UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING

Plans for Developing an Engineering and Technology Center on The North Campus

JUNE 1966
ANN ARBOR, MICHIGAN

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

PLANS FOR DEVELOPING AN ENGINEERING AND TECHNOLOGY CENTER ON THE NORTH CAMPUS

SUMMARY

The College of Engineering has made a study of its needs to complete the move to the North Campus and at the same time modernize and enlarge its facilities for the projected enrollment of 1976. To complete this Engineering and Technology Center some 700,000 square feet net, 1,200,000 square feet gross of classrooms, offices, laboratories and other facilities are needed. Table I sets forth the pertinent data for the College.

Since many departments already have a portion of their facilities on the North Campus and now have a divided faculty, it is of great concern that the new space be provided in as short a time as possible. The future of the College, long one of the top schools in the nation, is at stake in the execution of its building program.

The enclosed information should be sufficient to proceed with site and land use plans. When the arrangement of the several units has been considered, the College is prepared to refine the individual departmental requests in turn.

June 1966

PLANS FOR THE ENGINEERING AND TECHNOLOGY CENTER ON THE NORTH CAMPUS

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ENGINEERING AND TECHNOLOGY CENTER

ON

THE NORTH CAMPUS

FOREWORD

As the College of Engineering is developing its plans to move to the North Campus, it finds itself in a period of unprecedented growth and change. The advance in technology associated with the space age, such national problems as those associated with water resources, air pollution, transportation, and urban development, and the tremendous impact of computers on technology and industry typify the need for vigor, flexibility and dynamic leadership in engineering education and research. The College is prepared to provide such leadership, and to afford an opportunity for the students of this state and nation to have the finest in engineering education. It is necessary to provide an environment in which the faculty may develop their personal resources of knowledge, vision, and professional skills so that they will be able to accept technical responsibilities and leadership in education and research. It is in the furtherance of these overall objectives that these plans for construction of the engineering facilities on the North Campus have been developed.

There are three other points which should be considered in the overall objectives of the College. The first is related to the fact that this College has a tradition of being one of the top engineering schools in the nation and of having programs which provide its students with the finest in engineering education. There is some evidence that in recent years our position has slipped to some extent. The data shown in Table 4, which is taken from a recent study on Goals of Engineering Education, is but one indication of such a trend. It is our goal in the College of Engineering to reverse this trend, and to re-establish our position of national leadership in quality, vigor, and breadth of coverage in our undergraduate and graduate programs.

A second factor relates to the College of Engineering as a major engineering resource in the State. This College awards more than 75% of all doctorates of engineering in the State, and has obtained outside support for its research programs at a level of nearly $10,000,000 per year. This research program is larger, by a factor of 20, than any other engineering college in the State. The College also offers programs in continuing engineering education which are among the very best in the nation. The College is committed to its responsibility to serve as the major engineering resource of the State.

Thirdly, as the fundamental disciplines such as chemistry, physics and mathematics move into new areas of research, they leave behind certain areas which are of increasing technological importance. In many cases these are areas that the College of Engineering should continue to develop, and translate the basic knowledge into modern technological developments through programs of teaching and research. The College is alert to this situation and has the flexibility and vision required to move into these areas with vigorous academic programs.

Some of the specific objectives which we desire to accomplish through this move to the North Campus are as follows:

1. More than a decade ago the College made a commitment to move to the North Campus. A major factor in arriving at this decision was the fact that the College was increasing in size and complexity with a growing interdependence among the various engineering disciplines. There were very definite needs for (1) new facilities which would permit greater interaction between individual faculty members and academic units; (2) for a significant step function in the updating of our facilities; and (3) for an expansion which would enable us to meet the requirements of future student generations. The fact that a significant number of buildings (primarily large-scale laboratories) have been built has solved, in a measure, the need for space, but has only made it more difficult to provide effective communication and interaction in both teaching

and research throughout the College. Our first objective is therefore to bring the College together into an integrated facility which will permit effective and efficient operation of the College as a whole.

2. The new heavy-scale equipment and facilities provided by the Automotive Laboratory, Fluids Laboratory, Aircraft Propulsion Laboratories and the Ford Nuclear Reactor have provided badly-needed updating in the large laboratory category during the past decade. Now the primary need is for classrooms, small-scale laboratories, major service facilities, offices, and library, each located in close proximity to the others. Such factors as the impact of computers, the strategic importance of new areas of research, and the availability of new devices and techniques for teaching and research, are having a tremendous impact on engineering education and research. Even if we did not relocate, it would be imperative that the College undertake a major program of development to update its facilities to the point where the College can continue to work and teach at the forefront of modern technology. It is our objective in this move to provide adequate modern facilities for the College which will enable it to develop the finest possible programs of teaching and research.

3. The most important factor in developing excellent programs in teaching and research is the quality of the faculty. Today there is tremendous competition for outstanding faculty members. One of the most significant factors in attracting and retaining outstanding faculty members is adequate facilities. Today the required facilities must include not only adequate offices, laboratory space, and a readily accessible library, but also such factors as access to computers, and the availability of supporting activities and facilities, such as secretarial assistance, shops, electronic instrumentation and reproduction facilities. It is our objective to develop facilities which will enable us to attract and retain the best faculty available, and to maintain these facilities and provide the necessary support to enable this faculty to reach their full potential in accomplishment.

4. The College of Engineering is prepared to assume its full share of responsibility in the University community. In this spirit it is our objective to develop facilities which are in keeping with the overall developments and natural beauty of the North Campus, and to have facilities which will be a credit to the University as a whole.

5. The University has already made very remarkable progress in its plans to develop a strong research complex on the North Campus. The construction of the IST Building, the NASA Building, and the other engineering laboratories are evidence of a most remarkable development. However, the University has always recognized that teaching and research must necessarily go hand in hand, and can be most effectively accomplished by having all educational programs take place in an environment of vigorous research programs. It is the objective of the College in this move to exploit fully in its educational programs the present research activities on the North Campus. A necessary condition for this is a facility which effectively integrates the teaching and research activities.

6. With increasing size, the University is inevitably committed to geographical decentralization. Such decentralization affords an excellent opportunity to develop effective relationships between students and faculty. The Residential College which has been proposed by L. S. and A. is but one example of efforts to accomplish this on a decentralized basis. One objective of the College in moving to the North Campus is to provide a facility which will be the academic "home" for students in engineering and applied science. This will involve interaction with the faculty not only in formal classroom instruction, but more particularly in research, student organizations, and professional activities. It is our conviction in the College of Engineering that in an appropriate environment we can do a great deal toward helping our students develop their powers of creativity and enthusiasm, a sense of responsibility to society, respect for authority, and the importance of personal integrity.

There are a number of ways in which the several objectives discussed above have a direct bearing on plans for the College of Engineering facilities on North Campus. A number of these are listed below.

a. Because the programs of teaching and research will continue to change, it is essential to develop a plan of sufficient flexibility that departments are not "frozen" into a certain size or configuration. We believe that this flexibility can be provided by having relatively large buildings, with effective communication between buildings. In this way, a given activity can be contracted, another expanded, or an altogether new program introduced.

b. There should be an effective mix of offices, classrooms, and small laboratories throughout the engineering complex. We do not believe that it is desirable to have all the offices in one location, all the classrooms in another, and all the laboratories in a third. Rather, we believe that there are a number of ways in which offices, classrooms, laboratories and supporting facilities can be effectively interspersed throughout the new building.

c. To the greatest extent possible the facilities should be so designed that movement throughout the engineering facilities is made possible without going out of doors. Experience has shown that the separation of college activities into several buildings has offered many barriers to effective communication and has made for much needless inconvenience. Therefore, every effort should be made to make it possible to walk throughout any new facilities without going out of doors, and to connect into the new facilities the Fluids Laboratory, the Automotive Laboratory, and the Phoenix Laboratory.

d. Because engineering disciplines are undergoing rapid change, we believe that the building should provide considerable flexibility as regards future use. Yet we recognize that to provide complete flexibility of use can be very expensive. Therefore, in the requirements for the laboratories we have designated a typical "chemical" laboratory, a general-purpose laboratory, and a "dry" laboratory. We believe that this will provide the necessary flexibility, and at the same time permit the efficient and economical installation of services in the various laboratories.

e. A significant fraction of our faculty will be senior people of national stature, who are active in the affairs of government, industry, and professional societies. They will be men who, had they chosen to go into industry, would be presidents, vice presidents, or chief engineers of major industrial firms. They will be men who have accumulated a considerable library and reference files. These faculty members must be provided an adequate office, secretarial assistance, and space for files and reference materials. Those faculty who are of the same calibre but more junior will require adequate secretarial assistance and perhaps somewhat less office and file space. We recommend that in general, faculty offices be arranged into suites so that one secretary can serve from four to six faculty members. We further recommend that in each of the professional departments, 30% of the offices have 200 square feet, 50% have an area of 150 square feet, and 20% have 120 square feet. These latter offices would be used by either an assistant professor or two teaching fellows. In certain of the supporting departments, such as English, an office of 120 square feet would be adequate for all of the faculty. We are convinced that adequate office space and secretarial assistance are imperative if we are to have the calibre of faculty which we visualize as necessary to accomplish our overall objectives.

