Massachusetts Institute of Technology: 
A Systems-Level Analysis 
and Vision for the Future 
(The Grand Plan)

by

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Abstract

This thesis conducts a systems-level analysis of the Massachusetts Institute of Technology and develops a vision for its future, called THE GRAND PLAN. First, MIT's history, in particular the founding of the Institute and the objectives that were set for it, are examined. Then the thesis proceeds to discuss MIT as it is at the present. Next, the source of MIT’s reputation, its numerous scientific and technical achievements, is presented. The analysis is concluded by discussing some of the problems the Institute will face in the near term. Since these potential challenges pose a significant threat to MIT’s excellence and current efforts to meet them are insufficient, a vision for the Institute's future, THE GRAND PLAN, is put together. Developed from the analysis of the past, the present, and the potential challenges of the future, the plan will allow MIT to, not only maintain its position as the pre-eminent science and technology university, but enhance it dramatically.

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One might be surprised to see a thesis with the title “MIT: A Systems-Level Analysis and Vision for the Future (The Grand Plan)” from the Department of Aeronautics and Astronautics but what department is better suited? The important and exciting concept of systems engineering is only taught at MIT by that department. Producing or modifying an aerospace system involves the integration of many technical disciplines, thousands of people, and a deep understanding of financial, legal, environmental, and other considerations. No other area deals with more complex systems than aeronautics and astronautics. The principles of systems engineering in use in the aerospace business can be applied with great benefits to other systems. But the benefit is mutual. If an aerospace systems engineer learns how to analyze, improve, and deal with a system of a different kind, he or she can use that knowledge in the work with aerospace systems.

The Massachusetts Institute of Technology represents a highly sophisticated system. A system is a collection of components that work together to produce one or more outputs. In the case of MIT, thousands of people in academic departments, laboratories, centers, and administrative offices work together to teach and conduct research. Through the experience I have gained in writing this thesis, I am confident to be better prepared for dealing with aerospace systems. Vice versa, I hope to have contributed to the understanding of “the system MIT” by having used my experience and knowledge of aerospace systems engineering.

This thesis has three goals. The first is to provide an analysis of MIT’s past and present, that will be a useful “reference” for people within and outside the Institute. The second is to point out the challenges that the Institute will face and motivate further efforts to meet these challenges. The third is to present the concept of an idea how these challenges can be met and MIT’s position as the leading scientific and technical university further enhanced. This vision for MIT’s future is based on some unusual ideas for a university but if they are implemented enormous benefits would be derived from them.

The fundamental concept for the vision was developed in the fall of 1993. Since a project resulting from this vision would be a very large and ambitious undertaking, the concept was named THE GRAND PLAN. A formal letter with the idea was submitted to President Vest in January 1994. A proposal entitled “Grand Plan for MIT: A Plan to Create an International Technology Showcase and Upgrade the Institute to a High-Tech Community of the Future,” coauthored with colleague Michael S. Branicky, was submitted on March 14, 1994 to Dr. Vest.

The study began in September 1994 and a presentation on the progress of the study was given on February 2, 1995 to President Charles M. Vest, Provost Mark
S. Wrighton, Associate Provost Phillip L. Clay, Director of Special Services Stephen D. Immerman, and Director of Planning Robert Simha.

The fundamental idea of THE GRAND PLAN, a concept on how it can be implemented, and the benefits that would result from it are presented in this thesis. More results of the study and some work that remains to be done will be presented in a report to President Charles M. Vest and the senior staff in the summer of 1995.

The most rewarding part of my study has been the opportunity to meet many of MIT's outstanding people and I am deeply grateful for that. Without their help this thesis would not have been possible.

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- In the MIT Museum: Director Warren A. Seamans, Associate Director Mary Leen, Assistant Director for Marketing Kathleen A. Thurston-Lighty, Assistant Director for Collections Michael Yeates.
• In the Center for Advanced Engineering Studies: Director of the Advanced Study Program Paul E. Brown.

• In Information Systems: Vice President for Information Systems James D. Bruce, Information Officer Janet M. Daly, and Daniela Aivazian.

• In the MIT Libraries: Director Jay K. Lucker, Reference Archivist Elizabeth Andrews, Librarian Eileen G. Dorschner.

• President’s Office: Administrative Assistant to the President Laura Mersky, Administrative Secretary Doreen Lopes-Smith.

• In the Special Events and Information Center: Director Mary Morrissey, Associate Director Gayle M. Fitzgerald, Staff Associate Kathleen Barrett, Staff Associate Terri Priest.

• In the Admissions Office: Director Michael C. Behnke, Associate Director Elizabeth S. Johnson.

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1.1 The Premier Science and Engineering University

The Massachusetts Institute of Technology (MIT) was founded in 1861 by William Barton Rogers. He envisioned an institution that would "overtop the universities of the land." By teaching scientific principles as a basis for industrial applications, MIT responded to the nation's need for well-trained and broadly educated engineers. The Institute was highly successful and its size and reputation grew rapidly. Soon it was recognized as the leading school of engineering in the country. In the 1930s, MIT's ninth President, Karl Taylor Compton, strengthened the Institute by expanding teaching and research in the sciences. This and the Institute's commitment in supporting the country's war effort in the 1940s, transformed MIT into one of the world's leading research universities. In the Cold War that followed, an environment in which the United States competed with the Soviet Union and defense was the country's priority, MIT prospered even further.

Today, the Massachusetts Institute of Technology stands around the world as a symbol for cutting-edge technology. The Institute draws in large numbers the world's best students and faculty. Many of its curricula are rated as the best—and the others among the best. In 1995, its graduate programs in both engineering and management were ranked top in the nation. In probably the broadest range of laboratories, MIT conducts the world's largest volume of research of any university campus. The symbiosis of excellent teaching and research has paid off and MIT's faculty and alumni are a significant force in shaping the country's—and the world's—education, policy, industry, science, and technology.

1.2 A Threat to its Excellence

However, MIT's excellence is being threatened in the 1990s. In this current era of rapid change the Institute must learn to deal with the end of the Cold War and the resulting refocusing of the country's priorities. For almost fifty years much of the Institute's research was supported by the federal government directly or indirectly because of defense reasons. With the dissolution of the Soviet Union the United States has begun to decrease its research support and will continue to do so in the years ahead.

Because of changing priorities, research support from the federal government no longer has to be awarded based on merit. In "earmarking" (an effort to distribute funds) MIT and other leading research universities may not receive grants despite their superior proposals. Changing governmental regulations pose an additional
threat to the amount and quality of teaching and research. For example, due to new regulations, financing the research opportunities for undergraduate students became twice as expensive in 1994 and maintaining graduate students might became as much as 40% more expensive in 1998.

When MIT was founded in the last century, few universities in the world offered courses in engineering. Thus, despite its modest financial and other resources, the Institute was able to become the leading university focused on engineering. One hundred thirty years later, thousands of universities compete directly with MIT and strive to surpass it. Over the years, MIT has produced many of the nation’s professors in science and engineering—between five and ten percent in the latter field. Many of them have taught at MIT but a far larger number has helped to build up the quality of teaching and research at other universities.

Much of MIT's infrastructure is old. Up to the present day, the largest single construction on campus is the original group of buildings around the great court, which was erected in 1916. Following World War II, the campus expanded considerably and several buildings date back to these years. Modern facilities are critical to the success of MIT because of its focus on science and engineering. In a 1994 survey for the NSF, MIT itself considered the research space in not a single field as sufficient for current research programs. In addition, a fairly small percentage of the overall research space was rated as suitable for use in the most highly developed and scientifically sophisticated research in the field. Thus in the next decades, MIT will have to renovate or replace many of its buildings and laboratories.

The 1980s have seen the beginning of the computer revolution and the start of the penetration of high-technology in every part of life. The 1990s are seeing an explosion of computer and information technology, as the pace of development is further increasing. While MIT can be proud that its research has helped to bring this change about, it must find ways to cope with it. In conducting research this means that constantly new equipment has to be bought to stay abreast. In the administrative area, the staff requires not just a simple typewriter and calculator, but sophisticated computer, printers, and software that regularly need to be updated at a high cost. By the end of this decade, the computer revolution will most likely extend to teaching methods, bringing an end to the chalk and blackboard and requiring the remodelling of classrooms all over the campus.

Over a period of almost 50 years, business processes evolved that made incremental use of some new technology but still became more and more outdated. These highly inefficient and overly expensive processes limit the quality and flexibility of operation and burden the budget. Similarly, the acquisition and conduct of research is an extremely decentralized effort, with almost every single faculty member straining his or her own limited resources to attract grants and conduct individual research. Due to little communication within departments and even less across disciplines, resources are not shared and hence often inefficient use of laboratory equipment and employees is made.
1.3 Reengineering the Institute's Processes

Currently the growth rate of expenses exceeds the rate of revenues, which has resulted in recurring deficits. Starting in 1989, the expenses started to surpass the revenues and all current gifts, bequests, as well as additional funds needed to be used to pay for the operating gap. By 1992, the trend became evident and serious concern regarding the financial situation arose. This represented a “wake-up call” for the Institute. In November 1993, President Vest presented to the MIT Community the problem of the growing gap between income and expenses and the strategy to cope with it. That fiscal year marked a critical point. For the first time, funds from MIT’s “savings,” the endowment, needed to be used to pay for the deficit. Projections were made that without countermeasures the deficit would double by 1997.

The administration announced budget cuts over the next few years to reduce the gap but also commenced a large-scale reengineering effort. As Figure 1.1 shows, a single budget cut would not solve the deficit problem in the long-run.

![Diagram](image)

Figure 1.1: This figure illustrates that a single budget cut does not solve the problem of budget deficits. Since the rate of growth of expenses is higher than that of income, deficits will recur despite budget cuts.

The reengineering effort is the critical component of the evolving plan to bring the rate of growth of expenses to the same value as the rate of growth of revenues. Using the concept of reengineering laid out in the book Reengineering the Corporation: A Manifesto for Business Revolution by Michael Hammer and James Champy, MIT is redesigning the Institute’s business processes.

Over a period of three years, reengineering teams will be formed to redesign business processes, test them, and implement. Examples of areas that are being “reengineered” are custodial services, mail service, supplier relations, and management reporting. The goal set forth is to reduce the annual operating expendi-
Chapter 1: Introduction

tures by $40 million out of a “controllable” budget of $400 million. When subtracting the fraction that is paid as indirect cost by research sponsors, this would yield a net reduction of about $25 million annually.

While the reengineering effort is imperative to the well-being of the Institute, it alone is not sufficient. Savings of $40 million would avoid an operating gap under current conditions, but only a small surplus—if at all—would remain. Considering that the expenditures for on-campus activities were $822 million\(^1\) in 1994, MIT needs to find new ways of meeting the challenges in the years and decades ahead to considerably improve its teaching and research. Maintaining the current level is not sufficient, indeed it means falling behind as others catch up.\(^2\)

1.4 A Vision for the Future

The current situation is certainly difficult, yet it has a bright side, because it brings new opportunities with it. For instance, it has already motivated the reengineering of Institute business processes, providing near-term benefits with more improvements to be achieved in the future.

Prompted by the current difficulties and the associated opportunities, this thesis provides a system-level analysis of MIT and develops a vision for the future which has become known as THE GRAND PLAN. While the reengineering effort looks at the “sub-system level” and tries to make components smaller and leaner to reduce expenses, THE GRAND PLAN looks at the “system-level” and tries to expand selected portions of the Institute to increase revenues. Jointly, with reengineering, THE GRAND PLAN attacks the budget deficit—and turns it into a surplus by reducing the slope of the “expenses line” and increasing the slope of “revenues.”

The number one priority for the Institute has been stated as “maintain and enhance MIT’s position as the leading academic institution focused largely on science and technology.” All other stated priorities follow from that. How can an enhancement of MIT’s position be achieved with all the challenges the Institute is facing? The concept or strategy that can achieve enhancements that and more is the GRAND PLAN. The plan takes advantage of MIT’s unique resources, skills, and reputation to

- improve teaching to better prepare students for their careers and help them to find jobs in a competitive market.
- conduct more and better research, in close cooperation with industry, that will improve the lives of people all over the world.

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1. A total of $226 million for instruction and unsponsored research and $263 million for sponsored research.

2. For example, MIT’s Electrical Engineering & Computer Science Department is not rated as the best in the 1995 U.S. News & World Report Survey of graduate engineering programs.
Section 1.4: A Vision for the Future

- strengthen the Institute's financial resources to make it more flexible, independent, and entrepreneurial.
- help attract and keep the best faculty, students, and staff.
- provide the world's finest facilities and equipment to the MIT Community.
- dramatically improve the standing of the Institute in the view of the local community, the government, and the world.
- Provide an environment that yields the highest quality of life on campus.

As its name implies, THE GRAND PLAN is a highly ambitious undertaking. The plan would affect all areas and all people of the Institute. It asks for a paradigm shift for the Institute. But it is something MIT needs to do if it does not want to fall into mediocrity.

The Concept of THE GRAND PLAN is fairly simple and can be summarized with the words "opening up to the public” and “double use.”

Instead of being a bare and uninviting place for visitors, MIT would open itself up to the public and share its past, present, and future. A Visitor Center would be the starting point where all visitors would enter "the world of MIT." At the center, people would be able to learn about MIT in general through an IMAX film and several small exhibits. Prospective students and their parents would find in the center an expanded admissions reception center. Alumni and alumnai would find the Alumni Association and companies would start their interaction with MIT at the Industrial Liaison Office.

At the Visitor Center people would be able to go to the MIT Museum, the Technology Showcase, or on a tour of selected MIT laboratories. At the museum, visitors would gain an understanding of MIT’s past achievements and how the Institute has changed—and improved—all our lives. They would also learn about hacks and other things part of MIT’s culture.

The present state-of-the-art in technology would be shown in the Technology Showcase. The showcase would be a large exhibit area in which companies, small and large from all over the world that work with MIT, would present their upcoming products and provide a feel what people may expect to use in the near term. The prototypes and finished products on display would be of a large variety. They might include cars, computers, audio and video equipment, or anything else that is new or up-and-coming.

A unique glimpse into the future would be given to visitors through a tour of some of MIT’s laboratories. On these tours, people would learn about the on-going research at the Institute and how it can improve our lives. Through the “double use” of equipment and laboratories for research and exhibition, it is hoped that many companies would be willing to donate equipment and share the cost of renovating and upgrading facilities that need improvement.
In addition to the visitor facilities, a hotel and conference center would be erected nearby to accommodate the visitors and provide better facilities for conference that MIT has currently available as well as attracting many new ones.

At a later stage in the project, the goal would be to convert the entire campus into a “high-tech environment city.” MIT would serve as the testing ground for new technologies. Instead of helping industry develop them in the first place and then having to purchase them later on, the Institute would be able to use new products right away. Thus, the campus would become a “model environment” and place for individuals and companies to study what awaits them and what opportunities are there. As a consequence of being a model for the entire world, it becomes justifiable to build many new facilities or improve existing ones. Examples would be research and teaching support facilities such as a new library, or new computer clusters, or better components of the overall infrastructure such as better roads. No other universities could afford or justify to assemble an array of equipment and laboratories that would rival MIT’s and hence give the Institute a competitive edge in the future that it will need.

1.5 Outline of the Thesis

When an institution arrives at a critical point in its history, it is beneficial to go to the beginning, that is back to the roots and examine earlier key events. Chapter 2 “MIT’s History in Perspective” discusses the founding of the Institute and the vision that William Barton Rogers had for the institution. While the Institute has become a great school as was hoped, it was envisioned to be more than just a university. MIT was founded to be a triple organization of an engineering society, a museum of engineering, and a university. But only the component named last was realized. In THE GRAND PLAN the original vision for MIT could be finally fulfilled. It seems strange for a university always looking ahead, but MIT’s future may lie in the seeds of its past. Chapter 2 also discusses MIT’s relocation from Boston to Cambridge in 1916. The relocation represented a highly ambitious undertaking for the still young institution. However, after the project MIT not only gained a new magnificent home, but also strengthened its financial resources.

Chapter 3 “MIT Today” presents the structure and operation of the Institute today. It is beyond the scope of this thesis to discuss all parts of the Institute, hence Chapter 3 focuses on those parts of the Institute that would undergo major changes in THE GRAND PLAN. For readers outside MIT, it is especially useful to familiarize them with the Institute.

While MIT is highly regarded, few people—even at MIT—know how great the Institute really is. Part of that lack of knowledge is due to the fast pace of life, leaving little time for learning about the school; part of it is due to MIT’s lack of effort to educate its own community and the public about its achievements. Chapter 4 “The Premier Technical University” discusses accomplishments of the Institute and its people. When learning of all the contributions of the Institute, one realizes that MIT is a national and global treasure that has shaped our lives in end-
less ways. These past accomplishments and the on-going work for future ones provide MIT with the opportunity to share a vision with the public. It also gives the Institute a profound responsibility, since the work at MIT has and will change people's lives.

Many of the challenges that the Institute is facing and will face in the future have been mentioned earlier in this introduction. Chapter 5 “Challenges Ahead” examines in detail the internal and external that endanger the excellence of the Institute. In addition to an examination of the larger issues, Chapter 5 looks at the problems in admissions, the libraries, and the computer network that we must face in the years ahead.

How MIT can meet the challenges of the future, THE GRAND PLAN, is presented in Chapter 6. The chapter will discuss first the fundamental concept of THE GRAND PLAN such as “opening up,” “double use,” and how it fits with MIT’s past, the current priorities set, and fulfills our need for becoming more entrepreneurial. The implementation, such as the Visitor Center, the Technology Showcase, the MIT Museum, etc. would be discussed next. The chapter would be concluded with a discussion of the benefits THE GRAND PLAN would bring to MIT.

References


CHAPTER 2
MIT’S HISTORY IN PERSPECTIVE

To understand the Massachusetts Institute of Technology today and develop a vision for the future, it is useful to examine the Institute’s history. This chapter discusses two events of importance for the concept of THE GRAND PLAN—the founding of the Institute in and its relocation from Boston to Cambridge.

MIT’s founder William Barton Rogers envisioned a polytechnic institution that would “overtop the universities of the land.” His vision and how his dream was realized is presented in the first section of the chapter. What is little known, is the fact that MIT was intended to be more than just a university. The Institute was established to be a triple organization consisting of a Society of Arts, a Museum of Arts, and a School of Industrial Arts, where the term art was used in the meaning of engineering. However, only one component, the school, constitutes MIT today. Section 2.2 and Section 2.3 discuss the other two parts of the Institute that were thought to be the main components of the institution and that would interact extensively with the school but were never realized as the founder envisioned. As part of the vision for the future, the museum and the society would be realized in a modern form.

The most ambitious undertaking of MIT ever was the Institute’s move from its overcrowded and poor buildings scattered throughout Boston to its magnificent buildings in Cambridge. Section 2.4 shows that MIT, under President Maclaurin realized that the facilities are not only important to carry out the school’s work better but also reflect its standing as the world’s finest university focused on engineering. Also an insight on how the then fairly young institution accomplished such a formidable task while not diminishing its endowment but actually increasing it is provided.

2.1 The Founding of the Institute

The history of the Massachusetts Institute of Technology goes back to the 1840’s, when William Barton Rogers and his brother Henry Rogers started thinking seriously about a great new polytechnic school in Boston. The first engineers in the United States were mostly self-taught or had an apprenticeship to some of the few men in America that had a more extended knowledge of mathematics and mechanics. West Point, which was founded in 1802, became the first institution that offered a formal training in military engineering. By the 1840’s several schools were established that offered civil and military engineering but they could not meet the country’s need for well-trained engineers. The Rogers brothers considered the training provided by the existing schools as too narrow and vocational.
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William and Henry Rogers wanted to provide young men with a solid foundation for a professional career in engineering while at the same time providing a broad education more suitable than a traditional university would offer.

The Lowell Institute in Boston seemed like a perfect basis from which a scientific and technical education could be provided. In 1844, Henry Rogers established contact with John Amory Lowell, the only trustee of the Institute. Two years later Henry attempted to convince Mr. Lowell to establish a School of Arts as a branch of the Lowell Institute. In response to a letter from his brother, William described in a document his views on a Polytechnic School of Arts. This 1846 document which was later entitled “A Plan for a Polytechnic Institution in Boston” described in many details with numerous examples the plan for a school that would ultimately “overtop the universities of the land” and teach not just technical skills but instead the scientific principles that are the basis for industrial applications. This proposal for a technical school was presented by Henry Rogers to Mr. Lowell. However, the plan was turned down due to provisions of the will that had originally established the Lowell Institute. Henry left Boston in 1855 after accepting a professorship at Glasgow University, which left William alone to realize the polytechnic school.

The plan for a technical school lay dormant for thirteen years until the filling of Boston’s Back Bay provided a unique opportunity. Boston was growing steadily and needed more land, so the broad and shallow basin of the Charles River known as the Back Bay was filled to provide new land for development. In 1859, the governor of Massachusetts suggested to use some of this land for educational purposes. In response to this suggestion a group of scientific and educational societies under the name *Associated Institutions of Science and Arts* drew up a petition for state land to be used for these societies. Although the petition was presented, it was not granted.

In the following year another attempt was made to convince legislature to grant land. This time Dr. William Rogers was asked to prepare the petition. The plan outlining the institutions to be erected on the land was much more detailed than the original one which had been hastily written, but was still unsuccessful. The petition passed the House but was defeated in the Massachusetts Senate. Despite the defeats, a sub-committee of the petitioning group under the chairmanship of Dr. Rogers prepared a third proposal. This proposal entitled *Objects and Plan of an Institute of Technology; including a Society of Arts, a Museum of Arts, and a School of Industrial Science, proposed to be established in Boston* was addressed to “Manufacturers, Merchants, Mechanics, Agriculturists, and other Friends of Enlightened Industry in the Commonwealth.” In a letter to his brother Henry, William wrote that his plan was “very large, but ... much liked.” William and the other members of the committee turned for inspiration to large European museums and conservatories which sometimes included schools. They envisioned a three-part institution as the plan described:

> With the view of securing the great industrial and educational benefits ..., it is proposed to establish, on a comprehensive plan, an Institution devoted to the Practical Arts and Sciences, to be called the Massachusetts Institute of Technol-
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...ogy, having the triple organization of a Society of Arts, a Museum or Conservatory of Arts, and a School of Industrial Science and Art.

The goal of the Institute was to aid "the development and practical application of science in connection with arts, agriculture, manufacturers and commerce." It was hoped and expected that all three components would interact extensively and all contribute to the diffusion of knowledge.

The first part of MIT would be the Society of Arts. It was proposed to be "a department of investigation and publication, intended to promote research in connection with industrial science, by the exhibition, at the meetings of the Society, of new mechanical inventions, products, and processes." An important feature of the overall plan would be the establishment of the Journal of Industrial Science and Art. This journal would contain the proceedings of the Society, the condition and progress of the Museum, as well as the School of Industrial Science. It was hoped to become a record of the advancement of engineering and science in the United States and the world in general.

The "central feature" of the proposed Institute of Technology was to be the Museum of Arts. The departments of the museum would have the primary task of "forming a collection of objects of prominent importance, as illustrating the respective Arts." It is important to note that MIT's founders did not see the museum as just a collection of objects but rather as an important tool for instruction:

A mere miscellaneous collection of objects, however vast, has little power to instruct, or even to incite inquiry. The practical teaching and the real suggestiveness of a Museum is almost wholly dependent on the clear and rational arrangement of its parts, and the leading ideas which rule their classification. We would therefore aim at having the Departments of our Museum well distinguished from each other, and the objects in each placed in their connections, so as to display readily their nature or construction, and to facilitate their comparison with others of the same class.

Objects and Plan of an Institute of Technology described also that the Museum would be further enhanced by the exhibition of new inventions and by the display of machinery in actual working operation. The Museum was to appeal to "not only of those immediately devoted to industrial pursuits," but also to "intelligent fellow-citizens in every walk of life." For students, architects, and engineers the Museum would provide "large opportunities for comparison, and precious helps and incentives for improvement."

Since the Society and the Museum alone could not fulfill the mission of diffusing practical knowledge, the Massachusetts Institute of Technology was to include a third component—The School of Industrial Science and Art. In conjunction with the Society and the Museum it was to provide systematic training in the applied sciences.
Copies of *Objects and Plan of an Institute of Technology* were distributed throughout Boston and the Commonwealth of Massachusetts. The plan was well received and it was decided to hold a meeting on January 11, 1861, for the purpose of adopting measures preliminary to the organization of the Institute and to petition legislature for a charter and a portion of the Back Bay lands. A committee of twenty, in addition to chairman Professor Rogers, was appointed to obtain from legislature an act of incorporation and a grant of land in the Back Bay for its use. Three days later the third appeal to the Massachusetts legislature was made by the Associated Institutions of Science and Arts. This time, however, the plan was successful. Some opposition existed, but eventually, on April 10, 1861, the “Act to Incorporate the Massachusetts Institute of Technology” was approved by Governor John A. Andrew:

William B. Rogers, … , their associates and successors are hereby made a body corporate by the name of the Massachusetts Institute of Technology, for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science, and aiding generally, by suitable means, the advancement, development and practical application of science in connection with arts, agriculture, manufacturers and commerce; with all the powers and privileges, and subject to all the duties, restrictions and liabilities, set forth in the sixty-eighth chapter of the General Statutes.

By the act, the Institute was granted a two thirds of a piece of land in the Back Bay between Newbury Street and Boylston Street and given one year to raise a guaranty fund of $100,000 and accept the charter.¹

The task of raising the required amount in one year was considered difficult by MIT’s founders but proved to be impossible with the outbreak of the Civil War on April 14, 1861.

Barely before the deadline, Professor Rogers asked the members of the committee for a meeting on April 8, 1862, to officially accept the charter, elect a board of trustees, adopt by-laws, appoint ad-interim officers, and take other action necessary to organize the Institute. Since only a small fraction of the guaranty fund was raised, the Institute was forced to ask legislature for an extension. As ad-interim President, Professor Rogers made an application to the governor and the council. To President Rogers’s relief it was promptly accepted.

The first official meeting of the Massachusetts Institute of Technology as a corporation was held on May 6, 1862 in which the president and other officers were elected. Since this new institution was extremely short on funds, it could only inaugurate one of its three branches—the Society of Arts which did not involve any serious expenses. The first public meeting of the Massachusetts Institute of Technology was hence a meeting of the Society which was held on December 17,

¹. The act to incorporate MIT granted also aid to the Boston Society of Natural History by providing it the easterly third of the square state land in the Back Bay. The society was founded 31 years earlier and is today known as the Boston Museum of Science.
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1862, in Mercantile Hall on Summer Street in Boston. In his introductory address President Rogers said:

In its meeting as a Society of Arts, twice in every month, the Institute will have in view, as its leading object, the promotion of the practical arts and sciences through the medium of written and oral reports and communications and the exhibition of models, materials, products and other objects relating to them, as well as through explanations, descriptions and criticisms to which they may give rise. ... The present accommodations are amply sufficient for our immediate purposes as a Society of Arts, and nothing is needed for the success of this branch of the Institute but that members and friends shall contribute from their stores of knowledge and invention whatever may give value and interest to the meetings in this hall.

At this first meeting three technical papers were read. R. B. Forbes read a paper on "Sub-Aqueous Gun Firing" and one "On the Combination of Wood and Iron in Shipbuilding." E. S. Ritchie, a known maker of scientific instruments at that time, described in a paper his own "Improvements in the Construction of Ship and Boat Compasses." In addition, models of new inventions were displayed and remarks on various subjects made.

Before the first meeting of the Society, on July 2, 1862, President Lincoln had signed the Congressional Land-Grant Act (Morrill Act). Through this act, a fund was created by each state for the endowment of "at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts."

In response to the Congressional Land-Grant Act, Governor Andrew proposed a union of all schools in the Boston Area—or even Massachusetts. By virtue of its stature and vast resources, Harvard University would have been in this scheme the dominant and controlling component. However, this plan was strongly opposed by Professor Rogers. He made clear that the Institute would not accept any grant which would in the slightest interfere with its independence. The State yielded to the arguments presented.

A charter amendment on April 27, 1863, provided to the Institute a one-third share of the annual income of the state's land-grant fund. Though this income was significant in the beginning, it was never as important as expected. However, because of it, Professor Rogers and his associates promised to make the School of Industrial Science the major component of Institute. Thus, the focus on the school was mainly due to a lack of money.

By the end of March 1863, just days prior the second deadline for raising the guaranty fund, MIT had pledges for only $40,000. On the very last day of the grace period, Dr. William J. Walker, a Boston physician, announced a gift of $60,000 which completed the guaranty fund. This large gift ensured the survival of the Institute at its most critical moment.
With the guaranty fund completed, work on a building for the Massachusetts Institute of Technology began. Professor Henry Rogers mailed from Glasgow designs of schools in Europe to aid his brother in the task of designing MIT’s first building. In an August 1863 letter Professor William Rogers wrote to his brother in regard to the building:

We have come to no final decision as to the form of the building we are about to erect, but shall probably do so in the course of the present month. This structure is designed mainly for the teaching department, and will embrace lecture-rooms, laboratories and apparatus rooms, together with an ample space for the School of Design. This will leave room for the beginning of the practical museum, but it is proposed, as soon as the School of Practical Science has gone into successful operation, to put up a separate building for the museum, at the opposite end of the area to that occupied by the Natural History building, and symmetrical with that building.

Before the end of 1863, Professor Rogers’ plans for the new building in the Back Bay and a curriculum for the School were well on the way. In December President Rogers reported on the progress of the Institute to Governor Andrew for his annual message:

The Massachusetts Institute of Technology, having complied with the conditions of the Act allotting to its use a portion of the Back Bay land, has been put in possession of the same, and has commenced the erection of a building, one hundred and fifty feet long by one hundred feet wide, midway on the space assigned to this association and the Society of Natural History. This building, designed especially for the accommodation of the School of Industrial Science, will afford space also for the Museum of Arts and Manufacturers until it shall be found expedient to provide for the latter a separate edifice, to be erected at the western end of the assigned space in correspondence with the Natural History building now completed at the other extremity.

The Institute has formally accepted the Act of Legislature assigning to its use a portion of the fund accruing from the Congressional grant of public lands, for the benefit of Schools of Agriculture and the Mechanic Arts.

Besides its operations as a Society of Arts, begun last year and now in successful progress, the Institute is preparing to open some of its courses of practical instruction, and to begin the organization of the Industrial Museum.

On May 30, 1864, President Rogers presented to the Corporation a detailed plan for the School in which he outlined its structure, its courses of study, and the teaching methods. The document was adopted, published, and distributed under the title *Scope and Plan of the School of Industrial Science of the Massachusetts Institute of Technology*.

In early 1865, after two years of construction, the MIT building was still not completed. Reluctant to wait any longer, Professor Rogers opened a preliminary session of the School on February 20, 1865, at the Mercantile Library in downtown Boston with 15 students. The first regular session of the School began on October 2, 1865, with 72 students and 10 faculty members. Classes were still held in the
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hall of the Society of Arts. Only in the following spring was the MIT building completed and occupied.

Figure 2.1: MIT's first building, later named the Rogers Building, in Boston's Back Bay between Boylston Street and Newbury Street.

In January 1866, MIT published *The First Annual Catalogue of the Officers and Students and Programme of the Courses of Instruction, of the School of the Massachusetts Institute of Technology*. A copy was sent by President Rogers to Governor Bullock and members of the General Court. President Rogers was not only the head of the Institute but also a professor in charge of the Physics Department. In 1868, however, he suffered a stroke during a faculty meeting and Professor of Mathematics John D. Runkle was appointed acting president—two years later he was made the second president after President Rogers resigned due to his poor health. In these early years, MIT's School of Industrial Science grew faster than most people would have predicted. The student enrollment went from 72 in 1865–66 to 264 in 1871–72. The year 1873 was marked by a general economic depression which soon left the Institute struggling for money. It was decided not to cut faculty salaries but cutbacks in chairs and subjects taught were made.

In 1878 President Runkle resigned because of poor health and William Barton Rogers became again President of the Institute but under the condition that $100,000 were raised to ensure MIT's financial stability and that the search for a successor would begin immediately. This successor, to MIT's wisdom and luck, turned out to be Francis Amasa Walker, who assumed the Institute presidency in 1881. It was President Walker who transformed MIT in his 16-year presidency.
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from a school of regional importance to one of national and even international stature. In his President's Report 1891–92 Walker wrote:

To-day, after a quarter of century of zealous and disinterested effort, the Massachusetts Institute of Technology stands as the largest scientific and technical school in the United States, and one of the most important in the world.

President Walker expanded the faculty to 158, boosted the enrollment to 578, and quadrupled the space available to the Institute. But most importantly, he attracted numerous gifts. Constantly he reminded everyone of the pressing financial needs of the Institute. In 1894, he wrote that “its needs are so great because it itself is so much needed.”

As said earlier, the success of MIT's School was so great and the overall resources of the institution so small, that basically all funds were channelled towards the school. In 1888–89 the Twenty-fourth Annual Catalogue would state that “the School of Industrial Science, developed along the lines indicated at its foundation, has become the prominent feature of the work of the Institute; and, indeed, nearly all persons know it, and it alone, as the Institute.”

2.2 The Society of Arts

As was discussed in the previous section, the Society of Arts was the first component of the triple organization MIT. Since it did not require any significant funding, it was the first part of MIT that was inaugurated. From its first meeting on December 17, 1862, it held regularly meetings on the second and fourth Thursday of each month from October to May. First the meetings were held in Mercantile Hall on Summer Street but once the Back Bay building was completed, the Society of Arts used one of the larger rooms on its first floor for meetings.

An early annual catalogue of the Institute explained the purpose of the Society as follows:

The objects of the Society are to awaken and maintain an active interest in the practical sciences, and to aid generally in their advancement and development in connection with arts, agriculture, manufacturers, and commerce.

The Society invites all who have any valuable knowledge of this kind, which they are willing to contribute, to attend its meetings, and become members. Persons having valuable inventions or discoveries which they wish to explain, will find a suitable occasion in the Society meetings; and while the Society will never indorse by vote or diploma, or other official recognition, and invention, discovery, theory, or machine, it will give every facility to those who wish to discuss the principles and intentions of their own machines or inventions, and will endeavor at its meetings, or through properly constituted committees, to show how far any communications made to its are likely to prove of real service to the community.

In addition to holding meetings, the Society published in a journal the papers that were presented. The goals of the Society were essentially to advance technical knowledge under its aegis and become through its publications a record of the
progress made in all areas of science and engineering. Despite its sincere efforts, the Society was unable to accomplish its original mission—simply because of the change in conditions since its founding. In the middle of the nineteenth century, lectures were a popular mean of diffusing scientific and technical knowledge. When once on a rainy night Professor Rogers gave a lecture on "Physical Forces" some two thousand people came to hear him. But by the end of the century, lectures lost their appeal to the general public. For practicing scientists and engineers, specialized societies and journals became the primary choice of presenting their new theories, discoveries, and inventions.

In the early years of the Institute, the President's Report included in every issue information on the number of meetings, the attendance, and the titles (sometimes with abstracts) of the papers presented to the Society of Arts. In addition, the members of the society were listed in the back of the report. With the years, less and less pages of the President's Report dealt with the Society of Arts. Right after the turn of the century, from 1901–02 onward, the interest and attendance of the Society started to diminish drastically. While the average attendance of a meeting in 1901–2 was 216, by 1908 it was down to 60. On April 20, 1916, the 694th and last meeting of the Society in its original form was held. Then MIT President Richard C. Maclaurin suggested in January 1917 a new purpose for the Society of Arts. The plan was to give at the Institute a series of scientific lectures for the benefit of Boston Area high-school students. Since the response from the schools was extremely positive, the plan was inaugurated in February 1917, when Professor Henry P. Talbot gave the first lecture under the title "Chemistry and What it is About."

In the following decades the Society of Arts offered four or so Popular Science Lectures to students in preparatory schools and to the public. These lectures were highly successful and well attended.

### 2.3 The Museum of Arts

It is an irony that what was intended to be the "central feature" of the Massachusetts Institute of Technology was never realized. As was said earlier, MIT's founders envisioned the Museum of Industrial Arts and Science, or Conservatory of Arts as a vast collection of objects arranged by departments to use it as a tool for instruction. The museum was intended to be of great use to the students of the School as well as to practicing scientists, engineers, architects, etc. and to the general public. It would not only exhibit historic objects but also the newest inventions and machines in operation.

From the beginning it was understood that the magnitude of the museum's mission was vast. Clearly large amounts of money were needed to acquire, house, maintain, and keep current collections and machinery. For a new institution that was barely surviving it was certainly too big of a project to undertake immediately. However, President Rogers and others were confident to inaugurate the
museum as soon as the School was well established. In an 1865 letter to his brother Henry, President Rogers wrote in regard to the museum:

Please get from Archer [the curator of the Edinburgh Museum] a statement of the annual appropriation and expenditures for his museum, and any documents he has published relative to it. I am anxious rather to keep back this department of our Institute until the school is decently provided, as I know that in the way of building, etc., it would soon swallow up all our means. In the new building I am setting aside one grand large room for the beginning of the Museum; shall first provide a complete set of models, of machinery, or rather mechanism, and of architectural and engineering combination, etc., to help our instruction, as well as to form the beginning of a museum raisonné.

President Rogers hoped that in about two or so years funds could be raised to erect the second building of the Institute which would house the museum. Because of the almost overwhelming growth of the School and the severe financial problems, by 1881 there was still no sight of the museum. In November 1881, William Barton Rogers introduced at a Society of Arts meeting to the public Francis Amasa Walker as MIT’s new president. On this occasion MIT’s founder reflected upon the history of the Institute so far:

The Institute was founded originally for a threefold purpose,—for the establishment of a Society of Arts, a Museum of Industrial Arts and a School of Industrial Science. That particular element in the original constitution or charter of this Institute which stands last in the enumerating is that which we all recognize as vastly the most important; and yet this enumeration seems to indicate how much still remains for the friends of the Institute to do. The department of a Museum of Arts is to be established on a proper foundation. Great as our school has become in the eyes of those who are familiar with this class of institutions in this country and abroad, still it must be supplemented by a grand museum of practical art and the proper development of this Society of Arts, in order to give it that fullness and comprehensiveness which will correspond to its original plan.

President Walker and his successor were so consumed by the demands of the School and limited by the lack of funds that there was opportunity to undertake any serious steps to inaugurate the Museum. Finally, in 1936 the immediate needs of the Institute were satisfied and the financial situation bright enough to look again at the charter to examine what was still to be done to fulfill MIT’s overall mission. Karl Taylor Compton, who became MIT’s ninth president in 1930, offered in the 1935–36 President’s Report his view on what the Institute should do in the following years. The fourth item dealt with the establishment of the Museum:

In view of the fact that the Institute’s charter calls for a museum of arts, and in view of the undoubted value of a museum of science and industrial art for the enlightenment of the community and the educational experience to the students, thought has been given to means for providing this feature at the Institute in an economical and effective manner. To this end interesting exhibits are gradually being set up along the walls of the Institute’s three miles of corridor space, where they are easily accessible to students and visitors. Funds are needed to expedite this development and to secure some particularly valuable exhibition features whose acquirement now appears to be a possibility.
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In response to President Compton's call for a museum, the Committee on the Technology Museum was formed. This committee consisted of Chairman Professor Edwin S. Burdell, Secretary A. C. Watson, and four other members of the MIT faculty. This committee was appointed to study and direct the museum expansion throughout the Institute. The objective was "to record the steps in the development of science and engineering and to identify the men of science and engineering with their particular contributions." The Committee followed the original plan for the Museum of Arts in the sense that it pursued a policy of departmentalization. It was hoped and expected that "eventually each department would have its own museum in the corridors, alcoves and entranceways adjoining its own offices and laboratories." In addition, to the committee a Museum Council was formed to which each academic department was invited to send a representative.

In its first report the Committee on the Technology Museum had already a significant list of accomplishments to present. It remodeled the elevator alcove off the main lobby for rotating exhibits, provided exhibit cases for the Electrical Engineering Department, which displayed the evolution of the telephone and the vacuum tube. It also labeled machines and equipment in the major laboratories, added a new room to the Nautical Museum, arranged the exhibit of historic telegraphic instruments, and much more. In the following years significant progress was made and the committee was pleased with the cooperation from several departments of the Institute. The Mathematics Department for example created a mathematics museum at the entrance way to Lowell Court. In 1939, an outstanding addition to the Technology Museum was the Dard Hunter Paper Museum which was formally opened on Alumni Day. The collections was considered to be "complete and definitive in respect to the history and the technology of handmade paper, and … to the craft of printing."

Not only was the committee in charge of exhibits at MIT, but also outside. The Committee on the Technology Museum was assigned the task of putting together exhibits to represent MIT at the New York World's Fair. At the same time the Visiting Committee for the Museum was founded.

All the efforts to build up the Technology Museum that would be worthy of MIT's stature came to a halt in 1942 when the war effort consumed all of the Institute's energy. Incidentally, the 1941–42 issue of the MIT President's Report was also the last that included a discussion of both the Society of Arts and the Museum of Arts.

