms. Many planning departments, being part of local government, have been actively involved in advancing and assisting local governments and the general public in the decision-making and policy planning process in determining the feasibility of accommodating this type of land use.

An insight into the history, growth and development of research parks provide some important "clues" to their location and to the environment that attracts research industry.

This study reveals the geographical locations of the five dominant R & D centers in this country, namely, the areas of Boston, New York, Washington-Baltimore, Los Angeles and San Francisco. Other important R & D centers are being established across the country. Nevertheless, the five dominant areas will probably continue to exert a strong influence on R & D funds due to the large investments in terms of structures, education and training programs, and financial interests. Also, many research-based industries tend to cluster in an established environment of research. While research activity will undoubtedly become dispersed across the country to a far greater degree, it is unlikely that the established research centers will lose their dominance.

All research and development activity is not conducted in research parks or centers. Chapter II provides an insight into many reasons why research, as part of the total activity of a firm or institution, is conducted in a specific area, and based on many factors or criteria. The study reveals, for instance, that some kinds of research must necessarily take place at the plant location; namely, research related to production and processing. Other kinds of research must be located close to certain facilities to take advantage of such proximity. The latter involves types of research, for example, which complements the university or a medical complex. Regardless of the type of research and development activity, certain prime factors are at play which caused the R & D plant to locate in a specific area.

Research which is more flexible in its location, however, is usually suitable for location in a planned research park. The research park is a relatively new creature, having emerged after World War II. It gained ready acceptance partly because of the research upsurge that began after the War and because of the desire of research firms to locate in an environment that is stimulating to the researcher. As a result, over a hundred research-oriented parks have been developed with varying degrees of success. Several basic ingredients for the success of the park are obvious and are spelled out in Chapter IV. However, the most essential ingredients appear to be the proximity of a major university, the strength and attitude of the university, and the cultural, social, and educational environment of the community. These, the author feels, are some of the most important criteria that must be considered in attracting the research park. Because research personnel place great emphasis upon education institutions and the high-quality environment of a community, research firms and research park promoters recognize the importance of locating their facilities in communities that satisfy the needs of their research personnel.

This emphasis upon the total environment and personnel removes research park planning from the traditional approach to planning for industry. It is concluded that the failure to approach research park planning from this environmental standpoint has resulted in the failure of many parks to "get off the ground," and attract other research-oriented industry into the parks, and to give the impression that there is an oversupply of parks when actually, in the opinion of the author, the parks are simply not located in their proper setting. Of the 116 parks identified in the Appendix, 33 parks (28 percent) have one or no occupants even though 32 of the parks were in existence in 1965.

Today, more and more universities are playing a key role in promoting R & D activities and enlarging the scope of university research to accommodate the needs of government and industry. In turn, research industries gravitate naturally toward great universities and technical centers, where research people have ready access to the information they need for their work, and where top university scientists are available for consultation.

The study indicates that the only substitute for a major university appears to be the presence of a major government R & D facility, where it may be possible to attract other research firms to complement the government R & D facility. As a result, over 80 percent of today's R & D parks have located in proximity to either a major university or government R & D facility. It is concluded, however, that those research parks that developed with a strong university element appear to be in a better position to grow and shift with the rapidly changing tides of science and technology, such as the Boston, Palo Alto and Ann Arbor areas. On the other hand, the future of the more specialized complexes, such as those built primarily on defense contracts, is much less certain. Many firms whose activities have been concentrated in defense operations are seeking ways to diversify in order to be less dependent upon government. A few companies, on the other hand, are gambling that defense activity will still afford major economic opportunities for the future.[45] Large scientific operations cannot be quickly and easily assembled; therefore, for purposes of national security, the government must support them. The issue of how much federal backing is appropriate might ultimately have to be resolved by determining the level of desirable defense effort. Nevertheless, it appears that reorienting some of the defense employees and management to other types and kinds of research may be in order in the future. Certainly many of the defense-oriented research firms could intensify their efforts in exploring commercial possibilities of research, especially in the development of new products to meet demands of a changing and increasing population. In addition, such firms may make a greater contribution to research in other sciences such as the social