Summary of Space Needs

Table I presents a Summary of Space Requirements for 1976. Specific program statements from the departments are included in the report to document the details. These requests made by the several departments have been transmitted without curtailment. However, the basis used in all cases is an alloquot share of the predicted undergraduate enrollment of 3,900 and of graduate enrollment of 2,100 students.

The total space requirement for an updating of facilities and the modest growth predicted is 699,000 square feet of usable space. When applying a factor of 0.58 for fraction of gross which is usable, one computes a need of 1,200,000 square feet of gross building space to meet the requirements.

The next step is to plan a site to accommodate the total Engineering and Technology Center and grouping of needs into construction units. A priority for moving will be established then and the departmental requests refined in turn when the architects are ready to consider individual units of the Center.

College of Engineering

Table 1 - Summary of Projected Space Requirements for 1976

	Total Staff			Students		Space Needed - Usable Square Feet			
	Teaching Facility	Academic Research	Non Academic	Undergraduate	Graduate	Office, Conference	Laboratory	Other	Total
1 Engineering Administration	8					25,080			25,080
2 Aerospace	43		24	340	225	13,610	7,800	5,250	26,660
3 Chem.& Met.	51	15	38	355	205	47,500	16,000	12,000	75,500
4 Civil	45		32	265	150	16,150	34,580	2,500	53,230
5 Electrical	93	90	156	680	535	55,410	58,700	29,635	143,745
6 Eng. Mech.	51		19	50	80	13,111	7,360	2,250	22,721
7 Industrial	40	10	29	335	205	40,690	2,000	6,400	49,090
8 Mechanical	57		29	435	225	18,000	29,750	2,650	50,400
9 Met. & Oceon.	15	4	12	60	65	6,660	8,000	6,000	20,660
10 Naval Arch.& M.E.	16	6		170	40	6,240	6,800	1,000	14,040
11 Nuclear	27		11	195	155	8,820	21,000	4,350	34,170
12 Eng. Graphics	10		2			2,540			2,540
13 Eng. English	53		3			7,660			7,660
14 College Services								6,000	6,000
15 Bioengineering	5		3			3,000	15,000		18,000
16 Library								73,667	73,667
17 Classrooms									
all but 1st & 2nd yr.								51,480	51,480
1st & 2nd yr.								24,400	24,400
18 Other Students				1,015*	215**				
TOTALS	506	—	—	3,900	2,100	264,471	206,990	227.582	699,043

* Includes 950 freshmen ** Includes Bioengineering, etc.

$$\frac{699{,}043}{.58} = 1{,}200{,}000$$

MOVING THE ENGINEERING COLLEGE TO THE NORTH CAMPUS

Early in the planning of the North Campus the Engineering College made a commitment to move there. The Cooley Memorial Building completed in 1953 was the first unit located on the North Campus, followed by the Automotive Laboratories (1956), the Propulson Laboratories (1955), and the Fluids Building (1958, 1964), later called the George Granger Brown Memorial Laboratories. Most of the heavy-scale laboratories of the College were placed in these latter buildings with the understanding that the construction of offices, classrooms, and small laboratories would shortly follow. During this interim period there has been a division of both staff and facilities of most departments between the North and Central campuses, which has resulted in considerable inefficiency and ineffective communication.

For the College to move forward, the faculties and facilities of the College must be located together on the North Campus. The completed Engineering and Technology Center will be a real asset to the educational and research capability of the University.

Need for Bolstering Engineering Facilities

As with the University as a whole, the College of Engineering has been preeminent among the engineering schools of the nation. Its early start in 1853 was the beginning of a gradual growth to high strength in most departments. In recent years it has ranked among the first five schools in the nation on most counts, such as number of degrees granted, number of doctorates and graduates engaged in teaching. Tables 2 - 5 give statistical information to verify this statement. Because several other engineering schools in the nation have had a high emphasis in their states or at their institution, these schools have been pulling ahead of The University of Michigan. On recent polls, not the complete story to be sure, several of these schools have placed near the top of the list and now occupy the position the University held a decade ago.

Table 2a - B.S. DEGREES UNIV OF MICHIGAN BY YEAR ENGINEERING (FEB + JUNE + AUG)

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AERO-ASTRO	26	16	31	36	45	78	61	53	66	48	
CHEM-MET-MATLS	49	35	57	70	80	75	79	67	71	65	
CIV. ENG.	47	51	38	64	71	51	83	64	52	53	
ELEC. ENG.	54	55	80	106	126	139	152	154	144	126	
ENG. MECH.	2	3	6	7	4	14	10	11	10	7	
IND. ENG.	39	44	43	53	49	58	64	64	55	58	
MECH. ENG.	58	63	81	94	130	126	116	123	104	96	
NA-MAR. E	19	14	13	11	21	23	20	22	16	18	
PHYSICS	10	10	14	9	18	18	16	12	15	16	
MATH	18	19	31	35	37	48	61	54	63	55	
TOTAL	322	310	394	490	581	646	700	647	638	561	
ENGINEERING M.S. DEGREES UNIV. OF MICHIGAN											
AERO-ASTRO	46	23	29	34	39	32	36	26	34	33	31
CHEM-MET-MATLS	36	45	45	54	55	50	39	32	28	39	43
CIV-ENG	57	54	65	35	58	61	44	60	48	42	39
ELEC-ENG	32	58	48	46	49	42	67	54	54	90	70
ENG-MECH	10	12	5	6	6	10	12	20	18	17	16
IND-ENG-AD	--	--	--	6	3	4	10	10	25	35	33
NA-MAR. ENG.	6	4	6	2	4	7	6	15	8	10	10
N.E.-N.S.	1	5	14	32	33	29	24	30	25	28	18
INST.-CONT.	13	22	13	17	15	26	33	43	33	28	25
M.-O.	--	--	1	4	9	4	6	6	8	8	16
TOTAL	198	225	262	284	312	298	317	345	369	330	361
ENGINEERING DOCTORATE DEGREES UNIV. OF MICHIGAN											
AERO-ASTRO	2	1	2	2	2	--	2	--	1	--	5
CHEM-MET-MATLS	9	19	9	19	19	19	15	21	17	21	13
CIV-ENG.	6	2	6	1	3	4	4	2	3	8	10
ELEC. ENG.	7	12	5	2	9	4	12	7	7	12	17
ENG. MECH.	3	4	2	4	3	3	1	2	4	6	6
IND-ENG-AD.	--	--	--	--		1	--	1	1	5	4
NA-MAR. ENG.	--	--	--	-			1	--	--	--	1
NE-NS	--	--	--	-	3	2	6	5	9	10	11
INST-CONT.	--	--	--	2	--	--	1	1	3	4	3
M-O	--	--						1	1	2	3
TOTAL	27	38	28	32	45	38	49	47	61	68	79

Table 2b- Degrees in Engineering (1958-62)

Institution	Total Number
Bachelor's Degrees	
Purdue University	4520
University of Illinois	4029
University of Michigan	3185
Pennsylvania State University	3022
Georgia Institute of Technology	2938
University of Texas	2716
North Carolina State	2678
University of California, Berkeley	2608
Massachusetts Institute of Technology	2565
Master's Degrees	
Massachusetts Institute of Technology	2644
University of Michigan	1560
Stanford University	1393
University of Illinois	1392
New York University	1371
University of South Carolina	1214
Purdue University	1106
University of California, Berkeley	1008

Table 3 - Annual Number of Doctor's Degrees in Engineering

(Averaged over Period Indicated)

From Goals of Engineering Education 1965

Institution	1936-42	1950-56	1958-62	1964
MIT	13	68	95	150
University of Illinois	4	39	64	131
Stanford	2	22	47	94
Purdue	1	34	45	93
University of Michigan	12	30	45	75
University of California (Berkeley)	1	17	32	68

Am. Soc. for Engr. Education, Goals of Engr. Education, Info. Document No. 4, Appendix C pp. 23 and 24

Table 4 - Rank in Number of Doctor's Degrees Awarded in Engineering

(From Goals of Engineering Education, 1965)

Institution	1936-42	1950-56	1958-62	1964
Massachusetts Institute of Tech.	1	1	1	1
University of Illinois	7	2	2	1
Stanford	13	7	3	3
Purdue	22	3	5	4
University of Michigan	2	4	4	5
University of California(Berkeley)	17	11	6	6
California Institute of Tech.	3	5	11	8
University of Wisconsin	9	6	7	15
University of Minnesota	6	15	17	18
Cornell	4	10	12	20
John Hopkins	5	17	22	41

Table 5 - Institutional Sources of Faculty Doctorates in Engineering Schools

(From Report on Goals of Engineering Education, 1965)

No.	Institution		No. of Doctorates
1	Massachusetts Institute of Technology		436
2	University of Illinois		262
3	University of Michigan		246
4	Purdue		212
5	Stanford		190
6	Iowa State		164
7	University of Wisconsin		161
8	California Institute of Technology		143
9	Columbia		133
10	University of California (Berkeley)		127
11	University of Minnesota		122
12	Ohio State		121
		Subtotal	2317
	All Other Institutions		2204
		Total	4521

Place of The University of Michigan Among State Schools

The University of Michigan has been the leading engineering school of the State by any count. Table 6 lists the statistics on enrollment and degrees. University of Michigan graduates play an important part in Michigan engineering activities and professional organizations. One may wish to consider the number of engineers educated in Michigan in proportion to the population. Since the population of the State of Michigan represents about 4.5% of the U.S. population, Table 6 shows that the production of engineering graduates in the State's schools is in reasonably close balance with its population. However, in an era of emphasis on the technical base needed for fostering growth of industry, a leading industrial state cannot be content with matching averages, but should lead in producing larger than average numbers and high quality technically educated people.