2.4 Relocating from Boston to Cambridge

From its fairly modest beginning in 1865, the Massachusetts Institute of Technology had grown in a period of more than 40 years to a considerable size. In June 1909, when Richard Cockburn Maclaurin became MIT's sixth president, the Institute had a student body of almost 1,500 and a teaching staff of 300. To the original building in the Back Bay came fifteen others which were scattered throughout the Boston Area and were located as distant as Brookline, Mass. and Roxbury, Mass. Clearly the facilities were unable to meet the needs of the Institute.
Moving the Institute to a more spacious and quiet location from the Back Bay was considered seriously for the first time in 1902. In the following years the issues were investigated and debated. When President Maclaurin assumed his position it was generally agreed that moving MIT was the best solution to the problem. President Maclaurin realized even before he assumed the presidency that finding a new site and erecting new buildings for MIT would be the primary task of his work.

When Richard C. Maclaurin visited Boston in April 1909, alumnus Charles A. Stone pointed out that the Cambridge side of the Charles River Basin was one of the sites that were originally considered but rejected. The basin had resulted from the Charles River Dam and the land had been filled in the recent dredging of the basin. To Maclaurin this site struck as ideal. It was in his opinion perfect in location, size, accessibility, and dignity. However, Mr. Stone argued that there were too many objections to this site with the primary two being the resistance from Cambridge to further increase the amount of tax-exempt land and the opposition from Harvard.

In his first President's Report, Richard C. Maclaurin recapitulated the grounds for relocating MIT. From his ten-point list of reasons, the fourth is worthwhile of special attention:

_Fourth._—This overcrowding and scattering of buildings not only limits the efficiency of the Institute, but robs it of the outward dignity of a great educational institution. It should be part of the education of an engineer or an architect to be brought up under conditions that impress him with the dignity of his profession; the lack of such conditions, not only acts unfavorably on the student, but reacts on the public. It fails to attract their attention to the importance of the Institute and the claim that it has on their support.

Further, he wrote in his report:

I realize that most of the Institute's difficulties are due to its success and not to its failure, and I believe that a splendid future is assured to it, if, at this critical stage of its history, it does not falter through lack of courage. ... My own opinion is that the risk is not great, provided only we have the active co-operation of all those interested in the Institute.

The prospect of raising the money required to purchase a new site for MIT seemed rather bleak in the beginning. Appeals to Carnegie, Rockefeller, and others produced no results. Despite the rather negative outlook in 1910, President Maclaurin was convinced that 1911 would be a memorable year for MIT. An indeed it was. In alumnus T. Coleman du Pont, President Maclaurin found the man who had large funds and was willing to donate to MIT. Mr. Du Pont made a gift of $500,000 with two key conditions. One was that at least 45 acres would be found for MIT since he believed that “Technology will occupy a great position in the future and must have room to grow.” The second was that Alumni or others would raise $1,500,000 for the Institute. In addition, MIT appealed successfully to the state for assistance. Perhaps the key reason why aid was granted was the Congress of Technology. To support the growing public interest in the Institute and to
demonstrate its importance in science and engineering, MIT organized under the leadership of alumnus Arthur D. Little a Congress of Technology, which was held on April 10 and 11, 1911. The congress was highly successful. The Institute received national attention and the general public began more and more to realize that the future prosperity of the country was connected with technology.

President Maclaurin received invitations to relocate MIT from many communities—as far away as Springfield, Massachusetts and Chicago. At this stage, the city of Cambridge showed interest and open invitations were sent from various Cambridge organizations and most importantly from the City Council together with a personal endorsement of the mayor. By October 1911, the site problem was solved. The Institute would acquire for $775,000 the land President Maclaurin thought of from the very beginning. The pleasant fact was that the area purchased was with 50 acres five acres larger and the price $250,000 lower than expected.

Once the site was purchased, two new tasks were waiting. The first was to raise funds for the new buildings and the second to actually erect them. The key gift for the new buildings was from the anonymous “Mr. Smith” in the amount of $2.5 million. It was only eight years later revealed that “Mr. Smith” was George Eastman, founder of Eastman Kodak Company. Mr. Eastman showed great generosity over the years by donating $20 million during Maclaurin’s presidency.

In February 1913, William Welles Bosworth was chosen as the principal architect and in July the Stone and Webster Engineering Corporation as the construction company. President Maclaurin wanted New Technology, as MIT fondly referred to the future buildings, to be “in every way adequate to the magnificent site and to an institution of learning which was to be first in its field.” He was determined that MIT students should receive their education in a beautiful and magnificent surrounding.

Construction began in 1913 and was an enormous undertaking. From an engineering perspective, the main problem was the fact that the land was made from mud out of the Charles River and earth from subway construction. As a consequence a total of 22,000 piles had to be driven to support the buildings. When the financial situation became difficult at one point, it was suggested to use brick instead of Indiana limestone to save money, but Bosworth and Maclaurin prevailed in their beliefs that MIT must be housed in truly outstanding buildings. It fell upon President Maclaurin to supervise all plans and the construction of the buildings—he was personally involved in even the smallest decisions.

The original Plan was that the new buildings would house all departments and the entire Institute would move simultaneously. But a Supreme Court decision put restrictions on the sale of MIT’s first property in the Back Bay. To limit the expenses it was decided to house the Department of Architecture in the Rogers Building until the property could be sold. The “sacrifice” of the Department of Architecture was “a violation of President Maclaurin’s principle of educational unity which he never ceased to regret.”

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The dedication of the New Technology was a three day extravaganza. Samuel C. Prescott wrote that "the days from June 12 to June 14 [1916] witnessed a series of dramatic episodes unique in the history of college affairs." All hotel rooms in Boston were occupied by MIT alumni and their families and some ten thousand people attended the main festivities in the Great Court (now known as Killian Court) of the new buildings.

Figure 2.2: In 1916, MIT moved to its new campus in Cambridge facing the Charles River and the City of Boston.

The erection of New Technology was gigantic project for the still young Massachusetts Institute of Technology—especially when taken into account that in addition to the main buildings, a dormitory, a house for the Institute’s president, a power plant, and shortly thereafter, Walker Memorial for student recreation were built. The building of New Technology was "about a spirit of caring and cooperation that united the Institute’s faculty and staff, volunteer leaders and donors." Remarkably, MIT undertook a project of such dimensions without using up any of its small endowment. To the contrary, the Institute’s endowment grew considerably during construction and dedication of the new buildings.

References

1. Committee of Associated Institutions of Science and Arts, Object and Plan of an Institute of Technology including a Society of Arts, a Museum of Arts, and a School of Industrial Science, John Wilson and Son, Boston, 1860.

2. The Department of Architecture joined the rest of the Institute in Cambridge in 1938.


5. Massachusetts Institute of Technology, *Reports of the President, Secretary, and Departments, 1871–72*, Press of A. A. Kingman, Boston, 1872.


CHAPTER 3
MIT TODAY

This chapter provides an overview of MIT as it is at the present time. Since it is beyond the scope of this thesis, to discuss all departments of the Institute, only those of interest to THE GRAND PLAN, are discussed in detail. Recognizing that readers from outside the MIT Community will be interested into getting an insight into the Institute, the chapter has been written also with the objective in mind to familiarize readers with MIT.

The data contained herein is as up-to-date as possible, that is the figures are for Fiscal Year 1995 or Fiscal Year 1994. Due to the length of the chapter, a brief description of the Institute is given in Section 3.1. The following section examines the overall Institute by discussing its objectives, the decision making process, the organization, the academic programs, as well as students, faculty, and staff. An overview of the campus and the adjacent R&D Park is provided in Section 3.3. Research and the Educational resources are discussed in Section 3.4 and Section 3.5, respectively. The departments within MIT that are part of the public relations effort are examined in Section 3.6. The final section of the chapter presents the financial resources of the Institute. A breakdown of the operating expenses and revenues as well as a breakdown of the endowment is included in the section.

3.1 A Brief Description of the Institute

Mission and Educational Program
The Massachusetts Institute of Technology is one of the world’s outstanding universities and the leading school of science and engineering. It is an independent, coeducational, and privately endowed institution. Its mission, reflecting the original charter, is “to provide the highest quality programs of education and research in all areas of study and investigation where strength and competence have been developed, and to do so with a strong commitment to public service and to a diversity of backgrounds, interests, and points of view among faculty, students, and staff.”

The Institute’s educational program has two essential parts: teaching and research. Through teaching the Institute aims to develop in its students that “mastery of fundamentals, motivation for learning, and intellectual discipline and self-reliance which is the best foundation for continuing professional achievements.” In addition, it attempts to provide a liberal and professional education, such that its students acquire respect for moral values, the duties of citizenship, and the
basic human understanding and knowledge required for leadership. Through research MIT aims to extend the boundaries of human knowledge and understanding. In doing so, the Institute hopes to create an atmosphere of intellectual excitement and a climate of inquiry and innovation.

**Campus**

MIT is located on a 146-acre (591,000 square-meter) campus in Cambridge, Massachusetts that extends for more than a mile along the Charles River facing the City of Boston. Most university activities are conducted in a dense arrangement of more than 160 interconnected buildings allowing for easy communication between departments and schools. The main buildings of the campus date back to 1916 when MIT moved from its original site in Boston to Cambridge. Athletic facilities, playing fields, and dormitories are also located on the campus, thus enhancing even further the unity of the institution.

**Organization**

The chief executive officer of the Institute is the President and the chief academic officer who reports to the president is the Provost. The President, Provost, Associate Provosts, Vice Presidents, and Deans plus the Chair of the faculty make up the Academic Council of the Institute. The educational policies are determined by the faculty. The board of trustees, whose task is the overall supervision of MIT, is known as the Corporation. It consists of about 75 members and ex officio the chairman of the corporation, the president, treasurer, and secretary of the corporation.

The Institute is broadly organized into five academic Schools and a College: School of Architecture and Planning, School of Engineering, School of Humanities and Social Science, School of Management, School of Science, and the Whitaker College of Health Sciences and Technology. The Schools and the College are home to 21 academic departments and 58 major interdepartmental laboratories, centers, and programs. MIT also operates the federally sponsored Lincoln Laboratory in Lexington, Massachusetts and is affiliated with seven institutions and programs: The Charles Stark Draper Laboratory, The Dibner Institute for the History of Science and Technology and the Burndy Library, Harvard-MIT Division of Health Sciences and Technology, Howard Hughes Medical Institute, MIT-Woods Hole Oceanographic Institution, Northeast Radio Observatory Corporation, and Whitehead Institute for Biomedical Research.

**Faculty, Staff, and Students**

The Institute’s single faculty of 954 professors of all ranks instructs both undergraduate and graduate students. The distinguished faculty includes eleven Nobel laureates, 86 members of the National Academy of Engineering, 98 members of the National Academy of Sciences, and 209 members of the American Academy of Arts and Sciences. Four faculty members are recipients of the Kyoto Prize and seventeen past or present MIT professors were awarded the National Medal of Science. The total teaching staff with professors, lecturers, instructors, and gradu-
Section 3.1: A Brief Description of the Institute

ate teaching assistants numbers about 2,000. In addition to faculty and students, about 8,350 employees make up the MIT Community.

The student body is almost evenly divided between undergraduate and graduate students. In 1994–95 the undergraduate enrollment was 4,472 and the graduate enrollment 5,302, making a total student population of 9,774. These students came from all 50 states, the District of Columbia, three territories, and 101 foreign countries. International students accounted for 8% of the undergraduate and 34% of the graduate student body, making MIT one of the U.S. universities with the highest foreign student population. Most undergraduate students live in ten MIT dormitories, 34 fraternities and independent living groups, and about a third of the graduate students in MIT graduate student dormitories.

Admission to MIT, both at the undergraduate and graduate level, is most competitive. About 30% of applicants to the freshman class were offered admission of which 1,012 actually enrolled. At the graduate level applications are submitted to individual departments. In 1992 about 22% of applicants for graduate school received offers of admissions and of these 1,211 accepted.

Educational Resources

MIT’s educational resources are matched by few schools. The MIT Library System consists of five larger (divisional) libraries: Engineering, Science, Social Sciences and Management, Architecture and Planning, and Humanities. In addition to these, six smaller libraries/collections exist: Aeronautics and Astronautics; Earth, Atmospheric, and Planetary Sciences; Health Sciences; Industrial Relations Collection; Institute Archives and Special Collections; Music, and Visual Collections. The MIT Libraries hold more than 2.3 million printed volumes, 2.0 million microforms, and extensive collections of photographs, maps, audio, and video recordings; they subscribe to over 21,200 journals and periodicals.

MIT Information Systems (IS) provides extensive computing, networking, and telecommunications resources. The Institute’s computers include a large number of mainframes, workstations, and personal computers. One of the main components of MIT’s computing resources is the Athena Computing Environment. Athena is a network of 1,300 workstations and 100 servers located in public, departmental, and dormitory clusters throughout the campus, which are available free of charge to the entire MIT community for academic and research use. Most of the several thousand computers are connected through MITnet, the campus-wide high-speed data-network, to Internet and hence computers throughout the world. IS operates also a store from which members of the MIT Community can purchase a variety of computer hardware and software. Computing Support Services of IS provides on-line help, consulting, training, and publications.

Research

MIT is known throughout the world as one of the leading research universities. In fiscal year 1994, the total on-campus research revenues amounted to 354 million dollars with the biggest sponsors being the Department of Energy, Industry, the Department of Health and Human Services, the Department of Defense, and the
National Science Foundation. Combined with the $337 million sponsorship for the Lincoln Laboratory this amounts to total research revenues of $691 million. Year after year, MIT ranks as the number one U.S. university in the number of patents granted and signs between 75 and 110 license agreements annually.

MIT's research effort is conducted in 58 interdepartmental and several hundred departmental laboratories with sizes ranging from a few to several hundred people. Well known laboratories at MIT include the Artificial Intelligence Laboratory, the Francis Bitter National Magnet Laboratory, the Laboratory for Computer Science (LCS), the Media Laboratory, and the Plasma Fusion Center.

Financial Resources
Despite its medium size student body, MIT's budget exceeds one billion dollars, primarily because of its research effort. In 1993–94 the operating expenses totaled $1.137 billion and were met by revenues of equal amount. With a tuition of $19,100 in FY94, MIT derived about 17% of its revenues from tuition and related income.

In fiscal year 1993–94 the book value of MIT's educational plant was $431 million. The market value of its endowment in the same year was $1.778 billion, and the market value of all the Institute's investments exceeded $2.152 billion.

The endowment was greatly improved in the fund-raising drive Campaign for the future, which concluded in June of 1992. The purpose of this five-year effort was not only to strengthen MIT's capital holdings but also to build support for MIT faculty, students, and academic programs. The original target of the campaign was $550 million but by March 1990 it was clear that this goal would be met well ahead of schedule, and the target was raised to $700 million. At the end of the Campaign for the future, MIT had received gifts and pledges totaling $710 million.

3.2 The Institute

3.2.1 Objectives
The Massachusetts Institute of Technology was founded in 1861 by William Barton Rogers and admitted its first students in 1865. Today, MIT is an independent, coeducational, privately endowed university registered as a non-profit organization. Following its charter, MIT has established two objectives—a primary and a secondary. They are stated as follows:

1. Primary Objective:
   Advancement of knowledge through education and research, both pure and applied, in science, engineering, architecture and planning, management, social sciences, and humanities.

2. Secondary Objective:
   Service to the community and the nation through the use of the Institute's resources, both intellectual and material.
To guide the pursuit of these two objectives, underlying purposes and principles in the categories Education, Research and Scholarship, and Service have been established:

- **Education**
  It is the purpose of the educational program to develop in each student that mastery of fundamentals, versatility of mind, motivation for learning, and intellectual discipline and self-reliance which is the best foundation for continuing professional achievement ... To provide a liberal as well as professional education so that each student acquires a respect for moral values, a sense of duties of citizenship, a feeling for taste and style, and the basic human understanding and knowledge required for leadership ... and thereby to send forth men and women of the highest professional competence, with the breadth of learning and of character to deal constructively with the issues and opportunities of our time.

- **Research and Scholarship**
  The Institute seeks through research and reflection to extend the boundaries of knowledge and the horizons of the human intellect. In so doing, it aims to create an atmosphere of intellectual excitement, a climate of inquiry and innovation in which each student develops a consuming interest in understanding for its own sake.

- **Service**
  As a modern university and social institution, MIT recognizes an inherent obligation to serve its students and alumni, the professions, the world of scholarship, and society. As part of this obligation, the Institute seeks to serve the community and the nation directly through its faculty and through the use of its facilities and administrative resources whenever there is a compelling need to which it can respond without impairing its primary functions.

### 3.2.2 The Corporation

The governing body of the Institute is the board of trustees, known as the Corporation. The members of the Corporation constitute the body MIT. The Corporation carries the responsibility for MIT and controls either directly or indirectly all affairs of the Institute. Day-to-day activities of the university are controlled through its officers and committees.

The MIT Corporation consists as of June 30, 1994 of 94 members who are distinguished leaders in science, engineering, industry, education, and public service. The ex officio members include the four officers of the Corporation (the Chairman of the Corporation, the President of MIT, the Treasurer of MIT, and the Secretary of the Corporation), the President of the Association of Alumni and Alumnae, as well as three representatives of the Commonwealth of Massachusetts (at the present time the Governor of the Commonwealth, the Chief Justice of the Supreme Judicial Court, and the Commissioner of Education). Currently 42 members are so called term members since each of them serves a five-year term. Twenty-four men and women are elected life members and 20 are retired from active membership and are known as life members emeriti.
Chapter 3: MIT Today

The entire Corporation meets four times a year (in October, December, March, and on the day of graduation) and its committees at various intervals. The committees fall into three categories: *Standing Committees*, *Committees of Annual Recurrence*, and *Special Committees* as required.

The four Standing Committees are:

1. **Executive Committee**
   The Executive Committee consists of three *ex officio* members, namely the Chairman of the Corporation, the President, and the Treasurer. Its regular members are elected by the Corporation to serve five- or two-year terms. The Executive Committee has the responsibility for the on-going superintendence of MIT and meets on a monthly basis. It has the following powers and duties as described in *Bylaws of the Corporation*:
   The Executive Committee
   - recommends to the Corporation the names of candidates for the Chair of the Corporation, the President, the Treasurer, and the Secretary of the Corporation.
   - determines the compensation of all officers of the Corporation.
   - may appoint or remove any officers of the Corporation.
   - has the responsibility for the general administration and superintendence of all matters relating to the Corporation, such as: faculty and staff appointments and salaries, annual budgets, tuition, scope of the educational and research programs, special contract services for the federal government and other organizations, new plant and facilities, and the broad considerations concerned with providing new funds for Corporation purposes.
   - may authorize officers to borrow money in the name and on behalf of MIT in such amounts as it may from time to time determine.
   - works closely with the President and Chair of the Corporation and receives and acts upon their recommendations which require the approval of the Executive Committee or the members of the Corporation.
   - coordinates and oversees all other Corporation committees other than the Membership Committee.
   - may authorize an officer to purchase, sell, or lease real estate on behalf of MIT. The sale or disposal of any educational real estate whose value exceeds $1,000,000 requires approval by the Corporation and can only be recommended by the Executive Committee.
   - holds regular meetings (at the present time on a monthly basis). A quorum for any meeting consists of six members, at least four of whom are not *ex officio* members.

2. **Membership Committee**
   The Membership Committee consists of the President, Chair of the Corporation (*ex officio* members) and five members of the Corporation. Its purpose is to propose to the Corporation candidates for term or life membership and all Corporation committees.
3. Investment Committee
The Investment Committee consists of the Chair of the Corporation and the Treasurer of the Institute \textit{(ex officio members)} as well as seven regular members. Members are nominated by the Membership Committee and are elected by the Corporation for five- or two-year terms. The purpose of the Investment Committee is to establish policies and procedures with respect to investment of all funds of the Corporation. It has the general oversight of the investments of the Corporation and all special reserve funds, such as the Student Loan Fund.

4. Development Committee
The Development Committee consists of three \textit{ex officio members}—Chair of the Corporation, the President, and the Treasurer—and various members of the Corporation, alumni/ae, and friends of MIT. At the present time, the Development Committee consists of 78 members. The committee has the broad responsibility for sources of funds donated to the Institute. It establishes policies and plans for the procurement of endowment and operational funds. It cooperates with and encourages the Alumni Association in its fund-raising efforts. The Development Committee, with the concurrence of the Executive Committee, proposes to the Corporation campaigns or drives for raising large amounts of money at it deems appropriate.

The Committees of Annual Recurrence are:

1. Auditing Committee
The Auditing Committee is responsible for hiring a public accountant to examine MIT’s books and fiscal records. The committee meets with the staff of fiscal operations, MIT’s internal audit staff, and the external auditors to hear and approve reports of MIT’s financial status.

2. Visiting Committees
The purpose of the 26 Visiting Committees is to visit and inspect MIT’s academic departments and programs. These committees have between fifteen to seventeen members who are leaders in their respective professions. The total number of members is 457 made up of 358 actual persons. The committees visit every other year for two days to get an update from the department head and are briefed on current and long-range issue, see presentations from faculty and graduate students on their research, etc. They usually tour the facilities and meet separately with tenured faculty, untenured faculty, as well as graduate and undergraduate students to hear their concerns. Based on these visits, the committees make recommendations to the Corporation and provide advice for the departments and programs.

3. Corporation Joint Advisory Committee on Institute-Wide Affairs (CJAC)
The CJAC consists of six Corporation members, six faculty members, and six students to whom the Corporation can turn for consideration and advice and on special Institute-wide matters needing the attention of the Corporation.

3.2.3 Organization
MIT’s chief executive officer is the \textit{President}. The senior administrative officers are: the \textit{Provost}, the \textit{Associate Provosts}, the \textit{Senior Vice President}, and five \textit{Vice Presidents}. The senior academic officers are the \textit{President}, the \textit{Provost}, the \textit{Asso-
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- Department of Aeronautics and Astronautics (Course 16)
- Department of Chemical Engineering (Course 10)
- Department of Civil and Environmental Engineering (Course 1)
- Department of Electrical Engineering and Computer Science (Course 6)
- Department of Materials Science and Engineering (Course 3)
- Department of Mechanical Engineering (Course 2)
- Department of Nuclear Engineering (Course 22)
- Department of Ocean Engineering (Course 13)

School of Humanities and Social Science
- Department of Economics (Course 14)
- Department of Humanities (Course 21)
  - Anthropology/Archaeology Section (Course 21A)
  - Foreign Language and Literatures Section (Course 21F)
  - History Section (Course 21H)
  - Literature Section (Course 21L)
  - Music and Theater Arts Section (Course 21M)
  - Program in Writing and Humanistic Studies (Course 21W)
- Department of Linguistics and Philosophy (Course 24)
- Department of Political Science (Course 17)
- Program in Science, Technology, and Society (STS)

Sloan School of Management
- Management (Course 15)

School of Science
- Department of Biology (Course 7)
- Department of Brain and Cognitive Sciences (Course 9)
- Department of Chemistry (Course 5)
- Department of Earth, Atmospheric, and Planetary Sciences (Course 12)
- Department of Mathematics (Course 18)
- Department of Physics (Course 8)

Whitaker College of Health Sciences and Technology
- Division of Toxicology (TOX)
- Harvard-MIT Division of Health Sciences and Technology (HST)

At MIT, the capitalized word Course implies a curriculum leading to a specific degree, which often coincides with a department. For example, Course 16 is the number designating the Department of Aeronautics and Astronautics. The lowercase word course implies a specific course. For example, course 16.512 is the number used for the subject Rocket Propulsion.

3.2.4 Calender

Being a university, MIT naturally operates on an academic calender. The fall semester is preceded by the Freshman Residence/Orientation Week (R/O Week) which starts at the end of August. The purpose of the 10-day long R/O Week is to introduce incoming students to life at MIT. The fall term begins with the registra-
tion for courses *(Registration Day)* shortly after Labor Day in early September. Lasting about 15 weeks, including the final exams period, the first semester ends just days prior to Christmas.

The winter vacation lasts for about two weeks and is followed by the *Independent Activities Period* (IAP). The four-week long IAP, held every January, provides students, faculty, and staff with unique opportunities. Students may conduct research, study in their field or explore new areas of interest. The more than 600 IAP offerings include full-scale subjects, special lecture series, design laboratories, discussion-style seminars, physical education classes, as well as tours, movies, and concerts.

The spring term begins with course registration in early February. In the middle of the term, that is at the end of March, students are given a one week spring vacation. The spring semester ends in late May with the final exam period. Commencement Exercises are held in early June for all graduates of the past year.

During the summer session, the Institute offers a limited selection of subjects—some of which are also taught during the regular academic year and others designed for special interests and needs. The summer session is slightly shorter than a regular semester and lasts from mid-June to late-August. An academic year is therefore the period from September until June. The MIT Fiscal Year ends on June 30.

### 3.2.5 Academic Program

When MIT began its first year of instruction it offered 6 subjects to its student body. Today, the Institute boasts hundreds of graduate courses and undergraduate academic courses, several freshman seminars, and 37 Reserve Officer Training Corps (ROTC) courses in Aerospace Studies, Military Science, and Naval Science. In addition, the Athletic department offers 55 physical education courses. Annually, more than 1,000 seminars and lectures are held at the Institute of which almost all are open to the general public. The topics cover an extremely wide range. Recent examples range from “State of US-Russian Negotiations on Warhead Dismantlement and the Dispersion of Plutonium” to “Internal Spin Structure of the Nucleon.” In addition, hundreds of music, theater, and dance performances as well as readings, film/video showings, and exhibits are held at MIT during the academic year.

### 3.2.6 Students and Student Life

**Admissions.** Getting admitted to MIT, at both the undergraduate and the graduate level, is most competitive. The applicant pool is highly qualified as measured by grades and academic scores. In 1994, MIT received 26,588 preliminary applications and a total of 7,139 (U.S.: 5,846, International: 1,293) final applications to its 1998 Freshman Class. Only to 30.2% admission was offered. Of those students who were offered admissions, 1,107 actually enrolled of which 77 had their home outside the United States. An impressive 22% of the Freshman Class was ranked.
first in their high schools and 36% were in the top five percent of their class (excluding number one). The number of women students has reached with 40% an all-time record. The admissions decision is independent of the financial needs of the applicant and MIT imposes no quotas on students who are U.S., Canadian, or Mexican citizens or permanent residents. Also, unlike many universities of equal prestige, MIT does not favor children of alumni, nor allows gifts or donations to influence the outcome of the applicant's evaluation.

At the graduate level, applications are submitted to the individual departments which are solely responsible for the admission. In 1993–94, the number of graduate school applicants reached 11,590. In the ten-year period 1985 to 1994, the number of applications has increased by 44%. Of those who applied only 20% or 2,342 were offered admissions. The number of actual registrations was 1,159.

**Student Body.** MIT's student body is said to be the most able of any university focused largely on science and engineering in the United States. In the fall of the academic year 1994–95 it had a size of 9,774 with an almost even division of undergraduate and graduate students. Graduate students made up 54.2% of the student body and undergraduates the remaining 45.8%.

The students came from all 50 states², the District of Columbia, and three territories. The international student body was drawn from 101 countries. Foreign students make up 8.1%³ of the undergraduate students and 33.6% of the graduate students. Thus, from the overall student population, 21.9% are from abroad—this percentage is one of the highest among American universities. On average, each country, is represented by 3.6 undergraduate students and 17.6 graduate students. The countries sending the largest number of students are Canada (219), China (210), India (125), Japan (143), and Korea (100).

In 1994–95, there were 2,813 women students. Of these 1,604 or 35.9% were undergraduates and 1,209 or 22.8% were graduates students. As self-reported by students, the percentage of U.S. minority students was 36.8% or 1,644 students among undergraduates and 10.4% or 552 students among graduates.

A summary of the enrollment figures for undergraduate and graduate students, grouped by School is shown in Table 3.1. It should be noted that first-year students do not belong to any particular school since MIT students do not enroll in an academic department until the beginning of their second year of study and may even defer selecting a department until the third year.

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² The states with the largest number of students are: Massachusetts (1033 students), California (971 students), and New York (952 students).

³ MIT limits the percentage of international undergraduate students to 9 percent.
Table 3.1: Student Enrollment Fall 1994–95

<table>
<thead>
<tr>
<th>School/College</th>
<th>Undergraduate Enrollment</th>
<th>Graduate Enrollment</th>
<th>Total Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-year students</td>
<td>1,104 (25%)</td>
<td>—</td>
<td>1,104 (11%)</td>
</tr>
<tr>
<td>Undecided students</td>
<td>56 (1%)</td>
<td>—</td>
<td>56 (1%)</td>
</tr>
<tr>
<td>Architecture and Planning</td>
<td>83 (2%)</td>
<td>507 (10%)</td>
<td>590 (6%)</td>
</tr>
<tr>
<td>Engineering</td>
<td>2,086 (47%)</td>
<td>2,445 (46%)</td>
<td>4,531 (46%)</td>
</tr>
<tr>
<td>Humanities and Social Science</td>
<td>141 (3%)</td>
<td>345 (7%)</td>
<td>486 (5%)</td>
</tr>
<tr>
<td>Management</td>
<td>103 (2%)</td>
<td>729 (14%)</td>
<td>832 (9%)</td>
</tr>
<tr>
<td>Science</td>
<td>899 (20%)</td>
<td>1,084 (20%)</td>
<td>1,983 (20%)</td>
</tr>
<tr>
<td>Whitaker College</td>
<td>—</td>
<td>192 (4%)</td>
<td>192 (2%)</td>
</tr>
<tr>
<td>Total</td>
<td>4,472 (46%)</td>
<td>5,302 (54%)</td>
<td>9,774 (100%)</td>
</tr>
</tbody>
</table>

Traditionally, the largest share of students was enrolled in the School of Engineering, which includes also the two largest departments. Figure 3.2 on page 54 shows the departmental undergraduate and graduate student enrollment ranked by size.

**Housing.** At the undergraduate level almost all students live in dormitories or MIT approved living groups, thus making MIT essentially a residential university. Approximately 2,800 single men and women live in 10 on-campus dormitories, and about 1,350 single men and women live in 34 fraternities, sororities, and independent living groups (ILGs). With the exception of one all-female Institute house, all dormitories are coeducational but most houses provide single-sex living areas. The size of dormitories ranges from just over 100 rooms to about 350.

Students select their housing during the Freshman Residence/Orientation Week just prior to the registration for the fall term. All incoming students are guaranteed on-campus housing for four years and may make changes at any point. Most undergraduate dormitories are located on Memorial Drive facing the Charles River. Although some fraternities and sororities are located on campus, the majority of them are located in Boston’s Back Bay and two in the City of Brookline.

For single graduate students MIT provides housing through five dormitories in which approximately 30 percent of them reside. Two dormitories with 400 apartments provide housing to families and students with children.

**Athletics.** MIT has 39 intercollegiate (varsity) teams, more than almost any other college in the country. The teams range from Baseball, Basketball, Football, over Cross-Country, Rifle, to Wrestling. About 20 percent of the undergraduate student population participates in intercollegiate teams. In addition to varsity teams, there are 24 intramural sports, organized into more than 1,150 team, which attract 75 percent of the total student population. While at most universities in the country few play sports and many watch, at MIT many play sports and few watch.
ENROLLMENT

<table>
<thead>
<tr>
<th>COURSE</th>
<th>Undergraduate Students</th>
<th>Graduate Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Eng. &amp; Comp. Sci.</td>
<td>17.87%</td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>8.89%</td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>8.51%</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>6.24%</td>
<td></td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>5.58%</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>4.22%</td>
<td></td>
</tr>
<tr>
<td>Civil &amp; Environmental Eng.</td>
<td>4.21%</td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td>3.74%</td>
<td></td>
</tr>
<tr>
<td>Aeronautics &amp; Astronautics</td>
<td>3.11%</td>
<td></td>
</tr>
<tr>
<td>Materials Science &amp; Eng.</td>
<td>3.01%</td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>2.81%</td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td>2.65%</td>
<td></td>
</tr>
<tr>
<td>Urban Studies and Planning</td>
<td>2.28%</td>
<td></td>
</tr>
<tr>
<td>Economics</td>
<td>2.21%</td>
<td></td>
</tr>
<tr>
<td>Earth, Atm. &amp; Planetary Sci.</td>
<td>1.97%</td>
<td></td>
</tr>
<tr>
<td>Ocean Engineering</td>
<td>1.77%</td>
<td></td>
</tr>
<tr>
<td>Health Sciences and Tech.</td>
<td>1.62%</td>
<td></td>
</tr>
<tr>
<td>Nuclear Engineering</td>
<td>1.56%</td>
<td></td>
</tr>
<tr>
<td>Political Science</td>
<td>1.47%</td>
<td></td>
</tr>
<tr>
<td>Cognitive Science</td>
<td>1.19%</td>
<td></td>
</tr>
<tr>
<td>Media Arts &amp; Sciences</td>
<td>1.10%</td>
<td></td>
</tr>
<tr>
<td>Linguistics &amp; Philosophy</td>
<td>0.64%</td>
<td></td>
</tr>
<tr>
<td>Humanities</td>
<td>0.41%</td>
<td></td>
</tr>
<tr>
<td>CAES</td>
<td>0.37%</td>
<td></td>
</tr>
<tr>
<td>Toxicology</td>
<td>0.35%</td>
<td></td>
</tr>
<tr>
<td>Science, Tech. &amp; Society</td>
<td>0.24%</td>
<td></td>
</tr>
<tr>
<td>Applied Biological Sci.*</td>
<td>0.01%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.2: Fall 1994–95 Undergraduate and graduate student enrollment by Course. Note that the Applied Biological Science Course has been closed.

Financial Aid and Tuition. MIT admits its students regardless of their financial situation ("need-blind admissions"). For students admitted to the Institute’s undergraduate program, MIT meets 100 percent of each student’s demonstrated financial need up to the total cost of attending the Institute. To ensure an admission on intellectual capacity only, admissions officers reviewing the undergraduate application are not informed whether an application for financial aid has been submitted, and financial aid officers do not review aid applications until an admissions decision has been made.

The Academic Year 1994–95 (FY95) tuition for full-time students (for the fall and spring term, which is about 9 months) is for both undergraduate and graduate students $20,100 compared to $19,000 in year 1993–94. The summer session is not considered part of the regular academic year and its tuition is $6,700 in FY95. MIT estimates the cost of attending the Institute in FY 1994–95 for single undergraduate students to be about $29,150 and $31,950 for single graduate students (including tuition in both cases).
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To cover the cost of attending MIT, undergraduate students receive aid in the form of grants and loans. In 1993–94, a total of 2,660 students (59% of the undergraduate population) who demonstrated the need for financial aid, received assistance. Altogether $32,861,000 in grants and $12,677,000 in loans from various sources were provided.

Table 3.2: Grants and Loans Provided to Undergraduate Students

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount in 1992–93</th>
<th>Amount in 1993–94</th>
<th>Change in Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income from scholarship endowment</td>
<td>$9,080,000</td>
<td>$9,724,000</td>
<td>+7.1%</td>
</tr>
<tr>
<td>Current gifts</td>
<td>$984,000</td>
<td>$1,064,000</td>
<td>+8.1%</td>
</tr>
<tr>
<td>Federal grants (incl. ROTC scholarships)</td>
<td>$3,144,000</td>
<td>$3,740,000</td>
<td>+19.0%</td>
</tr>
<tr>
<td>Non-federal outside sources</td>
<td>$2,751,000</td>
<td>$2,810,000</td>
<td>+2.1%</td>
</tr>
<tr>
<td>MIT's unrestricted funds</td>
<td>$15,920,000</td>
<td>$15,523,000</td>
<td>-2.5%</td>
</tr>
<tr>
<td>Grants from agencies regardless of need</td>
<td>$2,248,000</td>
<td>$2,187,000</td>
<td>-2.7%</td>
</tr>
<tr>
<td>Technology Loan Fund</td>
<td>$1,329,000</td>
<td>$1,324,000</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Federal Perkins Loan Program</td>
<td>$3,636,000</td>
<td>$3,032,000</td>
<td>-16.6%</td>
</tr>
<tr>
<td>State's administered Stafford Student Loan Program</td>
<td>$5,949,000</td>
<td>$8,321,000</td>
<td>+39.9%*</td>
</tr>
<tr>
<td>Total</td>
<td>$42,548,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$45,538,000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+7.0%</td>
</tr>
</tbody>
</table>

a. This increase is due to new eligibility criteria and increases in the loan limits in the program.
b. The total does not include the grants awarded regardless of need.

Graduate Students typically receive financial assistance in the form of Research Assistantships (RA's), Teaching Assistantships (TA's), and various types of fellowships. In most instances the awards are made on the basis of academic merit; however, financial need may be a factor in some cases. At MIT, Research and Teaching Assistantships typically cover the full tuition and a monthly stipend between $1,220 and $1,390 (in FY 1995), depending on the student's status (candidate for a masters or doctoral degree) and the department.

Table 3.3 gives an overview on the sources and the amount of support graduate students received.

In addition to the support listed in Table 3.3, graduate students received in 1993–94 loans from MIT (under the Technology Loan Fund), the federal government (Federal Stafford Guaranteed Student Loan Program and Federal Supplement Student Loans), and other sources totaling $7,795,000, which represents an increase of 5 percent compared to the 1992–93 academic year.
### Table 3.3: Sources and Amounts of Graduate Student Support for 1993–94

<table>
<thead>
<tr>
<th>Category of Support</th>
<th>Actual Number of Students</th>
<th>Number of Students (EFS)</th>
<th>Total Annual Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Assistantships (RA's)</td>
<td>2,733 (52%)</td>
<td>2,021 (38%)</td>
<td>$61,203,000</td>
</tr>
<tr>
<td>Teaching Assistantships (TA's)</td>
<td>840 (16%)</td>
<td>429 (8%)</td>
<td>$13,185,000</td>
</tr>
<tr>
<td>Federal Fellowships/Traineeships</td>
<td>309 (6%)</td>
<td>253 (5%)</td>
<td>$7,181,000</td>
</tr>
<tr>
<td>MIT Endowed Support (Dept'l)</td>
<td>81 (2%)</td>
<td>51 (1%)</td>
<td>$1,527,000</td>
</tr>
<tr>
<td>MIT Endowed Support (ODGS)</td>
<td>86 (2%)</td>
<td>53 (1%)</td>
<td>$1,231,000</td>
</tr>
<tr>
<td>MIT General Support</td>
<td>591 (11%)</td>
<td>199 (4%)</td>
<td>$5,555,000</td>
</tr>
<tr>
<td>Industrial Fellowships</td>
<td>1,044 (20%)</td>
<td>505 (10%)</td>
<td>$14,258,000</td>
</tr>
<tr>
<td>Foundation Fellowships</td>
<td>158 (3%)</td>
<td>84 (2%)</td>
<td>$2,696,000</td>
</tr>
<tr>
<td>Billed by MIT to Outside Sponsors</td>
<td>530 (10%)</td>
<td>399 (8%)</td>
<td>$7,586,000</td>
</tr>
<tr>
<td>Total</td>
<td>4,122 (78%)</td>
<td>3,994 (76%)</td>
<td>$114,421,000</td>
</tr>
</tbody>
</table>

**Notes:**

- **a.** Many students receive partial support from one or more sources. Thus, the total number of students receiving support from any single source may exceed the total number of graduate students. This column shows the equivalent number of fully supported students (EFS) and is computed by dividing the total tuition support by the academic year tuition per student.

- **b.** This figure does not equal the total of the numbers above since some students receive funding from more than one source.

### Degrees

The Institute awards nine different degrees:

- Bachelor of Science (S.B.), awarded since 1868
- Master of Architecture (M.Arch.), awarded since 1921
- Master of Business Administration (M.B.A.), to be awarded first in 1995
- Master in City Planning (M.C.P.), awarded since 1936
- Master of Engineering (M.Eng.), awarded since 1994
- Master of Science (S.M.), awarded since 1886
- Engineer (each degree designates the field in which it is awarded), awarded since 1949
- Doctor of Philosophy (Ph.D.), awarded since 1907
- Doctor of Science (Sc.D.), awarded since 1911

The Sc.D. and Ph.D. are awarded by the School of Engineering and the School of Science interchangeably. The M.Eng. degree is a new Five-Year First Professional Degree program, first introduced by the Department of Electrical Engineering and Computer Science in 1992–93. Similar Master of Engineering Programs will be introduced in the Aeronautics and Astronautics, Civil and Environmental, and Ocean Engineering Departments in the next several years.

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4. Except in the Department of Biology and the Department of Brain and Cognitive Sciences.
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The Master of Business Administration (M.B.A.) represents the newest addition to MIT's degrees. Starting with the Sloan School of Management Class of 1995, students who choose to substitute additional coursework for the thesis will receive an M.B.A. degree, while those completing a thesis will continue to be awarded the Master of Science in Management.

In the academic year 1993–94, MIT awarded 1,092 bachelor’s degrees, 1,230 master’s degrees, 31 engineer’s degrees, and 516 doctoral degrees. With a total of 2,869 degrees, MIT awards currently significantly more advanced degrees (62%) than bachelor’s degrees.

Alumni. The total number of alumni that MIT has produced since its founding in 1861 as of August 1994 was 129,850 of which 97,174 or 74.84% are living. How “young” MIT’s alumni are can be seen by the fact that almost 10% of all alumni graduated in the five-year period 1988 and 1993.