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[45] Daniel D. Roman, <u>op. cit</u>., p. 62.

sciences and psychology. The National Science Foundation reported that in 1964 performance in these fields of science at the universities and colleges (where the greatest performance of basic research and research in the social sciences and psychology is performed) only 15 percent of the total non-federal funds (of which industry is the greatest contributor) was allocated to these sciences.[46] The remaining contribution of non-federal funds was devoted to the life sciences, physical sciences and engineering. Research in the latter three fields of sciences is most prevalent in the research park. Perhaps these parks may provide a proper environment for the conduct of social sciences and psychology as well, especially if the park is in proximity to a major university and the research program can augment research conducted at the university.

The selection and planning of the research park site must be given very careful and detailed consideration. One of the major issues which must be faced is the type of research and extent of prototype manufacturing activity that will be permitted, as well as the extent and type of light manufacturing, if any, which will be permitted. Studies on the subject reveal that over half of the research parks are not successful, and few research parks conduct research as

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[46] U.S. National Science Foundation, Scientific Activities at Universities and Colleges, 1964 (Washington, D.C.: Government Printing Office, 1964), p. 43.

the sole activity. In almost all instances, the more successful research parks (measured from the conceptual framework of the research park developer) allow some mixed uses, on a highly selective basis, controlled by carefully drawn protective covenants which make the mixed uses compatible with research activity. Recognizing that some research parks could not thrive by limiting the activity permitted solely to research, it is concluded that permitting prototype manufacturing, and even light manufacturing would be beneficial especially in those communities lacking sufficient resources to accommodate a large park. Regulations at the disposal of planners can assure such compatibility not only within the park but with adjacent land uses. It must be emphasized, however, that while numerous articles and promotional literature may relate to the "success" of research parks, to the planners the term implies more than success in terms of occupants and economic well-being of the park itself. Instead "success" must be measured in terms of the many costs involved, including public and private costs (both direct and indirect). In this connection, the net cost effects to the governmental unit concerned with different patterns of development, including such factors as density of development and spatial distribution of land uses must be developed, and in a far more sophisticated fashion than is practised today if the "success" of research parks and other land uses are properly assessed.

In the initial selection of the site, consideration must be given to accessibility to and from the local areas, utility provisions, topography and protection from incompatible uses. Certain key elements must be considered in the design of the park and written into the local ordinances and restrictive covenants. These elements must necessarily be geared to the type of research park desired as well as its ultimate objective.

As more and more research parks develop across the country, more will be learned about the needs of research. Park developers will certainly profit by the mistakes of others. Many areas of the country are now awakening to the impact of the Scientific and Technological Revolution that is now taking place, and examining their resources to determine their potential in luring R & D plants. Advances are needed in such areas as health, education, urban renewal, public welfare, natural resources, pollution, oceanography, etc. which provide opportunities to tap new resources and develop new products. Those geographical areas of the country named in this study which have understood the implications of this "Revolution," and capitalized on its challenges, are now reaping many of its benefits. Not every locality, however, has the necessary elements or ingredients for a research park. Such localities should explore other avenues of industrial and economic growth besides research and research related activities.

The planner as a professional may become actively involved in the early stages of a research park proposal within a community. As a member of the community's planning department, for instance, he becomes involved in the work of guiding development through a planning program. Among other things, this program involves (1) the establishment of development objectives, conduct of research on growth and development of the community, (2) development of policies, (3) plans and programs relating to such community development, and (4) coordination of development activities affecting the community's growth.

To be effective, the planner must operate within a framework of officially-approved development policy with broad development objectives established to give him direction not only for his planning activities but to give him a sense of the future growth of an area. This development policy should be long-range, comprehensive, and related to the community's goals and to social and economic policies.