Table 6 - Statistics for Engineering Schools in the State of Michigan, 1964-65*

	Undergraduate		Graduate		
	Enrollment Fall 1965	BS Degrees	Enrollment	MS Degrees	Ph.D. Degrees
Michigan State University	2212	201	298	56	27
Michigan Tech. University	2294	344	75	37	--
University of Detroit	1389	264	53	11	--
University of Michigan	3446	672	1212	330	67
Wayne State University	1610	137	457	56	5
Totals	10951	1618	2095	490	99
Total for All Engineering Schools in United States	253,412	36,691	57,137	11,933	2,102
% for Michigan Schools	4.33	4.40	3.68	4.10	4.70

* R. E. Dunham, J. Engr. Educ., p. 181, February 1966

PROJECTION OF STUDENT ENROLLMENT AND SIZE OF STAFF

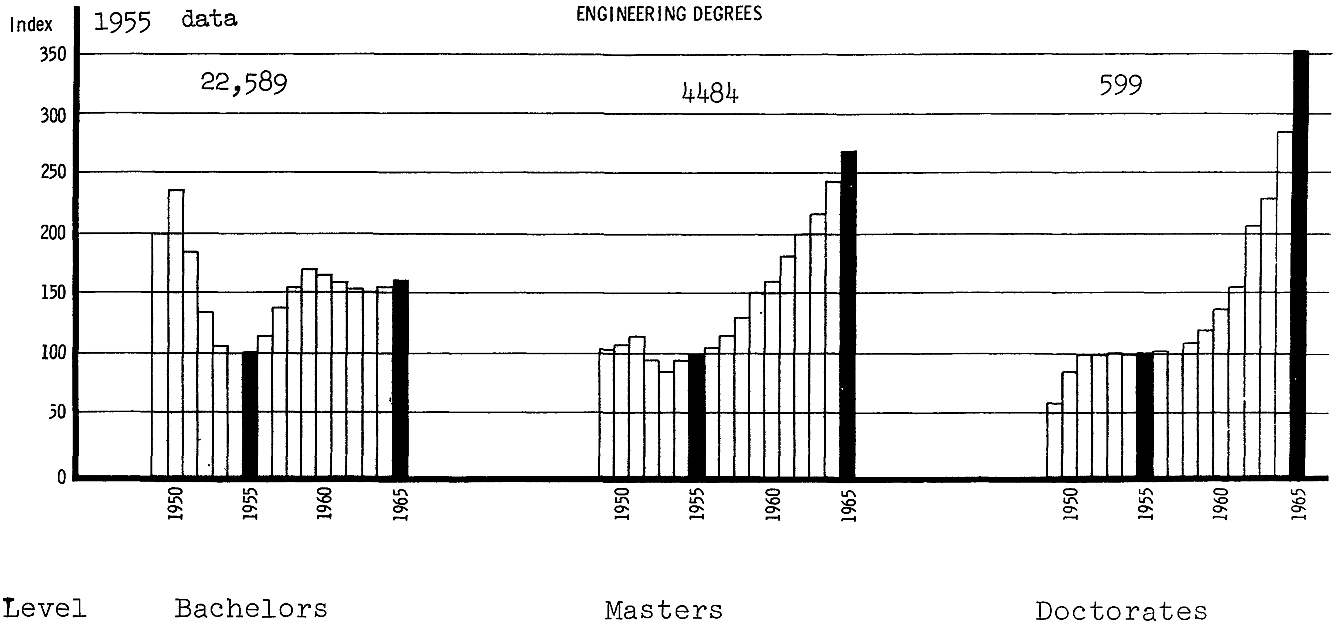
Requirements for facilities are necessarily related to the number of students enrolled in the College of Engineering. In projecting enrollments for the future, there are a number of factors to be considered. These include the number of persons of college age, the fraction of these who will attend college, the fraction of those attending college who will enroll in engineering, the pattern of enrollment in community colleges as compared to four-year institutions, the plans of the University for controlled growth, and the appropriate fraction of engineering students in the state that should be accommodated at The University of Michigan.

According to the statistics released by the U.S. Office of Education, the number of high school graduates in 1976 will be 26% greater than the number of high school graduates in 1966. The College of Engineering recognizes that it might be appropriate for other colleges of engineering to experience a greater rate of growth in enrollment than The University of Michigan. We also assume that the same percentage of high school graduates will enroll in engineering in 1976 as do at the present time. (While the total percentage of high school graduates going on to college is increasing, the percentage of college students enrolling in engineering is decreasing. However, the percentage of high school graduates who go into engineering appears to have remained reasonably constant.) The College of Engineering has projected its own rate of growth of undergraduate enrollment at one half of the increase in high school graduates; namely, 13%. Thus, we have projected an undergraduate enrollment for 1976 of 3446 x 1.13, or 3900 undergraduates.

Our estimate of the breakdown by classes is as follows: freshmen, 950; sophomores, 850; juniors, 1100; and seniors 1000. The rationale behind the increase of juniors over sophomores is the fact that we anticipate an increase in the number of students who will take their first two years in the junior colleges, community colleges, and private colleges of the state. At the present time, we accept approximately 275 transfer students each year. We estimate that this number will reach at least 300 to 350 students per year by 1976.

Figure 1 and Table 6a show the national enrollments in engineering since 1949 at the B.S., M.S. and Ph.D. levels. Figures 2 and 3 give the long time trend in population, bachelors and doctors degrees in engineering. From these two indications of trends in engineering enrollment, it is clear that the use of a 13% increase in 10 years at the bachelors level recognizes that other schools in the state and nation will grow more than The University of Michigan. As regards the graduate enrollment, there were 1043 on-campus graduate students enrolled in the fall of 1966. We anticipate that the graduate enrollment will increase to 2100 by 1976. The reasons for doubling our enrollment in the Graduate School are as follows: (1) there is an ever-increasing amount of emphasis on graduate enrollment in engineering, and each year a greater percentage of those who complete the Bachelor's degree work go on to graduate school. (2) There is an increasing number of four year colleges of engineering in the State (e.g. Oakland University, Saginaw Valley College) and many of these students will pursue graduate studies. We believe that many of them will wish to do their graduate work at The University of Michigan. The same will be true of the other Colleges of Engineering in the State. (3) This University will continue to be one of the major centers of engineering research in the State. Since graduate education and research go hand in hand, it is reasonable that a major portion of the increase in graduate enrollment in engineering in this State should take place at The University of Michigan. The growth in graduate enrollment is less than the national trend shown for the doctorate level of 11% per year. Figures 4 and 5 show the growth predicted in enrollments and number of faculty.

The College recognizes that, while we have based our projections on a very modest range of expansion, these might not be achieved at the



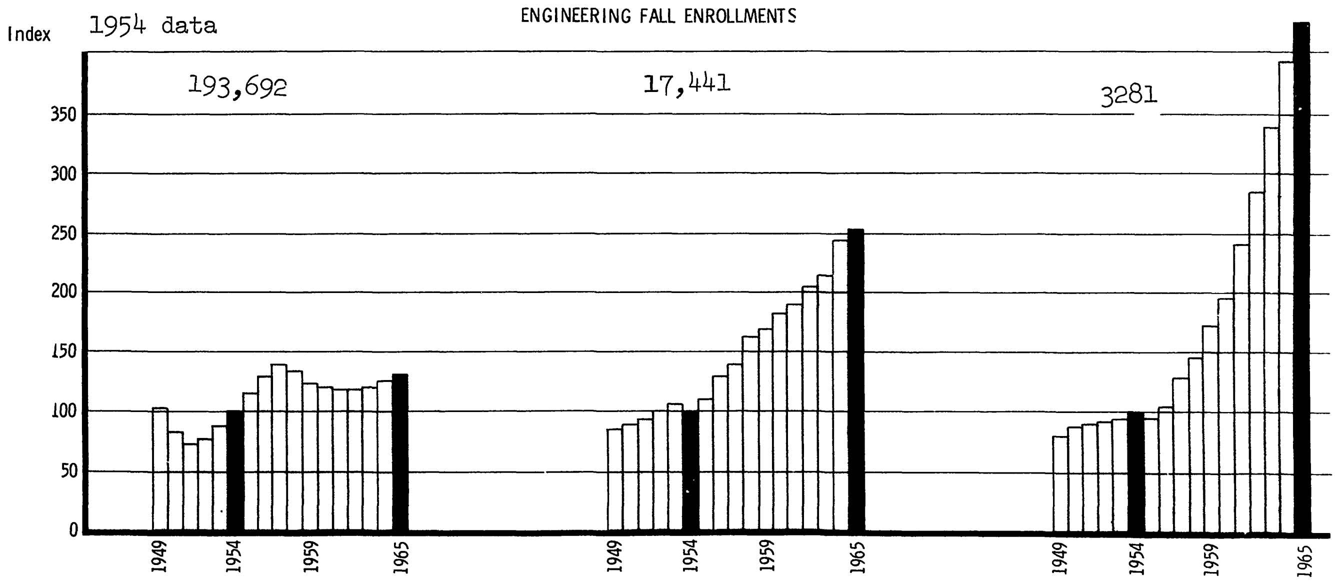


Figure 1 - Trends in Engineering Enrollments and Engineering Degrees.
U.S. Office of Education OE 54004-65