![Graph showing the number of living and deceased alumni since 1915.](image)

**Figure 3.3:** The chart show the number of living and deceased alumni since 1915.

The geographic distribution of the alumni is as follows: 75,191 or 77.4% have the United States as their country of residence with the states Massachusetts (23.4%), California (14.8%), and New York (8.5%) having the largest shares of alumni. The foreign countries having the largest share of international alumni are Canada (1,315), Japan (1,122), France (808), United Kingdom (676), India (383), and Mexico (337). The total number of alumni living outside the U.S. is 10,738, who reside in more than 120 countries.

MIT’s Alumni Association dates back to the Class of 1873. It was the first class that had more than 20 members. This enthusiastic class wished to recapture the fellowship of their student years and help their alma mater. At the first class
reunion in January 1874, the group formed a committee to investigate the possibility to form an alumni association.

The committee came quickly to the conclusion that it was the general wish of the alumni to form an association of alumni. The first meeting of the association was called by William A. Kimball, Class of 1873, on January 29, 1875 in which the 27 present alumni elected Professor Robert H. Richards, Class of 1868, to be the first president of the Association. In 1908, the Association of Class Secretaries which published Technology Review was merged with the Alumni Association. The Alumni Fund which encouraged annual giving to the Institute by alumni joined the Alumni Association in 1940 thus giving it the scope the association has until the present day.

Each June nearly 3,000 alumni/ae and guests return to MIT for Reunions and Technology Day. Reunions are held every five years from the 5th to the 70th year after graduation. Technology Day starts with a the traditional Tech Night at the Boston POPS Orchestra and is followed on the next day with numerous lectures, panel discussions, and a luncheon.

### 3.2.7 Faculty and Staff

MIT’s faculty is one of the most outstanding in the world. Many professors are considered to be the best in their field. The faculty numbering 954 professors of all ranks instructs both undergraduates and graduate students and conducts extensive research. Table 3.4 gives an overview of the size and breakdown of the MIT faculty for the last four years.

**Table 3.4: Size and Breakdown of the MIT Faculty**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Professors</td>
<td>582</td>
<td>595</td>
<td>616</td>
<td>608</td>
</tr>
<tr>
<td>Associate Professors.a</td>
<td>200</td>
<td>192</td>
<td>182</td>
<td>164</td>
</tr>
<tr>
<td>Assistant Professors</td>
<td>173</td>
<td>163</td>
<td>168</td>
<td>182</td>
</tr>
<tr>
<td>Total Faculty</td>
<td>955</td>
<td>950</td>
<td>966</td>
<td>954</td>
</tr>
<tr>
<td>Senior Lecturers, Lecturers</td>
<td>224</td>
<td>207</td>
<td>285</td>
<td>270</td>
</tr>
<tr>
<td>Instructors, Technical Instructors</td>
<td>56</td>
<td>59</td>
<td>124</td>
<td>104</td>
</tr>
<tr>
<td>Adjunct Faculty</td>
<td>71</td>
<td>77</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Total Faculty and Instructors</td>
<td>1,306</td>
<td>1,293</td>
<td>1,392</td>
<td>1,342</td>
</tr>
<tr>
<td>Teaching Assistants and Graduate Instructors</td>
<td>795</td>
<td>650</td>
<td>599</td>
<td>562</td>
</tr>
<tr>
<td>Total Teaching Staff</td>
<td>2,101</td>
<td>1,943</td>
<td>1,991</td>
<td>1,904</td>
</tr>
<tr>
<td>Total Enrollment</td>
<td>9,541</td>
<td>9,798</td>
<td>9,790</td>
<td>9,774</td>
</tr>
<tr>
<td>Student to Faculty &amp; Instruct. Ratio</td>
<td>7.3</td>
<td>7.6</td>
<td>7.0</td>
<td>7.3</td>
</tr>
<tr>
<td>Student to Teaching Staff Ratio</td>
<td>4.5</td>
<td>5.0</td>
<td>4.9</td>
<td>5.1</td>
</tr>
</tbody>
</table>

a. Includes associate professors with and without tenure.
How the number of employees on campus developed since 1969 is shown in Table 3.5.

Table 3.5: Number of On-Campus Employees by Category

<table>
<thead>
<tr>
<th>Category</th>
<th>FY '69</th>
<th>FY '74</th>
<th>FY '79</th>
<th>FY '84</th>
<th>FY '89</th>
<th>FY '94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty and Senior Officers</td>
<td>962</td>
<td>894</td>
<td>952</td>
<td>1,031</td>
<td>988</td>
<td>972</td>
</tr>
<tr>
<td>Other Academic</td>
<td>1,070</td>
<td>1,465</td>
<td>1,389</td>
<td>1,694</td>
<td>1,837</td>
<td>2,289</td>
</tr>
<tr>
<td>Research</td>
<td>814</td>
<td>869</td>
<td>799</td>
<td>1,019</td>
<td>1,011</td>
<td>926</td>
</tr>
<tr>
<td>Medical</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>150</td>
<td>152</td>
<td>1,301</td>
</tr>
<tr>
<td>Administrative</td>
<td>622</td>
<td>841</td>
<td>884</td>
<td>1,000</td>
<td>1,217</td>
<td>1,611</td>
</tr>
<tr>
<td>Support</td>
<td>1,612</td>
<td>1,490</td>
<td>1,322</td>
<td>1,628</td>
<td>1,691</td>
<td>929</td>
</tr>
<tr>
<td>Service</td>
<td>1,323</td>
<td>1,100</td>
<td>1,029</td>
<td>1,193</td>
<td>1,019</td>
<td>160</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,403</strong></td>
<td><strong>6,659</strong></td>
<td><strong>6,375</strong></td>
<td><strong>7,715</strong></td>
<td><strong>7,915</strong></td>
<td><strong>8,188</strong></td>
</tr>
</tbody>
</table>

Change since FY'69 w/o faculty | 0% | +6.0% | -0.3% | +22.8% | +27.3% | +32.6%

While the number of faculty and senior officer has increased in 25 year only by 1.0%, the number of staff members (excluding faculty and senior officers) has increased by 32.6%.

### 3.3 The Campus

MIT’s original campus was located in Boston’s Back Bay. It was in 1916 when the Institute moved to its new spacious home in Cambridge. MIT had purchased 50 acres of land and erected a magnificent neoclassic group of buildings which enclosed a great court. These buildings, with a total square footage of more than 750,000 (70,000 m²), provided the Institute the facilities it needed to conduct its expanding research and teaching efforts.

#### 3.3.1 Overview and Organization of the Campus

Cambridge, Massachusetts is known best in the world for being the home of both MIT and Harvard University. It has a total population of 85,000 with thirteen neighborhoods ranging from 700 to 15,000 residents. The Institute’s campus stretches for more than a mile along the broad basin of the Charles River facing historic Beacon Hill and central sections of Boston.

As of June 30, 1994, MIT’s academic campus had an area of 146.05 acres (591,050 square meters). In addition the Institute owned 65.07 acres (263,300 square meters) of land in Cambridge for investment purposes. Thus, MIT real estate holdings in the city of Cambridge are 211.12 acres (854,380 square meters) or about 5.3% of the total area of Cambridge which is around 4,000 acres.

The Institute’s academic area has only slightly, by 5.2%, increased over the last 25 years, while the total area held for investment purposes increased by a factor of
almost 4.5. How the MIT-owned land area changed is shown in Figure 3.4. The

![Figure 3.4: The figure shows how the amount of MIT-owned academic and investment land varied since 1969 on an absolute scale and as a percentage of the city of Cambridge.](image)

largest increase in investment area was due to the acquisition of the Simplex Wire and Cable Company property between 1969 and 1974. About half of the Institute’s Cambridge investment holdings have been devoted to the University Park project on that property as is described in detail in Section 3.3.2. In 1971, MIT sold its interest in 13-acres of land used for the Technology Square Project.

The campus is currently (as of June 30, 1994) made up of 162 buildings, where a building is not necessarily a separate structure. By tradition, MIT attempts to connect each new building with one or more existing ones either by “merging” them or constructing a bridge, or tunnel. Figure 3.5 on page 61 shows a map of the MIT campus.

Each MIT building has a unique number assigned to it. Buildings on the main campus east of Building 10 (The Great Dome) have even numbers and those west of it have odd numbers. For this reason, Building 7 is not next to Building 6. All buildings west of Massachusetts Avenue are designated W (e.g., W20), those north of the Conrail tracks N, those east of Ames Street E, and those north of the railroad and west of Massachusetts Avenue NW. The numbering system is also extended to individual rooms; any location on campus can be identified by a room number. In a typical room number such as 9-411, the figure(s) preceding the hyphen indicate the building number and the figure directly after the hyphen indicates the floor. The last two digits indicate the actual room.

The central feature of the main campus area are the Maclaurin Buildings designed by Welles Bosworth and dedicated in 1916. The enclose Killian Court which opens to a wide view to the Charles River. The corridor connecting Building 7 with Building 8 is known as the “infinite corridor.” This main throughfare of the
Figure 3.5: The figure shows a map of the MIT Campus.
Institute runs a distance of 251 meters (825 feet). The Maclaurin Buildings are home to most MIT's administrative offices and many departments such as Physics, Mathematics, Ocean Engineering, etc. The main campus area includes also buildings for the Center for Advanced Engineering Studies (Bldg. 9), buildings for the Department of Aeronautics and Astronautics as well as Center for Space Research (Buildings 33, 35, 37). The Electrical Engineering Department occupies Buildings 34, 36, and 38. The easterly portion of the main campus is includes buildings such as the Ralph Landau Building for Chemical Engineering, and the newest addition to the infrastructure the new Biology Building.

On the eastern end of the campus, the Alfred P. Sloan Building and the Grover M. Hermann Building house activities in management, economics, international studies, and political science. One also finds the Medical Department (in Building E23), the famous Media Laboratory, which is located along Ames Street.

The northeastern end of the campus includes Building N43 for the Laboratory for Computer Science and the Artificial Intelligence Laboratory, two buildings of the independent but affiliated Charles Stark Draper Laboratories, and another affiliated institution, namely the Whitehead Institute.

The western portion of the campus includes most of the university's dormitories and on-campus fraternities of which all are located more or less along the Charles River. This area of the campus includes also the Julius Adams Stratton Student Center, many athletic facilities including the Howard Johnson Athletic Center, and Briggs Field.

The northwestern sector of the campus includes mainly laboratories such as the Francis Bitter National Magnet Laboratory, the Nuclear Reactor, the Plasma Fusion Center, as well as the MIT Museum and two dormitories.

The buildings on campus have a gross square footage (GSF) of 9.742 million square feet (905,000 m²). Subtracting from the GSF the structural area, yield the net usable square footage (NUSF) of 8,704,265 ft² (808,653 m²). This area includes 784 floors and 30,690 spaces.\

A breakdown of the use of MIT facilities is shown in Table 3.6. One might expect to find that a large portion of a university is devoted to classrooms, but as the percentage in the table shows, at MIT only 2.1% of all net assignable square footage is classroom space. The estimated replacement value for all campus facilities is $1.7 billion. The annual custodial and utility cost are about $57.6 million.

5. *Spaces* usually coincide with rooms and hallways but a distinction is made when a room is used for more than one purpose. For example, a room that includes both a laboratory and offices would count as two *spaces*.
### Table 3.6: Summary of Space of Academic Facilities

<table>
<thead>
<tr>
<th>Net Usable Square Feet (NUSF): 100%</th>
<th>8,704,265 sf (808,653 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30,690 spaces</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Net Assignable Square Feet (NASF)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>74.4%</td>
<td>6,471,479 sf (601,220 m²)</td>
</tr>
<tr>
<td>21,573 spaces</td>
<td></td>
</tr>
</tbody>
</table>

| Offices: 19.1% | 1,664,561 sf | 9,334 spaces |
| Support: 14.7% | 1,277,444 sf | 2,691 spaces |
| Laboratories: 14.6% | 1,268,331 sf | 3,062 spaces |
| Residential: 10.7% | 929,727 sf | 3,529 spaces |
| General Use: 5.7% | 498,697 sf | 1,339 spaces |
| Study: 2.2% | 189,475 sf | 249 spaces |
| Classrooms: 2.1% | 184,967 sf | 266 spaces |
| Other: 5.3% | 458,277 sf | 1,103 spaces |

<table>
<thead>
<tr>
<th>Non-Assignable Square Feet 25.6%</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2,232,786 sf (207,433 m²)</td>
<td>9,117 spaces</td>
</tr>
</tbody>
</table>

| Circulation: 16.3% | 1,419,714 sf | 4,592 spaces |
| Mechanical: 7.7% | 670,468 sf | 3,094 spaces |
| Building Serv.: 1.6% | 142,604 sf | 1,431 spaces |

### 3.3.2 University Park at MIT

**Background.** In 1970, MIT purchased a 19-acre property adjacent to the campus from the Simplex Wire and Cable Company which relocated to Maine. The plans were to develop the parcel, bought for more than $12-million, with taxable housing and commercial ventures. Once MIT purchased the Simplex property, the Cambridgeport Planning Team, a federally funded neighborhood planning organization, demanded low-income housing and blue-collar industry. To increase the pressure on MIT, a committee, under the name Simplex Steering Committee, whose stated goal was “to keep our neighborhood affordable to poor and working people,” was formed in 1974. Four years later, Polaroid considered the site for the expansion of its Cambridge-based operation. Nonetheless, due to a downsizing of the company no transaction was made.

By 1980, the Institute had acquired several pieces of land next to the Simplex site, such as the property of the Fenton Shoe Company which increased the Simplex site to an area of more than 27 acres. However, the Institute had been so far unsuccessful so far in developing the site. In 1982, MIT sent out an information package about the site to some 20 selected large-scale real estate developers throughout the United States. In October 1983, the Institute announced a final agreement with Forest City Enterprises Inc. of Cleveland, Ohio to develop the parcel. Despite the selection of a developer, no concrete plans existed on either side on what should be built on the Simplex Site. The site, shown in Figure 3.6, was zoned for “industrial use only” with a 108-acre (4 million sf or 437,000 m²) limit.

Initial plans of Forest City Rental Properties Corporation, a subsidiary of Forest City Enterprises, which was put in charge of developing the parcel, were to optimize the investment and build 3.5 million square feet of leasable space. However, once again Cambridge’s long tradition of community activism showed itself. Res-
idents wanted affordable housing and a strong traffic control to avoid flooding already overcrowded streets. In response to these concerns Forest City proposed in March 1985, a smaller, $250-million, project and entered into an agreement with MIT to lease the property for a 75-year period. The proposed project included:

- Two million to 2.25 million square feet (209,000 m²) of office, research, and light industrial building space.
- 150,000 square feet (14,000 m²) of retail space
- A 325–375 room hotel including a conference center.
- 110 to 130 units of mixed income housing.
- Several garage structures that would house a total of 3500 to 3750 cars.

The project entailed construction of approximately 20 new buildings and the renovation of two existing structures over a 10 to 15-year period. The building heights ranged from three to twelve stories with most buildings being in the three to six story-range. In the proposal it was noted that “almost one-quarter of the project is devoted to usable open space in interconnected courtyards and park areas accessible to community residents.”

In September 1985, Forest City presented slightly revised plans for the site, which it had called University Park. The plans included 110 units of housing, one million square feet of R&D and light industrial space as well as 890,000 square feet of office space and 100,000 square feet of retail space, restaurants, movie theaters and a 300-room Sheraton Suites hotel and conference center. The master plan for University Park was developed by Koetter, Kim & Associates of Boston. The plan was well received and won in 1986 the Urban Design and Planning Award by Pro-
Section 3.3: The Campus

_gressive Architecture Magazine_. The site plan is shown in Figure 3.7 on page 65.

Figure 3.7: Site Plan for University Park in 1986. The gateway opens up to Massachusetts Avenue. The MIT campus is located to the right of the park.

The reaction from Cambridge citizens was still mixed. The Simplex Steering Committee asked for 450 units of housing and 650,000 square feet of light industrial space.

Phase I of University Park began in September 1986 with the clearing, clean-up, and landscaping of the site as well as the renovation of a former manufacturing building into office, R&D, and laboratory space, which was named the Dugald C. Jackson Building. While Phase I commenced, no new zoning was yet in place for University Park.

A big hurdle in the four-year planning and regulatory process was overcome when the Cambridge City Council approved a smaller University Park proposal in January 1988. The original industry-only zoning for over 4 million square feet was reduced by nearly fifty percent and zoning amendments requiring the increase of housing by at least 400 units. The unprecedented sequential zoning restrictions demand that the developer must build, with the first one million square feet, 110 housing units, 27 of them for low-income, and 60,000 square feet of open space. Once 1.75 million square feet are built, 200 housing units (75 for low-income) and 100,000 square feet of open space must be included. At 1.85 million square feet, the entire project must include 400 housing units of which 100 must be for
low income families and an additional 50 for moderate income households. The traffic limit at complete development was set to 1700 peak hour trips.

In retrospect it was thought by some that if MIT would have developed the original Simplex Site in the early 1970s Silicon Valley would not have grown in California but Cambridge would boast “Silicon Alley.” From MIT’s point of view University Park was “meant to make money as a real estate investment.” The big hope for MIT and the developer was biotechnology which emerged in the late 1980s as a strong new industry. MIT alone is credited with having spun off several hundred biotechnology companies worth billions of dollars. Forest City officials were optimistic that many new biotechnology companies would find their home at University Park.

In 1989, the University Park development ran into hard-line opposition from Cambridge residents whose homes were on the site of the planned hotel. It took two years, a decision from the state’s Appeals Court and numerous meetings to finally clear the path for the development of the hotel. In a settlement between MIT and the tenants, it was agreed to move the two three-story houses just a few blocks away and allow the tenants to remain in the units under rent control. Once the settlement was reached, the City of Cambridge expressed its approval and its hopes that the, soon to be built, Sheraton hotel would be a significant revenue source. While most parties involved in the dispute were satisfied, leaders of the Simplex Steering Committee remained opposed to University Park. Their fears were that the development is too big and will thus create too much traffic. It also had not enough retail and light manufacturing space to create more blue collar jobs for current Cambridge residents and 400 units are not enough to cover the increased demand for housing.

University Park Today. Despite the high hopes, University Park is only a modestly successful venture. Bordered by Massachusetts Avenue / Green Street in the northeast, Purrington Street in the south (adjacent to MIT), Pacific Street in the northwest, and Brookline Street in the north, University Park is in 1995 hardly developed.

At present, three office/R&D/laboratory buildings and one apartment complex constitute the site:

- **The Jackson Building**
  Located at 26 Landsdowne Street, it was opened in 1987 after a $5.5 million renovation. The five-story, 100,334 square feet buildings is currently 93% leased and committed. It is the home of several biotechnology companies.

- **The Clark Building**
  Completed in March 1989 at a cost of $8.2 million, the new five-story 121,622 square feet building provides office and R&D space to tenants such as NYNEX Corporation and T Cell Sciences.

- **The Richards Building**
  Completed in April 1990, the Richards Building is the newest addition to Uni-
Section 3.3: The Campus

University Park. The five-story building offers 126,065 square feet of office and R&D space to several biotechnology companies.

- The Kennedy Lofts
Located at 129 Franklin Street, the complex offers 142 units of rental housing and 3,000 r.s.f. of commercial space. The five-story, 250,000 square foot building is the original site of the F. A. Kennedy Steam Bakery and was converted to an apartment complex in February 1990. The building includes lofts, one, two and three bedroom apartments including a number of two story duplex units and is fully leased.

Despite the fact that Forest City is a large national real estate company with extensive resources—it owns approximately $2.4 billion of properties at cost in 19 states and in Washington, D.C.—it has been so far unable to develop the site as planned or create any enthusiasm for it. University Park is not a significant source of revenue to either MIT, Forest City, nor the City of Cambridge.

Some biotechnology companies have leased space in University Park but few start-ups can afford such expensive facilities. While electronics and software products in the 1980s needed only several months or a few years to reach the market, biotechnology products need about 10 years. After start-up, research and development, the products have to go through extensive clinical tests and FDA approval until they start generating any revenues. For this reason, new ventures need extensive capital and seek these from the state and banks. However, the Commonwealth of Massachusetts has not provided any help or guarantees to obtain loans from banks, which has limited the number of tenants that can afford renting space in University Park.

Once a biotechnology company has reached the market and is successful, it grows quickly. PerSeptive Biosystems, a “long-time” tenant at University Park, for example has recently relocated from its 10,000 square feet space in University Park to its own 30,000 square-foot building in Framingham, Massachusetts. The current tenant turnover is approximately five years.

The planned 300-room Sheraton Suites Hotel was not realized as planned because the hotel market dropped and the Sheraton Corporation lost its interest in the project. Meanwhile the market has picked up considerably and the Boston area occupancy rate is above 90 percent. Forest City is now conducting preliminary talks to erect a modest hotel with 250 inexpensive rooms and no amenities (that is, no restaurant, no ballroom, and no conference facilities).

6. Forest City Enterprises, Inc., has six subsidiaries. Its headquarters is in Cleveland with regional offices in New York, Los Angeles, Boston, Chicago, Portland, Tucson, Detroit, and Washington, D.C. In 1994, sales and operating revenues totaled $503 million. After three years of net losses the company was able to post net earnings of $718,000 in 1994. Including gains on disposition of properties and other provisions, Forest City posted earning before depreciation and deferred taxes of $80,979,000.
Similarly, early talks on constructing a retail center are being conducted. The five-story, 150,000 square foot facility would offer each tenant 25,000 or more square feet and would include a garage. The retail center might also include a restaurant behind the existing fire station. Since the response from retailers to Forest City’s ideas was quite positive the company is optimistic that the plans for the retail center might be realized.

To provide housing, Forest City plans to start construction in early 1995 of two new buildings on Brookline Street. First, a 72-unit building will be put up for an estimated cost of $9.1 million and thereafter another building providing 78 apartments.

3.4 Research

3.4.1 Overview of MIT Research
Essentially all 954 faculty members, most graduate students, and nearly half of the undergraduate students are engaged in research at any given time. Together with a research staff of more than 2800, the number of people conducting research at MIT is more than 10,000.

As mentioned earlier, the research is conducted in two types of laboratories: departmental and interdepartmental (interdisciplinary). As the names imply, departmental laboratories report to the head of the department to which they belong. They usually draw faculty and students from a single department. At MIT there is a total of more than 58 interdepartmental laboratories. These laboratories are usually significantly larger than departmental laboratories and draw faculty and students from several disciplines. These laboratories report directly to a dean of a School or the Vice President for Research. Figure 3.8 on page 69 lists all interdepartmental laboratories and shows to whom they report.

3.4.2 Research Sponsorship
MIT’s on-campus total research volume was in FY 1994 $359.674 million, since some of the research was sponsored by the Institute itself the total research revenues amounted to $354.236 million. Excluding major subcontracts, MIT’s on-campus net research volume amounts to $339.680 million or about 29% of all revenues. Funding for MIT’s research comes mainly from the U.S. Federal Government, which paid $241.738 million or 73.3% of the total research volume. The four largest sponsors are the U.S. Department of Energy (DOE), Industry, the U.S. Department of Health and Human Services (HHS), and the U.S. Department of Defense (DOD). In addition to the on-campus research facilities, MIT operates also the Lincoln Laboratory in Lexington, Massachusetts. In FY 1994, Lincoln Laboratory showed research revenues of $336.9 million, thus the total MIT research revenues are $691.1 million (60.8% of all revenues) Figure 3.9 shows a breakdown of the research sponsorship.
### MIT Interdepartmental Laboratories, Centers, and Programs

<table>
<thead>
<tr>
<th>PROVOST</th>
<th>DEAN, SCHOOL OF ARCHITECTURE AND PLANNING</th>
<th>DEAN, SCHOOL OF ENGINEERING</th>
<th>DEAN, SCHOOL OF HUMANITIES AND SOCIAL SCIENCES</th>
<th>DEAN, SCHOOL OF SCIENCE</th>
<th>DEAN, SLOAN SCHOOL OF MANAGEMENT</th>
<th>VICE PRESIDENT AND DEAN FOR RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark S. Wrighton</td>
<td>William J. Mitchell</td>
<td>Joel Moses</td>
<td>Robert J. Birgeneau</td>
<td>Glen L. Urban</td>
<td>J. David Lilley</td>
<td></td>
</tr>
</tbody>
</table>

| Center for Educational Computing Initiatives | Artificial Intelligence Laboratory (AI Lab) | Center for International Studies | Bates Linear Accelerator | Center for Computation Research in Economics and Management Science |
| Council on Primary and Secondary Education | Biotechnology Process Engineering Center | Integrated Studies Program | Center for Cancer Research | Center for Coordination Science |
| Facilities Use Committee | Center for Advanced Engineering Study (CASE) | Women's Studies Program | Center for Space Research (CSR) | Center for Energy Policy Research |
| Industrial Performance Center | Center for Technology, Policy and Industrial Development | | | Industrial Relations Section |
| MIT-Wellesley Upward Bound Program | Center for Transportation Studies | | | International Financial Services Research Center |
| | Concourse Program | | | International Center for Research on the Management of Technology |
| | Laboratory for Computer Science (LCS) | | | * Leader for Manufacturing Program |
| | Laboratory for Electromagnetic and Electronic Systems | | | MIT Center for Entrepreneurship |
| | Laboratory for Information and Decision Systems (LIDS) | | | Organizational Learning Center |
| | Laboratory for Manufacturing and Productivity | | | Program on the Pharmaceutical Industry |
| | * Leaders for Manufacturing Program | | | Systems Dynamics Group |
| | Materials Processing Center | | | |
| | Program in Biomedical Engineering | | | |
| | Program in Environmental Engineering Education | | | |
| | Program in Environmental Engineering Education and Research | | | |
| | Technology, Management and Policy Program | | | |

* Reports jointly

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**Figure 3.8:** An overview of the interdisciplinary laboratories, centers, and programs at MIT as of August 4, 1994.
Chapter 3: MIT Today

Figure 3.9: Breakdown of the MIT research sponsorship in Fiscal year 1994.

The School with largest research sponsorship was the School of Science, which had in Fiscal Year 1994 a net research volume of over $110 million. The single largest laboratory was the Plasma Fusion Center (PFC) with a research volume of $30.6 million, followed by the Laboratory for Nuclear Science with $26.5 million, and the Research Laboratory for Electronics (RLE) with $16.9 million. Table 3.7 on page 71 provides a comparison of the annual research of all Schools and departments/laboratories whose 1994 research sponsorship exceeded $5 million. Note that the interdisciplinary laboratories are grouped according to where they report to.

3.4.3 UROP

MIT pioneered the involvement of undergraduate students in research through its highly successful Undergraduate Research Opportunities Program, which is commonly referred to by its acronym UROP. Since the fall of 1969, UROP has provided undergraduates, from freshman to seniors, a unique opportunity: to join the faculty and graduate students in every academic department and interdisciplinary laboratory in carrying out research. Students can choose to receive academic credit or pay for their work. They also may simply volunteer to be a UROPer.

In the 1993–94 academic year, there were more than 2,000 on-going UROP projects. Well over 800 faculty members from all 21 academic departments and 40 interdisciplinary laboratories are involved in UROP. In the fall of 1992, 44% of all undergraduates (about 2000 students) carried out UROP work and it is estimated
that about 75% of all students are involved in a UROP at some point in the undergraduate career. During the fall and spring term students typically spend between 8 and 20 hours per week on their UROP, while a full-time commitment in the summer is the norm. In 1993, over 1,000 undergraduates remained on campus over the summer to do a UROP.

Most UROP wages were paid by faculty member’s research funds. In FY 1994, $4.6 million were paid by the faculty, supplemented by $600,000 from funds by the UROP Office. Funding was usually granted on a matching basis (60% research funds, 40% UROP funds), except when faculty lacked research funds and UROP paid the entire stipend. The minimum (and typical) hourly wage for UROP work is currently $6.90 per hour. The maximum direct funding that the UROP Office can provide is $950 per semester for part-time work (on average ten hours per week) and $3,300 during the summer for full-time work.
A more detailed account of UROP, including its history, can be found in Section 4.2.4.

### 3.4.4 Technology Licensing Office

The research conducted at MIT leads to many new inventions every year. Through licenses companies are granted rights to MIT patents for developing the inventions into products. The office in charge of obtaining patents and issuing licenses is the Technology Licensing Office (TLO). The TLO, with a staff of 23 (eleven professionals and twelve support personnel), is probably the most active university patent and licensing office in the United States. Year after year MIT is granted more patents than any other U.S. university. In 1994 alone, MIT received 122 patents—its entire portfolio of patents includes over 1000. Figure 3.10 on page 72 shows the number of MIT U.S. patent applications, the number granted, and the number of license and option agreements signed by the Technology Licensing Office. In 1994, a total of 84 license and option agreements were signed of which about a dozen were signed with start-up companies. In addition, the TLO was granted 18 new trademark licenses and 97 end-use software licenses.

The Institute derived a gross income of $8.7 million in FY 1994, which represents a 6.5% drop compared to the previous year. From the total gross income, $6.5 million was in royalty income, $1.7 million in patent reimbursement income, $275,000 in miscellaneous research support, and $155,000 cash-in of equity.

![Figure 3.10](image-url)
From the net income, $1.4 million will be distributed to inventors, $1.4 million to departments, and $873,000 to a general fund.

### 3.5 Educational Resources

#### 3.5.1 The Library System

The mission of the MIT Libraries is to support all of the Institute’s programs of study and research. Since departments and research centers are spread out over the entire campus, libraries are equally decentralized. They consist of five major divisional libraries for each of the five schools of the Institute and six smaller branch libraries to support an individual department or area of study.

The entire collection of the Libraries consist of 2.366 million printed volumes, 2.041 million microforms, and more than half a million slides, photographs, audio and video tapes, as well as manuscripts. The number of subscriptions to periodicals was 21,259 in the past year. A five-year summary of the MIT Libraries is provided in Table 3.8.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Printed Volumes</td>
<td>2,180,873</td>
<td>2,223,822</td>
<td>2,267,948</td>
<td>2,320,524</td>
<td>2,365,695</td>
</tr>
<tr>
<td>Microform units</td>
<td>1,733,362</td>
<td>1,785,133</td>
<td>1,893,561</td>
<td>1,969,869</td>
<td>2,041,520</td>
</tr>
<tr>
<td>Volumes added (gross)</td>
<td>55,710</td>
<td>55,015</td>
<td>58,857</td>
<td>59,646</td>
<td>54,887</td>
</tr>
<tr>
<td>Serials Received</td>
<td>21,313</td>
<td>21,577</td>
<td>20,858</td>
<td>21,136</td>
<td>21,259</td>
</tr>
<tr>
<td>Circulation</td>
<td>543,203</td>
<td>591,467</td>
<td>622,076</td>
<td>633,358</td>
<td>618,147</td>
</tr>
<tr>
<td>Librarians and other Academic Staff</td>
<td>82</td>
<td>82</td>
<td>86</td>
<td>87</td>
<td>85</td>
</tr>
<tr>
<td>Support</td>
<td>135</td>
<td>133</td>
<td>129</td>
<td>123</td>
<td>116</td>
</tr>
<tr>
<td>Student Assistants</td>
<td>28</td>
<td>30</td>
<td>29</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Total Expenditures (in thousands)</td>
<td>$11,669</td>
<td>$12,592</td>
<td>$13,248</td>
<td>$14,000</td>
<td>$14,025</td>
</tr>
</tbody>
</table>

The divisional libraries of the Institute are:

- **Barker Engineering Library**
  The engineering library is located directly underneath the Great Dome (Building 10). It contains over 265,000 printed volumes in essentially all areas of engineering (other than aeronautics and astronautics) as well as transportation and applied mathematics. Videocassettes, films, and film loops on engineering subjects together with playback equipment are located in the Media Services Area of the library.

- **Dewey Library** (Management and Social Sciences)
  The management library is conveniently located next to the Sloan School of Management at the north-eastern end of the campus. It has the largest number
of holdings; it contains collections emphasizing economics, political science, sociology, U.S. government and United Nations documents, corporate financial report. The Industrial Relations Collection of is one of the oldest and largest collections of its type in the United States.

- **Humanities Library**
  The Humanities Library is housed on the second floor of the Charles Hayden Memorial Library Building which is located on Memorial Drive facing the Charles River. In addition to collections in various areas of the humanities, it contains special collections such as college catalogues, telephone books, national bibliographies, and magazines.

- **Rotch Library** (Architecture and Planning)
  The Rotch Library was renovated in 1990 and has won several awards, among the award for best new building in Boston. The library is in Building 7 next to the departments of Architecture and Urban Studies. Its collections include architecture and building technology and history, art history, fine, applied and media arts, photography, film, and video, environmental design, urban studies and planning. Rotch also owns special collections on Boston-related materials, Historic American Buildings Survey on microfiche and microfilm, material on Islamic architecture and urbanism, and materials related to MIT campus architecture.

- **Science Library**
  Like the Humanities Library, the Science Library is located in the Hayden Memorial Library Building. Its collections are located on the first floor and the basement and include astronomy, biology, biotechnology, chemical engineering, chemistry, materials science, mathematics, medical sciences, nuclear engineering, and physics. A map room is can be found on the first floor. Videotapes on science and playback equipment are located in the Hayden basement.

The smaller branch libraries of the Institute are the following:

- **Aeronautics and Astronautics Library**
  Located in the same building as the Department of Aeronautics and Astronautics, the library has strong ties to the department and provides advice to students in several courses. It contains collections in all areas of aeronautics and astronautics as well as special collections of NASA technical reports and many society papers.

- **Institute Archives and Special Collections**
  The mission of the Institute archives is to preserve material related to the Institute. It is depository of all materials documenting MIT's history, including official records, personal papers of MIT faculty, staff, and alumni. It also includes all theses from 1868 to the present day.

- **Lindgren Library** (Earth and Planetary Sciences)
  Located on the second floor of the Green Building, the home of the Department of Earth, Atmospheric, and Planetary Sciences, the Lindgren Library contains collections of relevance to its corresponding academic department including many atlases and geological maps.

- **Music Library**
  The Music Library maintains a collection of books, music scores, periodicals,
Section 3.5: Educational Resources

LP’s, and CD’s. In-house facilities include stereo turntables, tape decks, and CD players.

- **Rotch Library Visual Collections**
  Located separately from the Rotch Library but also in Building 7, the Visual Collections contain slides; study photographs; film, videotapes, and videodisks of architecture, urbanism, art, and photography. Facilities include light tables, various videocassette and laserdisc players, slide projectors, and a photographic copystand.

- **Schering-Plough Library** (Health Sciences)
  Located next to the MIT Medical Department, the health sciences library contains collections in neurosciences, medicine, and medical imaging. A special collection of the library is devoted to medical information for the layperson.

An overview of the printed volumes added and withdrawn as well as the circulation for the year 1993–94 is shown in Table 3.9 on page 75.

### Table 3.9: Printed Volumes Added and Circulation in 1993–94

<table>
<thead>
<tr>
<th>Library</th>
<th>Added</th>
<th>Withdrawn</th>
<th>Moved to RSC</th>
<th>Holdings</th>
<th>Circulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautics and Astronautics</td>
<td>1,445</td>
<td>162</td>
<td>5,208</td>
<td>97,488</td>
<td>13,570</td>
</tr>
<tr>
<td>Archives / Harvard Depository²</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>66,805</td>
<td>—</td>
</tr>
<tr>
<td>Barker Engineering</td>
<td>10,083</td>
<td>5,142</td>
<td>3,822</td>
<td>265,815</td>
<td>101,652</td>
</tr>
<tr>
<td>Dewey (Social Sciences and Management)</td>
<td>13,525</td>
<td>784</td>
<td>10,509</td>
<td>558,020</td>
<td>157,714</td>
</tr>
<tr>
<td>Harvard Depository</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3,682</td>
<td>—</td>
</tr>
<tr>
<td>Humanities</td>
<td>6,403</td>
<td>1,549</td>
<td>2,738</td>
<td>242,754</td>
<td>148,561b</td>
</tr>
<tr>
<td>Institute Archives and Special Collections</td>
<td>2,934</td>
<td>3</td>
<td>1,507</td>
<td>23,721</td>
<td>—</td>
</tr>
<tr>
<td>Lindgren (Earth and Planetary Sciences)</td>
<td>1,323</td>
<td>384</td>
<td>3,500</td>
<td>48,998</td>
<td>10,624</td>
</tr>
<tr>
<td>Music</td>
<td>893</td>
<td>119</td>
<td>928</td>
<td>41,276</td>
<td>35,552</td>
</tr>
<tr>
<td>Rare Book Collections</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40,689</td>
<td>—</td>
</tr>
<tr>
<td>RetroSpective Collection (storage facility)</td>
<td>91</td>
<td>1</td>
<td>—</td>
<td>460,038</td>
<td>6,032</td>
</tr>
<tr>
<td>Rotch (Architecture and Planning)</td>
<td>8,030</td>
<td>436</td>
<td>733</td>
<td>192,690</td>
<td>112,286c</td>
</tr>
<tr>
<td>Schering-Plough (Health Sciences)</td>
<td>754</td>
<td>69</td>
<td>0</td>
<td>8,524</td>
<td>12,597</td>
</tr>
<tr>
<td>Science</td>
<td>9,192</td>
<td>1,101</td>
<td>2,754</td>
<td>295,791</td>
<td>148,561b</td>
</tr>
<tr>
<td>Space Center Reading Room</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>13,482</td>
<td>—</td>
</tr>
<tr>
<td>Technical Services and Administration</td>
<td>204</td>
<td>0</td>
<td>0</td>
<td>5,922</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>54,887</td>
<td>9,752</td>
<td>31,699</td>
<td>2,365,695</td>
<td>618,147d</td>
</tr>
</tbody>
</table>
a. Holdings of Archives/Harvard Depository increased by transfers of 3,364 volumes from RSC; holdings of Harvard Depository increased by transfers of 1,050 volumes from RSC.

b. This figure is the circulation for the Hayden Library containing both Humanities and Science.

c. The circulation for Architecture and Planning was 60,461 and for the Visual Collection 51,825.

d. The total circulation includes also a circulation of 19,559 of the Reserve Book Room.

The on-line catalog of the MIT Libraries, Barton, contains records for materials acquired by the Libraries since 1963 and selected earlier items. It does not include citations to journal articles or most maps, non-MIT technical reports, and pamphlets. Barton may be accessed through dial-in or via the Internet. The CD-ROM version of Barton, called CD-Barton, is available at public terminals (IBM-compatible PCs with color monitors) in every library. In addition to terminals dedicated to CD-Barton, the libraries offer PCs with CD-ROM drives to read various indexes and databases. Currently more than 65 different CD-ROMS in nine libraries are available—they include for example New York Times articles, aerospace abstracts, and U.S. Census of Agriculture data. In addition to computer resources, the Libraries provide copy machines, microfiche readers, microfiche reader-printers, audio/video equipment, and specialized machines.

The closing hours of the libraries vary according to their size. The small branch libraries, such as Aeronautics and Astronautics, close around 6pm. The medium-size libraries such as Engineering and Management close around 11pm during the week and on Sunday. On Friday and Saturday they close at around 6pm. The largest library, Hayden Memorial, which houses both the Humanities and the Science Library is one of the few libraries in the world open 24 hours during the week. It is only closed from Friday midnight to Saturday 8am and Saturday midnight until Sunday, noon. The reference hours of all libraries are from 9am to 5pm.

A recent innovation of the MIT Libraries is On-line with Libraries (OWL). The system offers on-line reference assistance to users of the Athena Computing Environment. By using the program OWL, a reference question can be asked at anytime. If a reference staff member is logged in, the communication is interactive through messages appearing on the screen. If no librarian is on-line or if the user logs out, he/she will receive an answer through e-mail within less than 24 hours. OWL is especially effective when information is needed about library services, facilities, and collections, or verification of bibliographic references.

Another on-line service of the MIT Libraries is FirstSearch. Also accessible through the Athena Computer Network, members of the MIT Community may access eighteen databases such as GPO, NewsAbs, and WorldCat. The service

9. More than 30 million bibliographic records starting from the year 1000.
Section 3.5: Educational Resources

is offered free of charge to the users and is available 23 hours per day, seven days per week. Recently, *Encyclopedia Britannica* and the *Oxford English Dictionary* became available on-line for MIT users through the World Wide Web (WWW or W3).

Since the Libraries are not large enough to hold all material collected, the Institute has established the *RetroSpective Collection* (RSC). The RSC is an off-campus storage facility for the MIT Libraries. Older material that is used infrequently is moved to the RSC but may be retrieved within 24 hours upon submission of a request. Theses and printed volumes that cannot be stored at neither the libraries nor the RCS are moved to the Harvard Depository in Southborough, Massachusetts.

### 3.5.2 Computing and Networking Resources

The organization responsible for computing, networking, information technology, and telecommunications resources is *Information Systems* (IS). It is organized into the following six departments and groups:

- **Academic Computing Services (ACS)**
  ACS is the office primarily involved in educational computing on campus. It works with Schools and academic departments of the Institute to provide assistance in acquiring information technology for educational purposes. The *Faculty Liaisons* group within ACS cooperates directly with faculty who use or plan to use the Athena Computing Environment and similar technology in a course.

- **Administrative Systems Development (ASD)**
  ASD develops applications in conjunction with MIT's administrative offices. It also offers in-depth business analyses and provides project management services.