The planner, with his orientation to viewing the community as a whole, together with his focus upon comprehensiveness and upon the future, plays a key role in coordinating public and private development within a framework of comprehensive development policy. Specific development proposals, such as research parks, are assessed in terms of the community's goals and objectives. Through careful, comprehensive analysis of the proposal, the planner relates the proposal to the total development plan of the community, recognizing the cause and effect relationships that the research park may have on other forces within the community.

Thus, the professional planner analyzes the many facets of the research park proposal as opposed to the narrow, one-sided approach of many park developers and promoters. The planner is perhaps better trained than most other public service professionals to assess the interrelatedness of the physical, economic, and social forces within the community. Consequently, he is able to assist and advise local governmental officials to adopt more meaningful development policies which can pertain not only to research parks, but other land uses as well. Through careful planning, a community is better able to assess the research park and to formulate carefully drawn policies to accommodate this specialized type of land use if the community is desirous of such development.

APPENDIX

APPENDIX: LISTING OF R & D PARKS RESTRICTED TO RESEARCH OR DESIGNED PRIMARILY FOR SCIENCE, 1968

State and City	Park	Research Only	Year Founded	Acres	Percent Occupied	No. of Occupants	Total Employ.	Scientists & Engrs.
ALABAMA								
Huntsville	Huntsville Research Park	-	1962	700	75	13	10,000	3,000
ARIZONA								
Phoenix	Phoenix Intl. Science Park	-	1962	55	10	1	20	--
Tucson	Research Park West	-	1965	70	5	1	15	12
CALIFORNIA								
Cupertino	Vallco Park	-	1964	350	38	6	1,000	80
El Segundo	El Segundo Industrial Park	-	1962	150	82	26	3,000	1,000
Fullerton	Southeast Industrial Park	-	1956	1,800	65	210	2,300	--
Goleta	Santa Barbara Research Park	-	1962	185	10	6	665	200
Los Angeles	Palos Verdes Research Park	-	1960	410	--	--	--	--
Menlo Park	Bohannon Industrial Park	-	1950	200	75	43	2,500	500
Monterey	Del Monte Research Park	-	1958	96	36	8	--	--
Oakland	Peralta Oaks Research Center	-	1963	65	--	--	--	--
Palo Alto	Stanford Industrial Park	-	1951	790	60	70	17,500	1,750
Palo Alto	Palo Alto Industrial Park	-	1955	65	66	7	800	--
Pomona	College Industrial Park	-	1963	250	30	30	2,950	900
San Diego	Research Park	x	1956	50	50	4	300	100
San Diego	Sorrento-Valley Industrial Park	-	1965	400	--	--	--	--
Sunnyvale	International Science Center	x	1960	130	75	20	10,000	1,000
Sunnyvale	Moffett Park	-	1965	621	--	--	--	--
Thousand Oaks	Rancho Conejo	-	1958	1,000	75	16	6,000	2,000
COLORADO								
Boulder	Boulder Industrial Park	-	--	40	50	7	--	--
Boulder	Boulder Research & Mfg. Area	-	1965	345	20	6	45	20
Boulder	Colorado Ind. & Res. Campus	-	1964	720	10	2	500	250
Boulder	Twin Lakes Tech. Park	-	1966	100	7	2	50	15
Colorado Springs	Pikes Peak Industrial Park	-	1958	300	58	8	2,000	168
Denver	Denver Technological Center	-	1963	140	20	9	1,200	60
Fort Collins	Foothills Research Campus	x	1958	1,700	25	10	200	50
Longmont	Longmont Ind. & Research Park	-	1961	35	5	2	--	--
Loveland	Big Thompson Industrial Park	-	1965	50	30	2	1,200	125
CONNECTICUT								
Meridan-Wallinford	Connecticut Research Center	x	1963	850	--	--	--	--
Stamford	High Ridge Park	x	1966	40	20	2	350	150
FLORIDA								
Gainesville	Gainesville Ind. Research Campus	-	1954	265	30	2	650	40
Orlando	Orlando Central Park	-	1963	2,000	7	16	350	15
W. Palm Beach	Electronic Park	-	1960	120	40	--	--	--
GEORGIA								
Athens	Univ. of Georgia Research Park	x	1960	300	35	8	234	87
Atlanta	Interstate N. Research Park	-	1965	100	3	1	--	--