Table 6a - National Enrollment Statistics in Engineering

TOTAL AND ENGINEERING ENROLLMENTS

YEAR	MALE ENROLLMENT TOTAL U S	MALE ENROLLMENT PC ENGINEERING OF
1949	1,577,343	12.6
1950	1,429,349	11.3
1951	1,277,882	11.6
1952	1,244,148	12.7
1953	1,275,875	13.5
1954	1,402,342	13.4
1955	1,550,474	13.7
1956	1,701,710	14.2
1957	1,765,319	14.6
1958	1,861,923	13.4
1959	1,913,124	12.5
1960	1,987,348	12.1
1961	2,102,219	11.3
1962	2,235,936	10.8
1963	2,401,230	10.3
1964	2,611,191	10.0
1965	2,873,042	9.5

NATIONAL ENGINEERING DEGREES

YEAR	BSE	MSE	PHD	PC BS	PC MS	PC PHD
1949	41,793	4,783	417	89.0	10.2	0.8
1950	48,160	4,865	492	89.9	9.1	1.0
1951	37,904	5,134	586	86.8	11.7	1.5
1952	27,155	4,132	586	85.0	13.0	2.0
1953	21,642	3,726	592	83.5	14.4	2.1
1954	19,707	4,130	590	80.5	16.9	2.6
1955	20,200	4,444	599	80.0	17.6	2.4
1956	23,547	4,678	610	81.6	16.3	2.1
1957	27,748	5,203	596	82.8	15.6	1.6
1958	31,216	5,751	647	83.0	15.3	1.7
1959	33,695	6,723	714	81.9	16.4	1.7
1960	33,173	7,128	786	80.6	17.4	2.0
1961	31,901	8,084	942	78.1	19.8	2.1
1962	30,326	8,874	1207	75.0	22.0	3.0
1963	29,426	9,600	1378	73.0	23.8	3.2
1964	30,850	10,803	1693	71.4	25.0	3.9
1965	32,305	11,933	2102	69.9	25.8	4.5

Data from Jr. of Engineering Education, Feb. 1966

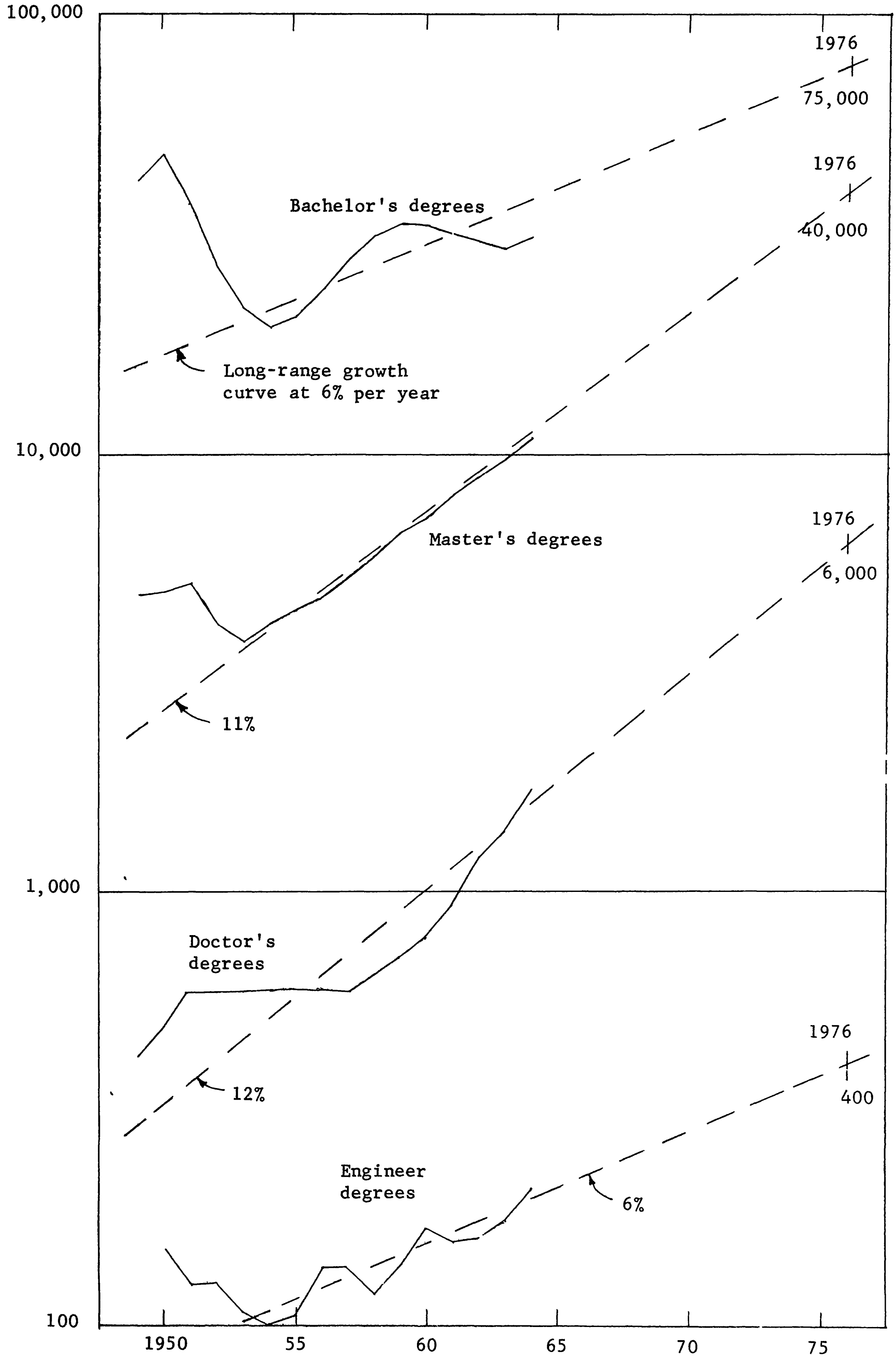


Figure 2 Growth of Engineering Degrees in the U.S.