- **Computing Support Services (CSS)**
  The focus of CSS is on microcomputers and workstations. The department provides a comprehensive list of services and products: *Consulting Services* group helps microcomputer and Athena users, *Computer Services* administers hardware maintenance contracts and software libraries, *Training Services* offers classes, seminars, minicourses on systems, Athena, and popular commercial software throughout the year, *Publications Services* prepares guides, manuals, etc.
  The CSS also manages the *MIT Computer Connection* (MCC). The MCC, located in the basement of the Student Center, sells to students, faculty, staff, and the Institute itself hard- and software. The current line of computers includes Apple, AT&T, DEC, Dell, IBM, Silicon Graphics (SGI), and Sun systems. Software, peripherals, and supplies for these systems from a variety of vendors are also being sold at the MCC.

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10.*FirstSearch* is not available from 2 am until 3 am.
Chapter 3: MIT Today

- **Distributed Computing and Network Services (DCNS)**
  DCNS main responsibility is the support and maintenance of MIT's distributed computing infrastructure (including MITnet and Athena). DCNS also develops applications such as TechMail (an electronic mail service for microcomputers), TechInfo (MIT's on-line campus-wide information system), and the MIT On-Line Directory.

- **Operations and Systems (O&S)**
  O&S maintains MIT's Data Center and provides centrally managed computer resources and access to an IBM mainframe for general-purpose computing.

- **Telecommunications Systems**
  Telecommunications Systems provides telecommunication services (installation and maintenance of all campus telephone, fax, and voice-mail services) throughout MIT.

The first three of these departments work closely together and constitute the Academic Computing Management Group which serves as the policy-making group for academic computing. This group employs about 45 to 50 people; its annual budget is about $6 million of which roughly one third goes towards equipment and related expenses, one third towards development, assistance, operation of systems/clusters, and the reminder towards various kinds of support and user assistance.

Since the variety of computers on campus is fairly large, the machines have little in common. However, most of the Institute's 8,000 computers, ranging from personal computers to mainframes, are connected to the campus network MITnet, which enables the communication with each other and with computers around the globe. MITnet, established in 1984, consists of a 100 Mbits/sec fiber optic spine more than 2.5 kilometers long to which 40 Ethernet 10 Mbits/sec subnets and in turn the actual computers are attached. The network reaches almost every academic building and many offices and laboratories on campus. Off-campus fraternities, sororities, and Independent living Groups were connected to MITnet in September 1993 and in January 1994 every single room in all undergraduate dormitories received an Ethernet drop to connect to the network. Four of the six graduate dormitories will be connected to the network during the 1994–95 academic year and the remaining two dormitories will receive their connections in the following year. As of the spring term 1994, approximately 400 students in dormitories and 350 in independent living groups have connected their computers to MITnet. All network users except students, pay a small flat-rate installation fee and a monthly charge.

The wide variety of computers on campus can be divided into several categories:
- Athena workstations and servers
- Workstations and personal computers for research purposes in laboratories
- Personal computers of faculty and staff for academic and administrative use

11. The MITnet connection to the dormitories is usually referred to as Resnet.
Section 3.5: Educational Resources

• Mainframes / Supercomputers

The Athena Computing Environment\textsuperscript{12} is one of MIT's most remarkable achievements of the last years. The Athena Computing Environment started in May 1983 as Project Athena by MIT in partnership with IBM Corporation and Digital Equipment Corporation (DEC) to respond to MIT's needs to provide widely available computing resources to the Institute. The project originated from a study in the early 1980s which found that there was little, if any, computer usage for educational purposes by undergraduate students compared to that by graduate students.

As MIT and its two partners saw it, Project Athena had two primary objectives:
1. Design and implementation a large-scale distributed computing environment.
2. Usage of that environment to improve undergraduate education.

The goal for the distributed computing environment was to include up to 10,000 UNIX-based workstations and accommodate heterogeneous hardware while being entirely coherent. The idea was that a user could go to any Athena workstation on campus and still have access to his or her own customized environment and personal files. This concept of a public workstation had many advantages. Users and their files were not associated with a unique physical workstation. The files of all users and application were stored at a central location and could be accessed through any Athena terminal on campus. For the system administration it meant that software was easy to install and update. Since this distributed client/server technology did not exist at that time, it took MIT, DEC, and IBM almost five years to make it a reality, which also prompted the extension of Project Athena from five to eight years. At the end of the eight-year partnership, on June 30, 1991, Project Athena was adopted by the Institute as the Athena Computing Environment and IS was put in charge of managing and maintaining it.

Athena became extremely successful and has changed the way students work and how they interact with fellow students and faculty. As a consequence, a decision was made in 1989 to grant Athena accounts to graduate students. As of last count, 1055 faculty members, 11,approximately 97% of the undergraduate students and 81% of the graduate student had accounts. Together with faculty and staff, the number of individuals with Athena access has reached more than 14,000. Presently, there are on average 7,000 discrete log-ins per day. MIT-wide about 11% of all regularly scheduled courses require the use of the Athena Computing Environment.

Currently Athena uses the following types of workstations and printer:
• DECstation 3100 and DECstation 5000
• IBM RS/6000 Model 220 and IBM RS/6000 Model 320
• Sun SPARCclassic and Sun SPARCstation 5

\textsuperscript{12}The computing environment is names after Athena, the greek goddess of wisdom.
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- In the near future Silicon Graphics Indy workstations will be added to the Athena network.
- Hewlett-Packard 4si Laserprinter (600 dpi)

The number and location of workstations and printers is shown in Table 3.10:

**Table 3.10: Number and Type of Athena Workstations and Printers**

<table>
<thead>
<tr>
<th>Computer</th>
<th>Public</th>
<th>Dept.</th>
<th>Dept.</th>
<th>Dept.</th>
<th>Dept.</th>
<th>Athena</th>
<th>Staff</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS3100</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>DS5000</td>
<td>176</td>
<td>47</td>
<td>54</td>
<td>0</td>
<td>102</td>
<td>57</td>
<td>4</td>
<td>436</td>
</tr>
<tr>
<td>RS6000</td>
<td>81</td>
<td>36</td>
<td>12</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>Sparc Classic</td>
<td>134</td>
<td>67</td>
<td>101</td>
<td>0</td>
<td>8</td>
<td>50</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td>Sparc 5</td>
<td>36</td>
<td>19</td>
<td>0</td>
<td>3</td>
<td>14</td>
<td>8</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>447</td>
<td>169</td>
<td>167</td>
<td>3</td>
<td>134</td>
<td>109</td>
<td>1029</td>
<td></td>
</tr>
<tr>
<td><strong>HP Printers</strong></td>
<td>35</td>
<td>23</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

The workstations have a large monitor (many of them color), keyboard, mouse, a system unit, main memory, a hard drive, and a disk drive. The most recently deployed Sun SPARCstation 5 also include a CD-ROM drive. The purchase price of typical Athena workstations ranges from $5,000 to $7,000 depending in the configuration.

The academic computing facilities open to the entire MIT community are:
- 14 public clusters with 447 workstations and 35 laserprinters open 24 hours 365 days a year. The largest and most popular cluster is the Student Center cluster which provides around 120 workstations
- Three electronic classrooms with about 20 workstations for students use
- Four lecture halls equipped with instructor workstations and video projectors
- A small networked Macintosh cluster\(^{13}\) available for scheduled classes or for public use by students.
- A Visitor Center equipped with a variety of workstations and a video projector.

The system software making the distributed Athena environment possible consists of three key elements:
- The **UNIX Operating System** controls the workstation hardware and includes a large library of standard commands for basic tasks.
- The **X Windows System** provides a graphical user interface that allows to divide the workstation's display into one or more windows with each window behaving like a separate terminal. X Windows was developed by MIT to become a worldwide industry standard.

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\(^{13}\)The room was organized by the School of Science primarily for its students and software useful to courses offered by the School.
The AFS (Andrew File System) distributed file system and the Athena developed "attach" capability allows the user to work with files stored anywhere in the Athena environment as if they were present on the local hard disk.

**General Application Software.** Because of the distributed client/server system of Athena, the purchase, installation, and updating of applications is fairly simple. All users have access to the same software in the computing environment. At the present time the following key applications are available on Athena:

- Mathematical and statistical analysis software: SAS, Matlab, Maple, S-plus, and a very limited number of Mathematica licenses
- Editors and word processors: Emacs, LaTeX typesetting language, EZ (a menu-driven word processor), document preparation system FrameMaker
- Spreadsheet: Xess
- Charting and Plotting: Tecplot
- Computer aided Design: AutoCAD, PRO/Engineer
- Drawing / Graphics: xv, xfig, Xpaint

On how many workstations an application can run at any given time, is determined by the number of licenses bought for Athena. Some applications, such as LaTeX have unlimited licenses while AutoCAD have a limited number of licenses. The major application used the most at any given time is the word-processing-publishing package FrameMaker.

In addition to these commercial software packages, numerous applications were written at MIT for specific courses with the goal in mind to improve the teaching at the Institute. Two of these are for general use:

- The Networked Educational On-line System (NEOS) gives students the possibility to turn in and professors to grade and return homework purely electronically.
- The On-Line Teaching Assistant (OLTA) software allows students to submit questions to their course teaching assistants in electronic form.

A variety of specific courseware was developed at MIT when Athena was still an educational project. One of the first large software suite for use in many subjects was Tódor. It took well over four years to develop this suite of 40 programs designed to do calculations and display simulations of aeronautical and astronomical phenomena including rocket reentry and airfoil design. Another successful package was Growltiger. This software gave students in Civil Engineering the tools to translate design and material attributes into simulated bridges and other structures and then see how the simulated structures reacted to various loads and stresses.

To access the Internet and the World Wide Web (WWW or W3), Athena offers among other software the Mosaic WWW browser, the Gopher information-repository browser, Telnet and FTP, as well as Netnews readers. For programers, Athena
provides a variety of programming languages such as C, C++, FORTRAN, Lisp, and C#. Toolkits, numerical and statistical libraries are also available.

A highly popular mean of communication within MIT in addition to e-mail is Zephyr. This MIT-developed system is an instantaneous notification service. Zephyr allows a user or a service to send a message to one more individuals who are logged in at that time. When a user receives a message, a small Zephyr window or Zephyrgram pops up in the corner of the screen with the message. Users also have the option to “subscribe” to classes of Zephyr messages. An example of a popular class are the weather Zephyrs. All subscribing users receive every 30 minutes an update on the local weather and a weather forecast. More serious instances are those for programming classes. A student taking a course on the C programming language can subscribe to the instance for the course and ask his/her fellow students questions.

To help users, Athena provides On-Line Consulting (OLC). This system, building upon e-mail and Zephyr, allows a user with a question to send an instant message to a group of consultants. More than 3,000 questions are answered by the consultants every month of which 95% are answered in less than five minutes. Frequently asked questions are also answered in the “stock answers” database.

Each Athena user is provided with limited amount of file storage space on Athena. This space on servers (known as a user’s “disk quota”) is currently 10 Megabytes. To store material beyond the quota, users can use floppy disks. However, if an Athena users needs a higher quota to work on a project or thesis he or she can request more disk space. Every year in September all users are given an allotment of pages they can print on Athena printers free of charge. This allotment (known as the “print quota”) is currently 1,200 pages. For any pages printed beyond that quota, users are charged 10 cents per page.

While Athena is an integral part of almost all students’ lives, it has little importance for many faculty and staff members. The reason for this discrepancy lies in the fact that the great majority of faculty and staff members use Apple Macintosh computers for their work.

3.6 Public and Industry Relations

3.6.1 The MIT Museum

The MIT Museum was founded in 1971 as the MIT Historical Collections to collect and preserve materials and artifacts connected with MIT and to use these materials to illustrate the history of the Institute—especially its role in the history of modern science and technology. Over the years the Historical Collections evolved from serving only the MIT community to a museum concentrating on a

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14. The disk quota has grown considerably over the last 5 years. In 1990, 1.2 MB were available. Later the quota was increased to 2 MB, then 5 MB, and finally to 10 MB.

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wider range of themes. Since 75% of the Museum’s patrons were not affiliated with the Institute, this evolution came naturally. To reflect the changes, the name was changed from Historical Collections to The MIT Museum in 1980 and the official policy statement revised in 1985 as part of the successful attempt for accreditation by the American Association of Museum (AAM). The 1985 statement of purpose, valid to the present day, is as follows:

The educational mandate of The MIT Museum is to make accessible to the community ... exhibits and programs [which] interpret the Institute’s educational and social history and its role in the development of science, technology, and the arts. This policy is implemented by exhibitions based on the Museum’s collections, on topics relevant to the MIT community, on topics which illustrate an interplay between art and science, and on topics which explore the impact of science and technology on society.

The MIT Museum’s main facility is located in Building N52 at 256 Massachusetts Avenue at the northern perimeter of the campus. It serves a diverse audience with its main constituency being the scientific community consisting of MIT students, faculty, staff, alumni, and many visitors to the campus. However, the Museum is also dedicated to reach a non-scientific audience, especially K–12 students.

The MIT Museum collections include approximately:

- 4,550 instruments, models, components, and related artifacts
- 138,100 drawings and prints
- 1,700 historical films, recordings, videotapes, and audio tapes
- 1,610 paintings and art objects
- 1,500 holograms
- 780 pieces of furniture and decorative art
- 641,000 photographs
- 810 cubic feet (23 cubic meters) of biographical materials

Because of the continuous flow of visitors and research requests, the MIT Museum operates on a regular 12-month schedule. The Museum’s main facility is open to visitors Tuesday through Friday from 9 am to 5 pm and on Saturday and Sunday from 1 pm to 5 pm, except on holidays. The Compton Gallery is open 9 am to 5 pm from Monday through Friday (except on holidays) and at other times for special events. Both the Hart Nautical Gallery (five separate exhibit areas) and the Edgerton Strobe Alley are open 8 am to 8 pm throughout the week.

Detailed attendance records are maintained for the central facility, but not for the galleries and campus corridor exhibits. The quarterly attendance is therefore extrapolated from sample counts made in the various campus locations at regular intervals during the year. The statistic for the period 1990–1993 is shown in Table 3.11 on page 84. Annually, about 3,000 visitors attend Museum sponsored lectures and programs. In addition 2,000 children came from as far away as Connecticut and New Hampshire in FY 1993. More than 60 MIT and non-MIT organizations used the Museum’s facility for evening events which drew 5,000 visitors...
Table 3.11: Quarterly Attendance of MIT Museum Exhibits

<table>
<thead>
<tr>
<th>Year</th>
<th>Oct–Dec</th>
<th>Jan–Mar</th>
<th>Apr–June</th>
<th>July–Sept</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990–91</td>
<td>69,000</td>
<td>57,000</td>
<td>67,000</td>
<td>57,200</td>
<td>250,200</td>
</tr>
<tr>
<td>1991–92</td>
<td>65,550</td>
<td>61,050</td>
<td>69,600</td>
<td>56,550</td>
<td>252,750</td>
</tr>
<tr>
<td>1992–93</td>
<td>60,850</td>
<td>59,500</td>
<td>61,600</td>
<td>47,650</td>
<td>229,600</td>
</tr>
</tbody>
</table>

to the MIT Museum. On average, the Museum receives annually 210 inquiries from researchers of which 60% are not MIT affiliated. About 95% of the entire collection is available to these researchers upon request.

Originally, the Museum reported to the MIT Libraries but several years ago its affiliation has been transferred to the Associate Provost for the Arts. The professional staff of the Museum consists of eleven members, who have numerous years of museum-related experience and all with an education appropriate for their position. An area of approximately 64,000 sf (5,900 m²) has been made available to the MIT Museum. The primary exhibition, office, and storage space of 25,000 sf (2,300 m²) is located on the second floor of Building N52, a four-story former factory building. The usage of the total space available is as follows:

- **Collection storage:** 30,300 sf or 2820 m² (47.3%)
- **Exhibitions:** 19,900 sf or 1850 m² (31.1%)
- **Education:** 3,300 sf or 310 m² (5.2%)
- **Exhibit preparation:** 3,300 sf or 310 m² (5.2%)
- **General storage:** 3,000 sf or 280 m² (4.7%)
- **Museum Shop:** 3,000 sf or 280 m² (4.7%)
- **Administration:** 1,000 sf or 90 m² (1.6%)

The largest and best collections of the Museum are in those areas of science and technology in which MIT has made important contributions. Examples are telecommunications material invented and used in the 1870s that assisted Alexander Graham Bell in his invention of the telephone, artifacts from early computer research, an extensive collection documenting the history of aviation in New England, 17th- through 20th-century scientific instruments, and materials and records from the Institute’s pioneering research in radar, stroboscopy, electronics, nutrition and health sciences, crystallography, spectroscopy, inertial guidance, high-voltage generation, and servomechanisms.

The latest large addition to the MIT Museum has been the purchase of the entire holdings of the defunct Museum of Holography in New York at an auction. Since MIT has been strongly involved in the development in the field, the Museum conducted research and fund-raising to bring the world’s premier collection of more than 1,500 holograms as well as the extensive archive on the history of holography to the Institute.

The Architectural Drawings Collection consist of rare 19th-century drawings by European and American architects and students of MIT’s Department of Architecture. The historically and artistically important collection is made up of 18,000
works in pencil, pen and ink, and watercolor. It documents impressively the development of architecture in the U.S. since the 1860s and the teaching of the MIT Department of Architecture.

Before the acquisition of the holography collection, the Museum’s *Hart Nautical Collections*, were the main attraction. The Hart collection is one of the world’s largest and most important holdings of materials related to the history of naval architecture, marine engineering, ship building, yachting, and whaling. The collection, started in 1922, includes 230 ship models, 310 half models, 110,000 ship and yacht plans (including the 13,000 yacht plans of the heavily used *Herreshoff-Haffenreffer Collection*), 2,700 monographs and rare books, 4,800 cartography and other fine art prints dating back to the 16th-century, 48,000 photographs and negatives, 95 cubic feet (2.7 cubic meters) of ship building records, and 320 nautical artifacts.

In fiscal year 1993–94, more than 7,000 negatives and 10,000 research slides taken by the late MIT Professor Harold “Doc” Edgerton, the father of stroboscopic photography, were transferred to the Museum and are being currently catalogued as part of the Edgerton Project to document 50 years of research by Professor Edgerton.

Current in-house long-term exhibitions of The MIT Museum are:

- **Holography: Artists and Inventors—The Museum of Holography Moves to MIT**
  This star exhibition encompasses several galleries and explores historical, technical, and artistic facets of holography. A videotape runs continuously to explain the holographic process.

- **Doc Edgerton: Stopping Time**
  Photographs, instruments, and memorabilia documenting Harold Edgerton’s development of the strobe light and ocean sonar. The exhibit features a continuous video presentation and an interactive strobe apparatus.

- **Math in 3D**
  Twenty-nine revolving sculptures (with diameters from 30 centimeters to almost 2 meters) based on mathematical formulas and color theory.

- **Sculptures by Bill Parker**
  Nine vivid plasma sculptures of ionized gases in glass spheres.

- **Crazy After Calculus: Humor at MIT**
  This popular exhibit chronicles MIT’s rich history of “hacks” (technical pranks). It includes historic photographs, cartoons, and a collection of artifacts associated with some of the most renowned pranks perpetrated by MIT students over the years. The latest addition to the collection is the campus police car placed on top of the Great Dome in May 1994.

- **Course XIII 1893–1993: From Naval Architecture to Ocean Engineering**
  In celebration of the Department of Ocean Engineering’s 100th anniversary, in 1993 this exhibit shows the evolution of the department through artifacts and historic photographs. The focus lies on current research activities including the development of small underwater research vehicles and acoustic sensing techniques.
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The Museum has also been successful in its educational outreach endeavors to its K–12 constituency. Two noteworthy programs are:

- **So You Think Math and Science are Boring...** (School Vacation Program)
  The Museum’s most popular educational program is designed to ignite a serious, life-long interest in the sciences. This school vacation program was created to engage students who, mainly for socioeconomic reasons, lack an impetus to explore careers in science and technology. In this program students get the rare opportunity to look at eight very different MIT laboratories and actually participate in experiments.

- **Flash!, Stopping Time, Seeing and Touching Geometry**
  (After-School and Weekend Programs)
  Both primary and secondary school groups participate in after-school programs. *Flash!* is a guide for students through the general exhibits. *Stopping Time* guides children through the *Strobe Alley* where they can create and star in their own stop-action photographs. *Seeing and Touching Geometry* uses the Math-in-3D exhibition and the adjoining *MathSpace* activities room to learn about mathematics through playing.

### 3.6.2 Special Events and Information Center

The stated mission of the Special Events and Information Center, which reports to the Director of Public Relations, is “to meet the informational needs of the MIT community, visitors to the campus, and the public; to promote a sense of community within MIT; to support conferences and events which enhance MIT’s role in the broader academic community.”

The Information Center is located in the lobby of Building 7 where most visitors arrive since it is MIT’s main address (77 Massachusetts Avenue). For many people who visit the Institute, the Center is the only point of contact, either through the campus tours it conducts or by answering/redirecting inquiries.

**Campus Tours.** The Information Center conducts from Monday through Friday twice a day campus tours for visitors. These student-guided tours leave from the main lobby in Building 7 at 10:00 am and 2:00 pm. The 1 hour and 15 minute walking tour of the campus follows the following route:

Student Center (Bldg. W20), Kresge Auditorium (Bldg. W16), Chapel (Bldg. W15), Hart Nautical Galleries (Bldg. 5), Infinite Corridor, Athena Cluster area in Building 11, MIT course 2.70 Introduction to Design display (Bldg. 3), Killian Court, Hayden Memorial Library (Bldg. 14), McDermott Court, Ralph Landau Building (Bldg. 66), Compton Court, classroom 26-100, Vannevar Bush Building (Bldg. 13), Barker Engineering Library (Bldg. 10), Prof. Edgerton’s Strobe Alley (Bldg. 4), classroom 10-250, Compton Gallery (Bldg. 10).

Following the tours, the Admissions Office shows a 15-minute film on MIT and offers a question and answer session for prospective undergraduate students and their families in the Admissions Reception Center.
On average, the number of visitors on a tour varies between 5 and 15 people. In the winter the attendance is with 4 to 8 people significantly lower than in the spring and summer where the size of the tour can be between 60 and 80. While most people taking tours are prospective students and their families, there is a large number of tourists and other visitors of which many are interested in the architecture and the sculptures. Table 3.12 gives an overview of the attendance of campus tours in FY 1993–94.

Table 3.12: Participants in Campus Tours in Fiscal Year 1994

<table>
<thead>
<tr>
<th>Visitors</th>
<th>Regular Tours</th>
<th>Special Tours*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospective Students</td>
<td>3,468</td>
<td>332</td>
<td>3,800</td>
</tr>
<tr>
<td>International Visitors</td>
<td>1,083</td>
<td>511</td>
<td>1,594</td>
</tr>
<tr>
<td>Others</td>
<td>5,449</td>
<td>79</td>
<td>5,528</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,000</strong></td>
<td><strong>922</strong></td>
<td><strong>10,922</strong></td>
</tr>
</tbody>
</table>

* Special tours are conducted for groups larger than 15 people who cannot join the regularly scheduled tours.

In 1993–94 a total of 498 short-term international visitor programs were arranged. Short-term international visitors are sponsored by the United States government and include leaders and potential leaders in a variety of fields such as heads of state and cabinet members.

The Information Center has 27 active student tour guides of which it actually uses only fifteen. From these one is designated as the Tour Guide Captain who handles the scheduling of tour guides and contacts the guides about regular and special tours.

**Conference Services Office.** The role of the office is to manage the logistical arrangements of conferences and meetings sponsored by MIT, the faculty, and staff. The typical number of attendees is between 10 and 2,000. In addition, Conference Services handles the arrangement for the recruitment presentation by companies and other organizations in conjunction with the Office of Career Services.

In 1994, Conference Services managed 25 events and 110 recruitment presentation and brought more than 8,000 visitors from all around the world. Examples of events hosted are Interactive Media Workshop, 127th Meeting of the Acoustical Society of America, Massachusetts Biotechnology Council Symposium and Trade Exposition, and the first Black Women in Academy Conference.

The biggest event held on campus was the try Summit co-hosted by the World Economic Forum and MIT in cooperation with Harvard University. For the event the Office assisted the main organizers with the logistical management and the registration.

**Information Source.** Two staff members answer questions from visitors, distribute printed material, and direct inquiries by telephone from the public and the
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MIT community. In FY 1993–94 the Center distributed 1,293 MIT catalogs, 23,169 maps and guides, as well as 16,147 other publications.

3.6.3 News Office
The News Office publishes weekly the official MIT newspaper *Tech Talk*. Together with the student-run newspaper *The Tech*, it represents a major source of information on the activities on campus. In addition to its primary product *Tech Talk*, the News Office issues news releases to the media about important events at MIT. In 1993–94, there was a total of 160 news releases. In December 1991, the News Office started the *Research Digest*, a single-sheet, two-sided, illustrated newsletter designed to disseminate abbreviated stories about MIT research to the news media quickly so that they could follow up on them immediately.

Recently the News Office made their News Releases and other information accessible through the World-Wide Web. As a result the number of calls to the office has increased by a factor of three to four. In addition, the callers’ background has changed. While in the past, most calls were made by journalists to inquire about information for articles, now most calls are by private individuals to inquire about certain research that somehow affects their lives.

3.6.4 Center for Advanced Engineering Studies (CAES)
The Center for Advanced Engineering Studies (CAES) was founded in 1963 by Alfred P. Sloan, Jr. with the primary objective to provide lifelong learning opportunities in engineering and science, enabling professionals to acquire new skills. To achieve this objective, the CAES offers two types of programs, the MIT Video Courses and the Advanced Study Program. In addition to these, the CAES, which is housed in Building 9, offers video support services, an editing suite to broadcast standards, and an interactive multimedia workstation.

The on-campus Advanced Study program allows the participating professionals to take regular undergraduate and graduate courses supplemented by seminars and individual studies according to their needs. Participation in ongoing research is also possible. Since the beginning of the program, professionals from more than 100 organizations in over 70 countries have participated full-time. These CAES fellows may enroll for one or more semester and are awarded certificates at the completion of their studies. In 1993–94, the Advanced Study Program had 68 fellows, 20 from the United States and 48 from 11 foreign countries.

The Center fellows are provided with study offices, computer facilities, a videotape library of courses and viewing facilities, as well as special subjects that are of particular interest to participants, such as *Project Management* and *Managing Technological Change*.

The Video Courses offered by the CAES extend MIT’s on-campus academic program through the distribution of videotaped courses. The courses are taught by a leading authority in the field, usually an MIT faculty member, and are designed specifically for use by professionals in the workplace. The courses are being used
by a range of businesses, government agencies, and educational, and training institutions to instruct their engineers, scientists, and managers. While usually vide programs are professionally produced studio course, sometimes live satellite broadcasts are used. With more than 75 titles, the MIT Video Course series cover a wide range of subjects in science, engineering, and management.

In recent years, the CAES has made considerable expansions to its audio-visual and multimedia capabilities and services. The Video Production facilities and services include, a full production television studio, a television classroom, videotaping on location, and on-line and off-line editing. The PictureTel videoconferencing system simultaneously transmits audio compressed digital video via telephone lines to up to 16 contact points and can be used for long-distance meetings presentations, remote instruction, and consultation worldwide. The interactive multimedia suite allows the development of multimedia program on CD-ROMs.

3.6.5 Industrial Liaison Program (ILP)

MIT’s Industrial Liaison Program (ILP) is part of the Corporate Relations Office of Resource Development. The Office of Corporate Relations has a staff of over 50 individuals who help companies build relations with MIT. At anyone time well over 300 corporations have active ties to MIT. These links include such arrangements as support and involvement in major educational and research initiatives, membership in consortia, sponsorship of individual research projects, and attendance at executive education programs.

Founded in 1948, the ILP was one of the first organizations established by a university to make its research accessible for industry. Currently, MIT’s ILP offers its 202 member corporations (versus 207 at the end of FY 1993) probably the broadest access to research. MIT is one of few of the 40 universities with similar programs that allows access to the entire campus rather than just to a specific laboratory. Fifty-four percent of the member corporations are from the United States, 19 percent from Japan.

The ILP allows companies to keep up with advances in research through various activities and information services, including the yearly series of 30 seminars and symposia, the award-winning monthly research newsletter, The MIT Report, a directory of the expertise and research interests of the Faculty and research staff at MIT entitled MIT Expertise. In addition, the ILP publishes Research at MIT, a comprehensive listing (including abstracts) under way at the Institute. The ILP companies can explore emerging business opportunities by staying informed on the latest trends and developments including patents granted to MIT researchers. In the case of technical and managerial problems, member corporations are introduced to the appropriate experts in the MIT community. By building relationships with students and faculty working, ILP members can recruit easier top graduates.

Each member corporation is assigned a Liaison Officer, who works closely with designated individuals at the corporation to match the company’s need with MIT’s
resources. The Officer is the principal MIT contact who responds to specific requests for assistance and information concerning any aspect of MIT. He or she will also identify research areas and emerging opportunities that be of interest to the member company and arrange visits.

For their membership, corporations pay on average $33,500 annually if they are U.S.-based, $48,367 if they are European, and $51,833 if they are Japanese, with fees depending on the size of the company. The FY 1994 revenues of ILP were $7.85 million, a 3.6% rise from the previous year despite the decrease of member companies by five from 207.

3.7 Financial Resources

3.7.1 Revenues and Expenses

As a non-profit organization MIT must balance its expenses with its revenues. In fiscal year 1993–94, the total operating expenses were $1,137,474,000 compared to $1,133,891,000 in 1992–93, which represents an increase of 0.3%. Total revenues were $1,125,036,000, thus MIT had an operating gap of $12,438,000 compared to $15,432,000 in 1992–93. To meet this operating gap, $6,246,000 of current gifts, grants, and bequests as well as $1,882,000 of investment income was used. The remaining difference between expenses and revenues, the deficit of $4,310,000, was paid with funds functioning as endowment. Compared to FY 1992–93 the operating gap of $12,438,000 was reduced by 19.4% from $15,432,000, while the deficit grew by 40.4% from $3,072,000. Table 3.13 on page 91 shows the operating expenses for FY 1994 (the year ended on June 30, 1994) together with comparative totals for 1993 and the percentage change. Similarly, Table 3.14 on page 92 shows the revenues and funds used in FY 1994 to meet the expenses of current operations. The table also includes comparative totals for 1993 and the percentage change.

Figure 3.11 on page 92 shows in chart-form a breakdown of the FY 1994 expenditures. Not surprising, the largest portions of the budget are sponsored research at Lincoln Laboratory in Lexington, Massachusetts, sponsored research on campus, instruction and unsponsored research, as well as expenses applicable to instruction, research, and depreciation. Sponsored research makes up slightly more than the total budget of the Institute (51%). Figure 3.12 on page 93 shows a breakdown of the FY 1994 revenues. While sponsored research accounts for 51% of the expenditures, it accounts for 61% of all revenues and fund used. Tuition and related fees account for 17% of the income, which proofs the importance of the tuition to the Institute. This portion of the income is in the only one over which MIT has direct control. However, this is a theoretical control, since the goal of the Institute is to keep the tuition as low as possible.

3.7.2 Gifts, Grants, and Bequests

Gifts, grants, and bequests are an important source of revenues for universities. In 1993–94, MIT received $92.85 million through various kinds of gifts. This
### Table 3.13: MIT Operating Expenses for FY 1993 and FY 1994

<table>
<thead>
<tr>
<th>Category</th>
<th>Total 1993</th>
<th>Total 1994</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept. Heads and Lab Directors</td>
<td>18,321,000</td>
<td>$19,215,000</td>
<td>4.88%</td>
</tr>
<tr>
<td>Institute Professors</td>
<td>6,012,000</td>
<td>6,087,000</td>
<td>1.25%</td>
</tr>
<tr>
<td>School of Architecture and Planning</td>
<td>15,801,000</td>
<td>17,135,000</td>
<td>8.44%</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>64,358,000</td>
<td>68,028,000</td>
<td>5.70%</td>
</tr>
<tr>
<td>School of Humanities &amp; Social Sci.</td>
<td>24,770,000</td>
<td>25,959,000</td>
<td>4.80%</td>
</tr>
<tr>
<td>Sloan School of Management</td>
<td>27,975,000</td>
<td>28,079,000</td>
<td>0.37%</td>
</tr>
<tr>
<td>School of Science</td>
<td>40,316,000</td>
<td>46,248,000</td>
<td>14.71%</td>
</tr>
<tr>
<td>Whitaker College of Health Sciences</td>
<td>8,955,000</td>
<td>6,210,000</td>
<td>-30.65%</td>
</tr>
<tr>
<td>Interdepartmental Labs and Centers</td>
<td>3,072,000</td>
<td>2,707,000</td>
<td>-11.88%</td>
</tr>
<tr>
<td>Other programs</td>
<td>5,960,000</td>
<td>6,417,000</td>
<td>7.67%</td>
</tr>
<tr>
<td><strong>Total 1993</strong></td>
<td>$215,540,000</td>
<td>$226,084,000</td>
<td>4.89%</td>
</tr>
<tr>
<td><strong>Instruction &amp; unsponsored research</strong></td>
<td>$263,335,000</td>
<td>1.59%</td>
<td></td>
</tr>
<tr>
<td><strong>Lincoln Laboratory research</strong></td>
<td>315,537,000</td>
<td>-5.12%</td>
<td></td>
</tr>
<tr>
<td><strong>Total sponsored research</strong></td>
<td>$591,787,000</td>
<td>$578,872,000</td>
<td>-2.18%</td>
</tr>
<tr>
<td>Administrative</td>
<td>3,685,000</td>
<td>$3,756,000</td>
<td>1.91%</td>
</tr>
<tr>
<td>General</td>
<td>2,560,000</td>
<td>2,221,000</td>
<td>-13.26%</td>
</tr>
<tr>
<td><strong>Research admin. &amp; general expenses</strong></td>
<td>$6,246,000</td>
<td>$5,977,000</td>
<td>-4.30%</td>
</tr>
<tr>
<td>Libraries</td>
<td>13,198,000</td>
<td>13,330,000</td>
<td>1.00%</td>
</tr>
<tr>
<td>Medical</td>
<td>8,337,000</td>
<td>9,095,000</td>
<td>9.09%</td>
</tr>
<tr>
<td>Plant operations and maintenance</td>
<td>69,913,000</td>
<td>71,070,000</td>
<td>1.65%</td>
</tr>
<tr>
<td>Administration</td>
<td>23,263,000</td>
<td>24,088,000</td>
<td>3.55%</td>
</tr>
<tr>
<td>Fiscal, personnel, other MIT-wide services</td>
<td>37,418,000</td>
<td>36,960,000</td>
<td>-1.22%</td>
</tr>
<tr>
<td>General expenses</td>
<td>25,894,000</td>
<td>21,822,000</td>
<td>-15.73%</td>
</tr>
<tr>
<td>Other instr. and research support activities</td>
<td>7,404,000</td>
<td>7,675,000</td>
<td>3.66%</td>
</tr>
<tr>
<td>Student services</td>
<td>20,114,000</td>
<td>20,989,000</td>
<td>4.35%</td>
</tr>
<tr>
<td><strong>Expenses applicable to instruction, research</strong></td>
<td>$205,541,000</td>
<td>$205,029,000</td>
<td>-0.25%</td>
</tr>
<tr>
<td>Dining services</td>
<td>2,203,000</td>
<td>2,131,000</td>
<td>-3.27%</td>
</tr>
<tr>
<td>Dormitories</td>
<td>10,867,000</td>
<td>11,353,000</td>
<td>4.47%</td>
</tr>
<tr>
<td>Housing</td>
<td>6,062,000</td>
<td>6,266,000</td>
<td>3.37%</td>
</tr>
<tr>
<td><strong>Dining and Housing</strong></td>
<td>$19,132,000</td>
<td>$19,749,000</td>
<td>3.22%</td>
</tr>
<tr>
<td>MIT Press</td>
<td>$16,159,000</td>
<td>$16,863,000</td>
<td>4.36%</td>
</tr>
<tr>
<td><strong>Operating expenses before capitalization of equipment</strong></td>
<td>$1,124,840,000</td>
<td>$1,122,605,000</td>
<td>-0.20%</td>
</tr>
<tr>
<td><strong>Capitalization of equipment incl. above</strong></td>
<td>$(16,704,000)</td>
<td>$(15,125,000)</td>
<td>-9.45%</td>
</tr>
<tr>
<td><strong>Depreciation of buildings and equipment</strong></td>
<td>$25,755,000</td>
<td>$29,994,000</td>
<td>16.46%</td>
</tr>
<tr>
<td><strong>Total operating expenses</strong></td>
<td>$1,133,891,000</td>
<td>$1,137,474,000</td>
<td>0.32%</td>
</tr>
</tbody>
</table>

The amount is slightly smaller (0.7%) than the 1992–93 amount of $93.45 million. About 93% of the total gifts are in the form of cash, while the rest is in the form of equipment gifts from manufacturer and other donors worth $6.09 million. An overview of the gifts received is given in Table 3.15.

From the total gifts of $92.85 million, 24.8% or $22.99 million were reported by the Alumni/ae Fund. These gifts are included in the various categories of the previous table and represent an increase of 21.2% as compared to 1992–93.
Table 3.14: Revenues and Funds Used in FY 1993 and FY 1994

<table>
<thead>
<tr>
<th>Category</th>
<th>Total 1993</th>
<th>Total 1994</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition and fees</td>
<td>$181,199,000</td>
<td>$191,488,000</td>
<td>5.68%</td>
</tr>
<tr>
<td>Other related income</td>
<td>$3,121,000</td>
<td>$3,376,000</td>
<td>8.17%</td>
</tr>
<tr>
<td><strong>Total Tuition and other related income</strong></td>
<td><strong>$184,320,000</strong></td>
<td><strong>$194,864,000</strong></td>
<td><strong>5.72%</strong></td>
</tr>
<tr>
<td>Depart. and interdepartmental</td>
<td>$350,106,000</td>
<td>$354,236,000</td>
<td>1.18%</td>
</tr>
<tr>
<td>Lincoln Laboratory</td>
<td>$355,795,000</td>
<td>$336,934,000</td>
<td>-5.30%</td>
</tr>
<tr>
<td><strong>Research revenues</strong></td>
<td><strong>$705,901,000</strong></td>
<td><strong>$691,169,000</strong></td>
<td><strong>-2.09%</strong></td>
</tr>
<tr>
<td>Endowment income applied to operations</td>
<td>$40,959,000</td>
<td>$43,371,000</td>
<td>5.89%</td>
</tr>
<tr>
<td>Scholarships and fellowships</td>
<td>$39,645,000</td>
<td>$41,130,000</td>
<td>3.75%</td>
</tr>
<tr>
<td>Restrict. and unrestricted purposes</td>
<td>$104,012,000</td>
<td>$103,771,000</td>
<td>-0.23%</td>
</tr>
<tr>
<td><strong>Gifts, investment income, and miscellaneous receipts for</strong></td>
<td><strong>$143,657,000</strong></td>
<td><strong>$144,901,000</strong></td>
<td><strong>0.87%</strong></td>
</tr>
<tr>
<td>Plant fund used (additions)</td>
<td>$9,051,000</td>
<td>$14,869,000</td>
<td>64.28%</td>
</tr>
<tr>
<td>Dining and Housing</td>
<td>$18,412,000</td>
<td>$18,998,000</td>
<td>3.18%</td>
</tr>
<tr>
<td>MIT Press</td>
<td>$16,159,000</td>
<td>$16,863,000</td>
<td>4.36%</td>
</tr>
<tr>
<td>Other fund balances</td>
<td>$7,051,000</td>
<td>$1,882,000</td>
<td>-73.31%</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>$3,072,000</td>
<td>$4,310,000</td>
<td>40.30%</td>
</tr>
<tr>
<td><strong>Gifts, other fund balances used to meet expenses</strong></td>
<td><strong>$15,432,000</strong></td>
<td><strong>$12,438,000</strong></td>
<td><strong>-19.40%</strong></td>
</tr>
<tr>
<td><strong>Total revenues and funds used</strong></td>
<td><strong>$1,133,891,000</strong></td>
<td><strong>$1,137,474,000</strong></td>
<td><strong>0.32%</strong></td>
</tr>
</tbody>
</table>

Figure 3.11: Breakdown of the FY 1994 expenditures.
### Section 3.7: Financial Resources

#### 3.7.3 Funds

*Endowment funds* are gifts and bequests where the donor has stipulated, as a condition of the gift, that the principal is to remain inviolate in perpetuity and is to be invested for the purpose of producing present and future income. *Funds functioning as endowment* are gifts, bequests, and other receipts that had no restrictions as to the expenditure of principal, which the Institute designated as additions to endowment for the present. About $4.3 million of the funds functioning as endowment were used in FY 1994 to pay for the operating gap.

A *fund* is a self-balancing entity of assets, liabilities, and a fund balance. The funds are kept at book value and do not record unrealized appreciation on the

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**Figure 3.12:** Breakdown of the FY 1994 revenues and funds used.