APPENDIX--Continued

State and City	Park	Research Only	Year Founded	Acres	Percent Occupied	No. of Occupants	Total Employ.	Scientists & Engrs.
ILLINOIS								
Arlington Heights	Arlington Ind. & Res. Center	-	1965	350	18	5	--	--
Champaign	Interstate Research Park	-	1963	200	30	4	225	100
Lake Bluff	N. Shore Ind. & Research Center	-	1966	86	10	3	100	30
Urbana	Modern Research Industries Park	-	1954	118	60	--	--	--
Urbana	Tawney Research Park	-	1963	60	--	--	--	--
INDIANA								
W. Lafeyette	Purdue Industrial Research Park	x	1961	95	70	10	1,460	200
IOWA								
Des Moines	Bell Av. Industrial & Research Park	-	1960	70	50	9	--	--
KANSAS								
Lawrence	Research Park	-	1961	20	15	1	--	--
Manhatten	Manhatten Research Park	-	1961	35	14	1	--	--
KENTUCKY								
Jeffersontown	Bluegrass Research & Ind. Park	-	1965	612	10	2	260	100
Lexington	Spindletop Research Park	x	1962	190	16	1	27	20
LOUISIANA								
New Orleans	Herbert Research Center	x	1965	347	--	--	--	--
MARYLAND								
Annapolis	Annapolis Science Center	x	1964	67	28	4	460	325
Baltimore	Greater Baltimore Industrial Park	-	1962	450	35	19	7,000	4,000
Bethesda	Washington Science Center	-	1963	96	30	6	2,000	--
Columbia	Oakland Ridge	-	1967	176	23	4	176	125
Gaithersbury	Metropolitan Grove Ind. Park	-	1964	32	8	1	--	--
Rockville	Danac Technological Park	-	1962	76	28	2	--	--
Rockville	Natl. Capital Research Park	-	1962	50	30	--	--	--
Rockville	Southlawn Office & Research Park	-	1961	290	--	15	--	--
Rockville	Washington Natl. Pike Ind. Park	-	1963	109	20	1	--	--
Rockville	Washington Rockville Ind. Park	-	1958	150	75	50	--	--
MASSACHUSETTS								
Bedford	Bedford Research & Office Park	-	1959	215	65	13	3,000	60
Cambridge	Technology Square	-	1960	14	100	21	1,500	500
Lexington	Lexington Industrial Park	-	1961	53	33	5	400	20
Lexington	Lexington Office-Research Park	-	1958	147	100	3	650	30
Lexington	Minuteman Research Park	-	1960	42	50	1	--	--
Lowell	Lowell Industrial Park	-	1954	200	70	7	1,600	550
Waltham	Waltham Research & Dev. Park	-	--	127	95	20	3,500	30
MICHIGAN								
Ann Arbor	Greater Ann Arbor Research Park	-	1960	210	30	7	125	--
Ann Arbor	Huron View Research Park	-	1961	19	--	--	--	--
Detroit	Detroit Research Park West	-	1966	--	--	--	--	--
East Lansing	Red Cedar Research Park	-	1964	50	5	1	12	5
Grand Rapids	Kent Research Park	-	1964	405	1	4	75	--
Jackson	Hurst Research & Dis. Park	-	1966	200	10	2	100	--