ASEE Goals Report

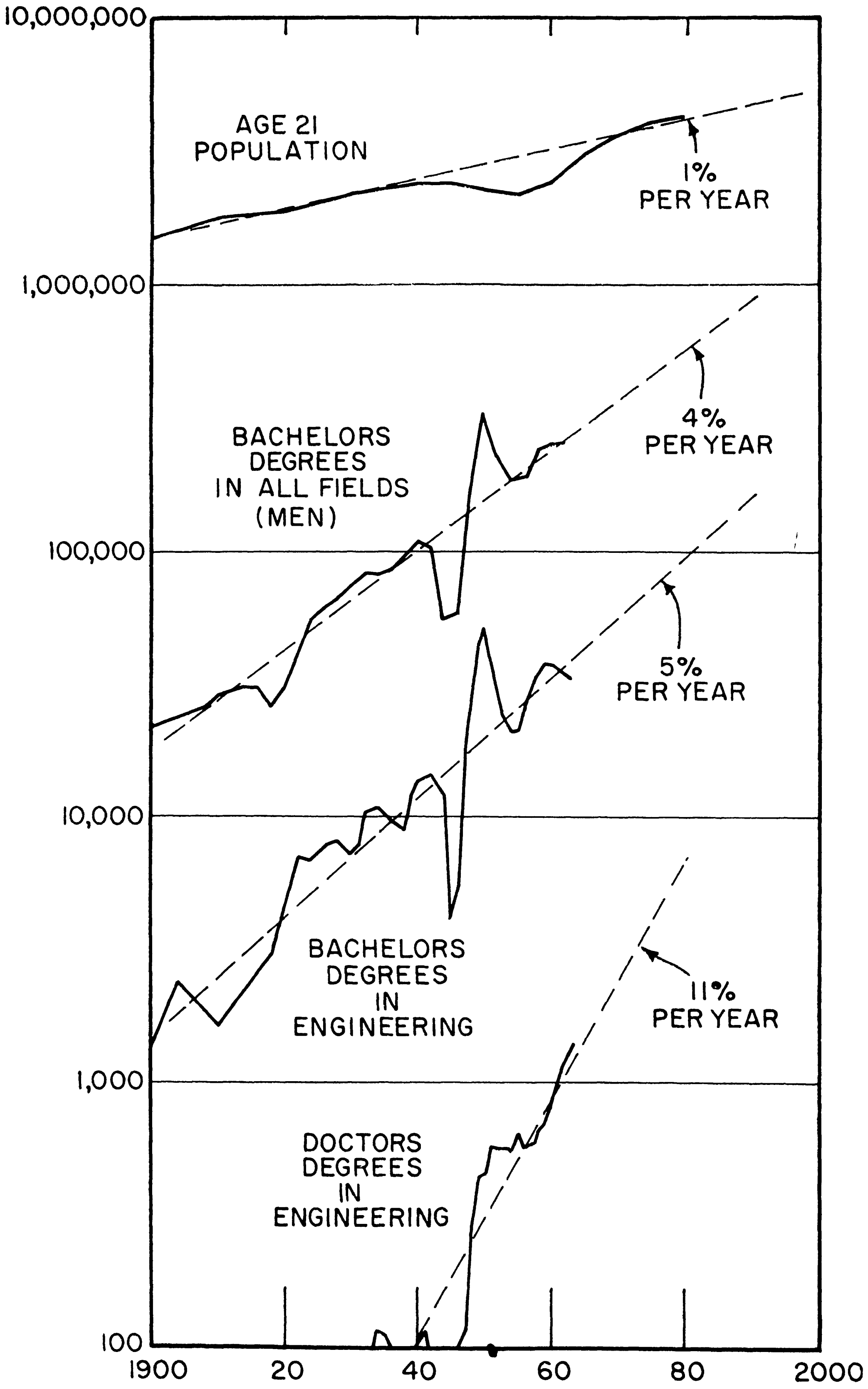
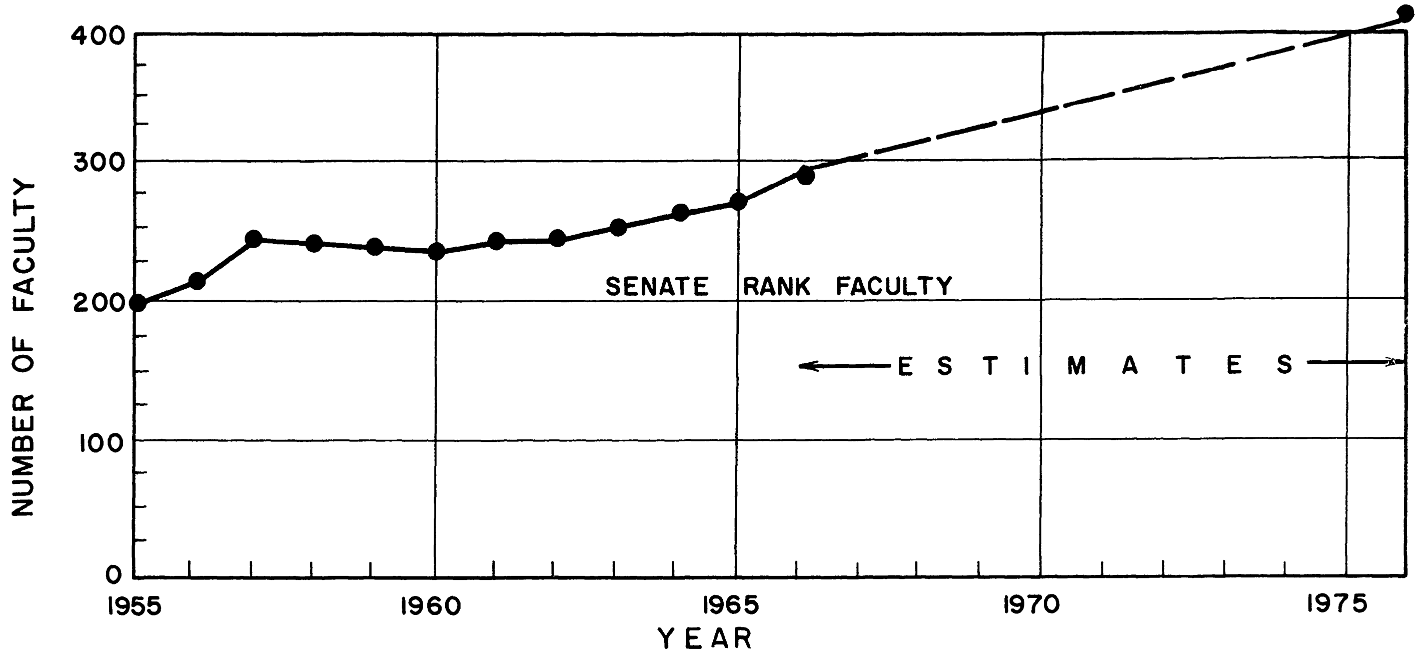


Figure 3 Growth of U.S. population and degrees, with approximate average rates of increase. Jr. of Engineering Education, January 1965, Vol. 55, No. 5



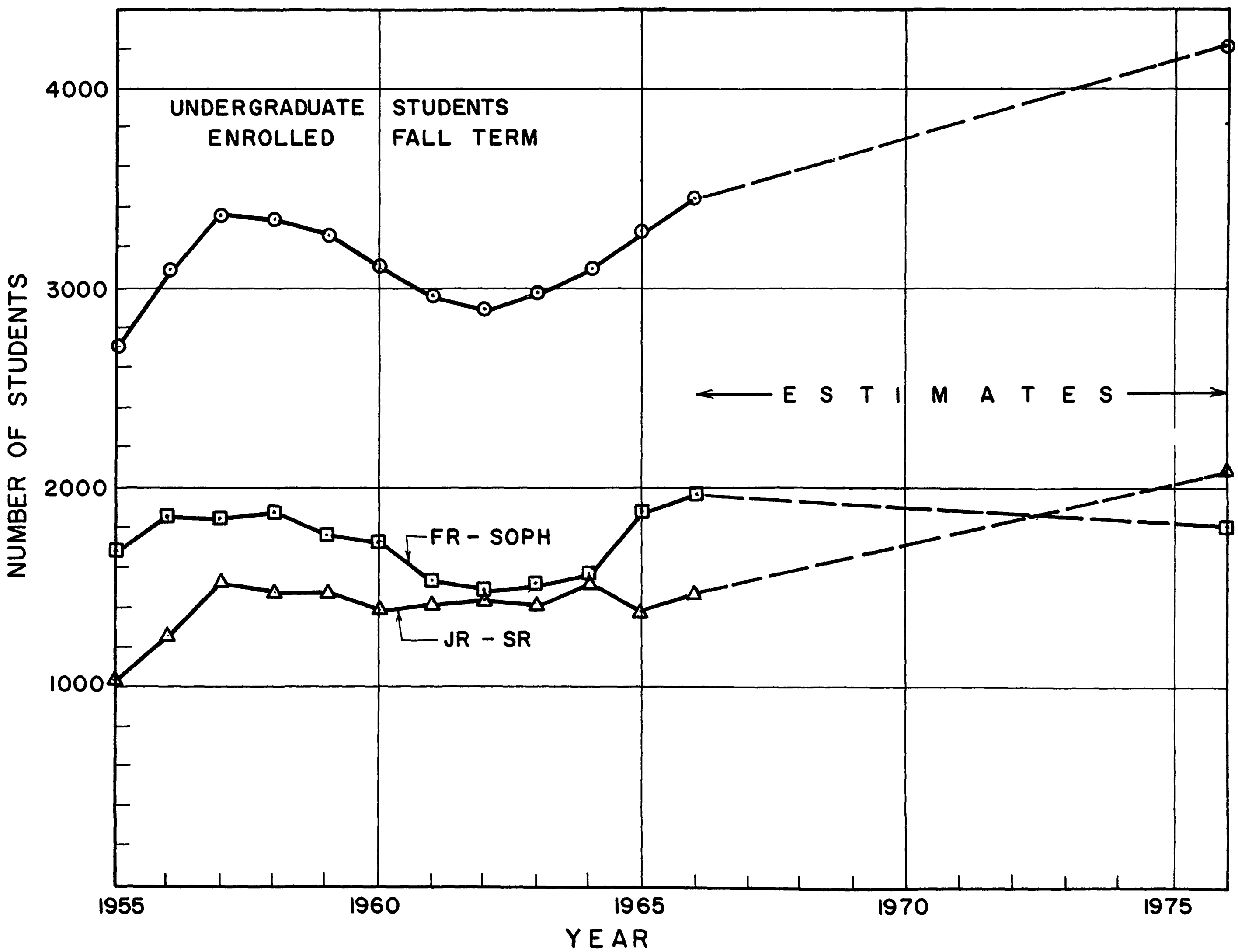


Figure 4 Growth Predicted for Undergraduate Enrollment and Faculty.