**Table 3.15: Gifts, Grants, and Bequests to MIT (in thousands)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Endowment</td>
<td>$24,587</td>
<td>$24,668</td>
<td>0.3%</td>
</tr>
<tr>
<td>Buildings</td>
<td>6,581</td>
<td>3,649</td>
<td>-44.4%</td>
</tr>
<tr>
<td>Life Income Plans and Agency Funds</td>
<td>4,713</td>
<td>8,462</td>
<td>79.6%</td>
</tr>
<tr>
<td>Student Loans</td>
<td>31</td>
<td>15</td>
<td>-51.6%</td>
</tr>
<tr>
<td>Current funds-restricted</td>
<td>42,617</td>
<td>39,295</td>
<td>-7.8%</td>
</tr>
<tr>
<td>Current funds-unrestricted</td>
<td>5,309</td>
<td>6,246</td>
<td>17.7%</td>
</tr>
<tr>
<td>Grants-in-aid</td>
<td>5,348</td>
<td>4,426</td>
<td>-17.2%</td>
</tr>
<tr>
<td><strong>Total gifts to funds and grants-in-aid</strong></td>
<td>$89,186</td>
<td>$86,761</td>
<td>-2.7%</td>
</tr>
<tr>
<td>Gifts of equipment</td>
<td>$4,267</td>
<td>$6,089</td>
<td>42.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$93,453</td>
<td>$92,850</td>
<td>-0.7%</td>
</tr>
</tbody>
</table>
invested assets. Table 3.16 on page 94 shows the book value of the funds grouped by major categories. The book value of the total funds was $2,056,339,000 on June 30, 1994 compared to $1,866,822,000 on June 30, 1993.

### Table 3.16: Book Value of Major Funds by Categories (in thousands)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Income for unrestricted purposes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endowment</td>
<td>$54,310</td>
<td>$55,304</td>
<td>1.83%</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>74,658</td>
<td>74,820</td>
<td>0.22%</td>
</tr>
<tr>
<td>Income for restricted purposes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endowment</td>
<td>$448,787</td>
<td>$474,753</td>
<td>5.79%</td>
</tr>
<tr>
<td>Funds functioning as endowment</td>
<td>119,431</td>
<td>125,965</td>
<td>5.47%</td>
</tr>
<tr>
<td><strong>Total book value of endowment funds</strong></td>
<td>$697,186</td>
<td>$730,842</td>
<td>4.83%</td>
</tr>
<tr>
<td>Accumulated net gains from investments</td>
<td>$554,820</td>
<td>$688,740</td>
<td>24.14%</td>
</tr>
<tr>
<td>Investment income for distribution to funds</td>
<td>25,751</td>
<td>25,751</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Total endowed funds</strong></td>
<td>$1,277,757</td>
<td>$1,445,333</td>
<td>13.11%</td>
</tr>
<tr>
<td>Educational plant funds—expended</td>
<td>$196,877</td>
<td>$207,824</td>
<td>5.56%</td>
</tr>
<tr>
<td>Educational plant funds—unexpended</td>
<td>70,398</td>
<td>68,793</td>
<td>-2.28%</td>
</tr>
<tr>
<td>Expendable funds held in current funds</td>
<td>231,816</td>
<td>238,340</td>
<td>2.81%</td>
</tr>
<tr>
<td>Student loan, life income, and agency funds</td>
<td>89,974</td>
<td>96,049</td>
<td>6.75%</td>
</tr>
<tr>
<td><strong>Total funds</strong></td>
<td>$1,866,822</td>
<td>$2,056,339</td>
<td>10.15%</td>
</tr>
</tbody>
</table>

The total amount of endowed funds increased from FY 1993 by 13.11% to $1,445,333,000. Since the Institute holds a relatively high percentage of the endowment in common stocks and other equities, the difference between the book and market value has grown over time. The total market value of the endowed funds is $1,777,777,000 as is summarized in Table 3.17. The difference between the book and market value in 1994 was $1,046,935,000.

### Table 3.17: Book and Market Value of Endowment Funds (in thousands)

<table>
<thead>
<tr>
<th></th>
<th>June 30, 1993</th>
<th>June 30, 1994</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total book value of endowment funds</td>
<td>$697,186</td>
<td>$730,842</td>
<td>4.83%</td>
</tr>
<tr>
<td>Accumulated net gains from investments</td>
<td>554,820</td>
<td>688,740</td>
<td>24.14%</td>
</tr>
<tr>
<td>Investment income for distribution to funds</td>
<td>25,751</td>
<td>25,751</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Total endowment funds at book value</strong></td>
<td>$1,277,757</td>
<td>$1,445,333</td>
<td>13.11%</td>
</tr>
<tr>
<td>Unrealized appreciation</td>
<td>$475,186</td>
<td>$332,444</td>
<td>-30.04%</td>
</tr>
<tr>
<td><strong>Total endowment funds at market value</strong></td>
<td>$1,752,943</td>
<td>$1,777,777</td>
<td>39.13%</td>
</tr>
</tbody>
</table>

Table 3.18 on page 95 shows a breakdown of the endowed funds by purpose for FY 1993 and FY 1994. The largest shares are for salaries, with a market value of $525 million, and for unrestricted purposes, with a market value of $432,963,000.

### 3.7.4 Educational Plant

The value of the educational plant assets was $431.083 million at June 30, 1994 compared to $383.968 million with the year before. The net additions were $82,015,000 and the net depreciation was $34,900,000. The total indebtedness for the educational plant was $163.323 million as of June 30, 1994. Of this $129.145
Section 3.7: Financial Resources

Table 3.18: Value of Endowment Funds by Purpose (in thousands)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>June 30, 1993</th>
<th></th>
<th>June 30, 1994</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Book</td>
<td>Market</td>
<td>Book</td>
<td>Market</td>
</tr>
<tr>
<td>Unrestricted purposes (general)</td>
<td>$129,966</td>
<td>$433,768</td>
<td>$130,124</td>
<td>$432,963</td>
</tr>
<tr>
<td>Departments and research</td>
<td>134,964</td>
<td>262,303</td>
<td>142,086</td>
<td>268,110</td>
</tr>
<tr>
<td>Library</td>
<td>2,100</td>
<td>5,980</td>
<td>2,179</td>
<td>6,033</td>
</tr>
<tr>
<td>Salaries (professorships, etc.)</td>
<td>236,342</td>
<td>511</td>
<td>252,556</td>
<td>525,006</td>
</tr>
<tr>
<td>Graduate fellowships (general)</td>
<td>8,286</td>
<td>23,939</td>
<td>8,634</td>
<td>24,187</td>
</tr>
<tr>
<td>Graduate fellowships (departmental)</td>
<td>35,478</td>
<td>55,691</td>
<td>38,013</td>
<td>57,847</td>
</tr>
<tr>
<td>Undergraduate scholarships</td>
<td>83,127</td>
<td>212,188</td>
<td>88,234</td>
<td>216,145</td>
</tr>
<tr>
<td>Prizes</td>
<td>2,689</td>
<td>5,102</td>
<td>2,790</td>
<td>5,175</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>65,232</td>
<td>170,297</td>
<td>66,226</td>
<td>170,542</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>$697,186</strong></td>
<td><strong>$1,680,858</strong></td>
<td><strong>$730,842</strong></td>
<td><strong>$1,706,008</strong></td>
</tr>
<tr>
<td>Invest. income for distrib. to funds</td>
<td>25,751</td>
<td>72,085</td>
<td>25,751</td>
<td>71,769</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$722,937</strong></td>
<td><strong>$1,752,943</strong></td>
<td><strong>$756,593</strong></td>
<td><strong>$1,777,777</strong></td>
</tr>
</tbody>
</table>

million was tax-exempt debt financed through the Massachusetts Health and Educational Facilities Authority.

3.7.5 Investments

The total book value of MIT's investments was $1,802,781,000 and the market value $2,152,102,000. The market value rose by $26,045,00 or 1.2 percent compared to FY 1993. Table 3.19 gives an overview of the book and market value of the investments.

Table 3.19: Book and Market Value of Investments (in thousands)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Book</td>
<td>Market</td>
<td>Book</td>
<td>Market</td>
</tr>
<tr>
<td>Fixed income</td>
<td>$578,702</td>
<td>$616,680</td>
<td>$459,582</td>
<td>$453,512</td>
</tr>
<tr>
<td>Equities</td>
<td>$859,092</td>
<td>$1,304,778</td>
<td>$1,137,403</td>
<td>$1,470,781</td>
</tr>
<tr>
<td>Real estate held for present or future academic use</td>
<td>$33,101</td>
<td>$33,101</td>
<td>$32,234</td>
<td>$32,234</td>
</tr>
<tr>
<td>Real estate held for investment or other purposes</td>
<td>$60,456</td>
<td>$66,102</td>
<td>$72,498</td>
<td>$81,383</td>
</tr>
<tr>
<td><strong>Total general investments</strong></td>
<td><strong>$1,531,351</strong></td>
<td><strong>$2,020,661</strong></td>
<td><strong>$1,701,717</strong></td>
<td><strong>$2,037,910</strong></td>
</tr>
<tr>
<td>Separately invested</td>
<td>$38,871</td>
<td>$45,889</td>
<td>$41,236</td>
<td>$46,833</td>
</tr>
<tr>
<td>Life income funds</td>
<td>$48,104</td>
<td>$59,507</td>
<td>$59,828</td>
<td>$67,359</td>
</tr>
<tr>
<td><strong>Total investments</strong></td>
<td><strong>$1,618,326</strong></td>
<td><strong>$2,126,057</strong></td>
<td><strong>$1,802,781</strong></td>
<td><strong>$2,152,102</strong></td>
</tr>
</tbody>
</table>

The market value of the general investments was $2.038 billion compared to $2.021 billion for the year before (a 0.9 percent increase). Mainly due to MIT's largest fund-raising campaign ever, the Campaign for the future, the market value of the general investments has increased by over $596 million since 1989.

References


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29. Forest City Development, “University Park at MIT Project Description,” Cambridge.


CHAPTER 4
THE PREMIER TECHNICAL UNIVERSITY

This chapter discusses past accomplishments of the Institute and its faculty, staff, students, and alumni. Being aware of the school's past accomplishments is important for people at MIT and outside.

- As part of The Grand Plan, MIT would use the accomplishments discussed in this chapter, to attract the public to visit the Institute.
- In order to successfully extend the UROP program to industry, companies need to be aware of the potential of MIT students.
- The same is true for graduates. In a competitive job market, the university must do as much as possible to help its graduates. For MIT this means to properly show the work of its alumni.
- Often students question the benefits of going through an intense MIT education because they know little about how well it will prepare them for their careers and how much their predecessors have achieved.

Section 4.1 presents the awards that faculty member have earned and how the Institute is ranked. How the teaching of science, engineering, management, and economics was innovated by MIT is the subject of Section 4.2. A more detailed treatment is given to the Undergraduates Research Program discussed earlier and the famous 2.70 and 6.270 Design Contents. Timelines of MIT's research achievements can be found in Section 4.3. Two of these are discussed in more detail, namely the Radiation Laboratory/War Effort and the human-powered aircraft. The first shows what the Institute can accomplish with a full commitment and the second shows the kind of research that was strongly supported by undergraduate students and captured the imagination of the public and creates for MIT the kind of image that the Institute is seeking. MIT has been extremely successful in bringing out the entrepreneurial spirit in its graduates. Section 4.4 discusses some of MIT's most famous entrepreneurs and a few of the companies that they founded. The last section of the chapter demonstrated the potential of MIT students, by discussing some of the alumni achievements not mentioned in previous section.

4.1 A Symbol for Cutting-edge Science and Engineering

4.1.1 Image

While many universities are conducting cutting-edge research and would capture a considerable audience if presenting their work, no organization in the world can compete with MIT in being a symbol for leading research in science and engi-

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neering. The name MIT is used in newspaper and magazine cartoons, films, company brochures. This image cannot be bought or earned in a short amount of time, thus giving the Institute a competitive edge that it needs to use more often.

MIT's reputation does not rest alone on the big achievements to be discussed later but rather on the sum of "little things" that make MIT so unique. All degrees at MIT have to be earned, unlike most other universities, MIT does not give out any honorary degrees. The Institute offers no merit or athletic scholarships and doesn't engage in bidding wars for "superstars." There is no Dean's List or similar honors program—graduating from MIT is seen as being difficult enough as it is. The MIT cheers consists of mathematical expressions. The campus is easily the most nocturnal in America and the preferred means of communication is electronic mail. While student prankster may receive local attention and disapproval for their work, MIT's pranksters, called "hackers" receive often nationwide media coverage. The most recent of the well-publicized high-tech pranks was the placement of a campus police cruiser replica complete with flashing alarm lights, a dummy police officer, coffee cups, and donuts on top of the Great Dome.

4.1.2 Rankings

U.S. News & World Report publishes annually a survey of America's best graduate schools. In its 1995 listing, the magazine ranked MIT's programs in both engineering and management as the best in the United States. The School of Engineering has been ranked first every single year since the survey has been established in 1990. MIT's business school, the Sloan School of Management, rose from sixth position in 1993 to second in 1994, and to first in 1995. MIT is the first university to have been rated as number one in the related areas of engineering and management. In specific areas, MIT's graduate engineering programs were first in aerospace, chemical, civil, materials/metallurgical, mechanical, and nuclear engineering. Its computer science/engineering and electrical engineering curricula were ranked second and its biomedical engineering program fourth in the nation. In business specialties the Sloan School of Management was ranked first in information systems and production/operations management; it ranked fourth in real estate and fifth in finance.

In a ranking of doctoral programs in economics MIT's Department shared the number one rank with Princeton University, University of Chicago, Harvard University, and Stanford University. The Institute's Political Science Program was ranked eight.

In its related annual ranking "America's Best Colleges" U.S. News & World Report MIT was ranked as the fourth best national university—surpassed by Har-

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1. An example is an Apple Computer brochure that used the phrase "It doesn't take a Ph.D. from MIT to understand that..." 
2. For those interested it is "E to the U du dx, E to the X dx! / Cosine! Secant! Tangent! Sine! / 3 point 1 4 1 5 9! / Integral, radical mu dv / Slipstick, slide rule, M.I.T.!”
Section 4.1: A Symbol for Cutting-edge Science and Engineering

...ard University, Princeton University, and Yale University. However, MIT shared with Harvard's the number one position in academic reputation.

The quality of MIT's graduate students is also illustrated by the fact that MIT typically attracts about 15% of all U.S. National Science Foundation fellowship winners—the percentage may be higher except for the fact that the NSF does not pay the full tuition and MIT needs to pay for the difference.

4.1.3 Awards

Over the years MIT's faculty, alumni, and staff have won Nobel Prizes in all categories. By 1994, the number of MIT-related Nobelists had reached 27. Among the current faculty of 950, there are 11 Nobel laureates. All but three of these faculty members received the prize for work done at MIT. Table 4.1 on page 101 lists current (names in bold) and former faculty and staff members who have won the Nobel Prize. Twelve alumni (eleven if excluding David Baltimore '61 who is presently a faculty member) have won the Nobel Prize. A list is shown in Table 4.2 on page 130.

Since the first Nobel Prize awarded to an MIT-related person was only in 1956, the Institute has contributed 27 Nobelists in only 29 years. In addition to these 27, four physicists worked in MIT's Radiation Laboratory during World War II and later won the Nobel Prize in Physics. These were I. I. Rabi of Columbia Univer-

Table 4.1: Faculty and Staff Nobel Prize Winners

<table>
<thead>
<tr>
<th>Year</th>
<th>Faculty Member</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>Charles H. Townes</td>
<td>Physics</td>
</tr>
<tr>
<td>1968</td>
<td>Har Gobind Khora</td>
<td>Medicine or Physiology (shared)</td>
</tr>
<tr>
<td>1969</td>
<td>Salvador E. Luria</td>
<td>Medicine or Physiology</td>
</tr>
<tr>
<td>1970</td>
<td>Paul A. Samuelsen</td>
<td>Economic Science</td>
</tr>
<tr>
<td>1975</td>
<td>David Baltimore</td>
<td>Medicine or Physiology</td>
</tr>
<tr>
<td>1976</td>
<td>Samuel C.C. Ting</td>
<td>Physics (shared)</td>
</tr>
<tr>
<td>1979</td>
<td>Steven Weinberg</td>
<td>Physics</td>
</tr>
<tr>
<td>1985</td>
<td>Franco Modigliani</td>
<td>Economic Science</td>
</tr>
<tr>
<td>1985</td>
<td>Eric S. Chivian(a)</td>
<td>Peace (shared)</td>
</tr>
<tr>
<td>1987</td>
<td>Susumu Tonegawa</td>
<td>Medicine or Physiology</td>
</tr>
<tr>
<td>1987</td>
<td>Robert M. Solow</td>
<td>Economic Science</td>
</tr>
<tr>
<td>1990</td>
<td>Henry W. Kendall</td>
<td>Physics (shared)</td>
</tr>
<tr>
<td>1990</td>
<td>Jerome I. Friedman</td>
<td>Physics (shared)</td>
</tr>
<tr>
<td>1993</td>
<td>Phillip Sharp</td>
<td>Medicine or Physiology (shared)</td>
</tr>
<tr>
<td>1994</td>
<td>Clifford G. Shull</td>
<td>Physics (shared)</td>
</tr>
</tbody>
</table>

\(a\) Staff member Dr. Chivian is a psychiatrist in the MIT Medical Department.
Chapter 4: The Premier Technical University

sity (1944), Edward M. Purcell (1952) and Julian Schwinger of Harvard University (1965), as well as Luis W. Alvarez of the University of California (1968).

MIT’s past and present faculty members have also been honored in many other ways:

- **National Medal of Science**

- **Kyoto Prize**
  Four faculty members have been awarded Japan’s prestigious academic award, the $285,000 Kyoto Prize: Noam A. Chomsky (1988), Morris Cohen (1987), Edward N. Lorenz (1991), and Claude E. Shannon (1984).

- **National Academy of Sciences**: 98
- **National Academy of Engineering**: 86
- **American Academy of Arts and Sciences**: 209
- **Institute of Medicine**: 17

4.2 Teaching

The Massachusetts Institute of Technology is recognized as one of the best universities in the world to receive an education from. Its curricula, programs, and textbooks have had an impact on the education all over the world.

4.2.1 Curriculum

When MIT’s founder William Barton Rogers conceived the concept for MIT in the 1840s, he envisioned a polytechnic institution which would provide engineers with a solid scientific foundation and a broad, rather than a pure vocational education. Before MIT was established most, engineers were self-taught or learned their skills in a short apprenticeship. When the Institute began its instruction in 1865 it offered some of the first formal engineering courses and the very first curriculum in architecture in the United States.

It continued to pioneer curricula in the decades following. In 1882, Charles R. Cross, Class of 1870 offered the nation’s first electrical engineering course in the Department of Physics. The Department of Electrical Engineering was inaugurated twenty years later. In 1917, students from the department began the nation’s first cooperative program when they went to General Electric to gain experience. The nations first courses in chemical engineering were offered by Lewis M. Norton in 1888 and the first department at any college was established in 1920. The formation of the department and the leadership of faculty members William H. Walker, Warren K. Lewis ’05, William H. McAdams ’17 together with Chem-
Section 4.2: Teaching

Alumnus Arthur D. Little were responsible for transforming "empirical and messy nineteenth-century arts" into the engineering discipline it is today.

Some forty years earlier, in 1893, Cecil H. Peabody, Class of 1877 established at MIT the nation's first Department of Naval Architecture and Marine Engineering. After conquering the oceans, MIT began to think about conquering the air. In 1913, MIT President Richard C. Maclaurin asked Jerome C. Hunsaker '12 to develop courses in aeronautics. After going to Europe to learn of research and education there, Hunsaker inaugurated the first aeronautical engineering courses in the United States. In 1928, aeronautical engineering Professor Carl-Gustav Rossby established the nation's first curriculum in meteorology.

The nation's first instruction in nuclear physics were offered in 1935 and one of the first courses in nuclear engineering were put together in 1952. About a decade later, in the early 1960s Professor Marvin Minsky offered the world's first instruction on Artificial Intelligence (AI) and by the mid 1960s MIT was among the first universities to develop an undergraduate program in computer science. As computers and electronics become increasingly important, the Department of Metallurgy and Materials Science was the first materials department to offer courses on electronics materials.

In 1930, MIT began to further widen its curriculum from engineering and science by forming the Department of Business and Engineering Administration out of a part of the Department of Economics and Statistics. One year later, MIT established the Alfred P. Sloan Fellows Program. It was the country's first program to provide mid-career managers with advanced academic and professional training in management. In 1941, MIT established a doctoral program in economics and in 1961 in linguistics. With leadership from economist Paul A. Samuelson and linguist Noam Chomsky these programs become the best in the country.

Traditionally, undergraduate laboratories asked students to perform prepared experiments whose outcomes were known to the faculty. In 1960, the Department of Aeronautics and Astronautics undertook a new approach when it asked its students to conceive and carry out original experiments. It followed the concept set forth by the Mechanical Engineering Department in the late 1950s. It had initiated a design curriculum in which students received broad problems and were asked to design and build original solutions. In 1974, the Department of Aeronautics and Astronautics developed a new method of teaching second-year engineering students with the start of the subject "Unified Engineering." Conceived by Professors James Mar, Jack Kerrebrock, and Jim Covert, Unified Engineering has taught in one single course all the fundamental aerospace engineering disciplines and their interrelationship. Thus providing students with the ability to apply their knowledge of more than one discipline to solve real engineering problems. Unified Engineering is not only among the best known subjects offered at MIT but remains to the present day as one of the most challenging.

3. Now renamed Department of Materials Science and Engineering.
Chapter 4: The Premier Technical University

With the establishment of the Whitaker College of Health Sciences, Technology, and Management in 1977, MIT created a pioneering academic structure for interdisciplinary studies in health-related sciences. In a related area, MIT established the interdisciplinary Biotechnology Process Engineering Center through funds by the National Science Foundation. It is the only one of its kind whose focus is on biotechnology. Its educational goal is to train professionals to develop basic concepts for commercial applications.

In 1981, the Institute launched the MIT-Japan Program. The goal of the program is to increase the cooperation and understanding between U.S. and Japanese researcher. As one of the first in its kind in the United States, it placed MIT students for one year in a research setting in Japan.

The program in city planning, established at MIT in 1932, was the nation’s second at a college. However, the real estate program inaugurated in 1984 was the first in the U.S. at the university level. In the same year the Media Laboratory was established in the School of Architecture and Urban Planning. It offers pioneering educational programs in computer music, film, graphics, holography, photography, and other media technologies.

4.2.2 Publications

MIT’s faculty members have written some of the world’s most influential and best-selling books of all times. MIT’s first two professors in chemistry, Charles W. Eliot and Francis H. Storer, developed a new way of teaching the subject and published *Manual of Inorganic Chemistry Arranged to Facilitate the Experimental Demonstration of the Facts and Principles of the Science* with their “Compendious Manual of Qualitative Chemical Analysis,” which revolutionized the teaching of chemistry in the United States in the late 1860s. The revitalization and reformation of electrical engineering teaching in the 1940s was due to MIT’s three-volume electrical engineering textbook series. Slightly earlier, in 1938, Chemistry Professor Frederick George Keyes and Mechanical Engineering Professor Joseph H. Keenan ’22 published *Thermodynamic Properties of Steam*. Their steam tables have been used by engineers ever since. The MIT Spectroscopy Laboratory conducted a program of wavelength measurements which resulted in *MIT Wavelength Tables of Spectrum Lines*. It is now used as a standard throughout the world.

Professor Arthur A. Noyes, Class of 1886 initiated *Review of American Chemical Research* which became later the influential *Chemical Abstracts* of the American Chemical Society.

Norbert Wiener, who is regarded as MIT’s greatest genius, coined the term *cybernetics*. He authored several books and papers of which *Cybernetics, or Communication and Control in the Animal and the Machine* is one of the world’s classics. It

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4. In 1869, MIT Professor Charles W. Eliot was elected as President of Harvard and transformed “a great college into a great university.”
is an exhaustive mathematical analysis of the theory of feedback and automated processes.

One of the most influential management books of recent years is *Reengineering the Corporation: A Manifesto for Business Revolution*. Written in 1993 by two MIT alumni, Dr. Michael Hammer '68 SM '70 PhD '73 and James Champy '63, it has become the guide for reorganizing a company's processes, structure, and culture. Two other books on management topics have gained international fame. Professor of Management and Economics Lester Thurow published *Head-to-Head: Coming Economic Battles Among Japan, Europe, and America*. Professors Michael L. Dertouzos, Richard K. Lester, Robert M. Solow, and the MIT Commission on Industrial Productivity published *Made in America: Regaining the Productive Edge*. In 1990, James P. Womack, Daniel T. Jones, and Daniel Roos published *The Machine that Changed the World* based on a five million dollar, five year study by MIT on the future of the automobile.

Many of the most often used textbooks in universities in the United States and around world were written by MIT faculty but two truly stand out. Professor Paul A. Samuelson's *Economics: An Introductory Analysis* is the most widely read economics book of all times. Currently in its 14th edition, it sold since it was first published in 1948 more than 4 million copies and was translated in more than 20 languages. One of the best-selling mathematics textbooks of all time was written by Professor George B. Thomas. The first edition of *Calculus and Analytic Geometry* was published in 1953. By 1995, in its eight edition, it has sold more than 1.5 million copies.

### 4.2.3 Independent Activities Period (IAP)

Since the regular terms are highly stressful, strict in many regards, and full of academic rigors, students and faculty have little opportunity to broaden their horizons, spend a period of time focused on one task, or just interact informally. MIT introduced in 1971 a innovative program entitled *IAP* or *Independent Activities Period* to allow faculty, students, and staff to do things that they normally cannot or do not have time to do. The program became soon “hardwired” into MIT’s life and celebrated in 1995 its 25th anniversary. MIT’s Independent Activities Period is held every January during a four-week period after the winter vacation and before the spring term (i.e., early January to early February).

IAP offers unparalleled opportunities in teaching and learning. Students can set their own educational agenda. They can take courses, attend seminars, read books, do research, pursue personal interests, relax, or even stay at home until the beginning of the spring term. Students, professors, and staff members are free to design their own activities or courses. Many faculty members use IAP to focus on their research or try out innovative educational experiments as IAP activities. Both faculty and students enjoy the chance of interacting on an informal basis, take the time to discuss topics that the regular terms do not provide, and even switch roles in classrooms.
The *IAP Guide* lists more than 600 special activities such as field trips, seminars, lectures, films, individual projects as well as 80 courses for academic credit, and 30 courses for physical education credit. General IAP offerings include some MIT stereotypical such as “Bicycle Design and Development Workshop,” “Fuzzy Logic: What, Why, and How?,” “Die Brücke: Bridge Design Competition,” “Everything You Wanted To Know About Viscoelasticity, But Were Afraid to Ask” to less conventional activities such as “East Meets West: Let’s Make And Eat Sushi,” “Charm School,” “The Political Culture of *Star Trek,*” and “Run Away and Join The Circus.” Courses for credit include “Computational Tools for Engineering,” “Germany Today: Intensive German Language And Culture,” “Introduction to Special Relativity,” and many others.

All members of the MIT Community, including staff, can join non-credit activities and all IAP activities are free. Bureaucracy is reduced to a minimum, so that registration is accomplished by just attending classes and no official “add” or “drop” dates exist for subjects for credit. One might speculate that few students would want to return to MIT or even fewer would take subjects involving a substantial amount of work. However, typically 75% of the students come back to MIT for IAP and more than 1,000 enroll in courses approved for academic credit (81 were offered in academic year 1994–95, which is a new record).

### 4.2.4 Undergraduate Research Opportunities Program (UROP)

MIT’s Undergraduates Research Opportunities Program (UROP) is the world’s leading program in allowing undergraduate students to conduct research. From the day they set foot on campus, students can use their creativity and ambition to work side by side with some of the best researchers.

The history of UROP dates back to 1957. Dr. Edwin H. Land, the inventor of instant photography, the founder and president of the Polaroid Corporation, became a visiting professor at MIT in 1956 and was asked to give a lecture to the Institute. In the now famous lecture he gave on May 22, 1957, entitled “Generation of Greatness: The Idea of a University in an Age of Science,” Dr. Land encouraged the involvement of undergraduate students in research with leading faculty. Dr. Land expressed his concern that universities were focusing only on the teaching of what was already known and that they discouraged creativity. He believed out of his own frustrating experience at Harvard in the late 1920s that a hands-on experience was the key to the development of a students’ creative capabilities. Dr. Land envisioned undergraduate students working with faculty mentors in research teams and learning from doing.

Following this historic lecture, MIT’s administrators and faculty experimented modestly to find a way to realize Dr. Land’s vision. A program was initiated to invite freshmen to join faculty research but the effort turned out to be unsuccessful and was abandoned in 1961. In 1968, however, Dr. Land made a gift for the initiation of an educational program starting with the 1969–70 academic year. This gift

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5. Except for fees to cover the cost of materials where applicable.
Section 4.2: Teaching

prompted a discussion at the level of the provost and chairman to find a program that would achieve involving undergraduates in the faculty’s research efforts. Since no such model existed, a new invention was necessary and an entire set of procedures and regulations had to be established. Provost Paul Gray gave junior faculty member Margaret L.A. MacVicar full rein, solid backing, and modest resources ($50,000 initially) to design and set UROP in motion.

UROP was planned to span all departments from engineering and science to the humanities, social sciences to arts. No area was left out except by its own choice. Similarly, all undergraduate students regardless of grade point average or other considerations were invited to participate. Other guidelines were established as well. Since research projects have no fixed starting or finishing dates, UROP has to provide the same flexibility. Consequently, UROP involvement was permitted to begin at any time during the academic year and could last as long as desired—regardless of semester time boundaries. Likewise, the time spent per week during the course of the term had to be flexible since students had more time in the beginning of semesters than at the end. The reward scheme, academic credit or pay and how much of either needed to be flexible as well. Last not least, in order to encourage both faculty and students to participate initially and to make it as easy as possible necessary paperwork was set to and maintained up to the present day an absolute minimum. The program that Prof. MacVicar put in place was the nation’s, and probably, the world’s, first program that allowed undergraduates at all stages and from all disciplines to conduct research as junior colleagues of faculty.

Most of the UROP framework was in place within several years. The growth rate of the program was enormous. In the first semester of UROP, in the fall of 1969, 150 students participated. In the third year, the participation had grown to 800 and by the fifth year, about 75% of all undergraduates became involved in a UROP. While the program grew dramatically over time, few changes were made over the years since its built-in flexibility has kept UROP able to adapt to ever-changing conditions.

Every year the UROP Office publishes the UROP Directory listing faculty members who are interested and willing to take a UROP student and operates a bulletin board with available UROP positions. While the directory and board are helpful in locating opportunities, many students find their UROPs by asking faculty members directly. All undergraduate students are eligible to participate—it is not an “honors program.” Students are usually not expected to have had any experience in the area of study. Although in some cases specific courses or knowledge (e.g. programming experience) may be desirable. What students do not know they are being taught by the faculty member or learn on their own through reading.

One of the greatest aspects of UROP is the fact that MIT undergraduate students can develop a close relationship with some of the world’s best faculty. The faculty member serves as the supervisor and mentor. The student and the professor discuss how many hours the student wants and can commit and the kind of reward scheme. Afterwards the student prepares a “letter of intent” (if the UROP is for
academic credit or a “proposal” if the UROP is for pay) which is reviewed by the
department’s assigned UROP coordinator and approved by the UROP staff.

Most UROP students remain with a research project from one and a half semes-
ters to two years. As a guideline (not set limits), UROP work should require
between eight and twelve hours per week. Although most students spend over the
course of a term between six and twelve hours a week, during intense periods,
UROPers may spend as much as twenty or more hours on their projects in addi-
tion to their coursework.6

When choosing a reward scheme, students have the option to work for academic
credit, pay (since 1973), or simply volunteer. During the 1970s the majority of
UROP students worked for academic credit but when in 1983 tuition approached
$10,000 and the self-help level was $4,300, students shifted to conduct UROP
mostly for pay. This trend has continued ever since and in 1993 some 80% of the
UROPs were done for pay.

At the end of each term, both the faculty member and the student are asked to sub-
mit an evaluation for feedback. The faculty member evaluates the student’s
progress and the student evaluates the research experience and comments on the
mentorship of the faculty member.

How UROP improves the undergraduate education and how it helps prepare MIT
students for their careers is probably best illustrated by quotes from their evalua-
tion letters:

• “The UROP helped me to feel comfortable in a highly scientific environment. I
  began to feel that the work I was doing was making a significant contribution
to scientific advancement.”

• “I learned a great deal about the difficulties associated with scientific research,
  and the tremendous patience required to be able to work consistently on one
  problem for an extended period of time.”

• “I had a wonderful experience at my UROP this fall. It was nice not to be
doing menial tasks, but actually my own research where I got to design the
  experiments to optimize the results we were obtaining.”

• “My UROP experience this past term has been invaluable. I consider it to be
  the best learning experience that I have had thus far at MIT. Not only have I
gained hands-on experience, but I have also learned what it is like to be part of
  a research team.”

Some of the tangible student achievements include patents, publications in lead-
ing journals, professional society prizes for research presentations, invitations to
appear on radio and television programs, job offers from industry, adoption of rec-
ommendations by government agencies, grants from funding agencies, and invita-
tions to lecture.

6. In some cases the students get so excited and involved in their UROP that they neglect
their coursework for a week or two.
MIT’s UROP program has received widespread recognition and has been subject of national public radio and national public television features (e.g. NOVA series), and magazine and newspapers articles (e.g. New York Times). The program is listed in a report by the United States Department of Education’s National Commission on Excellence in Education as an example of the quality the Commission is seeking for the nation as a whole.

Many universities around the world have expressed their interest in implementing a program similar to UROP. Every year, several serious requests for information and support are made. Several universities have programs modelled on UROP, such as the University of Delaware, Stanford University, Utah State University, Imperial College of Science and Technology, Johns Hopkins University, and Harvard University. While these programs are quite successful at these institutions they needed to be changed to adapt to the peculiarities of the host university. Since no university can match the Institute’s overall culture, the intensity, scope and success of UROP at MIT remains unrivaled.

4.2.5 The 2.70 and 6.270 Design Contests

While at most universities athletic events attract the largest number of spectators, at MIT it is a contest held as part of an undergraduate course. The course is 2.70 “Introduction to Design” which features the highly popular 2.70 contest at the end of the term. The addition of the contest to the course was the idea of Professor Woodie Flowers PhD ’73. The principal goal of 2.70 is to teach the process of design from brainstorming and idea selection through detailed design and fabrication. The last six weeks of the term are occupied by a project in which each student designs a remotely controlled machine to perform a simply defined task in competition with another machine. The constraint is that the machine can only be built from equipment given in a box of parts donated by sponsoring companies. The parts includes conventional engineering materials such as aluminium, steel, several motors and gears, but also strange items such as plastic toy components.

While “Introduction to Design” is a course only required for undergraduate mechanical engineering students, about 25 percent of the 200 students are from outside the Department of Mechanical Engineering. The contest at the end of the term is the highlight of the course in which the students compete with their machines in a single elimination competition. The purpose of the contest is to celebrate the students’ design achievement and not to test them.

The objective of the contest varies widely from year to year so that the students have to constantly come up with innovative and intriguing machines. Examples in the past include “Pebble Beach,” “Wreckit Ball,” and “Not In My Back Yard.” In “Pebble Beach” (the 1995 competition) students designed and built machines to collect ping-pong balls and deposit them into their bins. The machines had 30 sec-

7. E.g. 24-hours, seven-days-a-week access to laboratories, computing facilities, and libraries.
onds to collect the balls and had one opponent per contest table. The device that collected the most ping-pong balls in every round was the winner.

The 2.70 contest has become so popular that it is broadcast by numerous TV stations and channels in the U.S., Japan and Britain. It has been the subject of a 30-minute documentary film and was featured numerous times on the PBS television series “Discover: The World of Science.” In Japan, the contest is broadcast by NHK which has been shown to audiences of 20 million people. Videotapes of the contest are also shown in science courses in several thousand high-schools around the U.S.

The first offshoot from the 2.70 contest was The International Design Contest (IDC) which was started with the Tokyo Institute of Technology (TITECH). The first IDC was held in August 1990 in Tokyo and by 1993, Cambridge University in the United Kingdom, Technische Hochschule Darmstadt in Germany, Seoul National University in Korea, and University of Sao Paulo in Brazil had joined. In the International Design Contest teams are formed with a student from every participating country. The IDC educates MIT students and the students from the other universities how to work as designers in collaboration with engineers from other countries, to study how engineers from different cultural backgrounds and different languages can work together for a common objective.

Course 6.270 “The LEGO Robot Competition” was developed by MIT undergraduate student Michael B. Parker as the electrical engineering’s answer to mechanical engineering’s “Introduction to Design.” The first contest was held in 1987 and did not involve any hardware—it was a programming competition in which students wrote computer programs to control computer-simulated robots. The difference between 2.70 and 6.270 was that in the electrical engineering version, there was no human control of the robots during the competition while in the mechanical engineering course, students control their creations with a joystick and some switches.

After Michael Parker observed a project called “LEGO/Logo” in MIT’s Media Laboratory, he had an idea how to improve the course. In Professor Pappert’s “LEGO/Logo” children build robots and other mechanical devices out of LEGO bricks, motors, and electronic sensors, and afterwards write simple programs to control them using a special version of the Logo programming language. Just weeks prior to the start of the 6.270 contest during IAP, Michael Parker saw the opportunity to build real robots rather than computer-simulated ones as in the past.

Fred Martin and Randy Sargent were recruited to develop the necessary hardware over their holiday break. They designed in two weeks an interface board that connected to a PC or Macintosh computer, controlling motors and providing input from a few simple sensors. While many difficulties were experienced, the twenty student teams who competed were highly enthusiastic about their experience.
The unique feature of the course was that the students were running the course themselves. Not a single faculty member has been involved with the organization or teaching of 6.270. Students learned from other students, which was one of their key success ingredients of the course.

In the years following the first use of real robots, the 6.270 became more and more structured and organized while remaining highly exciting due to continuing improvements in the hardware and software used for the competition. By 1992, the enthusiasm for the course was almost overwhelming. Over 300 students signed up to take the course while only 150 spots were available.

The 6.270 contest has a special educational value. MIT students from various departments are choosing to stay up all night building robots rather than taking ski trips or relaxing otherwise. In doing so, they are learning about engineering design and robotic technologies from first-hand experimental involvement. The course provides to students the tools and materials necessary to work with complex electronic, mechanical, and software ideas. Teamwork, learning-by-doing, and learning from one’s peers are the fundamental characteristics and provide MIT students a welcomed change from the theoretical lecturing in its core subjects.

In 1995, the 6.270 “LEGO Robot Competition” has expanded to six organizers and 15 teaching assistants. About half of the nearly 300 applicants were accepted to create 50 teams.

Like “Introduction to Design,” the LEGO Robot Competition enjoys the sponsorship from several companies. Major support comes from LEGO System Inc., Microsoft Corp., and Motorola Semiconductors Inc. In 1993, Motorola sent a film crew to MIT to document 6.270 from the distribution of the robot design kits to the final round of contest.

### 4.3 Research

MIT’s overall record of achievements in science and technology is matched by very few universities. Since MIT’s principle is learning by doing the Institute has been a fertile ground for research achievements. No other university in the world has more research under way than MIT. This section highlights some of the past achievements to illustrate how MIT has shaped the world in the past. This is by no means a complete account and does not even attempt to do justice to all the success stories that MIT and its people had over the years. The goal is to provide a quick overview over accomplishments that made a big impact for the world and the public. Also, in order to avoid judging accomplishments that have not yet proven themselves the account that follows focuses on events that are ten or more years old.

#### Aeronautics and Astronautics
1896  Probably the nation’s first wind tunnel is built by a student using air current from the Institute’s ventilation system. With wind speeds of only 25 kilometers per hour (15 miles per hour) the set-up is small and modest, but it allows other students to conduct thesis research of effects on various surfaces.

1915  Professor Jerome C. Hunsaker and his assistant Donald W. Douglas ’14 complete America’s first really effective wind tunnel. It is modeled after the wind tunnel at the National Physical Laboratory in Teddington, England.

1940s  Professor Charles Stark Draper’s Instrumentation Laboratory and the Servomechanisms Laboratory develop inertial guidance and navigation systems using gyroscopes. The systems are used to direct weapons and control flight vehicles. Draper’s sight uses the precession of gyroscopes to compute the lead necessary to shoot down fast moving objects. The gunsight Mark XIV is used in defending U.S. naval vessels in attacks from dive bombers, torpedo planes, and kamikazes. The SINS (Submarine Inertial Navigation System) enables submarines to cruise underwater anywhere in the world without any navigational assistance from the outside.

1960s  The MIT Instrumentation Laboratory develops under Charles Stark Draper the inertial guidance system for the Apollo moon landings. Throughout the missions, the staff of the Instrumentation Laboratory monitored all flights from Cambridge and made computer program modifications when necessary.

1985  On the Space Shuttle Atlantis Mission 61-B, EASE becomes the first space structure assembled in space. The hardware was built by MIT students.

1988  Under the leadership of alumnus John S. Langford, MIT sets the world’s distance and duration records in human-powered flight. On the historic flight on April 23, 1988, Daedalus 88, piloted by Kannellos Kanellopoulos, flies a distance of 116.58 km in 3 hours, 54 minutes, and 69 seconds, thus breaking the previous records held by a factor of 5 in distance and 74 minutes in duration.

1991  Professor Mark Drela and students design the hydrofoil Decavitator, the world’s fastest human-power watercraft. The 45-pound craft, whose propulsion system is similar to that of the human-powered aircraft Daedalus is powered by bicycle-type pedals that turn a rear-mounted 10-foot air

8. The Instrumentation Laboratory was separated from MIT in 1973 and renamed in honor of its founder into The Charles Stark Draper Laboratory. However, it has remained affiliated with the Institute.