APPENDIX--Continued

State and City	Park	Research Only	Year Founded	Acres	Percent Occupied	No. of Occupants	Total Employ.	Scientists & Engrs.
MINNESOTA								
Minneapolis	Valley Industrial Park	-	1958	2,275	10	6	600	6
MISSOURI								
Columbia	Univ. of Missouri Res. Park	x	1962	300	60	8	212	142
NEW HAMPSHIRE								
Concord	Tirrell Industrial Park	-	1954	600	20	12	--	--
Keene	Keene Industrial Park	-	1956	50	90	6	2,200	100
Manchester	Greater Manchester Ind. Airpark	-	1955	130	64	12	3,570	160
NEW JERSEY								
Lawrence Twp.	Princeton Pike Park	-	1962	500	22	4	500	25
Princeton	Princeton Center for Ind. Research	-	1964	300	5	1	30	10
NEW MEXICO								
Albuquerque	University of N. Mexico Res. Park	-	1963	25	12	2	100	70
NEW YORK								
Ithaca	Cornell Industry Research Park	x	1965	300	25	21	300	200
Middletown	Mills Industrial Park	-	1964	400	5	--	50	--
Tuxedo	Sterling Forest	-	1954	20,000	--	6	1,000	230
NORTH CAROLINA								
Charlotte	University Research Park	-	1967	2,000	--	--	--	--
Research Tri. Pk.	Research Triangle Park	x	1959	5,000	30	14	5,000	2,100
OHIO								
Akron	Grant-Wash. Res. & Dev. Park	-	1964	75	15	2	--	--
Cleveland	University Circle Research Center	x	1965	12	90	9	200	100
Dayton	Research Park of Dayton	-	1965	43	10	2	75	35
OKLAHOMA								
Ada	Sci. & Natural Resources Res. Park	-	1962	--	28	1	--	--
Norman	Sweerington Research Park	-	1957	900	10	26	750	100
OREGON								
Eugene	Bailey Hill Research Park	-	1964	25	2	5	15	--
Portland	Sunset Science Park	-	1962	76	19	4	250	16
PENNSYLVANIA								
Ft. Washington	Ft. Washington Industrial Park	-	1955	600	30	53	9,000	--
Montgomery County	King of Prussia Park	-	1957	710	50	34	2,000	--
Philadelphia	University City Science Center	x	1964	22	15	3	540	100
Pittsburg	RIDC Industrial Park	-	1963	600	40	22	3,800	--
State College	Science Park	-	1958	238	15	2	1,200	600
SOUTH CAROLINA								
Clemson	Ravenel Research Center	x	1959	250	10	1	150	50
TENNESSEE								
Oak Ridge	Oak Ridge Park	-	1960	200	20	3	300	50
TEXAS								
Austin	Industrial Terrace	-	1962	91	25	7	--	--
Clear Lake City	University Park	x	1964	500	33	1	1,100	--
College Station	Noble Park	x	1967	94	1	3	20	15
Dallas	Dallas North Research Park	x	1963	1,200	5	4	1,100	--
Houston	Westpark	-	1961	80	75	36	800	100
San Antonio	Science Industrial Park	-	1964	700	--	--	--	--

APPENDIX--Continued

State and City	Park	Research Only	Year Founded	Acres	Percent Occupied	No. of Occupants	Total Employ.	Scientists & Engrs.
UTAH								
Salt Lake City	Univ. of Utah Research Campus	-	1965	400	10	7	400	209
VIRGINIA								
Blacksbury	Univ. Research Park	-	1962	168	--	--	--	--
Charlottesville	Albermarles County Res. & Ind. Pk.	-	1962	700	--	--	--	--
Hampton	Langley Research & Development Pk.	-	1965	150	10	10	475	45
McLean	Westgate Research Park	-	1962	102	60	19	2,200	600
Newport News	Virginia Center for Advanced Tech.	-	1965	240	25	1	65	11
Reston	Reston Industrial Center	-	1964	970	15	9	1,000	250
Sterling	Sterling Park Aerospace Center	-	1963	16	--	2	--	--
WASHINGTON								
Redmond	Overlake Park	-	1958	400	35	12	1,100	300
Richland	Richland Industrial Park	-	1964	290	5	1	50	21
WISCONSIN								
Madison	Fitchburg Research Park	x	1963	175	10	7	65	1,000
Oak Creek	Northbranch Industrial Park	-	1965	650	2	30	6,000	1,000
Wausau	Weston Research Park	-	1963	60	33	2	136	32

Source: "1968 I-R Science Park Directory," Industrial Research, X, No. 5 (May 1968), 95-96.

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