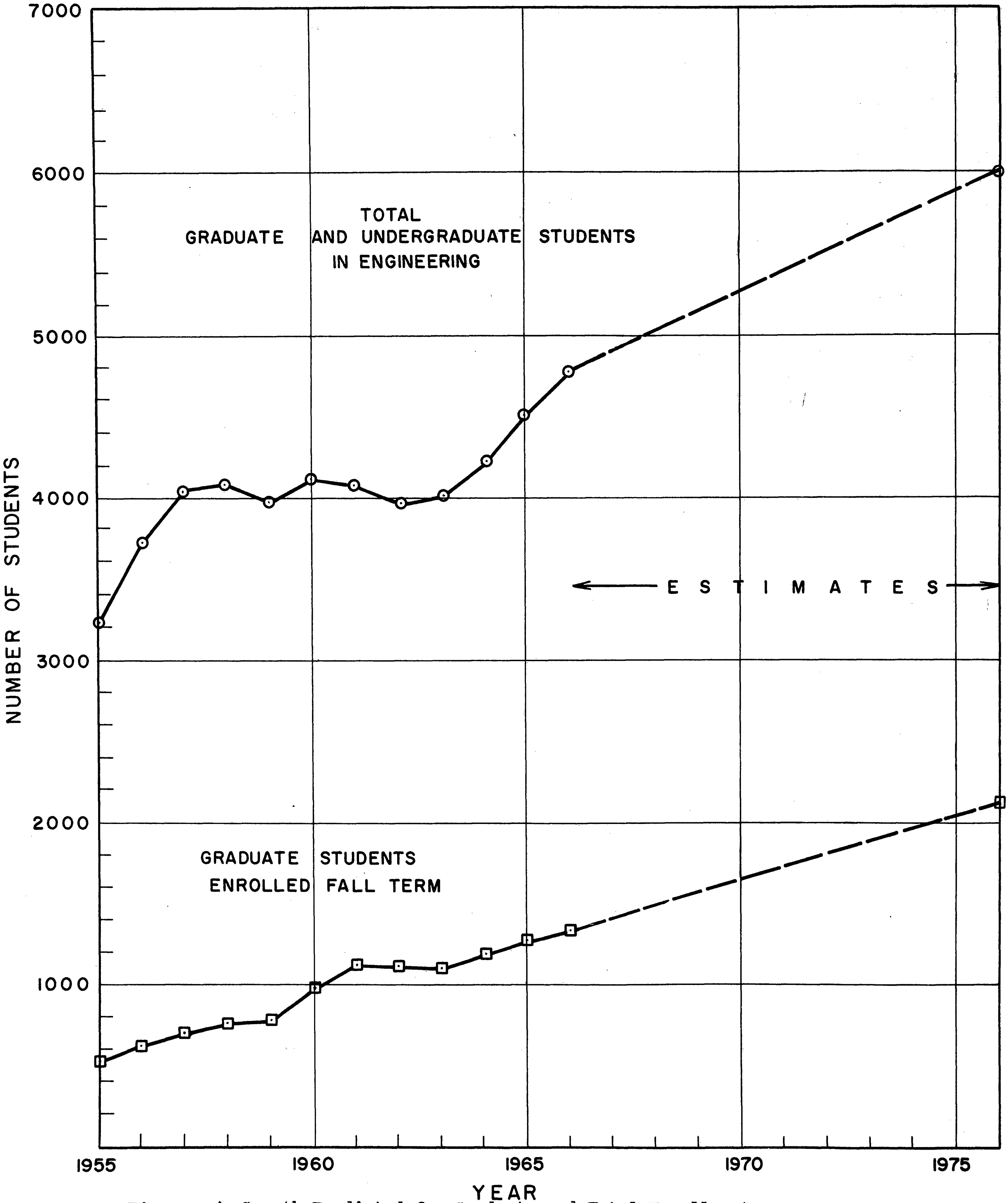


Figure 5 Growth Predicted for Graduate and Total Enrollment.

projected date of 1976. If there is a tendency for the projected enrollment to be achieved earlier, it will be necessary to control enrollments in accordance with the facilities available at any given time. If the projected enrollment is achieved at a later date it might be desirable to postpone the rate at which the final phases of the building plans are completed.

The College also faces the question of enrollments between one department and another and of accommodating new areas of technology which are constantly being developed. Table 7 gives the present distribution and scaled up enrollments predicted for 1976. Because of all such considerations the College will attempt to maintain a maximum flexibility in its building program in the use of facilities so that changes in distribution of enrollment from one department to another, changes from the projected rate of growth, and changes necessary to accommodate new areas of technology can be efficiently and effectively accommodated within the facilities.

Size of Faculty

The present and projected size of the faculty which will be needed is given on Table 8. The senate rank faculty and total faculty including instructors, lecturers, visiting faculty, and emeritus professors are separately listed by departments. In general the growth in size of faculty equals the 6000/4284 = 1.40 growth in total enrollment i.e. 422/291 = 1.45 and 515/392 = 1.31. In some cases the trend in research participation served as a guide.

It should be appreciated that the predicted growth takes place in the upper classmen and graduate level. In these areas the growth is much greater than the 1.4 factor. Taking the graduate and upper classmen in 1976 in relation to 1966, one obtains a factor of $\frac{4200}{2518} = 1.67$. Thus there is an improved effectiveness of teacher time contemplated with growth.

Table 7 - Present and Projected 1976 Enrollments by Departments

College of Engineering

Program	Student Enrollment		Projected Student Enrollment as of 1976	
	Under-Graduate	Graduate (on campus)	Under-Graduate	Graduate (2)
Aerospace	287	97	340	225
Chem. and Met.	227	131	355	205
Civil	158	81	265	150
Electrical	449	285	680	535
Engr. Mech.	24	39	50	80
Industrial	212	73	335	205
Information and Control	---	44	---	---
Mechanical	349	130	435	225
Meteor. and Ocean.	28	44	60	65
N. A. and M.	139	17	170	40
Nuclear	---	83	195	155
Other	256	19	65 (1)	215 (3)
Freshmen	1112	---	950	---
Totals	3241	1043 (4)	3900	2100

(1) Includes such programs as Applied Mathematics, Bio-engineering, Science Engineering, and Engineering Physics.

(2) Includes Information and Control Engineering.

(3) Includes such programs as Bio-engineering, Space and Planetary Sciences, and Water Resources Engineering, Science Engineering, Physics, Mathematics.

(4) 467 are Ph.D. students beyond Masters.

Table 8 - Present and Projected (1976)

Size of Faculty

	Present+		Projected for 1976	
	Senate Rank	Total Faculty	Senate Rank	Total Faculty
Engineering Adm.	6	6	8	8
Aerospace	24	27	37	43
Chem. and Met.	35	39	44	51
Civil	22	35	36	45
Electrical	53	73	72	90
Engr. Mech.	20	33	33	51
Engr. English	22	35	40	53
Engr. Graphics	8	21	8	10
Industrial	17	25	37	50
Mechanical	47	55	48	57
Meteor. and Ocean.	10	12	13	15
N. A. and M.	9	12	14	16
Nuclear	18	19	22	27
Other	--	--	10	15
Totals	291	392	422	515

+Roster, October 1965

The predicted student teacher ratio of 6000/515 is 11.6. Actually, many of the 515 total faculty will be serving part-time on research projects. This actual ratio could be up to 14.5 students per full time teacher. It should be recognized that in addition to giving some 1000 bachelors' degrees in engineering, some 500 masters' and 150-200 doctors' degrees will be awarded per year by this faculty.

The attainment of the year-around schedule for students will increase the need for staff in residence. Although the staff will normally teach only two terms, most will require office and research space for the full year. Currently, about 20% of the undergraduate students enroll during the summer terms, and this teaching load can be handled by the staff which teaches the other two terms, i.e., some 40% of the staff is able and willing to teach one-half of the summer term in a given year. Should a high fraction of the students enroll in summer due to such forces as the draft, then more faculty would be required for the same enrollment. On the other hand, year around operation no doubt will reduce the enrollment since students will be in residence less years. The faculty is projected on the basis of 3900 x (1 + 1 + .2) 2.2 = 8550 term x undergraduate students plus a doubling of the graduate enrollment. Graduate students traditionally conduct research in the summer, with a small class enrollment. However, research supervision is required on the part of the faculty. This practice is expected to continue.

SPACE NEEDS

This study presents the space needs first to move the professional departments to the North Campus and then the first and second year students with the teaching staff of Graphics and English. These space needs constitute a replacement of facilities as well as updating and enlarging for projected growth. Before giving the space needs in detail, the objectives in the planning will be set forth.

Four main objectives for a completion of the Engineering and Technology Center will be emphasized: modernization, integration, space and services.

The Need for Space seems obvious in that much of the space specified is replacement of present facilities. Many groups in the College have very inadequate space now. With the growth expected to occur primarily in the upper classes and graduate areas, where laboratory space is needed, the increase requested is not excessive.

Modernization of facilities should take place in a fast moving technology much more rapidly than past practice has followed in engineering laboratories. Although some laboratories in present campus facilities are only 20 years of age, others are 40 or more years old. The East Engineering building was constructed in 1923 and many laboratories are still with the original equipment. A first class engineering school must have a plan of continued modernization and the move will be an important step in fulfilling this objective.

Integration of all activities so as to develop a feeling that there is an Engineering and Technology Center is an important objective for students and faculty. First, the teacher should be near his classroom and laboratories so students will "wander" into his office on occasion and he does not need to waste time traveling to and from classes and laboratories. The association of the faculty with their peers in other parts of the College as well as in departments facilitates acquaintance and communication. Recent studies of information flow show a high fraction (30% or more) of the information a scientist or engineer needs is obtained by personal contact. So both informal and formal contacts are helpful in developing acquaintances. Space arrangements, traffic flow, etc. are very pertinent factors in developing both student faculty and faculty-faculty relationships.