9. Greek Olympic cyclist and 14-time national champion.
Section 4.3: Research

propeller. In runs on the Charles River, Professor Drela pilots the craft to a record speed of 21.27 miles per hour (34.23 kilometers per hour).

Biology

MIT’s Department of Biology began its focus on molecular and cellular biology, microbiology, and biochemistry in 1960s. to build its strength and reputation, it decided to attract the most promising graduates in biology instead of hiring recognized leaders in the field. The strategy paid off and today the departments boasts four Nobel laureates among its 55 active faculty members.

1895 In one of the first faculty-student collaborations Professor Samuel C. Prescott, Class of 1894 and third-year student William Lyman Underwood begin time and temperature studies to investigate food spoilage. Their research provides the scientific foundation for spoilage-free canned food.

1960s Professor Salvador E. Luria makes pioneering advances in viral genetics. Twenty years earlier he made a monumental breakthrough in virology with the discovery of mutations in viruses for which he receives the Nobel Prize for Physiology and Medicine in 1969.

1969 Ionnis V. Yannas begins his work on developing artificial skin to treat burn victims.

1970 Professor David Baltimore ’61 discovers reverse transcriptase, an enzyme that catalyzes the conversion of RNA to DNA. His discovery provides biologists with a technique for studying the relation between certain types of viruses and cancer. Five years later, Baltimore shares the Physiology/Medicine Nobel Prize for this research.

1970 Professor Har Gobind Khorana announces the first artificial copy of a gene.

1976 A team led by Professor Har Gobind Khorana completes the first complete synthesis of the first synthetic gene that is fully functional in a living cell.

1971 Junior faculty member Phillip A. Sharp discovers the phenomenon of RNA splicing which implies that genes are not laid out in a continuous strand of DNA as previously thought but are separated by “nonsense” or surplus DNA that has no encoded message. When genes splice, DNA turns into the messenger RNA, which filters out the “nonsense” parts of the DNA. The remaining genetic information is assembled in the right order so that it can be read to make proteins, the building blocks of life. The discovery is of fundamental importance to research in microbiology in the 1990s, as well as for medical research on cancer and other diseases. In 1993, Professor Sharp shares the Nobel Prize for Physiology and Medicine for his findings.
### Chapter 4: The Premier Technical University

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1979</td>
<td>Professor Robert A. Weinberg <em>identifies and isolates oncogenes</em>. These altered genes are involved in triggering the uncontrolled cell growth which leads to cancer.</td>
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<tr>
<td>1980</td>
<td>David Botstein and colleagues initiate the use of DNA restriction fragment-length polymorphisms as a <em>precise method for mapping human genes</em>.</td>
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<tr>
<td>1984</td>
<td>Professor Susumu Tonegawa describes <em>the structure and rearrangement of the genes for receptors on the surface of T cells</em>—cells that recognize and inactivate foreign invaders such as bacteria, viruses, and some kinds of cancer. In 1987, he receives the Nobel Prize for Physiology or Medicine for his earlier work in understanding the body’s immune system.</td>
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### Brain and Cognitive Science

#### 1960s
- Walle J. H. Nauta pioneers in mapping the brain’s structure and function at the cellular level.

### Chemistry

#### 1957
- John C. Sheehan achieves the first chemical synthesis of penicillin. The result of his nine-year research effort permits the development of new penicillin variants having superior medical qualities, such as effectiveness against a wider range of infections including some natural penicillin-resistant ones.

### Civil and Environmental Engineering

#### 1960
- Charles L. Miller develops the Integrated Civil Engineering System (ICES). This system is later adopted worldwide by engineering organizations to solve problems in areas such as structural engineering, transportation, and urban systems.

### Economics

#### 1940s
- Paul A. Samuelson applies mathematical techniques to economical analysis, leading to seminal contributions in both theoretical and applied economics and shaping the character of modern economics. In 1970, Professor Samuelson is the second person to win the Nobel Prize in Economic Science.

#### 1950s
- Franco Modigliani develops the “life-cycle” theory of savings and the theory of corporate finance, both of which are critical to the foundation of modern economic practices. In 1985, Modigliani receives the Nobel Memorial Prize in Economics.
1961  Robert M. Solow formulates one of the first general models of economic growth. His estimates of the contribution of technological change to overall growth become a major influence on national policies for stimulating new technologies. In 1987, he receives the Nobel Prize in Economics.

1985  Martin L. Weitzman develops the “Share Economy” theory, providing a new perspective on economic policy by showing that economic growth and price stability are more compatible when wage payments are based on a “profit-sharing” system. Weitzman’s policies attract much attention in the United Kingdom and other European countries.

Psychology and Linguistics

1960  Hans-Lukas Teuber identifies areas of the brain responsible for specific functions, such as perception, sensory-to-motors transformation, and memory.

1957  Noam Chomsky publishes *Syntactic Structures* in which he advances the understanding of the underlying principles and rules determining a speaker’s ability to produce and understand the sentences and words of language. His formulation of “transformational grammar” reshapes linguistics and is recognized as one of the most important works in the field of twentieth century.

Electrical Engineering and Computer Science

1925  Vannevar Bush ’16, Herbert R. Stewart ’24, and Frank D. Gage ’22 develop Product Integraph—the world’s first analog computer, a machine designed to solve differential equations.

1941  Harold L. Hazan ’24 suggests how Vannevar Bush’s Product Integraph can be improved. A more efficient, but also more complicated, machine with the name Differential Analyzer is built. The second version of the computer, the Rockefeller Differential Analyzer, weighs 100 tons, includes 2000 electronic tubes, 200 miles of wires, 150 motors, and is used during World War II twenty-four hours a day on radar, fire control, and other problems.

1930s  Research Associate and later Associate Professor Robert J. Van de Graaf builds the Van de Graaff generator. The device whose concept he conceived while a graduate student is used for producing a very high electrostatic potential. Later John G. Trump ’33 joins Van de Graaff to develop and construct more efficient generators including ones that can emit X rays for treatment in cancer therapy.

1934  Harold E. “Doc” Edgerton ’27 and Kenneth J. Germeshausen ’31 devise electrical circuits and special gas discharge (flash) tubes allowing the
development of high-speed photography and the development of the stroboscope. The stroboscopic stop-action photos such as the wings of a hummingbird, the bullet through the apple and the splashing milk drop became famous around the world.

1940 The Radiation Laboratory is established to develop microwave radar for the Allied war effort. In five years 150 radar systems are developed. (See also "The War Effort and the Radiation Laboratory" on page 121.)

1940 Claude E. Shannon ’40 lays the groundwork for design of electronic digital computers. The work is the result of his problems in operating the relay circuits of Vannevar Bush’s Differential Analyzer and are described in his master’s thesis. In 1948, while working at the Bell Telephone Laboratories, Shannon publishes “The Mathematical Theory of Communication” in the *Bell System Technical Journal* and sets the foundation for Information Theory.

1948 Norbert Wiener creates the field of *Cybernetics*. The interdisciplinary field is based on common relationships between humans and machines and is uses today in control theory, automation theory, and computer programs to reduce many time-consuming computations and decision-making processes formerly done by humans.

1948 Jay W. Forrester ’45 develops the random access core memory. The magnetic core memory consists of doughnut-shaped ferrite rings strung on fine wires and solved the memory problems for the Whirlwind computer. It became the basis for many advances in computer technology. IBM purchased the rights to use the patented technology of magnetic core memory which gave the company the competitive edge to become the world’s largest computer maker.

1951 Yuk Wing Lee and Jerome B. Wiesner develop and apply auto-correlation techniques for signal detection and analysis. The work is used in such scientific experiments as detecting radar echoes from the moon. These techniques are still in use today in very long-range communications, such as space exploration.

1952 Jerome B. Wiesner and William H. Radford ’32 develop tropospheric scatter for over the horizon communication.

1953 At MIT’s Research Laboratory for Electronics, Jerrold R. Zacharias and colleagues develop the atomic beam clock accurate to one second in 1000 years.

1953 Jay W. Forrester ’45 develops and builds *Whirlwind 1*. It is the world’s first high-speed, general purpose electronic digital computer able to operate in real time. Whirlwind grew out of plans to build a flight trainer for pilots and becomes a key element of the SAGE Air Defense System.
Building on the mathematical theory of communication he developed earlier, Professor of Mathematics and Electrical Engineering Claude E. Shannon '40 defines a unit of information and shows the relationship between signals, noise, and rate of transmission of information, providing a conceptual basis for solving communications problems.

MIT’s Lincoln Laboratory sends the world’s first television message through space—it is simply “M.I.T.” The TV signal is transmitted from the laboratory in Lexington, Massachusetts to the Echo I balloon satellite and received by a station in California.

John S. McCarthy defines the LISP (List Processing) programming language, the first language developed for the emerging field of Artificial Intelligence (AI).

The MIT Servomechanisms Laboratory brings the pilot design of a numerically controlled machine tool in operation. Started in 1949, the research program leads to the wide industrial adoption of a new system by which machine tools are controlled automatically by software, thus providing a basis for the revolution of manufacturing through robotics.

Ivan E. Sutherland '63 builds the world’s first Computer-aided Design (CAD) System based earlier work of Steven A. Coons and Douglas T. Ross. Named “Sketchpad,” the system becomes the basis for the now widely used CAD/CAM systems that revolutionized design and manufacturing.

Marvin S. Minsky publishes Steps Toward Artificial Intelligence an seminal work in Artificial Intelligence. In his research he develops a computer-controlled robot with a TV-camera as an eye that can accomplish simple tasks such as stacking blocks.

Fernando J. Corbato '56 demonstrates a pioneering computer time-sharing system, CTSS. A single computer is linked to several control consoles and can serve several users at the same time. It does it at such a speed that each user perceives to have his own machine. In 1963, CTSS becomes a basic tool in MIT’s Project MAC (Machine-Aided Cognition and Multiple-Access Computer), a major research study in human-machine interaction led by Robert M. Fano '41.

Professor Joseph Weizenbaum design the computer program “Eliza” to simulate a psychotherapy session.

Joel Moses and others begin the development of MACSYMA, the world’s first extensive computer program able to manipulate algebraic expressions and perform operations such as differentiation and integration. The program represents the first step in developing “expert systems.”
Chapter 4: The Premier Technical University

Materials Science and Engineering

1930s  Morris Cohen begins work on the atomic and molecular structure of metals, which lays the groundwork for the development of high-strength materials.

1962  After 25 years of pioneering research in steelmaking, John Cohen explains the complex chemical reactions in the steel making processes. As a result, steel can now be produced in enormous quantities, with the chemical composition precisely adjusted.

1985  Harry C. Gatos and students produce the first semi-insulating indium phosphide. Production of this material opens up a wide range of potential applications for the electronics industry.

Mathematics

1923  Norbert Wiener, who joined the faculty in 1919, publishes the paper “Differential Space” in the Journal of Mathematics and Physics which provides the mathematical foundations for the modern theory of stochastic processes, which has many applications to control theory, filtering, and prediction theory.

1974  Norman Levinson takes a giant step toward the solution of the Riemann Hypothesis, one of mathematics’ most difficult and most famous problems. The hypothesis is concerned with the distribution of prime numbers and Levinson shows that one-third of the zeros of the Riemann zeta-function lie on the conjectured line.

1977  Ronald L. Rivest, Adi Shamir, and Leonhard Adleman invent the first workable public key cryptographic system. The new code, which is based on the use of very large prime numbers, employs published keys, and allows secret communication between any pair of users.

Media Science

1986  Professor Stephen A. Benton and students at the Media Laboratory invent a hologram that projects a wide-angle, computer-generated image into space. Thus, parking an automobile literally in mid-air. The ability to present 3-D computer data in space enhances visualization in areas as diverse as medicine, design, and communications.

1989  Professor Stephen A. Benton and students create instant animated holograms.

Mechanical Engineering
1965  Professor Robert W. Mann '50 co-develops the “Boston Arm,” an artificial arm that is controlled by the bioelectric signals generated in the muscles of the wearer. The artificial arm demonstrates Norbert Wiener’s hypothesis of a naturally controlled cybernetic prosthesis for limb amputees.

Earth, Atmospheric, and Planetary Science

1930s  Hurd C. Willett begins the development of the Norwegian polar front theory and methods of air mass analysis for weather forecasting in the United States. With the assistance of Jerome Namias, he develops the five-day forecasting technique now used by the U.S. Weather Service.

1961  Edward N. Lorenz finds the first mathematical system with chaotic behavior in a computer model of how the atmosphere behaves. Since small changes in initial condition lead to chaos, weather predictions are inherently difficult to predict. Lorenz’s work attracts attention from other fields and creates a new branch of mathematics, *Chaos Theory*.

1978  Gordon Pettengill, a pioneer in the application of radar techniques for studying planets, heads the radar experiment on the Pioneer Venus orbiter spacecraft. The experiment reveals in remarkable detail the complex nature of Venus’s surface.

1988  Professor James L. Elliot and Edward W. Dunham discover that Pluto is surrounded by what appears to be a substantial atmosphere, thus ending years of debates among researchers, some of whom believed that the planet’s gravitational field is too weak to retain an atmosphere. The discovery is made possible by Pluto’s passing in front of a faint star, a phenomenon known as occultation.

Ocean Engineering

1985  Dr. Robert Ballard of the MIT affiliated Woods Hole Oceanographic Institute leads a French-American expedition that discovers the wreckage of the *Titanic* at a depth of 3,800 meters (12,500 feet). The ocean liner, that sank in 1912, is located approximately 625 km southeast of St. John’s Newfoundland or about 1600 km east of Boston.

Physics

1930s  Francis Bitter devises an electromagnet that produces a magnetic field 200,000 times as intense as the earth’s magnetic field. It is the strongest continuous field attained up to that time.

1946  After years of research Professor Samuel C. Collins invents the *Helium Cryostat*, providing the first reliable and inexpensive supply of liquid helium. His apparatus opens the doors for extensive experimental studies
in low-temperature physics and later advances in cryogenics, such as the low-cost production of liquid oxygen for new steelmaking methods.

1951 Martin Deutsch discovers positronium, an atomic system composed of a bound electron and positron. The discovery leads to many important applications in condensed matter physics, biology, and medicine.

1953 Applied mathematician Chia Chiao Lin and Frank H. Shu explain the spiral structure of galaxies. They show that a spiral structure is a natural result of any large-scale disturbance of the density distribution of stars in a galactic disk. Calculating the mutual interaction of stars, it can be found that the resulting density distribution takes on a spiral pattern that does not rotate with the stars but rather moves around the nucleus more slowly as a fixed pattern.

1955 George R. Harrison and colleagues in the MIT Spectroscopy Laboratory develop the world’s largest and most accurate diffraction gratings to replace prisms in spectroscopy. Diffraction gratings, which absorb and analyze light, are now critical to research in astronomy, physics, and the metals industry.

1958 Professors Bruno Rossi and Herbert Bridge discover solar wind through observations by Explorer X.

1960 George B. Bent invents and applies the technique of quasi-elastic light scattering spectroscopy to probe critical phenomena in the gas-liquid phase transition.

1962 Bruno Rossi and Riccardo Giacconi spot the first observed x-ray source other than the sun. The source, called Sco X-1, proves to be after more research a faint blue star in the Scorpio constellation.

1967 Steven Weinberg develops a fundamental theory that unifies the weak and electromagnetic forces. In 1979, he receives the Nobel Prize in Physics for his work.

1968 Professors Jerome I. Friedman and Henry W. Kendall conduct inelastic electron scattering experiments that confirm the existence of quarks of which atomic particles are made up. Friedman and Kendall share the 1990 Physics Nobel Prize for their work.

1974 MIT Professors Samuel C.C. Ting, Ulrich Becker and Min Chen discover at the Brookhaven National Laboratory the so called “J” particle. It points to the new building block of atoms, the quark. In 1976, Ting shares the Physics Nobel Prize for his discovery.
1979 Physicists Samuel C.C. Ting, Ulrich Becker and Min Chen discover the first physical evidence of the gluon, the particle that forms the “glue” in binding quarks together to form elementary particles.

1981 Professor Alan H. Guth provides the first satisfactory explanation of the early universe. His inflationary universe models receive widespread international attention; it explains the development of the universe during the first $10^{-35}$ seconds after the “Big Bang.”

The War Effort and the Radiation Laboratory

During World War II MIT became the world’s largest research organization. Under 400 contracts it conducted research worth $117 million dollars—far more than any other university or corporation. The war effort by MIT included foremost the development of radar, but also servomechanism systems to control batteries of guns, gyroscopic gun-sights, underwater mine detectors, special metals for the atomic bomb, antisubmarine technology, aerial flash photography, blood chemistry, battle field nutrition, and many others. Since the research volume was so large and included the development of radar, some said that the war was won at MIT. The director of the laboratory, Dr. Lee A. DuBridge, once remarked that radar won the war but the bomb ended it. Nobel laureate I. I. Rabi put it even stronger; if it hadn’t been for radar, the Allies would have lost the war.

In June 1940, former MIT Vice President and Dean of Engineering Dr. Vannevar Bush ’16 persuaded President Roosevelt to establish an agency to contract with universities and industry for defense research. Bush envisioned it as a framework within which science and technology would be mobilized to support the nation’s military programs. The day after Germany marched into Paris, on June 15, 1940, signed a document officially establishing the National Defense Research Committee (NDRC) with Dr. Bush as the chairman of the committee. MIT President Karl Taylor Compton became the head of Division D, the NDRC division focused on detection, control, and instruments.

Out of the four sections in Compton’s division, “detection problem” was the most urgent. In those years detection meant radar. Radar (Radiation Detection and Ranging) was developed earlier by Britain and an operational system was available, but its performance was not yet useful because of problems with long wavelengths and low power. The breakthrough was made by scientists at the University of Birmingham in England who succeeded in building a resonant cavity magnetron tube that produced 10-centimeter radiation at an intensity several thousands of times greater than any existing tubes. Britain urgently needed a fully developed 10-cm radar for fighter planes but the country’s resources were strained to the limit. Thus, in a mission headed by Sir Henry Tizard, Britain brought the magnetron to the United States to manufacture it in large quantities and develop practical radar.

One of the panels in Compton’s division was put in charge of the development and soon became called the Microwave Committee. Several unsuccessful attempts were made to locate a laboratory near Washington then the Committee augmented
by Bush himself asked Compton in his role as MIT President to locate the radar development at MIT. Compton hesitated initially for two reasons. First he was head of the NDRC division and such a decision would have been seen as favoritism and second that the federal government would sponsor a major project laboratory on a university campus which might decrease its academic independence and freedom. However, President Compton was persuaded by two reasons. First, the development of radar would require a strength in both theory and application, which was exactly what MIT had achieved under his leadership. Secondly, the United States was at peril and the nation might lose. On October 16, 1940, Compton accepted the arguments by the Microwave Committee and at MIT Executive Assistant to the President Killian freed up 11,000 square feet of space for the secret project.

The Radiation Laboratory, as the project was called to disguise its real purpose, devoted itself to three major missions:

1. The development of a 10-cm airborne radar for fighter aircraft in night-time combat
2. The development of an accurate precision gun-laying radar.
3. The design of a long-range navigational system.

At its peak, the laboratory employed about 1,200 scientists and engineers including about 20 percent of the country’s top physicists. In addition 2,700 technicians and support staff worked in the laboratory and 9,000 servicemen were trained to operate radar. The “temporary” facilities along Vassar Street used up more than 600,000 square feet (55,000 square meters) of floor space at MIT.

During the course of the war, the Radiation Laboratory developed 150 different radar systems and built thousands of sets for the armed forces. It also is credited with the development of LORAN, the long-range navigation system. Not a radar but a system of radio signals for use by ships and airplanes in determining their location which became in use throughout the world.

In his book The Education of a College President, former MIT President James R. Killian wrote about the Radiation Laboratory (p. 27):

By its success the Radiation Laboratory provided a demonstration of the power of integrated research, which was later to be influential in the organization of research by universities and industry. It also encouraged universities, especially MIT, to devise postwar interdepartmental organizations for integrating new fields of learning and research requiring a partnership of disciplines. ...

More than most of the other large-scale wartime university research projects, this laboratory contributed directly to the conduct of fighting in the theaters of war and brought its civilian research personnel in operational contact with the personnel of the fighting military forces. This brought to the laboratory a sense of urgency and of direct sharing in battle operations and bequeathed to those Radia-

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10. One of the buildings, Building 20, still exists and is occupied.
Section 4.3: Research

While the Radiation Laboratory was dissolved shortly after the end of the war, it left its mark with the establishment of MIT’s interdisciplinary Research Laboratory for Electronics (RLE) out of its research divisions in 1946. The RLE was the first of the federally-funded research centers, that became so common in America. In addition, the Radiation Laboratory made research an equal partner with teaching on campus.

**Project Daedalus**

Few MIT achievements of the last decade have captured so strongly the attention and imagination of people and media around the world as the *Daedalus Project*. Faculty, alumni, students, and staff of MIT’s Department of Aeronautics and Astronautics with help from Yale, NASA, and engineers set forth to break the world record for the longest flight by a human-powered aircraft by flying from the island of Crete to the island of Santorini in Greece.

The 3,500-year old Greek myth of the brilliant Athenian inventor and craftsman Daedalus holds that he and his son Icarus were held prisoners on Crete after incurring the wrath of King Minos. To escape the island Daedalus fashioned wings from feathers and wax. Flapping the wings, he flew across the Aegean Sea from Crete to the Greek mainland. While Daedalus landed safely, Icarus flew to close to the sun and fell into the sea as the wax melted.

To recreate the myth of Daedalus by building a human-powered aircraft and fly it across the Aegean was proposed by Dr. John S. Langford to MIT. While a student at MIT, he led the construction of two human-powered airplanes, *Chrysalis* (built in 1979) and *Monarch*, which won the first prize in the Royal Aeronautical Society’s Kremer World Speed Competition in 1984. The Daedalus Project was far more challenging. To recreate the legend took almost three years and $1 million. It involved a total 36 people, including, five engineers, twenty students (mostly undergraduate), historians, physiologists, and athletes. The *Daedalus Project* was organized into three phases. In Phase 1 a feasibility study of the flight with research in aerodynamics, structures, meteorology, and physiology was conducted. In the second phase, a prototype, called *Michelob Light Eagle*, was built and tested, and in the third and last phase, *Daedalus 88* was flown across the Aegean.

The United Technologies Corporation was the primary sponsor for the construction of *Daedalus 88* providing financial and technical support worth $430,000. Support also came from the Smithsonian Institution, NASA, the Hellenic Industrial Development Bank of Athens, and others.

The aircraft had a wingspan of 34 meters (112 feet), which is lightly larger that of a DC-9, but had a mass of only 31 kg (69 lb). *Daedalus 88* featured an 11-ft propeller and extra thin-wings that provided 30% more aerodynamic lift than conventional wings.
Chapter 4: The Premier Technical University

On the flight on April 23, 1988, Daedalus 88 was piloted by the Greek cycling champion Kannellos Kanellopoulos from Heraklion on Crete to the island of Santorini where it crash-landed. The historic event broke three world records in human-powered flight:

- **Daedalus 88** covered a distance of 116.58 km (72.44 miles) and broke the existing record for straight-line human-powered flight set in 1979 by the Gossamer Albatross which flew 22.5 miles across the channel.

- **Daedalus 88** broke the existing distance record of 37.2 miles for human-powered-flight set by the Daedalus prototype Michelob Light Eagle.

- With a flight time of 3 hours, 54 minutes, and 69 seconds, **Daedalus 88** broke the record for duration time aloft, which was set at 2 hours and 29 minutes by the Gossamer Albatross.

The achievement was called a “triumphant and historic flight—an astonishing physiological and engineering feat built on dreams” and attracted considerable media coverage from around the world. After the flight on Saturday, almost every Sunday newspaper in the United States carried an article on Daedalus—many of them on the front page. The Associated Press, United Press International, and The New York Times Wire Service offered stories and photos on the flight which were used extensively. On the east coast The New York Times and on the west coast the Los Angeles Times printed major stories on the flight, accompanied by photographs, starting on page 1. Prominent coverage on the flight was also given by magazines from around the world. In the U.S., the National Geographic featured a spread of 11 pages in their August edition. Sports Illustrated used five pages and TIME one page to cover the event. The TV networks NBC and ABS as well many local affiliates and CNN provided television coverage. Later, the public broadcasting science program NOVA broadcast a one-hour documentary on Daedalus and human-powered flight.

### 4.4 Entrepreneurship

In the 1992 article “Can MIT Save America?,” Boston Magazine called MIT the country’s most powerful engine of entrepreneurship. As one examines MIT’s record in establishing business one has to agree that the Institute has been a formidable might in creating businesses. It is estimated that MIT alumni have started more than 1,000 business around the globe.

The commercialization of new ideas has been an integral part of MIT’s culture from the very beginning. Since the 1940s the Institute has encouraged the faculty to spend one day a week pursuing outside professional interests. These interests and the resulting experiences and contacts have created in them and their graduates the entrepreneurial spirit. A study showed that 50% of MIT alumni who started businesses in the Commonwealth of Massachusetts did so within only five years after graduation.

This section attempts to give an overview of some of the most prominent and best known companies founded by MIT alumni. It is by no means a complete account
and does include companies which were not founded but strongly shaped by MIT alumni such as General Motors, General Electric, Du Pont, Eastman Kodak, and many others.

One of the first companies to be founded by MIT alumni was a chemical engineering firm named Griffen and Little. Started in 1886 by Arthur D. Little, Class of 1885, it turned later into the Arthur D. Little, Inc.—the world’s first industrial consulting firm. Another well known company started by an early MIT alumnus is the Campbell Soup Company. It was founded by John Thompson Dorrance who received his Bachelor’s degree from MIT in 1895. MIT’s main campus buildings were built by Stone & Webster, which was founded in 1889 by Class of 1888 classmates Charles A. Stone and Edwin S. Webster.

One of the largest employers in the Commonwealth of Massachusetts is the Raytheon Corporation which was founded by Vannevar Bush and is among the best known MIT-linked companies. Dr. Bush who earned his MIT doctorate in 1916 joined the MIT faculty in 1919. He also became involved with the American Research and Development Corporation in Medford, Massachusetts. This small company was pioneering the manufacturing of radio components and through a series of corporate changes, he turned the company into Raytheon, Inc. Raytheon helped MIT in engineering radar during World War II and has gained fame during the recent Gulf War as the maker of the Patriot missile. The company is now based in Lexington, Massachusetts and has more than 63,000 employees.

During the second world war Harold E. Edgerton ’27, Kenneth J. Germeshausen ’31 and Herbert E. Grier ’33 conducted research on high-speed photographic and stroboscopic techniques. After the end of the war Edgerton and Germeshausen worked together to market the technology they had developed at MIT over a period of thirteen years. Later, Herbert Grier joined and they founded Edgerton, Germeshausen & Grier, Inc. (EG&G) in 1947. Since the company was initially unsuccessful in selling strobes as commercial products, they started to consult businesses to solve industrial problems using strobe photography. Almost fifty years later EG&G has expanded its activities enormously. It provides scientific and technical services and products to commercial and governmental clients. It also supports the U.S. space program, the Department of Energy, the Army, etc. At NASA’s Kennedy Space Center EG&G is the Base Operations Contractor and for the DOE it manages the close down of the SCC (Superconductor-Collider). EG&G has now offices in 27 states and 24 foreign countries.

In 1958, MIT and Robert Everett ’43 founded the MITRE Corporation in Bedford, Massachusetts. It was organized as an independent non-profit organization whose purpose was to carry out large-scale construction and manufacturing that was needed for the SAGE System developed by MIT’s Lincoln Laboratory for the Air Force. Once the corporation was established, 500 employees transferred from Lincoln Laboratory to MITRE. Later the company became responsible for the development of the air reconnaissance system AWACS.
Teradyne, Inc. of Boston is a leading supplier of automatic test equipment used by the electronics industry in testing integrated circuits and other electronic devices and assemblies. Founded in 1960 by Alexander V. d'Arbeloff '49 and Nicholas DeWolf '48, Teradyne employs about 4,000 people and generates sales of over $554 million annually (as of the end of 1993).

As electronics and especially computers became increasingly important, MIT's alumni started to form numerous companies throughout Massachusetts and the emerging Silicon Valley in California. One of the largest computer companies is the Digital Equipment Corporation (DEC). The company was founded in 1957 by Kenneth H. Olson who received his Bachelors degree in electrical engineering in 1950. Today, DEC with its headquarters in Maynard, Massachusetts is one of America's technology giants and the world's leading manufacturer of network computer systems and associated peripheral equipment. DEC is Massachusetts' largest private employer. While DEC is the best known MIT-linked computer/electronics company it is certainly not the only one. MIT alumnus Cecil H. Green '23 founded in 1938 Geophysical Sciences, Inc. Later, in 1951, its name was changed to Texas Instruments. Also mentioned should be Analog Devices, Inc. which was founded in 1965 by Raymond Stata '57 SM '58 and Matthew Lorber '55. The company is a leading manufacturer of linear integrated circuits that process analog based signals, such as light intensity, temperature, pressure, audio, sonar, radar, and x-ray such that they can be read by digital computers.

While the MIT-spin offs in Massachusetts were concentrated on Route 128, California's spin offs settled in or close to Silicon Valley. In 1990, the Chase Manhattan Bank conducted a study entitled "MIT Entrepreneurship in Silicon Valley." Its findings were impressive. Nearly 200 companies in Northern California, with annual sales exceeding $20 billion, were founded by MIT alumni members. The total number of employees of these companies was more than 90,000 of which 43,000 were based in Silicon Valley. An additional 47,000 jobs were created in related and support industries in Silicon Valley, and another 15,000 elsewhere in California, thus the total number of jobs created due to MIT was 152,000. MIT's entrepreneurs were not only influential in the growth of Silicon Valley but have also contributed to its establishment in the first place. MIT's 1924 graduate Frederick Terman is acknowledged as the "father of Silicon Valley." William Shockley, who received his PhD in 1936, co-invented the transistor and Robert Noyce '54 devised the integrated circuit and later established Intel Corporation. One of Silicon Valley's largest and best known companies, Hewlett-Packard Company, was co-founded by William Hewlett, who received an MIT Master's degree in 1936. Another MIT-linked company is National Semiconductor, which was founded in 1959.

Closer to Cambridge, MIT alumni formed Data General, Inc. and Thinking Machines Corporation. Thinking Machines was formed in 1983 by Sheryl L. Handler PhD '85 and W. Daniel Hillis '78 SM '81 PhD '88 and Professor Marvin S. Minsky to develop high speed, massively parallel computers. Its Connection Machine was developed in only three years and set in 1986 a new standard in supercomputing.
MIT has produced not only hardware but also software companies. While there are dozens of them, one is particularly well known, **Lotus**. MIT graduate Mitchell Kapor '80 created with Jonathan Sachs '70 the spreadsheet program Lotus 1-2-3 and founded Lotus Development Corporation in Cambridge. In Brookline, Massachusetts, **GCC Technologies, Inc.** was formed in 1981 by Douglas B. Macrae '81, Kevin Curran '81 and John Tylko '79 who all lived in the same MIT dormitory. The company started as a maker of video game and one of the firm's first products became one of the most successful videogames—"Ms. Pac Man" generated over $300 million in revenues for GCC. Other MIT-linked software companies are **Phoenix Technologies** and **Interleaf**.

Amar G. Bose, a graduate of the class of 1951 and since 1956 a professor of electrical engineering, is known as the inventor of Bose 901 and 401 high fidelity speakers. Started in 1964 by Professor Bose, the **Bose Corporation** has sold millions of speakers worldwide and is the top loudspeaker manufacturer in both the U.S. and Japan. In recent years the company has expanded its product line to stereosets for home and cars. Its car stereo is sought after by automobile manufacturers like General Motors, Mercedes-Benz, Honda, Nissan, and others.

Raymond C. Kurzweil '70 and Aaron Kleiner '69 were roommates at MIT and founded not only one but three companies. **Kurzweil Computer** was founded in 1974 to develop print-to-speech reading machines for the blind and optical character readers. **Kurzweil Music Systems** (1982) manufacturers electronic musical instruments that accurately reproduce sound of traditional instruments. **Kurzweil Applied Intelligence** develops and manufactures large vocabulary voice recognition machines.

When the number of start-ups in the computer hardware and software started to decline, a new "hot" field started to emerge and MIT alumni and faculty were very much a part of its. Biotechnology has experiences tremendous growth in recent years and everything seems to indicate that it will change our lives as much as computers. Companies like **Amgen**, **Biogen**, **Repligen**, and **ImmunLogic Pharmaceutical** have all MIT-links.

MIT alumni were and still are active in forming companies in the aerospace sector as well. They formed one of the largest traditional aerospace firms and the most promising start-up. Donald Douglas graduated from the MIT Department of Mechanical Engineering in 1914 and worked for a number of years with Jerome C. Hunsaker until he went into industry and formed the Douglas Aircraft Company in 1920. Several years after Douglas left MIT, James S. McDonnell received a Bachelors Degree in 1925. He would also head for industry and form the McDonnell Aircraft Corporation in 1939. Incidentally, these companies merged in 1967 to form the **McDonnell Douglas Corporation**, one of the world’s largest aerospace companies. In 1994, the company had 70,000 employees and probably the largest line of aerospace products in the United States.

David W. Thomson received from MIT a Bachelor's degree in Aeronautics and Astronautics in 1976. Several years later, in 1982, founded **Orbital Sciences Cor-**
poration (OSC), to develop and market upper stages for the Space Shuttle. However, the company became well known through a different product, Pegasus. In June 1988, OSC and engine manufacturer Hercules Aerospace announced a partnership to develop an air-launched small orbital delivery system. OSC’s subsidiary Orbital Communications Group (Orbcomm) is in the process of launching a constellation of satellites into orbit to allow global commercial communication of short messages. Once launched, it would be the first system of its kind in the world.

Among alumni that turned to publishing, Patrick J. McGovern stands out. He received an SB in 1959 in Biophysics and Quantitative Biology. In 1964 he founded International Data Corporation (IDC) a market research organization for the computer industry. After a 1967 study by IDC revealed that consumers felt that there was no place they could turn for reliable information on computer products, McGovern published within three weeks’ notice the premier issue of Computerworld. Within four weeks it became the country’s biggest computer magazine. IDC grew over the years to become International Data Group (IDG), the world’s largest publisher of computer-related information. The company issues over 220 computer publications in 64 countries with a monthly readership of 40 million. IDG is based in Framingham, Massachusetts. More recently the director of the Media Laboratory Nicholas Negroponte helped create Wired Magazine, which is quickly becoming the “bible of cyberspace.”

While MIT alumni have founded companies throughout the United States and the world, many have their headquarters in Massachusetts. In 1989, the Bank of Boston published an extensive study on the economic impact of MIT on the Massachusetts economy. The study found that in 1989 there were 200 MIT-founded companies with either 100 or more employees or sales of more than $10 million in Massachusetts alone. Out of the 351 cities and towns in Massachusetts, one third were home to MIT-generated businesses with Cambridge home to 138. In the period 1867 to 1988, MIT alumni created 636 businesses in Massachusetts alone which had translated to approximately $10 billion in annual revenues and more than 300,000 jobs for state residents.

4.5 Alumni Achievements

Corps of Astronauts

Many of the country’s astronauts have earned degrees from MIT. A 1993 NASA fact sheet reported that nine of the current American astronauts were MIT alumni.

11.McDonnell Douglas products range from civil jetliners like the MD-80 series and the MD-11 to fighter aircraft such as the F-15, F-18 over helicopters like the Apache, to large rockets like the Delta II.

12.That is, it would launch from an aircraft flying at high altitude.

13.U.S. publications include PC World, Macworld, Federal Computer Week, Publish and more than 20 others.
Section 4.5: Alumni Achievements

Together with eleven former astronauts, MIT has produced twenty astronaut. Thus making MIT the civilian institution with the largest number of astronaut graduates, and overall third largest—surpassed only by the U.S. Naval Academy (36 astronaut graduates) and the U.S. Air Force Academy (26 astronaut graduates). The most famous of the MIT astronauts is Edwin E. “Buzz” Aldrin Jr. ScD '63 who, as pilot of Apollo 11 in 1969, became the second person to walk on the Moon. In addition to Aldrin, three other MIT alumni landed on the moon and one orbited the moon. Hence, one third of all men to walk on the moon had degrees from MIT.

Architecture and Art

Among its graduates in architecture, many have earned considerable fame. The most prominent and most successful among them is I.M. Pei '40. Pei designed some of the world’s most notable buildings, such as the East Building of the National Gallery of Art, the John Hancock Tower in Boston, the Xiangshan Hotel in Beijing, and the Morton H. Meyerson Symphony Center in Dallas. He was commissioned for the renovation of the Louvre Museum in Paris and designed the glass-faceted pyramid for a new entrance. Four of the building’s on campus were designed by Pei of which the Media Laboratory is the newest.

Luis H. Sullivan, the most noted American architect of the 19th century was enrolled at MIT from 1872–73 and Raymond Hood '03 who built the Rockefeller Center in New York.

Among MIT artists, Daniel Chester French, Class of 1871, has a special place. He was the sculptor of the Lincoln Memorial in Washington, D.C., the Minuteman in Concord, Massachusetts, and John Harvard’s stature in Harvard Yard.

Industry

Two members of the class of 1895 become the most successful MIT managers. Alfred P. Sloan, Jr. was president of General Motors and Gerard Swope president of General Electric. Sloan became president and chief executive officer of GM in 1923 and transformed the corporation from a loose cluster of business units into the business structure it has retained to the present day. He reorganized the company into the five different automobile divisions. Through Sloan’s leadership General Motors became the largest automobile maker in the United States and eventually the largest business corporation in the world.

Among all the world’s corporate research laboratories, none has been more successful than the famous Bell Telephone Laboratories. The man who really put the laboratory together and directed it was Frank B. Jewett, who received his S.B. degree from MIT in 1903.

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14. Russell L. Schweickart '56 orbited the moon on Apollo 9 and Edgar D. Mitchell '64 on Apollo 14, David R. Scott '62 on Apollo 15, and Charles M. Duke Jr. '64 on Apollo 16 landed on the moon.
Science and Engineering
Since its establishment in 1861, MIT has produced many of the world’s top scientists and engineers. Some stayed at the Institute as professors but many left to make seminal contributions elsewhere.

Among MIT alumni, twelve have won the Nobel Prize and are listed in Table 4.2. Living Nobel laureates are shown in bold.

Table 4.2: Alumni Nobel Prize Winners

<table>
<thead>
<tr>
<th>Year</th>
<th>Alumnus</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>William Shockley PhD '36</td>
<td>Physics (shared)</td>
</tr>
<tr>
<td>1965</td>
<td>Richard P. Feynman '39</td>
<td>Physics (shared)</td>
</tr>
<tr>
<td>1965</td>
<td>Robert Burns Woodward '17</td>
<td>Chemistry</td>
</tr>
<tr>
<td>1966</td>
<td>Robert S. Mulliken '17</td>
<td>Chemistry</td>
</tr>
<tr>
<td>1969</td>
<td>Murray Gell-Mann PhD '51</td>
<td>Physics</td>
</tr>
<tr>
<td>1972</td>
<td>John Robert Schrieffer ’53</td>
<td>Physics</td>
</tr>
<tr>
<td>1975</td>
<td>David Baltimore '61</td>
<td>Medicine or Physiology</td>
</tr>
<tr>
<td>1976</td>
<td>Burton Richter ’52 PhD ’56</td>
<td>Physics</td>
</tr>
<tr>
<td>1980</td>
<td>Lawrence R. Klein PhD ’44</td>
<td>Economic Science</td>
</tr>
<tr>
<td>1987</td>
<td>Charles J. Pedersen SM ’27</td>
<td>Chemistry</td>
</tr>
<tr>
<td>1989</td>
<td>Sidney Altman '60</td>
<td>Chemistry (shared)</td>
</tr>
<tr>
<td>1990</td>
<td>Elias J. Corey Jr. ’48 PhD ’51</td>
<td>Chemistry</td>
</tr>
</tbody>
</table>

The first MIT-related person to win the Nobel Prize was alumnus William Shockley PhD ’36 who with his colleagues Walter H. Brattain and John Bardeen invented the transistor at the Bell Telephone Laboratories in 1947. The invention of the transistor played a pivotal role in the advancement of electronics by replacing the vacuum tubes, they enabled the miniaturization of computers. For the discovery the three scientists shared the 1956 Physics Nobel Prize.

One of the best known American physicists was Richard P. Feynman ’39. Feynman reinvented quantum electrodynamics—the theory of the interaction between light and matter and therefore changed the understanding of the nature of waves and particles. His problem solving tools, such as the Feynman diagrams, permeated into many areas of theoretical physics. While a professor at Caltech, Feynman shared the 1965 Nobel Prize in Physics for his work in quantum electrodynamics.

As the physics timeline pointed out MIT Professors Kendall and Friedman did the experimental work that confirmed the existence of quark. The theoretical work on quark and its existence was suggested by MIT alumnus Murray G. Gell-Mann MIT PhD ’51. For his work Gell-Mann received the Nobel Prize in 1969.