Services provided by Universities for faculty are normally much poorer than services provided by industry for comparable status people. The professor cannot help but observe his young Ph.D. students take a position in industry which provides within a five year period such services as a secretary in an adjacent office, a well appointed office with rugs on the floor, and many services which facilitate his productivity. Is not an upgrading in the investment for such services in an educational institution of equal value to accomplishing the overall objectives of developing and maintaining a staff who are capable, efficient, and productive? The office arrangements are long overdue in making secretarial service at hand. Reproduction services for paper work and supply services for laboratories are prerequisites for a modern Engineering and Technology Center. The Library, to be useful, must be in close proximity to as large a segment of the faculty as possible. With remote consoles and time sharing on the computer, its services will be brought to the site needed, but careful planning of this new facility is needed.

Time is of the essence with students too. A recent trend is for students to hold meetings with speakers during the lunch hour. Now, improvised sandwich luncheons are held in class or seminar rooms. Faculty members attend these luncheons too, and facilities are needed to make the most use of the 12:00 to 1:00 hour for these meetings.

This report will discuss the space needs for administering the college-wide activities, the educational and research needs by departments, and then the general facilities which make up the proposed Engineering and Technology Center.

ADMINISTRATION OF THE COLLEGE

The college-wide administrative activities are divided into five areas as follows:

I. General Administration

II. All-Purpose Area and Faculty Center

III. Administrative Work Associated with Undergraduate Students

IV. Placement

V. Student Activities

It is important that certain functional aspects of these five areas be housed in contiguous quarters. The needs for each area are detailed below and summarized on page 40.

I. General Administration

The space for General Administration should be an integral unit. A description of particular offices, the 1976 requirements for staff and space and the present staff and space, are summarized in Table 9.

Table 9 - Space for General Administrative Staff

	1976 Staff	1976 Space sq ft	Present Staff	Present Space sq ft
Dean's Office, Washroom and Closet	1	500	1	750
Associate Dean - Private Offices	3	600	2	360
Assistants to the Dean - Private Offices	4	720	3	360
Administrative Assistants - Private Offices	4	600	2	200
Secretaries to the Dean's General Admin. Staff	8	1200	5	530
Reception Office & Waiting Room	2	460	1	300
Editorial Office (Engineering College Review)	2	350	-	---
Engineering Alumni Fund Office	3	450	-	-
Work Room (Xerox, Ditto, Etc. & Sink)	1	300	-	60
Confidential File Room	-	120	-	35
Open File Room	1	240	-	-
Secretarial Pool Room	3	300	-	-
Small Conference Room	-	300	-	-
Dean's Conference Room	-	500	-	345
Totals	32	6640	14	2940

Based on the growth in enrollments, faculty, and research activity, estimates have been made of the numbers and kinds of supporting staff required for 1976.

There are several areas that require special comment. The Dean's office is now used as a conference room. With provision being made for conference facilities apart from the Dean's office this will no longer be required and the total space for the Dean's office can be reduced.

At the present time there are two Associate Deans, one of whom is responsible for graduate programs and the other primarily responsible for general college administrative problems. We anticipate the addition of a third associate dean with the growth of the general administrative burden as our student body and faculty expands.

There are three Assistants to the Dean in general administration - one is responsible for the Engineering Summer Conferences and for scholarships and fellowships; another is responsible for the allocation of space, rehabilitation and remodeling, and for equipment; and the third Assistant to the Dean is responsible for budget administration and planning. We anticipate adding a fourth Assistant to the Dean in the general administration area to be responsible for the newly established College of Engineering Alumni Fund and for the ENGINEERING REVIEW. (Two other Assistants to the Dean, responsible for placement and student affairs, are accounted for in other sections of this report).

There are two Administrative Assistants in the Dean's general administrative offices. We anticipate the addition of two more Administrative Assistants by 1976.

There are five secretaries to the Dean's general administrative staff at the present time. We anticipate an expansion of this staff to eight by 1976.

We now have a reception office, waiting room and secretaries' office of 300 square feet. We expect that the reception office and waiting room will serve all of the general administrative area and will require half again as much space as we have now.

In the fall of 1966 we will begin publishing an ENGINEERING REVIEW that will be distributed to all of our active alumni, to engineering libraries and to the College faculty. This will be a major publishing effort involving at least two people.

An Engineering College Alumni Fund has been established and is expected to absorb the efforts of three full time people.

We will require a work and mail room to accommodate office duplicating machines as well as mail boxes, postage meters, scales, etc., to serve the whole of the College of Engineering's administrative activities.

We will require a small confidential file room for working storage of faculty records, budgetary information, and other administrative confidential material.

In addition to the confidential file room we will require an open file room that will contain correspondence, open faculty records, and other common material needed by the faculty and administrative staff.

We propose to establish a secretarial pool to provide secretarial assistance for overload work to the entire administrative activities in the Dean's office and to the various departments within the College. Mr. Allmand, Personnel Officer, has encouraged us to establish this kind of service, and we feel that it is urgently needed.

At the present time the Dean's office is used as a small conference room accommodating up to 25 people. We see a need for a small conference room in the immediate area of the Dean's office for use by the Executive Committee and Standing Committee of the College on the continuing basis and for other meetings at the college level.

Table 10 - All-Purpose Room and Faculty Center

	1976	Present
All-Purpose Room	4000 $ft.^2$	
Faculty Center (The only space now used for this purpose is the room over the Arch in West Engineering)	2800 $ft.^2$	400 $ft.^2$
	5800 $ft.^2$	400 $ft.^2$

We now have a conference room that can accommodate about 20 people for relatively short meetings. We need a larger conference room able to accommodate about 30 people for rather lengthy meetings. This would be used by the College Curriculum Committee, the Graduate Advisers Committee, and by other college—wide committees for half-day and full-day conferences. It should be sufficiently spacious to comfortably accommodate a large group for full-day meetings.

II. <u>All-Purpose Area and Faculty Center</u>

Our planning includes a room of approximately 2500 square feet for a college-wide faculty meeting center and lounge. A kitchenette of about 300 square feet should be associated with this center. Because of the remoteness of the North Campus location from many Main Campus facilities, this room may well serve also as a social center for the entire faculty of the College. It will also be used for department colloquia and for other meetings too large to be accommodated in the conference room in the Dean's office area. These facilities should be able to accommodate 300 faculty members at a given time.

It is also necessary to have an all-purpose assembly room able to accommodate about 300 people, separate from the faculty meeting center and lounge and immediately adjacent to it. This room would be used for interdepartment meetings, faculty meetings of the college, and for certain student activities. It might also, at times, be used for special large lectures and classes. This all-purpose room should be about 3,000 square feet. Provision should be made for normal lecture usage, for audio-visual equipment, and for the possible use of closed circuit television.

III. Administrative Work Associated With Undergraduate Students

The Assistant Dean's Office provides a central service for all undergraduate engineering students for enrollment, classification, registration, and for special counseling. The office provides for orientation of incoming freshmen and for counseling during the first year; for admission and orientation of transfer students; and for a final audit of a student's record and progress toward graduation. The office also maintains a file on each undergraduate student. Associated with these services is the necessary preparation and maintenance of the college catalogs, and the various materials, forms, and routines required in the relationships with undergraduate students.

Future requirements in both staff and space reflect anticipated changes in procedures, an increased use of modern files and data processing equipment for which we predict an increase in overall efficiency as well as providing extended and improved services to the College.

The estimated space for administrative work associated with undergraduate students is detailed in Table 11. The peak load for this space and the peak load for the space provided for Placement, as given in Table 12 fall at different times. It is essential that the floor plans be designed so that these two areas are adjacent in order to make efficient and convenient use of the combined areas.

In order to take care of the increased enrollment of transfer students, we have provided for an additional Assistant to the Dean for admissions and interviewing of these students, and for additional space for the typing and clerical services associated with that function.

Even though we plan for increased enrollment we are of the opinion that an improvement in the filing facilities and in the arrangement will increase the efficiency of the clerical staff so that no additional employees will be required for maintaining the records of the undergraduate students.

Table 11 - Space Needs For Administering Undergraduates

	1976		Present	
	Staff Number	Space Sq. Ft.	Staff Number	Space Sq. Ft.
Assistant Dean's Office (with room for 5 visitors)	1	200	1	140
Assistants to the Dean (admissions of transfer students and general counseling)	2	300	1	100
Assistant to the Asst. Dean, file, desk & table	1	150	1	80
Secretary and pool of typists	4	400	1	100
Receptionist, files, catalog cabinet, waiting room	1	300	1	250
Supervisor of Records Office	1	150	1	100
Clerical Staff and files	3	360	3	440
Freshman Counseling, Receptionist & Secretary	2	240	1	150
Three Counseling Rooms (occupied by members of faculty on counseling assignments)	-	300	-	300
Waiting Room with writing tables	-	200	-	160
Director of scholarships, & secretary	2	300	2	250
Scholastic Standing Committee Office	-	150	-	---
Time Schedules, Classroom Assignment, Orientation, etc. Office	1	150	*	---
Storage, office machines, sink, etc.	-	400	-	500
Totals	18	3600	12	2570

* Now part-time activity for Professor Lipphart in his Department office.