Herbert Kalmus ’03 paid tribute to his alma mater, when naming the color process for films he invented Technicolor. The process was first introduced in the

In 1929, Lt. James Doolittle ScD '25 is the first person take off, fly, and land an airplane relying solely on instruments. Major General Leslie R. Groves studied civil engineering at MIT before he went to West Point. As head of Manhattan District he was in complete charge of history’s biggest engineering task.

Nathanael Herreshoff, Class of 1870 pioneered modern catamaran design in the 1870s and designed and built the navy’s first torpedo boats. The five yachts that defended the America’s Cup between 1893 and 1920 were all designed and built by Herreshoff. Since after 1901 all U.S. Naval Academy graduates who desired to become shipbuilders were sent to the Institute for training, practically all U.S. Navy vessels in this century were built by MIT alumni.

George Ellery Hale, Class of 1890, was probably the greatest American astronomer of his time. He built the Yerkes Observatory for the University of Chicago and went to California as director of the Mount Wilson Observatory. He originated the idea and made possible the design and construction of the 200-inch Hale telescope on Mount Palomar. He was also the leader in building the California Institute of Technology into a world-class institution.

**Publishing / Journalism**

An early graduate of the Chemical Engineering Department was Eric Hodgins ’22. After graduation he remained at MIT as the editor of the Alumni Associations’ magazine *Technology Review*. He resigned in 1930 and became a nationally prominent journalist and writer and publisher of *Fortune* magazine.

**Government**

Considering that MIT does not have a law school like Harvard and Yale, MIT has made a big impact on the government and produced many public servants. Both faculty and alumni have served in many appointed federal positions.

Dr. Vannevar Bush ’16 was President Karl Taylor Compton’s Vice President and Dean of Engineering. In Washington, Bush was head of NASA’s predecessor NACA (National Advisory Committee on Aeronautics). Later he became head of the NDRC which was in charge of the country’s research effort during World War II. Out of the NDRC came the Office of Scientific Research and Development (OSRD) and Bush was at the helm of the largest scientific and technological enterprise in the history of the world.

After the shock of the Soviet Sputnik launch on October 24, 1957, President Dwight D. Eisenhower created a position in the White House of a Special Assistant to the President for Science and Technology, the first “science advisor” and appointed MIT President James R. Killian, Jr. ’26 to that position. It was Killian

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15. In the early years MIT was referred to as Technology and later Tech.
Chapter 4: The Premier Technical University

who recommended the creation of the National Aeronautics and Space Administration (NASA).

When John F. Kennedy became president, Professor Jerome B. Wiesner (who later became MIT’s 13th president), followed in Killian’s footsteps. Wiesner continued his service when Lyndon B. Johnson became president and returned to MIT in 1964. In the Carter Administration MIT’s head of the Department of Earth and Planetary Sciences, Professor Frank Press, was asked to advice the President on science and technology issues.

Under President George Bush, John H. Sununu ’61 SM ’63 PhD ’66, a mechanical engineer by training, served as the White House Chief of Staff and as Governor of New Hampshire.

In the Clinton administration, Sheila E. Widnall became Secretary of the Air Force, the first woman to head a branch of the military. Professor Widnall holds three degrees from MIT (SB ’60 SM ’61, ScD’64) and had at MIT the position of Associate Provost before her appointment.

MIT chemistry professor and former provost John M. Deutch PhD ’61 is also on leave to serve in Washington. From 1977 to 1980, Deutch served as director of the Office of Energy Research in the Energy Department. Later he became acting assistant secretary for energy technology and finally undersecretary of the Energy Department. Furthermore, John Deutch served on President Carter’s Nuclear Safety Oversight Committee, the Army Scientific Advisory panel and the Defense Science Board. In 1993, President Clinton, appointed John Deutch as Undersecretary for Technology and Acquisition at the Department of Defense and later became Deputy Secretary of Defense and is currently nominated as Director of the CIA.

Not only in the area of defense but also in economic policy can MIT alumni be found in Washington. In the Clinton Administration, the economic policy is largely shaped by MIT graduates. The three-person Council of Economic Advisors, chaired by Laura D’Andrea Tyson, PhD ’74, consist of three MIT-trained economists. In addition, the chief economist at the Labor Department and the international Under Secretary of the Treasury Department received degrees from MIT. Hence, it is not surprising that the New York Times called an MIT diploma in economics practically a White House pass.

Outside the United States, civil engineer Clarence D. Howe ’07, became one of Canada’s greatest statesmen. Luis A. Ferré ’24 was governor of Puerto Rico, José Figueres Ferrer ’26 president of Costa Rica, and Moshe Arens ’47 minister of defense in Israel.

References


11. Harry West, "Introduction to Design—The 2.70 Contest"


The account of MIT achievements in the previous chapter is by any standard highly impressive. However, MIT must not fall into the trap of resting on its laurels. Especially not now when in this era of rapid change there is a substantial threat to the Institute’s excellence. The threat has both internal and external reasons. While MIT is not alone affected by the external challenges, they are often more serious for the Institute than for other schools.

5.1 Introduction

In the current post-Cold War era—an era marked by rapid changes—the quality of university programs is threatened by a variety of factors. MIT and other leading research universities have already or will face the following challenges in the near future:

1. Internal Financial Difficulties
2. A Changing External Environment
   a. End of the Cold War and Decreased Defense Spending
   b. Financial Constraints of the Federal Government
   c. Globalization of the World
   d. Information Technology
   e. Public Perception and Public Support
3. Increased Competition while Decreased Supply of Research Sponsorship

The first represents an internal factor. Expenses constantly exceeded revenues of many universities and administrators were forced to make severe budget cuts. In 1991–92 for example, 57% of the nation’s colleges and universities implemented mid-year budget cuts. While schools can make budget cuts and absorb deficits with their often fairly large endowment, these “solutions” work only for the short term as Figure 1.1 on page 19 showed.

The end of the Cold War has seen an expected reduction in defense spending. For MIT, that has been heavily involved in research with the Department of Defense, these cuts have been and will be painful in the future. At the Lincoln Laboratory for example, the sponsorship was reduced from $440 million in FY90 to $354 million in FY94, a 20% reduction. When defense is no longer the biggest priority, grants no longer have to be awarded to the most able applicant. The concept of “earmarking” in which funding is distributed according to other criteria than the
Chapter 5: Challenges Ahead

quality of the proposal and without a peer review, endangers the sponsorship of
the leading universities in the country.

As a result of decades with extremely large military expenditures, the federal gov-
ernment faces financial constraints. To reduce the budget deficit in the short-run
and the national debt in the long-run, budget cuts have been and will be continued
to be implemented. Federal student financial aid will continue to decline, the gov-
ernment will carry less and less of the indirect cost associated with research, and
the amount of research that it will sponsor will be greatly reduced.

Tied with end of the Cold War period and the availability of technology, comes
the globalization of the world. Universities must consider programs like distance
learning to serve a global market since it is beyond their capacity to bring all qual-
ified students to their campuses.

The explosion in information technology will bring fundamental changes to the
way universities operate. After all, a research university is in the “information
business.” It conveys information or knowledge to students through its educa-
tional programs and it produces information or knowledge through its research
programs.

Public support for higher education does clearly exist but it said to be “a mile
wide and an inch deep.” The public is concerned about the high cost of attending
universities and through events such as the overlap case, may perceive established
elite universities as rich enterprises that are accumulating more and more wealth
rather than non-profit organizations that charge for an education, in the case of
MIT, only half of what it actually costs, in order to keep it affordable.

America’s best universities have educated hundreds of thousands of excellent
researcher over the last decades. While their quality is subject to pride and joy,
their sheer number will cause increasing problems. When research supply was
large, the number of qualified researchers that could apply for grants was small.
Engineering faculty at MIT now face a heavy competition from its former stu-
dents who have taken faculty positions at universities around the nation.

The challenges discussed so far apply not only to MIT but to many universities.
As was mentioned earlier, some of these challenges such as “earmarking” are
especially dangerous for MIT, while lower ranked competing universities will
actually profit from it. The rest of this chapter discusses some of the MIT-specific
challenges such as the hardening of academic salaries, the lack of support for pub-
lic relations and image care, as well as the decreasing quality of the educational
resources. The chapter is concluded with a discussion of MIT’s response to its
budget imbalance—the reengineering effort.
5.2 Pressure on the Budget

MIT's budget has been lately under considerable pressure but as is discussed in this section, more difficulties are on the horizon.

5.2.1 Current Imbalance of Expenses and Revenues

The biggest threat to the future of the Institute has been the widening gap of expenses and revenues. MIT's rate of growth of expenses exceeded the rate of growth of revenues. During the last decades MIT's total expenditures exceeded budgeted revenues and an operating gap resulted. This gap was filled with unrestricted gifts, grants and bequests that were donated in that year. When these funds were not sufficient, a deficit resulted. To cover the deficit, other funds, and in the worst case, funds functioning as endowment were used. Figure 5.1 shows how current gifts and fund balances were used over the last 10 years to meet operating expenses. From the chart it can be seen that over the last two years (FY 1993 and FY 1994) funds functioning as endowment needed to be used. In other words, parts of MIT's savings were used to meet the years' expenses. In FY 1994, the operating gap was $12.4 million and the deficit was $6.2 million. The Academic Council reviewed the situation and came to the conclusion that if the situation was left unchecked, the budget deficit would grow to at least $10 million and the operating gap would approach $20 million in the most optimistic forecasts for FY 1996 or FY 1997. While these numbers may appear small compared to the overall budget, one has to consider that much of the budget is “fixed” through external sponsorship. An operating gap of $20 million in comparison with the “controllable” budget of about $400 million represents 5%.

Realizing that the budget imbalance would quickly erode MIT's endowment, the Institute embarked on a “reengineering effort” to reduce the operating gap by $40 million ($25 million net of indirect cost recovery). Realizing that different growth rates of expenses and revenues are largely due to inefficiencies in operations, the
reengineering effort will redesign administrative processes to keep expenses in line. The reengineering effort will be discussed later in Section 5.7.

5.2.2 Tuition

MIT is committed to keep the tuition as low as possible to provide students access to an MIT education regardless of their economic background. Tuition and related income is the single largest portion of the revenues that the Institute has control over. In FY 1994 tuition income made up 17% of all revenues or $195 million. However, limiting the growth of tuition is seen as critical to MIT and thus it cannot be arbitrarily increased. MIT’s student body is traditionally composed of students whose financial needs are greater than those of other schools MIT is competing with (for undergraduate students) such as Harvard, Princeton, Yale, Stanford, etc. While this is the case, MIT’s tuition and self-help expectation is already the highest among competing schools as Figure 5.2 shows. In academic

![Figure 5.2](image)

**Figure 5.2:** The chart gives an overview of the tuition and the self-help level for the 1994–95 academic year for MIT and a selection of other leading universities.

year 1994–95, MIT’s tuition was with $20,100 the only one above the $20,000 mark—though only 1.4% above Harvard’s tuition. The self-help level was with 38% (as a percentage of tuition) significantly higher than that of Yale (25%), Princeton (27%), Harvard (30%), and the others. One can only estimate that the gap between MIT and the other schools would grow since the cost of equipment and facilities needed for MIT’s operation are higher than for many programs at Harvard, Yale, and Princeton. In order to maintain the growth of tuition at a reason-

1. The amount of money students are expected to earn themselves when receiving financial aid.
able level and remain competitive to other schools, MIT must make significant additions to its endowment so that its investment return could help more to subsidize tuition.

Closely connected to the tuition is the financial aid need of students to pay for attending MIT. The last several years have seen a rapid growth in financial aid needs because of a substantial decline in federal support for scholarships and because of a weak economy. While one can hope for an improvement in the economy, it is unreasonable to expect federal scholarship support to rise to Cold War levels. The impact of this is felt at all universities that accept students regardless of their financial needs but at MIT the impact is the highest as Figure 5.3 shows.

![Bar Chart](image)

**Figure 5.3:** The bar chart shows for MIT and seven other leading schools the percentage of students in the class of 1995 that receive grant aid.

With 60% of the Class of 1995 receiving grant aid, MIT provides more grant aid than other elite schools. The Institute will have to compensate for the decline in federal scholarship support through its own resources.

### 5.2.3 Hardening of Academic Salaries

Traditionally, the salaries of MIT faculty members were paid with so-called “soft money,” money that the faculty member themselves received through research grants. Thus, the Institute was heavily reliable on the outside. If, for whatever reason, the funding in an area would have been cut off, the department head could not have paid the faculty’s salaries.

Over the last several years, the trend has begun to “harden” the faculty’s academic salaries. “Hardening” means that a higher and higher percentage of the salary would be paid by MIT through its own income. There are many reasons to do so. Other than the “internal reasons” such as improving the quality of life for the fac-
Chapter 5: Challenges Ahead

ulty, reducing the pressure to do uninteresting research, loyalty, there are three external ones. These external ones are:

- Federal agencies, such as the NSF, are increasingly reluctant to support academic salaries and one can foresee that in the near future, research sponsors would not carry any portion of the salary.
- Academic year salaries budgeted in research proposals make applications appear to be less competitive than those from many competing institutions which do pay the full academic salary.
- When a proposal is funded there is often a “bottom-line” support level such that full academic year salary support can be used to fund more students.

MIT has achieved hardening the salaries such that all new faculty appointments now carry full academic salary support, as do all new appointments to named professorships. The fraction of all faculty academic year salaries charged to research grants and contracts has dropped from 17% in 1987 to about 10% in 1994. While a significant progress has been made, still much remains to be done, especially in the School of Engineering. To reduce the faculty salaries charged to research to zero would required an increase in endowment of about $200 million or increasing the book value of MIT’s total endowed funds by 14%.

5.3 Increasingly Inadequate and Aging Infrastructure

In all parts of the Institute, with the exception of the new Biology Building opened in 1994, the amount and quality of research space is well below what is needed to conduct the best possible teaching or research.

Most of MIT’s classrooms have basically remained unchanged for close to 80 years. They are bare, uninviting, and not to today’s standards. Since the old classrooms and lecture halls are antiquated, they do not permit the faculty to teach in the best possible manner due to poor blackboards, bad lighting, poor acoustics, lack of space for demonstrations, etc. This is particularly true for general teaching facilities that serve the freshman and the undergraduate core programs.

In addition to the quality of rooms comes their size. According to a survey conducted by the Dean of Undergraduate Education, the faculty can schedule only 40% of their courses in appropriately sized rooms.

With the overall lack of office and research space comes inefficiency and diminished flexibility to correspond to new opportunities. To quantify the inefficiency and diminished flexibility is difficult, however, an evaluation of the scientific and engineering research space at MIT by the departmental administrative officers exist.

In response to the 1994 Survey of Scientific and Engineering Research Facilities at Colleges and Universities sponsored by the National Science Foundation (NSF) and the National Institutes of Health (NIH), MIT evaluated the amount and quality of its research space in several fields. The total amount of net assignable
Section 5.3: Increasingly Inadequate and Aging Infrastructure

square feet (NASF) of research space at MIT was 1,874,301 and the NASF for instruction was 875,560. Thus, the total NASF for teaching and research in science and engineering was 2,749,861.

This space was by amount and condition insufficient for its purpose. According to the departments' administrative officers, the amount of research space available was ranked in every category as "generally adequate amount; sufficient to support most of your research needs in the field but may have some limitations." Not in a single category was the amount sufficient for all current needs of the researchers. Similarly, the current condition of research space was disappointing for MIT—the leading school of science and engineering. The results of the evaluation by the administrative officers is shown in Figure 5.4. Less than a quarter of the total space was considered "suitable for use in the most highly developed and scientifically sophisticated research in the field." About 14% was considered as either in need of major repair or renovation to be used effectively or in need of a total replacement.

As a consequence of this situation much new space is needed. The approved institutional plan for the next 10 years includes a large amount of "deferred space."

Figure 5.4: The graphs shows the percentage of research space according to its condition by field. The conditions are classified as follows: A—suitable for use in the most highly developed and scientifically sophisticated research in the field, B—effective for most purposes but not applicable to category A, C—effective for some purposes but not in need of limited renovation or repair, D—required major repair or renovation to be used effectively, E—requires replacement.

space was considered “suitable for use in the most highly developed and scientifically sophisticated research in the field.” About 14% was considered as either in need of major repair or renovation to be used effectively or in need of a total replacement.

As a consequence of this situation much new space is needed. The approved institutional plan for the next 10 years includes a large amount of “deferred space.”

2. The fields applicable to MIT were Engineering, Physical Sciences, Environmental Sciences, mathematics, Computer Sciences, Biological Sciences (other than medical school), Medical Sciences (other than medical school), Social Sciences.

3. Note that the survey was conducted before the opening of the new Biology Building.
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Deferred space is defined as space that is necessary to meet the critical needs of current faculty and programs, and space not scheduled to be constructed before Fiscal Year 1996, and space for which no funding exists yet.

For scientific and engineering facilities alone MIT needs $30 million to conduct the repairs and renovations critically needed. In addition, $180 million are needed for new construction. Thus, funds of $210 million are needed to just meet the critical needs of current programs in science and engineering with no expansion taken into account. For the entire Institute several hundred million dollars more are needed in the near term.

5.4 Decreasing Quality of Educational Resources

MIT's main educational resources are the Library System and the Athena Computing Network. Both of these resources are highly regarded but are both well below the current state-of-the-art and are being threatened of falling even further behind in the years ahead.

5.4.1 The MIT Libraries

One key aspect of the MIT Libraries is to provide its users access to information. Information is typically stored in books, serials, CD-ROMs, on-line databases, maps, etc. and bought by the libraries. In order for MIT to maintain excellence in teaching and research, faculty, students, and staff must have access to all the information of relevance. Hence, the quality of MIT's research and teaching depends on the quality of its library system which has more and more difficulty maintaining its quality and will be well below the standard set by other libraries around the country and the world. An update on the strategic plan of the libraries said that "... increasing costs, increasing publication rates and limited funding will prevent us from purchasing many of the materials required to fill the needs of the MIT community." The main reasons are the increasing volume of information and its spiraling cost, the need for more shelving space, and outdated library facilities.

**Amount and Cost of Material.** The volume of material printed every year that is relevant to MIT's program is increasing dramatically. So is the amount of information produced and distributed in electronic formats. For example, the number of pages of the journal *Physical Review* increased by a factor of five in 25 years—and this is just one journal in an established discipline. The number of formats in which information becomes available increases similarly. While in the past books and journals were the primary media, they have been supplemented in recent years with CD-ROMs, databases, videodisks, etc.

But not only the amount of material but also its price is increasing at an alarming rate. Over the last decade, the inflation in the cost of library materials has been among the highest in the Higher Education Price Index, rivaled only by the inflation in fringe benefits. The increasing fringe benefits costs were budgeted by universities but the rising cost of library materials were not. Although all libraries in colleges and universities are affected by the price increase, MIT, with its emphasis
on science and engineering, and the higher cost and faster growth of these materials, is especially vulnerable.

In 1988, 1991, and 1993 the MIT Libraries cancelled many serial subscriptions for budgetary reasons. Other universities undertook serial cancellation projects as well but MIT had to cancel more and fell even further behind other universities. A statistic by the Association of Research Libraries (ARL) shows that of the 106 or 107 ARL libraries reporting between 1987 and 1992 (the last year for which data was available), MIT's rankings have fallen substantially:

<table>
<thead>
<tr>
<th>Category</th>
<th>Rank in 1987</th>
<th>Rank in 1991</th>
<th>Rank in 1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current serials held</td>
<td>49</td>
<td>56</td>
<td>62</td>
</tr>
<tr>
<td>Serials purchased</td>
<td>62</td>
<td>71</td>
<td>72</td>
</tr>
<tr>
<td>Materials expenditures</td>
<td>80</td>
<td>87</td>
<td>90</td>
</tr>
</tbody>
</table>

This rankings are extremely negative considering MIT's leadership in science and engineering. Sixty-five percent of the budget for serials, which itself is 75% of the entire materials budget is allocated to titles which support science and engineering, and the percentage is growing because the most expensive titles are concentrated in those disciplines.

The MIT Libraries “Strategic Plan: Update and FY1995 Budget” summarizes the situation with the words: “Even funding which matches inflation will not provide adequate funds to keep up with expanded scholarly production or with new formats.”

**Shelving Space.** From a shelving space point of view the condition of the libraries is catastrophic. All divisional libraries are approaching or have surpassed working capacity. Among the major libraries the Dewey Library has passed the working capacity, the Humanities and Science Libraries located in the Charles Hayden Memorial Library not only surpassed the working capacity but also exceeded the stated capacity of the buildings. The Barker Engineering Library underneath the Great Dome (Building 10) will reach its capacity at the end of 1995, while the Rotch architectural library is expected to be at that point in the year 2000.

As a result of the lack of space, the MIT Libraries designed a storage program to remove lesser used materials from the campus libraries to the RetroSpective Collection (RSC) adjacent to campus and the Harvard Depository (HD). The RCS is operated by the MIT Libraries and is close to campus. Items can be retrieved overnight at no extra cost. Not so with the Harvard Depository, located in Southborough, Massachusetts (approximately 40 miles from MIT). As the name already implies it is not owned or operated by the Institute. The delivery of an item costs

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4. Working capacity is reached when the shelves are 85% full. Beyond that point, the shelving of additional material requires frequent shifting of books and journals.
Chapter 5: Challenges Ahead

$2.50 with a charge of $15 per trip. Typically between three and five items are being retrieved per trip at the current time, thus the cost of retrieving an item from the Harvard Depository lies between $5.50 and $7.50 per item and requires about three days. This cost is entirely carried by the Institute since the Libraries make the decision what items should be placed in the HD.

Since the space on-campus does not increase, the fraction of material available on campus is steadily decreasing. Table 5.2 shows the number of volumes on campus and in storage since 1972 with a projection for the year 2012. At the current rate of acquisition, without the addition of shelving capacity on campus, approximately 42% of the MIT collection would be in storage and 26% of the total collection would be in storage in the Harvard Depository in 2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>Volumes on Campus</th>
<th>Volumes in Storage</th>
<th>Total Number of Volumes</th>
<th>Percent of Total in Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>1,383,492</td>
<td>0</td>
<td>1,383,492</td>
<td>0%</td>
</tr>
<tr>
<td>1982</td>
<td>1,634,333</td>
<td>234,840</td>
<td>1,869,173</td>
<td>12.6%</td>
</tr>
<tr>
<td>1992</td>
<td>1,794,899</td>
<td>473,049</td>
<td>2,267,948</td>
<td>20.9%</td>
</tr>
<tr>
<td>2002</td>
<td>1,800,000</td>
<td>885,591</td>
<td>2,685,591</td>
<td>33.0%</td>
</tr>
<tr>
<td>2012</td>
<td>1,800,000</td>
<td>1,296,591</td>
<td>3,096,591</td>
<td>41.9%</td>
</tr>
</tbody>
</table>

In many areas of science and engineering the latest material is the most important and the storage of older materials does not reduce the effectiveness of the research and education too much. But in the social sciences, the humanities, architecture, mathematics, etc. the increasing fraction of material kept in storage, reduces the quality of the MIT Libraries to the users. Material in storage would not be available to patrons who browse and students who should be able to read secondary materials conveniently in order to support their course work and academic interests.

"The Library as a Place". An important aspect of the library’s function is that of the “library as a place.” The MIT Libraries need to be a place for self-education and discovery outside the classroom and a retreat from the pressures of academic life and living groups. They should also serve as the setting for forming social and intellectual bonds. In order to achieve this, the libraries must be conveniently located, useful, comfortable, and attractive.

Harvard University and the University of Chicago, as well as others maintain comprehensive collections in an elegant setting that encourage independent intellectual exploration. Other schools like the Georgia Institute of Technology, the California Institute of Technology, Stanford University, the University of Pennsylvania, and Carnegie Mellon University understand their libraries as “rich learning environments for students, where information can be explored and assimilated to knowledge.” and support the concept of the “library as place.”
Section 5.4: Decreasing Quality of Educational Resources

At MIT the libraries cannot play this important role. With the exception of the renovated Rotch Library, the MIT Libraries are in buildings that are outdated, in poor shape with the surroundings and the furniture being unattractive and uncomfortable. In addition, books are shelved in a way that they are difficult to find since they are distributed within a library and libraries distributed over the campus, thus making it difficult to browse and explore.

MIT’s library buildings were designed and built under the paradigm that the primary purpose of the library program was the acquisition, cataloging, and management of large collections of printed materials. Library patrons would come to the library to consult these materials and to use the various printed materials. The new paradigm is that the primary purpose of the library program is to provide access to information, which requires a much stronger consultative relationship between the users and the librarians. The current physical layout of the MIT Libraries does not support the new consultative role—either in person or through computers—of librarians.

Outlook. The Libraries are a critical component of the Institute and are not recognized enough by the Institute. As was said earlier, their quality is important to the success of all other academic departments, especially in the coming era where the amount of information will be so vast that an efficient organization must be in place to filter the information and provide what is critical to researchers and students. If no major changes occur in the next several years, the MIT Libraries will not be competitive with other leading research libraries and will certainly not be up to the standard set by the Institute as a whole. In “MIT Libraries Strategic Plan: Update and FY1995 Budget” the outlook for the future was stated as follows:

Over the next ten to twenty years, it will be extremely important to renovate many of the major library facilities on campus—the Hayden libraries (including Music), Dewey Library, and Barker Library—to modernize them and to increase their capacity their capacity. ... Campus planning for the next decade is well underway, and projections are being made considerably beyond the next decade. The Libraries, however, are not included in that planning, nor are library services for those programs that might move to new parts of campus. It is critical that planning for the future of library services on campus be integrated with other campus planning activities.

What is the impact of doing nothing? More and more of the collection will be off-site, and the cost of moving, storing, record alterations, and retrieval of these materials will grow. The Libraries will not be able to provide effective access to the electronic information that will be available, nor be able to provide high quality instruction to users on access to and use of this information. Research and a study in many disciplines will suffer, and the effectiveness of the Libraries program will be diminished. Our current use of rented space as the Harvard Depository costs approximately $35,000 per year. In twenty years, at today’s dollars, it will cost sixteen times that figure, or $560,000 per year, and this figure does not include the staff and operating costs involved with the storage and retrieval of the materials in storage.
5.4.2 The Athena Computing Environment

As was described in Section 3.5.2, MIT’s Athena Computing Environment has changed the life for MIT students and its products became industry standards. When MIT started Project Athena in 1983 with its key corporate partners DEC and IBM, the IBM PC was just two years old and the Apple Macintosh was not even introduced yet. MIT spent at least $20 million (for an initial 5-year period) as well as faculty, staff, and student labor and its partners $50 million to conduct pioneering work.

Because the technical challenge was so great, Project Athena had to be extended from a 5-year to an 8-year effort in order to accomplish all that was planned. After 8 years, in 1991, the word “Project” was dropped from the name and Athena became an integral part of Information Systems which was accompanied with a sudden drop in funding.

A quick examination of the development of the Athena Computing Environment over the last four or five years reveals that the computational power of the hardware has increased manyfold. While in 1990, VAXstations 2000 and 3100 as well as IBM RT PC’s were common, in 1995, Sun SPARCclassic and IBM RS/6000 machines are filling the clusters. These improvements were made because the machines were purchased by MIT and adapted for the Athena environment by the staff and the performance of the hardware is impressive for a university environment. While an improvement in the available hardware was made, the software—and as some argue the more important component—has seen little improvements.

Packages such as FrameMaker, Tecplot, as was described in Section 3.5.2, were purchased but overall Athena lacks quality software. Leading spreadsheets like Excel or Lotus 1-2-3 are not available, nor is a professional drawing program like Adobe Illustrator or Freehand. While an increase in applications has been accomplished, very little improvement in the Athena system software has been made over the last 5 years. For example, the program handling E-mail (xmh) has remained completely the same. While it is useful to have students write their own applications for the system which they can make available to all, it does not speak for the quality of the network when the only source of critical tools (such as a screensaver) are in student lockers or the locker of a student group with software “disappearing” when a student graduates.

When in 1991, the performance of the Athena system and its interface looked impressive to a PC or Mac user, it does not so anymore since system software like Windows and the Mac Operating System have considerably improved over the period and by 1996, both operating systems will probably surpass that of Athena’s in overall performance.

Since Athena is model of a university computing environment, several schools have purchased the Athena software. Others built their own advanced networks of workstations, and a third group simply purchased PC’s and Macintosh computers. What once stood as the leading computing network, is today only one out of many similar computer networks and if one compares its performance from many dif-
Section 5.5: Lack of Support for Public Relations and Image Care

Different aspects, it does not represent the state-of-the art. If MIT strives to be a leader in educational computing it cannot allow itself to stop researching and maintain a level because most other universities will catch up and thus result in the Institute falling behind on a relative basis. With computers the research (the "Project") can never stop if one wants to maintain leadership.

As was shown earlier the popularity of Athena grew considerably over the years, but the number of workstations did not. How heavy the usage of public machines is, can be illustrated by the fact that in the spring semester 1995, on a typical Saturday night at 3am (or Sunday morning) almost one third of all public workstations were in use. At the end of every term when theses, final projects, etc. need to be completed, basically all workstations are in use and in popular clusters, such as the one in the student center, students have to wait a considerable amount of time to again access to a machine. While connecting dormitory rooms to MITnet will reduce the problem, it will not solve it. Even if money for workstations is available, more space for clusters need to be created.

MIT will face over the next years and next decades a considerable challenge in keeping its Athena network modern and satisfy the needs of faculty and staff. While the commitment of renewing hardware every four years is sufficient at the current time, the issue of up-to-date software and the merging of platforms in the years ahead will have to be addressed. New hardware, new software, and the labor necessary to install and maintain both will not come cheaply. The Institute must find millions of dollars to once-again make Athena a system at the cutting-edge and keep it there.

5.5 Lack of Support for Public Relations and Image Care

How MIT is seen by the public has traditionally been a small concern of the Institute. Being confident of its quality in teaching and research and too busy to pay attention to such "minor things," MIT's "offices" that directly interact with the outside are often in an embarrassing condition.

MIT must realize that visitors who cannot see every or most parts of the Institute or understand the quality of its research equipment, will judge MIT on the little they will see. Offices like the Information Center, the Admissions Office, the Office of Career Services, Resource Development, the Corporate Relations, and the MIT Museum are critical in forming the public's opinion about MIT. Two of these, the Office of Career Services and the MIT Museum, are discussed in here.

5.5.1 Office of Career Services

Men and women from all over the world come to MIT for its primary service—for an education and a degree. Their common motivation is to find better jobs after having received their education from MIT. For this reason, the success and quality of MIT's educational program can be measured by the successful placement of its graduates. MIT's Office of Career Services and Preprofessional Advising, naturally plays an important role, to help MIT graduates to find the jobs they are look-
ing for. While the staff is excellent, the location and facilities available are a

The Career Office has one large room available which is usually overcrowded and

noisy with nervous students waiting for interviews and students looking through

material of recruiting companies. Instead of separate rooms for interviews, open

booths, providing no privacy, are all that is available. Excerpts from several letters

are printed below to illustrate the situation best:

In a 1990 letter to the late Vice President and Secretary of the Corporation Con-

stantine B. Simonides, the MIT Office of Corporate Relations wrote:

I am writing to strongly encourage you to consider expanded and better quality

space for the Career Services and Preprofessional Advising interview facilities. I

advance this “recommendation” largely because we are seeing that recruiting of

our graduates is an increasingly important aspect of M.I.T.’s overall relationship

with corporations, and having stronger influence on the support M.I.T. receives

from corporations.

... [F]rom reports we have heard from companies and from my own personal

observation of the space, we are not putting our best foot forward—indeed, in

many ways we are putting the worst possible foot forward by relying on the inade-

quate space in Building 12.

...

3. We are also finding that corporate recruiters are often a source of financial sup-

port for M.I.T, especially for scholarships and fellowships. For this reason, we

have begun a practice of strongly encouraging Industrial Liaison Officers to take

recruiters to lunch when they are on campus. These visits have resulted in several

gifts. These folks are very likely to be a lot more generous if we treated recruiting

more “seriously” with good space.

4. These conversations have also revealed widespread dissatisfaction with the

facilities we can offer the recruiter—especially compared to other universities.

Fred Gross reports the following two situations as illustrative:

“My favorite two quotes from recruiters to illustrate these concerns were: from a

Vice President of bankers Trust who states ‘I remember feeling that I was on the

hotseat during my interviews while I was a student here at M.I.T., but I really felt

sorry for the students I interviewed this morning who literally were on the hot-

seat—it was over 100 degrees in the room and a couple of them were probably

wearing a wool suit for the first time in their life,’ and from a you lady (computer

scientist) from Ashton-Tate who commented, ‘Many of the people I interviewed

were oriental men who were so embarrassed when I had to move close to them

and virtually put my ear next to their mouth in order to hear their soft speech over

another interview being conducted less than three feet away.’”

I would dare to say that our facilities for their overcrowding and poor ventilation

are really a disgrace to our students, and an affront to many of our corporate

recruiters.

I cannot measure precisely the impact on the financial support we get—or do not

get—from industry because of the facilities, but I can say with certainty that cor-

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porate support of M.I.T. is going to be increasingly important and we must increasingly put our best image forward in developing the relationships with companies. Recruiting is almost uniformly the most important dimension of a company’s relationship with M.I.T., yet it is the worst image—facilities-wide—of any part of our interaction with them.

A letter from Xerox PARC stated:

Lastly, the situation with interview rooms has been getting progressively worse. It really hit a low point this year. Interviewing in an unheated kitchen Californians aren’t used to freezing indoors!

A letter from the Exxon Research and Engineering Company stated:

Very often our first formal interaction with your graduates is in the on-campus interview. The facilities which are provided to the interviewers, in terms of interviewing space and layout, several restrict the interviewing process and are not up to the standards that MIT represents in many other areas. The crowding of two interviewers into one office, or the open plan arrangement in what used to be a lounge in Building 12, makes it difficult to conduct an interview and offer the student a measure of privacy.

In a time where Wall Street firms like J.P. Morgan and consulting firms like McKinsey and Company are hiring more graduates than IBM, Ford, and other engineering companies, modern and elegant space becomes increasingly important. Ivy League schools like Harvard, Princeton, Yale, etc. have been the traditional supplier of employees to these firms and provide in their facilities an elegant setting that expresses wealth, confidence, and sophistication with which MIT needs to compete now and more so in the future. The superior analytical skills of MIT students will not be sufficient enough in the future, the MIT placement office will have to be able to do its share in selling MIT graduates to firms.

### 5.5.2 The MIT Museum

The responsibility for preserving MIT’s rich history in all of its fascinating manifestations—artifacts, documents, instruments, inventions, drawings, oral histories—falls to the MIT Museum. An overview on the MIT Museum has been given in Section 3.6.1. The “attic of the Institute,” the MIT Museum is committed to showcasing the pivotal past and present contributions of MIT and its alumni. As such it has great potential to educate the public about MIT and its usefulness to society as well as attract company sponsorship and students.

However, today the MIT Museum is far from being an appropriate representation of MIT. The current quarters repel, rather than attract, museum visitors. Regardless of good publicity, many visitors are so intimidated by the shabby building, that they actually decide against going inside.

The MIT Museum is not a resource that appropriately represents a world-class institution. Some of the problems are:
Chapter 5: Challenges Ahead

- Lack of space and low ceilings make it impossible to exhibit important MIT Museum artifacts such as the human-powered-vehicle Daedalus which is exhibited by the Boston Museum of Science.
- The position of the loading dock and freight elevator make unloading of exhibition-related materials difficult—for example, many artifacts from the Buckminster Fuller exhibition would not fit in the elevator.
- Lack of air conditioning prohibits exhibiting works on paper from June through September. It also prohibits receptions, educational programs, and lectures during the period.
- Lack of meeting and classroom space prevents running more than one event or lecture at a time.
- Lack of reception space limits the size and number of functions that may be hosted. No more than 80 guests can be accommodated for dinner and 300 for receptions.
- Of the 1500 pieces of the holography collection only 70 (less than 5%) can be displayed at any one time.
- The Museum’s staff has noted over the years that most visitors expect to experience an in-depth exhibit about MIT and its history considering its rich past. However, visitors find no exhibition on MIT in general and are disappointed.

In a time when the MIT president states that public and congressional support is important, the MIT Museum should thrive since it is the best existing source for educating the public and gaining their support and understanding. Nonetheless, little support due to lack of funds and other priorities threaten the museum’s existence. A recent report by the Museum Advisory Board stated:

The vast majority of the Museum’s holdings are in dire need of conservation and preservation. While several small conservation/preservation grants have been obtained in the past, major investments of time, effort, and funds are needed to maintain the Museum’s massive collection…

To move the museum to more appropriate facilities and improve the collection will require a substantial amount of money. While $20 million were estimated by the advisory board, bringing the MIT Museum to a top standard may cost $40 million or more.

5.6 Changing Federal Regulations

Over the last several years, changing federal regulations have become increasingly costly for the Institute. These changes in regulation make both undergraduate education and graduate education at MIT more expensive and are a formidable threat to the excellence of the Institute. In this section the UROP Program and the graduate student tuition are discussed. While changes in federal regulations affecting these two are the best known, they are not the only ones.
5.6.1 UROP

MIT's pioneering program to involve undergraduate students in research, UROP, has been discussed earlier in Section 3.4.3 and Section 4.2.4. While the program has been highly successful and is a major factor in making an MIT undergraduate education so superior, the program is in danger.

Since 1973, students were able to receive pay instead of credit for their UROP. As the tuition and the self-help level grew rapidly in the 1980s, paid UROP became more and more attractive. Since academic year 1983-84, the number of UROPs done for pay exceeded those done for credit.

The pay or stipend has been usually paid from the faculty’s sponsored research and supplemented by UROP. In FY 1994, the funds were as follows: $4,525,000 from faculty and $744,861 from the UROP Office ("direct UROP funds"). For both sources of the stipends overhead and employee benefit costs were waived. Thus, the faculty supervisor’s account was charged exactly the amount paid to the student. This has made UROPers even more attractive as junior research partners and allowed the students to earn more. For students receiving financial aid from MIT, the UROP stipend amounted to 15% of total expected self-help earnings.

The change came when in July 1993 the U.S. Office of Management and Budget approved Circular A-21, which revised the structure of indirect costs and employee benefits. As a result, since fiscal year 1995, the UROP Office was no longer permitted to waive overhead or employee benefits. UROP’s own funds were henceforth charged 6.5% for employee benefits, and sponsored research stipends, with 6.5% benefits, would bear the Institute’s 52% indirect cost rate for research, thus UROPers became about twice as expensive for faculty members than before.

Even before, the change in regulation, the financial situation became more and more difficult. In an article in the November 1993 issue of The MIT Faculty Newsletter, Norma McGavern, Director of UROP, wrote:

Even $5 million has never gone far enough. ... [T]he ceiling on demand for research support has not yet been sighted, much less reached. Each year UROP[ers] notice that funds are running out appears on our bulletin boards a little bit earlier. Each year negotiations with faculty who would like to have four UROP students, but will have to settle for three or two, get harder. Each year we notice how quickly faculty new to MIT sign up for UROP students.

The new regulation took effect during the summer term (on July 1) 1994. To help faculty supervisors carry the higher cost of UROPers, the Provost granted $1 million in discretionary money to pay for the additional overhead and employee benefit charges in July and August. In the first semester under the new regulations, the Fall 1995 semester, UROPs for pay decreased by 47%, while UROP for credit increased by 15%—amounting to a drop in overall UROP participation by 32%. This decrease in UROP work means that it will become more difficult for inexperienced students, to obtain a UROP. Figure 5.5 illustrates the sudden drop.
To counteract the new regulations, MIT students have lobbied unsuccessfully in Washington, the Provost appointed a UROP Working Group in the spring of 1994 to review the situation and make recommendations, and both the Alumni Association and the Class of 1995 have made UROP the focus of their fund-raising activities. While several hundred thousand dollars have been added to the UROP endowment in this way and through gifts, an additional $50 million is needed to make UROP as strong as before with no source for the funds identified so far.

5.6.2 Graduate Student Teaching and Research Assistantships

Graduate students are similarly affected by new regulations. Through an agreement made with the Office of Naval Research (ONR), the Institute has been able to support graduate student tuition with funds derived from MIT’s Employee Benefit pool (EB) pool. Contributions to the EB pool were made from both the on-campus facilities and the off-campus facilities. The off-campus research facilities include the Lincoln Laboratory, whose research expenses are with $315.5 million larger than all combined on-campus research expenses of $263.3 million and thus are an important contribution to the EB pool.

While this arrangement resulted in considerable savings to the federal government in the cost of carrying out sponsored research at the Institute, it has been disallowed by the Office of Management and Budget. After a grace period ending with the first budget period after September 30, 1997, MIT will be required to support the costs of its Research Assistant graduate student (RA’s) through direct charges levied on grants and contracts of on-campus sponsored research. This change of agreement has an enormous impact to the Institute since the contributions from
sponsored research at Lincoln Laboratory resulted in as much as a $13 million infusion of funds into the EB pool that was used for graduate student support.

The most obvious solution would be to increase the percentage of the total tuition charged directly to graduate students since the net tuition cost for graduate students has been subsidized through the EB pool by both Lincoln Laboratories and MIT Institute General Funds (IGF)5. A committee convened by the Provost, determined that in the absence of a subsidized tuition, the costs of tuition and stipend would rise from $33,000 to $47,000 (in FY 1993 dollars), a 42% increase.

Since such a high increase in cost would result in a considerable drop in research assistants due to the inability of many research grants to support the students, the committee rejected full tuition charges. Under the solution decided by the committee, the IGF would subsidize 45% of the tuition costs of an research assistant, while the remaining 55% would be carried by the research grant. Thus, the cost of an RA would rise from $33,000 to $37,000—a 12% increase. As a result of this increase, it is anticipated that the number of RA’s would decrease by about 10%. This decline in terms of percentage is still well below the increase in RA’s in the period 1983 to 1985. In that period the number of RA’s jumped by 24.5% from 1,515 to 1,886.

While the 10% decline in the total number of RA’s may not be seen as having a negative impact on the Institute, it does for small research programs for which it becomes increasingly expensive to support graduate students and which might use postdoctoral associates instead. For the Institute the new level of subsidy for the tuition will require $13.5 million per year in addition to the current $9 million.

5.7 Reengineering: A Response to the Budget Imbalance

The threat by the budget imbalance has been realized by the senior staff and ongoing reengineering effort has grown out of this threat.

In a message to the MIT Community President Charles M. Vest announced in November 1993, the effort to eliminate the deficit:

MIT—the institution and its people—stands for excellence. That quality is being threatened by continuing budget deficits that cut into our ability to be the very best we can be in teaching, research, and service.

We have to come to grips with these financial trends now—not simply by cutting our expenses while trying to do all that we do in the same way we have been doing it for decades. We need to take a fundamental look at how we operate, and reduce and realign our expenses on the basis of what makes sense for MIT, both in the short term of the next few years into the future.

Only in this way can we preserve the excellence that is MIT.

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5. The IGF represent the operating funds of the Institute and include income raised from tuition, from sponsored programs, and from outside donors.
To make the Institute leaner and more efficient, the administration embarked on an effort to “reengineer” the administrative processes. The concept of reengineering was developed and promoted by Dr. Michael Hammer, an MIT graduate and former faculty member.\(^6\) The reengineering movement grew out of an article by Dr. Hammer in the July–August 1990 edition of *Harvard Business Review*. Subsequently Dr. Hammer authored with James Champy the book *Reengineering the Corporation: A Manifesto for Business Revolution*. Mr. Champy\(^7\) is chairman of CSC Index, Inc. the Cambridge-based consulting firm that pioneered the implementation of reengineering.

In their book Hammer and Champy demonstrate how corporations and other organizations can reinvent themselves with a technique they call *business reengineering* and which is suppose to be “the next revolution of business what the specialization of labor was to the last.” The fundamental concepts of the technique are quite simple and have been often summarized as “starting all over, starting from scratch.”

The following quotes from *Reengineering the Corporation* illustrate the ideas:

> At the heart of business reengineering lies the notion of discontinuous thinking—identifying and abandoning the outdated rules and fundamental assumptions that underlie current business operations.

> Reengineering, we are convinced, can’t be carried out in small and cautious steps. It is an all-or-nothing proposition that produces dramatically impressive results.

> When someone asks us for a quick definition of business reengineering, we say that it means “starting over.” It doesn’t mean tinkering with what already exists or making incremental changes that leave basic structures intact. It isn’t about making patchwork fixes—jury-rigging existing systems so that they work better. It does mean abandoning long-established procedures and looking afresh at the work required to create a company’s product or service and deliver value to the customer. It means asking this question: “If I were re-creating this company today, given what I know and given current technology, what would it look like?” Reengineering a company means tossing aside old systems and starting over. It involves going back to the beginning and inventing a better way of doing work.

> In reengineering, radical redesign means disregarding all existing structures and procedures and inventing completely new ways of accomplishing work. Reengineering is about business reinvention—not business improvement, business enhancement, or business modification.

> People with hearsay knowledge of reengineering and those just introduced to the concept often jump to the conclusion that it is much the same as other business improvement programs with which they are already familiar. “Oh, I get it.

\(^6\) Michael Hammer received from MIT an SB degree in mathematics in 1968, an SM degree in electrical engineering and computer science in 1970, and a Ph.D. in EECS in 1973. He was a faculty member in the EECS department from 1973 until 1986.

\(^7\) James Champy received from MIT an SB and SM in civil engineering in 1963.
Reengineering,” they may say, “is another name for downsizing.” Or they equate it with restructuring or some other business fix of the month. Not at all. Reengineering has little or nothing in common with any of these other programs and differs in significant ways even from those with which it does share some common premises.

First despite the prominent role played by information technology in business reengineering, it should by now be clear that reengineering is not the same as automation.

Reengineering is about beginning again with a clean sheet of paper. It is about rejecting the conventional wisdom and received assumptions of the past. Reengineering is about inventing new approaches to process structure that bear little or no resemblance to those of previous eras.

In our experience, the companies that have the most success in selling change to their employees are those that have developed the clearest message about the need for reengineering. Senior managers in these companies have done the best job of formulating and articulating two key messages that they must communicate to the people who work in their organizations. The first of these is: Here is where we are as a company and this is why we can’t stay here. The second is: This is what we as a company need to become.

We have names for the documents that companies typically use to articulate and communicate these two essential messages. We call the first a “case for action” and the second a “vision statement.”

The most egregious way to fail at reengineering is by not reengineering at all, but rather conducting process changes and just calling it reengineering.

The objective of reengineering, is not to make incremental improvements such as a 10 percent savings or speeding up a process by 20 percent, but to achieve “a quantum leap in performance—the 100 percent or even tenfold improvements that can follow from entirely new work processes and structures.” Several corporate reengineering success stories are presented in Dr. Hammer and Champy’s book, companies like IBM Credit, Xerox, Taco Bell, Hallmark, Bell Atlantic, and others.

Under the leadership of Vice President for Information Systems Jim Bruce, an eight-member Core Team of veteran MIT administrators analyzed the external forces driving changes at MIT, identified the Institute’s business processes, and assessed opportunities for process improvement. It also selected focus areas for process redesign.

In the first stage the Core Team identified and described five business processes at MIT, that have been considered as among the most important and whose activities contribute to MIT’s greatness:

- Student support
  The collection of administrative functions performed for students from arrival on campus to graduation, including registration for subjects, recording grades, administering financial aid, placement, support by the Office of the Dean for Undergraduate Education and Student Affairs, etc.
Chapter 5: Challenges Ahead

- **Research acquisition**
  Those functions performed between identification of a research opportunity and receipt of an awarded grant or contract.

- **Laboratory operations**
  Functions that support the operation of a laboratory, including plant and operations; worker health and safety; regulatory oversight; research services such as animal care, radiation protection and environmental medicine; and equipment maintenance.

- **Management reporting**
  This process focuses on the provisions of reports that are necessary to manage one of the Institute's departments, laboratories, centers, or administrative units.

- **Buying and paying for supplies**
  This process focuses on the functions involved in acquiring a product or a service for use at the Institute and reaches from the determination of need by an individual or project to accounting paying the bill.

In its first redesign phase the reengineering effort has concentrated on:

- **Management Reporting**
  The goal is to design methods to improve tracking, reporting and analysis of information relevant to the effective operation of an Institute's department, laboratory, center, or administrative unit. The initial focus has been on finances, including financial commitments associated with the procurement of goods and services. Later the focus will shift to other information such as information about personnel, property and space.

- **Supplier Consolidation**
  The goal is to identify the Institute's purchasing patterns in order to increase effectiveness by reducing the number of supplies of routine goods and services and to decrease MIT's cost.

- **The Mail Service**
  Building upon the results of a committee that had been formed well before the start of reengineering program, the goal is to implement changes suggested by the committee.

- **Facilities Operations**
  The goals are to improve the quality and responsiveness of service and to reduce the costs of repairing and maintaining of facilities. This reengineering effort also builds upon previous work.

- **Custodial Services**
  The goal is to develop team-based organizational practices that enhance employee commitment, development, and ownership to economically respond to the ever-growing campus and increasing customer requests for service.

- **Information Technology (IT)**
  The goal is to design and implement a management framework which achieves fundamental improvements in information technology services across the Institute.

- **Appointment Process**
  The goal is to redesign of MIT's process in making academic, administrative,
and support and service staff appointments. In particular the objective is to make the entire process paperless through the use of IT.

After the identification of these areas in June 1994, teams of about 8 people each were formed. The task of the teams were defined in four stages:

1. Redesign (3 months)
2. Prototype testing in a controlled environment (6 months)
3. Pilot program in an actual Institute operation (3 month)
4. Phased Deployment across the Institute

What will reengineering accomplish? MIT’s Senior Vice President stated that “Reengineering will simplify what we do, thereby making work easier, more effective, more efficient.” and President Vest stated that reengineering is about “becoming organizationally lean and effective.”

In addition to operating more effectively, the goal is to reduce the operating gap annually by $40 million ($25 million net of indirect cost recovery). During the redesign of processes, about 600 employee position (across the Institute) will be eliminated.

### 5.8 Conclusions

The challenges presented in this chapter are formidable and in many cases no plans exist how they can be met. Many problems will have to be addressed by the Institute and a separate extensive thesis can be written just on this topic. While not having discusses all the challenges awaiting the Institute, it is hoped that the picture is clear. More needs to be done.

MIT’s reengineering effort is essential to the well-being of the Institute. Many of the administrative processes in use come from the 1950’s and have essentially not changed since then. The use of computers has improved the efficiency and quality. One might state as an example the replacement of typewriters by computers with laser printers or the replacement of calculators with sophisticated spreadsheets. While the new technology brought about improvements; the improvements are marginally. The reengineering effort at MIT is focused on the use of existing information technology to redesign processes from scratch with the currently available information technology in mind. Considering the expertise of the staff involved in MIT’s reengineering effort it can be expected that the redesigned process will achieve the expected improvements of the processes.

However, the on-going reengineering is not sufficient to prepare MIT for a highly demanding and competitive future. In a letter to the reengineering redesign teams President Vest said, “We are asking for a revolution.” Redesigning MIT’s processes to reflect current technology represents a “catching up with the world.” Once completed, staff members and faculty members will still do the same work. There will be fewer and they will do it more efficiently but tremendous improvements cannot happen.
If indeed the operating gap is reduced by $40 million, no funds are available to many of things described in this chapter. Certainly no substantial funds exist to take on new and exciting ventures.

References


CHAPTER 6
A VISION FOR THE FUTURE: THE GRAND PLAN

Based on the analysis of MIT’s past, present, and its future challenges, this chapter sketches out the concept of a plan, the so-called GRAND PLAN (GP), to not only meet all the challenges, but to transform MIT into the truly greatest technical university. THE GRAND PLAN requires a fundamental reorientation of MIT in many ways and the effort that will be necessary to implement it would be great. But MIT must contend with the fact that the Institute has always been a leader and as such must not hesitate to take on a large and ambitious project if it carries so many potential benefits.

6.1 Introduction

The President and Provost have stated the following seven priorities for the Institute:

- Maintain and enhance MIT’s position as the leading academic institution focused largely on science and technology.
- Maintain merit-based, need-blind admissions.
- Moderate the rate of growth of tuition and self-help levels.
- Compensate faculty and staff consistent with their high quality.
- Increase the use of MIT resources (rather than research funding) to support faculty salaries.
- Build a more diverse faculty, staff, and student body.
- Improve the efficiency and value of the services we provide.

Of these priorities the first is the most important since most others follow from it. The key words of the first priority are “maintain and enhance,” although it should say only “enhance” since by maintaining an absolute position, a leading institution will tend to fall behind on a relative scale.

Now, in light of the challenges discussed in the previous chapter, how can MIT enhance its position on an absolute basis and in comparison to other universities? How can MIT become the greatest university focused largely on science and technology with such a lead that it is recognized everywhere in the world and by everyone in its standing? Can a comprehensive plan be developed that, despite the challenges ahead, will achieve all that? The answer is a yes, since challenges inherently present new opportunities and new ways. THE GRAND PLAN represents such a comprehensive answer to the challenges ahead.
In a letter to the Institute's reengineering teams, President Vest asked for a revolution. Reengineering the administrative processes will not yield a revolution because it deals with "sub-systems," namely the processes. THE GRAND PLAN looks at the overall system—MIT as a whole. How can MIT be redesigned? This is by far a more complex and challenging problem that will require much courage to be implemented than the current reengineering plans but then again one can expect much bigger benefits. In a special edition of the MIT newspaper Tech Talk on the budget deficit, Dr. Vest stated that by "finding new ways to accomplish our work better, we will lead the nation in cutting-edge research and education and in providing broad access to it." THE GRAND PLAN provides just such a new way and represents the dramatic action necessary to achieve the impressive results the Institute needs.

6.2 The Concept

The basic idea of THE GRAND PLAN can be summarized simply as "opening up to the public." What is meant is that MIT should attract and accommodate large number of visitors to the Institute to inform and educate them about the Massachusetts Institute of Technology and science and technology in general. Because of its achievements, its people, and, as Nobelist David Baltimore remarked, the "probably the broadest range of resources available in any scientific environment in the world," MIT is a national and global treasure.

Visitors will have the opportunity to learn about the past, present, and future of MIT and therefore science and technology. The MIT Museum would have the task of being the guide to MIT's history. Visitors would learn about MIT and its numerous accomplishments since its conception in the last century. The present state-of-the-art in science and technology would be conveyed through the Technology Showcase. A permanent exhibit of the newest scientific and technical developments by MIT's departments, companies, and other universities.

A glimpse into the future of science and engineering would be provided through tours of many of MIT's outstanding laboratories. While many of the laboratories and the equipment represent the state-of-the-art and are fascinating to see, some laboratories can be improved and new facilities justified through their "double use." At the present, any large equipment or facility, such as a wind tunnel or a supercomputer has to be justified purely for its research value. Through the "double use" of facilities, made possible through the "opening up" of the Institute, even more and better equipment can be accumulated on campus.

In THE GRAND PLAN MIT would ultimately become a high-tech community of the future. MIT is seen as a symbol of cutting-edge technology but a visit to the campus does nothing to strengthen the image. Rather, it will raise doubts in the visitor's mind. With the visitor facilities in place, the MIT campus would slowly be converted into a "city of tomorrow" that uses everywhere state-of-the-art technology. The infrastructure would be improved to reflect the newest advancements in construction, transportation, and communication. Essentially the entire campus
Section 6.2: The Concept

would become a model; a place for engineers, scientist, architects, companies, and nations to learn from and for the general public a unique and fascinating attraction allowing them to see what is ahead in the development of science and engineering.

While visitors have always come to MIT, they have never come in large numbers because the Institute did not much to encourage them to come and offered little to see. Visitors hear not much about MIT's history, its achievements, and are denied access to laboratories because of logistical reasons. In THE GRAND PLAN, new facilities would be built specifically to attract and accommodate visitors. While this concept of extensive visitor facilities to inform and educate the public is new for MIT and universities in general, it is not new to NASA's space centers. In fact, the GP's concept of having visitor facilities is derived from the facilities provided to visitors at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC).

At the Kennedy Space Center in Florida, the visitor complex is known as Space-Port USA in which people learn about the importance of the space program, the space shuttle, and of course the activities at KSC. The highlight of a visit are tours to the Vehicle Assembly Building (VAB) and the space shuttle launch pads. At the Johnson Space Center in Texas, the visitor complex is known as Space Center Houston. Opened in October 1992, Space Center Houston is a $70 million high-tech visitor facility designed by Walt Disney Imagineering to educate and inform the public about manned spaceflight. Space Center Houston shows films on the space program, a film about becoming an astronaut, provides interactive exhibits, such as a shuttle landing simulator, and displays actual space hardware from historic space missions. As at the Kennedy Space Center, visitors have the opportunity to visit the actual working facilities such as the famous Mission Control or the Weightless Environment Training Facility. NASA and its public affairs departments have recognized well before MIT and other large research universities that one must constantly justify itself and explain why and how one is useful if funded by the taxpayer. Essentially the mission of the visitor facilities is to show to the public and to Congress what has been accomplished, what is being done now, and why it important in a time of little support for the U.S. space program. At MIT the facilities would have the same purpose; show the justification for continued support.

In addition of seeing on tours MIT laboratories and equipment, the Technology Showcase would allow people to see the newest technical developments from around the world in use. Museums of science and technology, as they exist throughout in almost any major city show only old and used artifacts donated to the museum or acquired by the museum after its useful life. Through THE GRAND PLAN MIT would assemble in cooperation with companies from around the globe the exhibit items right after they were developed. While they would not stay at MIT permanently, they would be on display long enough for the MIT community and the public to learn about them.
Chapter 6: A Vision for the Future: The Grand Plan

The origin for the idea of creating a high-tech community comes from Walt Disney’s original idea for EPCOT. The acronym EPCOT stands for Experimental Prototype Community of Tomorrow, which Walt Disney envisioned as a community living and working as people might in the future. Speaking of EPCOT Disney said,

It will take its cue from the new ideas and new technologies emerging from the creative centers of American industry. It will always be introducing and testing and demonstrating new materials and systems.

In short, EPCOT would be a giant laboratory for testing new systems and concepts, a functioning community inhabited by several thousand people, operating in the tomorrow today.

Large companies would have the opportunity to try out their latest inventions. In exchange for acting as guinea pigs, residents of EPCOT could experience the newest and most exciting creations before anyone else.

For the Walt Disney Company to build such a real city from scratch would have been extremely difficult. Instead Disney’s successors chose to make EPCOT a park with technology as the theme and attached a world showcase to it. Walt Disney’s original vision remains unrealized.

The MIT campus is already a complete community. Students, some faculty, and the president live there, faculty, staff, and students work there. The campus has its own set of land, it has a police, a medical department, and its own set of rules. Most importantly, it is a community devoted to research at the forefront of science and technology and helps bring the things that Disney wanted to assemble in EPCOT to reality.

The idea of the Technology Showcase and converting the campus to a high-tech community may seem to some as radical, strange, or unreasonable for MIT to do. Nevertheless, the ideas presented are more than consistent with MIT and its stated mission. As Chapter 2 discussed, William Barton Rogers proposed in his Objects and Plan of an Institute of Technology; including a Society of Arts, a Museum of Arts, and a School of Industrial Science, proposed to be established in Boston an MIT that would be a triple organization—not just a school but an institution devoted to all aspects of science and engineering. The Museum of Arts that he envisioned can finally become a reality with THE GRAND PLAN. As was described, the museum was seen as the “central feature” of the Institute. It would,

• “form a collection of objects of prominent importance, as illustrating the respective Arts.”
• “exhibit new inventions and machinery in actual working condition.”
• “appeal to not only of those immediately devoted to industrial pursuits but also to intelligent fellow-citizens in every walk of life.”
• “provide for students, architects, and engineers large opportunities for comparison, and precious helps and incentives for improvement.”
Section 6.3: Implementation

Even after more than 130 years, William Barton Rogers' ideas remain valid and will help the Institute in the 21st century. The MIT seen in THE GRAND PLAN would remain of course an institution focused on teaching and research but it would improve the core by augmenting its activities as described in here. The Institute has the potential of not only teaching students and conducting research, but to bring the world’s newest technologies together in one place for the interest of scientists, engineers, and the public; to educate and inform the public about science and engineering; and assemble the science and engineering communities in conferences and symposia and help mark the path into the future.

6.3 Implementation

MIT stands for cutting-edge technology as such the buildings that would be erected as part of THE GRAND PLAN would be futuristic without losing their functionality. They will always have the dual purpose of providing more resources or amenities to the MIT Community.

Since the MIT campus is already highly developed and leaves no space for any new large construction without displacing important facilities, the entire visitor complex would be located adjacent to campus. While it requires a thorough study on deciding a location, the suggested location is north-west of the campus along Massachusetts Avenue towards Central Square.

6.3.1 Visitor Center

The focal point of all visitor activities would be the Visitor Center (VC). All visitors to the Institute would enter the campus through the VC which would serve as the starting point for their visit. The VC would have an Information Center, small exhibits on MIT, a gift shop, special exhibits, and a film theater.

The heart of the center would be the film theater. Using the IMAX film format it would show on a several-story high screen a short (less than an hour long) film on MIT’s history, the programs offered, and the on-going research. The IMAX film with its superb quality would far better than any tour can inform about the Institute.

The Visitor Center would also become the home of several of MIT’s offices that interact extensively with the outside. First of all, the Admissions Reception Office would be provided with ample accommodations to deal with appropriately with prospective students and their parents. For them special tours would be conducted.

1. The IMAX motion picture projection system delivers the world’s finest cinematic experience. Accepted as the state-of-the-art in motion picture technology, the film frame is ten times the size of a standard 35mm film frame and three times the size of a standard 70mm film frame. Combined with a specially designed high fidelity digital sound system, the audience experience is one of complete involvement.
Similarly, the Office of Career Services would be placed in the VC. In it, the office would provide recruiting companies with rooms for presentations and have separate interview rooms and in general facilities appropriate for an institution of MIT’s standing. The accommodation would be of a “corporate style.”

The Alumni Association works closely with Resource Development to raise money for the Institute but its current offices are far apart in the present Institute buildings. In the Visitor Center they would be located next to each other and would be exactly where alumni and visitors would enter MIT. The positive experience of placing the Alumni Association Office underneath the Great Dome has proven the importance of well-placed offices.

As said earlier, the Visitor Center is only the starting point. It would be the gateway to the MIT Museum, (dealing with the past), the Technology Showcase (dealing with the present), and the MIT Laboratories (dealing with the future). Visitors would also be directed to any talks, lectures, or other special on-going events on a particular day that are open to the public.

6.3.2 The MIT Museum

If visitors choose to learn about MIT in general and its history, they would be guided from the Visitor Center to the MIT Museum. The museum would be in a separate 300,000+ square feet facility with an atrium large enough to display the human-powered aircraft Daedalus. After all, the time has come to move our treasures from the “attic” and get our “trophies” back on campus and display them with pride and the prominence they deserve.

The key exhibits would be devoted to a general overview of MIT’s history including “hacks” (as is shown in “Crazy after Calculus: Humor at MIT”). Other exhibits suggested by the museum’s staff may be:

- “MIT Goes to War” (MIT’s contribution to World War II with an emphasis on the development of radar.)
- The History of Computers (Essentially incorporating the computer museum in Boston which uses many of MIT artifacts.)
- Harold “Doc” Edgerton’s Strobe

and many others from inertial navigation to artificial limb technology. In summary, a wide range of science and engineering history of the last 130 years would be presented with every visitor surely being able to find something of great interest.

The exhibitions in the MIT Museum would utilize multi-media and hands-on exhibits and would be a joint effort with relevant MIT organizations and departments. The museum would also work closely with students in the STS (Science,

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2. This area has been determined by simply doubling the amount of square feet needed according to The MIT Museum Advisory Board.
Technology, and Society) Program to assist with the research. To help in the research students would receive a research assistantship (RA).

As suggested by the Associate Provost for the Arts, the museum would also include a small theater for the MIT Community and help alleviate the shortage of space for performances.

### 6.3.3 The Technology Showcase

To show the present state-of-the-art in science and technology is the purpose of the Technology Showcase. A mix between a museum and a fair, the showcase would display the newest products in “actual working condition” as William Barton Rogers hoped to accomplish in the Museum of Arts.

The exhibit pavilions\(^3\) would be for three types of users. First, there are the MIT departmental laboratories, and interdisciplinary centers and laboratories. Second, there are corporations, and third universities, the government, or other organizations.

Often MIT’s faculty needs to spend a great deal of time and effort explaining their work and their results. With the implementation of the Technology Showcase they would no longer have to spend so much time doing that. A special MIT office would assist in presenting the research work to the outside. So much interesting research is on-going at the Institute, but little of it becomes known to the MIT community and the public in general.

Company exhibits would probably take on a large amount of space to share their newest products or prototypes with the public. Corporations like AT&T, DEC, IBM, General Motors would make eager use of such an opportunity.

Many pavilions could be put in place. For example:

- The Audio and Video Pavilion would display the newest developments in this sector and present plans for future products. The pavilion would be much more than an “electronics trade show”, it would explain the functioning of current and upcoming technology such as the MiniDisk, High Definition Television (HDTV), and so on. Visitors would also get an insight into research undertaken at MIT’s Media Laboratory and the Department of Electrical Engineering, ranging from HDTV through “Movies of the Future” and “TV of Tomorrow” to real-time holograms.

- The Automotive Technology Pavilion would allow car manufacturers to display prototypes of cars and show in which direction the automobile industry is heading. A significant portion of the exhibition would be devoted to electric, solar, and hybrid cars and make the public aware of the long-term advantages of “cleaner” automobiles.

\(^3\)The term “pavilion” signifies a portion of a building devoted to an exhibition.
the students would have been able to share the results of their work with a wider audience and for longer period of time.

- The Computer Pavilion would deal exclusively with current machines and prototypes of future models. Visitors would have a chance to see some of the numerous computers on campus. While companies like Digital and IBM would display their newest workstations and mainframes, MIT faculty and students would share their latest research results in VLSI and other areas.

- The Aerospace Pavilion would include actual flight hardware and mock-ups of present and future aircraft and spacecraft. In cooperation with Orbital Sciences Corporation, an actual Pegasus rocket could be on display. General Electric could provide an insight into its newest engine, the GE90. Visitors would have a chance to experience the power and utility of simulation technology through the newest flight simulators. MIT’s Space Engineering Research Center (SERC) could display their work on trusses for Space Station Alpha.

- The United States is committed to building the Information Superhighway. Likewise, many corporations are completing networks or competing to offer new network services. A pavilion on communication technology and networks could explain the concept and working of the information superhighway to the public. The World-Wide-Web (W3) Consortium, located at MIT, could educate the public about the web. Other technologies that could be presented include: global voice communication, video conferencing, and optical fiber networks.

- Virtual Reality (VR) is currently a hot topic that promises to transform both entertainment, design, and the way science and engineering research is done. Applications range from video games and thrilling simulations to interactive design of aircraft and molecular compounds. A pavilion devoted to VR would give visitors the chance to experience the newest “virtuality” games as well as get a glimpse into how this technology is being used to conduct serious scientific research.

One could go on and on with the list of exhibits. Two more examples are: A pavilion devoted to biotechnology explaining the Human Genome project and a marine pavilion showing the winning MIT yacht designs for the America’s Cup as well as the Autonomous Underwater Vehicle (AUV).

Some space in the showcase would be available to other universities. If such spots were allocated on a competitive basis, MIT would most likely be apprised of all major new developments in science and technology produced by other universities and government laboratories on a deeper level than a news release.

### 6.3.4 MIT Laboratories

As MIT likes to describe it, the work done in its laboratories is shaping the future. The results of MIT research will affect—and improve—all our lives. Through touring some of MIT’s laboratories, visitors would be given an insight into the ongoing research at the Institute and the results that can be expected from it.
Section 6.3: Implementation

Seeing MIT's laboratories has always been difficult for visitors. While people on tours constantly ask to see laboratories they have been denied access so far because, the visitors would disturb the work and no plans existed to guide them.

However, it is very well possible to open MIT's laboratories and most interesting facilities to the public with disturbing the research. As was described earlier, Space Center Houston conducts tours to the actual working facilities at the Johnson Space Center and visitors are permitted into the heart of the manned spaceflight operations. All that was necessary to accomplish these tours were small modifications in the buildings. At one place at MIT, the necessary "modifications" have been put in place. Along the Infinite Corridor an Athena Cluster was placed with a large sound-proof window. The cluster, known as the "Fishbowl" allows visitors to the Institute to see the workstations in use. It is perhaps the most popular part of the campus tour.

Two examples of laboratories that seem to predestined for tours are the Plasma Fusion Center and the Francis Bitter National Magnet Laboratory. In particular, the Plasma Fusion Center has an interesting control room. Currently, the only way to see it is to be inside the room, but if sound-proof windows would replace a wall, visitors could observe the activities in the control room without disturbing the researchers. Both laboratories conduct outstanding research but are in need of funds to finance further activities. Especially for fusion research, it is important to inform the public about the potential of this clean source of power and the fact that much more research money is needed to build a fusion power plant.

Since the location of mainframes is largely independent of that of its users, some of MIT's computers can be relocated to buildings where visitors can see them without disrupting their use. Due to the financial constraints, the MIT Computer Facility was dissolved, thus the Cray X-MP supercomputer is no longer available to MIT. Through the "dual use" of facilities for both research and visitors this important research tool could have been maintained on campus. After all, many people know about Crays—but how many have actually seen one in operation?

The small inconvenience of visitors is more than offset by having more extensive facilities available and gaining a considerable amount of publicity. This dual use of facilities would justify spending money to upgrade all laboratories opened in this manner. For new buildings, such as the planned new Laboratory for Computer Science and Artificial Intelligence Laboratory Building, the planning would take large number of visitors into account. The MGM Studios that are part of Disney World in Florida would serve as a model. The facilities in which Disney's staff creates animated film have hallways exclusively for visitors from which, through sound-proof windows, visitors can see the work being done. For an explanation visitors can watch short films on monitors installed in the hallway. Similarly, monitors showing short films are installed at the Johnson Space Center.

Because of the fact that many visitors would see the laboratories, the facilities can be larger and better. The additional funding would come through the companies
which would not only profit from the research done by MIT’s faculty and students but also through the PR associated with sponsoring the tour of the laboratory.

6.3.5 Hotel and Conference Center
With the visitor facilities in place, there would be a great need for a hotel with an integrated conference center. It would not be built or run by MIT but rather, by a hotel chain such as Hilton or Sheraton.

Without any advertisement on MIT’s part and rather inadequate conference facilities, the Institute has been successful in attracting many conferences. With state-of-the-art facilities in place, there is no doubt that MIT would host numerous technical conferences and events such as the World Economic Forum because of its image. With facilities equipped to handle 10,000 or so people, MIT would be able to host conventions that are too large for the World Trade Center or the Hynes Convention Center.

If the proposed Megaplex is not realized, a seating capacity of 10,000 would allow MIT—and Boston—to capture many of the large conferences that the city currently cannot handle. For instance, at the very least, such a complex could have hosted last year 65,000 conferees (worth $78 million) based on estimates by the Greater Boston Convention & Visitors Bureau.

Should the Megaplex be realized, it could bring several hundred thousand additional people to Boston of which many could be interested in visiting MIT. Though in this case, to avoid competition with the Megaplex, the MIT conference complex would be scaled down to provide seating for 500 to 5,000 people. This would place MIT squarely in the conference market niche between the small (World Trade Center and Hynes Convention Center) and the large (Megaplex).

6.3.6 Retail, Service, and Entertainment Complex
As part of the facilities for visitors a retail, service, and entertainment complex would be built the visitors, the MIT Community, but also Boston area residents. It would include a bookstore, computer store, food court, and movie theater.

Bookstore. The Boston area has more than fifty universities and numerous high-tech companies but lacks a large technical bookstore that can serve the area. The bookstore will carry one of the world’s largest selections of books in the areas of engineering, science, and technology and replace the Harvard Cooperative Society as the supplier of MIT’s textbooks. Through its size and selection, it will attract many people from the Boston area and could become a major supplier of books through mail order. In addition, journals, magazines, and newspapers from around the globe would be carried. The store could be erected and run in conjunction with the MIT Press.

Computer Store. A similar situation exists with regard to computers: there is no well-known, large computer store in the Boston area carrying a wide selection of hardware and software. The MIT Computer Connection (MCC) is a successful
operation but serves only the MIT community. MCC’s service would be expanded
to encompass the needs of other universities in the area as well as the general pub-
lic. The variety of its products would be increased in accordance with the change
in its scope.

Food Court. The primary purpose of the food court is to provide visitors a place
to eat during their stay at MIT. The food court would be established in cooperation
with food chains such as McDonald’s. Their restaurants would not only be func-
tional but also experimental in nature. The chains could learn, test, and evaluate
new techniques of food preparation and service and new restaurant designs. The
secondary purpose of the food court is to provide additional dining choices for
people from MIT and area businesses.

Movie Theater. The movie screens used during the day for the showcase can be
used at night to screen new movie releases for general viewing as well as slightly
older movies at a lower ticket price for MIT students through the Lecture Series
Committee (LSC).

6.3.7 A High-Tech Environment
The ultimate objective of THE GRAND PLAN is to transform the campus into a
high-tech environment or a “city of tomorrow.” The entire infrastructure would
reflect the newest developments in science and engineering which implemented at
MIT would serve as a model.

By having various sources, from companies to the federal government, fund the
implementation, MIT’s community would enjoy the most outstanding facilities in
return for showing them. MIT’s educational resources, the libraries and the com-
puting environment would hence enjoy significant support and would be dramati-
cally improved for the teaching and research.

In the case of the MIT Library system, some libraries would be relocated to a new
building sufficiently large to shelve all materials, provide modern and extensive
study areas, as well as house the Athena cluster mentioned above. The libraries
would be equipped with the most modern methods for computerized information
search. In an initiative much like that for Project Athena, this “Library of the
Future” could be built as a model for libraries around the world. Also like Athena,
the concept and method could be sold to others. Finally, tours would allow visitors
to examine MIT’s “Library of the Future.”

A variety of improvements would be made to enhance the overall sensation of
being in a “city of tomorrow.” For instance:

- new public phones developed in cooperation with telephone companies
- electronic bulletin boards and kiosks in high-traffic areas to replace cork
  boards
- interactive terminals for accessing information on events, class schedules,
  operating hours, directions to lecture halls, etc.
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- TV monitors providing a variety of information: time and weather information, announcements, broadcast of special events, etc.
- campus-wide security system of cameras, card readers, etc. to ensure the safety of the MIT community members and equipment and restrict visitor access

Currently the only “transportation system” at MIT is Safe Ride, a van shuttle service. As part of THE GRAND PLAN a new transportation system needs to be developed. It could be as simple as a tram or as sophisticated as a monorail. Shuttle buses would run back and forth between the Kendall Square subway station and the visitor center.

After several years of operation, it may be possible to build a Maglev train system to transport visitors and members of the MIT community through the enlarged campus. Part of the Maglev track would run along the Charles River, giving an excellent view of Boston. The Maglev system was developed by MIT researchers and could revolutionize transportation in the U.S. Furthermore, it would provide a testing ground for the MIT Maglev system in a temperate climate.

6.4 Benefits

There are manifold benefits of THE GRAND PLAN, several of which have been mentioned throughout this report. The final criterion though is how the plan improves MIT's position as the leading school of science and engineering, that is how it improves teaching and research at the Institute.

The most direct impact on teaching and research comes through “dual use” of equipment and facilities as was explained throughout the discussion. Because equipment would not only be used for research purposes but also for exhibit, it is hoped that companies would donate a lot of new equipment. For example, MIT could once again have a supercomputer available, it would finally be able to house a large flight-simulator, upgrade its wind tunnel, and many other items that faculty would like to see on campus. Bringing the newest technical developments to the campus will make teaching better. While at other schools students would see only pictures of new hardware, at MIT they would see the actual hardware—and use it.

The improved MIT library system with a new building and enhanced equipment will make research for faculty and students easier. The libraries will also be able to keep up to date with published material. An integrated Athena cluster would alleviate the current shortage of workstations and improve MIT’s computational resources.

Indirectly, the GP will improve the quality of MIT by strengthening its financial resources. The implementation of THE GRAND PLAN will yield a new, substantial source of income to the Institute. It would arise from the following: admission charges to visitors; contributions by sponsors; conference fees and hotel charges; gift, book, and computer store receipts; food court rental fees; etc. For example, if
the IMAX film on MIT is distributed worldwide and enjoys the same success as NASA's film *The Dream is Alive*, it would be seen by 4 million people annually and bring in revenues of several million dollars. In addition, it would be the best-possible worldwide PR effort. Alumni who are unable to visit MIT with their families could watch the film and so show them their alma mater.

Upgrading MIT to a high-tech environment and producing a technology showcase would gain MIT a considerable amount of worldwide publicity. This is of great importance since MIT is still not very well known internationally despite its numerous achievements. By becoming better known, MIT would be able to attract more general support for the Institute. By presenting its on-going research in a more impressive way and to more organizations, MIT will be able to attract more research grants—especially from industry. By bringing in members from Congress and letting them “experience MIT,” the lobbying effort might be much more successful than through visits to Washington and talking about MIT.

By bringing in new technology from around the world to display and test it, students and faculty alike would have the opportunity to work and learn from new developments before others could. This would give faculty an edge in their research and graduates a better chance of finding employment.

Some of the other benefits the GP would bring are the following:

- Since MIT would construct facilities that would not be tax-exempt, the city of Cambridge and the state of Massachusetts would benefit through increased tax revenues. In addition, new jobs would be created.

- As noted by President Vest, the appearance of the campus is an important aspect of a great and competitive institution. The implementation of the GP would yield a substantially improved campus that would be unique in the world. This would help attract students who not only decide on a place to study but also a place to live.

- Campus life would be notably enhanced for members of the MIT community and especially for students. MIT would offer more dining choices, more entertainment facilities, and a better transportation system, making the campus better for all. The goal is to make the life for students better, to make them proud of their university.

- In a time where financial aid needs grow steadily, jobs on campus or UROPs become increasingly important for students. The implementation of THE GRAND PLAN would provide many positions that can be filled with students and are useful in their education.

- MIT would have the opportunity to inform and educate the general public about the importance of scientific and technological development. The public would then be more able to weigh the benefits of such undertakings as the superconducting super-collider, the space station, or the information super-highway.

- The MIT faculty spends a considerable amount of time explaining their research and giving tours of their laboratories. Another benefit of pavilion displays is that they would reduce the time faculty would have to devote to these
tasks. Further, by allowing faculty to have direct input into the design and display of exhibits, many professors can get more publicity for their research without having to spend money on public relations or time being “in the spotlight.”

• The Institute would be able to help excite America’s young people about science and engineering and motivate them to take more classes in science and engineering or even pursue careers in these fields.

• MIT would show that Massachusetts is one of America’s centers of high-tech research and development. Hence, even more new and established companies would be attracted to the state.

• An increased awareness of developments in all areas of research through numerous exhibits, talks, and presentations would enhance cross-fertilization of ideas, which is essential as inter-departmental research becomes increasingly important.

• Technology transfer would be aided by increased awareness of MIT developments by industry and vice versa.

References


CHAPTER 7
FUTURE WORK

The previous chapter presented the concept of THE GRAND PLAN and a few of the existing ideas for its implementation. The next step is the preparation of a full proposal to the senior staff of the Institute. A substantial amount of work needs to be done to present a comprehensive proposal for the GP. This thesis represents just the beginning of the effort.

7.1 MIT Community Involvement

The GRAND PLAN would heavily influence many parts of the Institute and a single person or a small group of people cannot possibly have all the ideas. Several workshops need to be held involving members of the staff, faculty, and student body to hear their opinions and allowing them to contribute to this vision for the future. In these workshops the concept of the GP would be presented and people from across departments would be asked to provide criticism and make suggestions.

7.2 Visitor Projections

Much of the overall success of THE GRAND PLAN will depend on the kind of attendance the visiting facilities, the number of guests in the hotel, and the number of conferees the conference center can expect. What remains to be done is to make some early projections on the number of people MIT could expect to see under various scenarios.

It will be difficult to make a prediction on the attendance, but a crude projection can be made based on the fact that the Boston Museum of Science had in 1992–93 a gross attendance of 1.62 million visitors. A record attendance was set in 1988–89 with the Ramesses Exhibits in which the museum boasted more than 2.23 million visitors. The most successful museum in the world is the National Air and Space Museum of the Smithsonian Institution in Washington, D.C. Annually more than 7 million people visit the museum. Based on these figures, an initial guess is that MIT can expect as many as 2 to 4 million visitors per year.

7.3 Financial Feasibility and Fundraising

If fully implemented THE GRAND PLAN would require funding between $1 and $2 billion. This is a large amount of money, especially considering the fact that the
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Institute has a deficit and that the amount is close to the total market value of the endowment.

The final report will have to address the issue of how funding can be secured and through what sources. Since THE GRAND PLAN is modular and can be, and should be, implemented in stages, the initially required amount may be as low as $150 million. In addition, it is hoped that the GP while grand in the amount of investment needed, is also grand in the excitement generated for investors. The real issue is not the size of the project but how much money can be raised for it. A $1 billion project full of excitement and many potential benefits will most likely be more successful with investors than a $100 million project that lacks imagination.

7.4 Real Estate and the Cambridge Community

Perhaps the biggest concern to the implementation of the project is land. MIT’s location along the Charles River and in the City of Cambridge, limits its expansion significantly. All proposed facilities for visitors combined would require a substantial amount of land. At the present time the MIT campus covers an area of approximately 600,000 square meters of which almost all is highly developed. Thus, none of it can be used for facilities dedicated to visitors. MIT owns about 100,000 square meters of land right adjacent to campus, which it leases to companies and may use for the GP. The final proposal will have to address the placement of the facilities and the required area.

While land is an important issue, it will not be an unsurmountable obstacle. After all, Disneyland in Anaheim, California has a total area of 530,000 square meters. Of this only 320,000 square meters is open to the public.

The Cambridge Community is a big concern. As was somewhat evident from the discussion of University Park in Section 3.3.2, Cambridge has a long history of community activism. Some may see THE GRAND PLAN as just an expansion of MIT that would diminish taxable land and create “more burden” for Cambridge residents. The final proposal must present the concerns that would be raised by local residents and show that many will be unjustified and others properly addressed. Some of issues that need to be considered are: taxes, traffic, parking, housing, replacement of exiting businesses and the loss of jobs, community involvement in the design.