Based on transferring student records to Registrar

With an improved arrangement for handling the freshmen, and by using the interview rooms in the Placement area during the peak load we will be able to provide satisfactorily for the freshmen without a large increase in square feet of space.

Provision is made for an office for the Scholastic Standing Committee headquarters so that this function can make use of the files in the Assistant Dean's Office and of typing services.

Provision is made for the Chairman of the Scholarship Committee and his secretary to make use of the nearby student files and other services provided by the Assistant Dean's Office.

Privision is made for an office for the coordination of time schedules, classroom assignments, orientation and registration planning, etc. This is now handled by Professor Lipphart in his departmental office.

IV. Placement

The College of Engineering considers the proper placement of its graduates to be very important, since it is recognized that the first years of professional experience are of great significance in developing the full capabilities of the young engineer. For this reason and to provide a convenient opportunity for employers and candidates for employment to come together for an interview, the College provides an Engineering Placement Service for both its students and alumni. This service includes the arranging of employment interviews on campus, the announcement of openings received by mail and providing of career and placement information through counseling and published material.

Summer and other short term training positions in industry are also offered by many employers, especially to students who have completed at least three years of an engineering program. The Placement Service provides all possible assistance in this area since such experience is generally considered to be a very valuable adjunct to formal and technical education.

Approximately 500 employers of engineering graduates visit the campus during a school year. Some of them come during both fall and winter terms, some will send more than one representative and some will require more than one day to handle all the interviews. The peak load extends over a period of approximately eight weeks, generally requiring 20 interview rooms and at times more. During this peak period it is proposed that any spare rooms in the Assistant Dean's Office would be scheduled for this purpose, as well as other vacant rooms available in the vicinity. Each room should be approximately 90 square feet, (a 9 x 10 room serves quite well). Each room should have individual lighting, air conditioning, and be satisfactorily sound-proof from adjacent rooms. Some of them could be interior rooms.

The staff includes a director and a clerical group of four. An assembly room will take care of morning luncheon end-of-day arrangements which would overcrowd the Director's office, and provide a coat storage and a "coffee" room (a kitchenette should be included).

By combining the Placement library and the waiting room an improved service is provided for both of these functions. Ample bulletin board space, approximately 120 feet, should be included for posting notices, and a special pigeon-hole cabinet for the convenience of signing up for interviews. Also a nearby storage and office maching room is required. Summary of the space is covered in Table 12, Space Needs for Placement.

Table 12 - Space Needs for Placement

	1976		Present	
	Staff No.	Space Sq. Ft.	Staff No.	Space Sq. Ft.
Office for Director of Placement	1	200	1	110
Office for Staff and Files	4	480	3	320
Assembly Room for interviewers, coat storage, sink	-	300	-	---
Placement Library and Waiting Room	-	600	-	520
Storage	-	240	-	130
Bulletin Board Space	-	280	-	400
Interview Rooms (now have 14, need 20)	-	1800	-	1200
	5	3900	4	2680

The Placement Library and Waiting Room and the 20 interview rooms will be used during the several orientation and counseling periods at the beginning of each term for both freshman counseling and for the Committee on Scholastic Standing when interviewing students with low scholastic performance. A means of communicating between the interview rooms and the receptionist should be provided.

Consideration should be given to isolating certain of the office sections from the interview rooms so that the interview rooms, the library, and the freshman waiting room tables could be made available to students for daytime study, by schedule when not in use, and for evening study.

V. Student Activities

The College believes that participation by students in various activities associated with the College provides an important contribution to the personal and professional development of its students. Well regulated activities constitute an important part of the University life and engineering students are encouraged to take an active part in them after they have satisfied their scholastic time budget.

Presently a few scattered offices are made available for use by the Technirama staff and few student societies. It is recommended that in the facilities closely associated with the Assistant Dean's area that a centralized area be provided for all college-wide student activities. It is also recommended that the student lounge be adjacent to the office space for student organizations. Consideration should be given to arranging the student lounge so that it could also be used during the evenings as a study room.

The arrangement of space for the student organizations should be planned around a central secretary and file space for all organizations and a small waiting room totalling 200 square feet. Michigan Technic and Engineering Council should have considerable spaces assigned to them. Other groups including the Honor Council, Tau Beta Pi, Vulcans, Triangles, Technirama,

Table 13 - Space Needs for Student Lounge and Student Organizations

	1976 Staff No.	1976 Space Sq. Ft.	Present Staff No.	Present Space Sq. Ft.
Student Lounge - suitable also as a study room by schedule	-	4000	-	1500
Receptionist and coordinator of files and space including small waiting space	1	220	1	----
Michigan Technic and The Arch	-	600	-	485
Engineering Council	-	120	-	90
Two rooms available to any student organization by schedule	-	200	-	----
Totals	1	5140	-	2075

Table 14 - Summary of Space Needs for Administration

		1976 Staff No.	1976 Space Sq. Ft.	Present Staff No.	Present Space Sq. Ft.
I.	General Administrative Staff	32	6640	14	2940
II.	All Purpose Room and Faculty Center	--	5800	--	400
III.	Administrative Work Associated With Undergraduates	18	3600	12	2570
IV.	Placement	5	3900	4	2680
V.	Student Activities	1	5140	--	2075
	Totals	56	25080	30	10660

Graduate Student Council could make use, by schedule, of two small rooms each containing 100 square feet. A large conference room with table and capacity for 30 would serve the needs of large committee meetings such as the Engineering Council and the Honor Council.

A summary of the space needs as proposed above is in Table 13 and for Engineering Administration as a whole in Table 14.

DETERMINATION OF NEEDS IN DEPARTMENTS

In the fall of 1965, each department was asked to study its needs for moving to the North Campus and handle its share of the enrollment predicted for 1976. The College Planning Committee studies and presented information on changes in the past and gave predictions for the future. Interdepartmental meetings were held and subcommittee reports prepared relative to office sizes, college services, 1st and 2nd year students, etc. A draft of the total report including the departmental reports was prepared in March 1966 for limited review. In May it was decided to revise the enrollment predicted for 1976 to the 2100 graduate and 3900 undergraduate students, at which time the departmental reports were revised.

In many cases, departmental committees spent considerable time planning the type of facilities that would be desirable when they moved to the North Campus. These resulting reports given in the appendix set forth program statements for the department as a whole and for the facilities requested.

Early in the planning, it was stated that the policy would be for each department to have the opportunity to plan the facilities needed. However, a portion of the space requested should be of such a general nature that it could be used by several groups. In view of the elapsed time from the planning stage to occupancy, a portion of such general space would remain unassigned until the time for occupancy approached. In this way, emerging needs can be handled and full space allocated as requirements materialize. An adaptive plan is needed which gives an opportunity to modify space usage when the space becomes available without interfering with responsible planning on the part of the departments for the essentials of their educational programs. It is believed that departmental planning for some 80% of the space agreed upon as justified by their prospective needs along with the construction of similar adjacent space of offices and laboratory space which will be unallocated until occupany will provide the needed flexibility.

Summary tables for the several departments have been prepared based on the individual departmental reports in the appendix. They are given in turn on the following pages. The summary Table 1, given at the end of the foreword, was constructed from the information on these departmental tables and their reports.

Table 15 - Space Requirements for Aerospace Engineering

Item	Staff		Students		Space		
	Academic	Non Academic	Under-Graduate	Graduate	Office	Lab.	Other
			340	225			
Dept. Chairman and Conference	1				500		
Professors'Offices	43				6750		
Secretaries		12			1800		
Teaching Fellows		26			1560		
Predoctoral Students		40			2400		
Conference (2)					600	13,610 $ft.^2$	
Laboratories							
Small Labs.							
Structural Mechs(3) (3 x 600)					1800		
Propulsion (1)					600		
Aerodynamics (2) (2 x 600)					1200		
Planetary and Space Sciences (1)					600		
Guidance and Control-Aero (2) (2 x 600)					1200		
Information and Control Engr. (4) (4 x 600)					2400	7,800 $ft.^2$	
Supplementary Facilities							
Design Room					1000		
Library					250		
Shop					4000	5,250 $ft.^2$	
			Total		13,610	7800	5250

Total Space 26,660

Table 16 - Space Requirements for Chemical and Metallurgical Engineering

	Teaching Faculty	Academic Research	Non-Academic	Students: Undergrad.	Students: Post MS	Students: Ph.D	Office Confer.	Lab	Other
Total	51	15		355	80	125			
Faculty Offices	50						7950		
Dept. Office	1		5				1200		
Secretarial			11				1650		
Conference Seminar							2400		
Student Soc. & Reference							1800		
Shops			6						6000
Teaching Fellows						10	600		
Grad Students						30	1800		
Faculty and Graduates									
Research Lab				36	80	85	27300		
Instruction & Res. Lab.								16000	
Special Facilities									6000
Computation							2800		
							47500	16000	12000

Total Space 75500

Table 17 - Summary of Space Requirements for Civil Engineering Department

	No. of People Involved				Space (ft^2) Req'd (1976) New Building		
	Academic	Non-Academic	Undergrad Students	Grad Students	Office	Lab	Other
Total Personnel	45	32	265	150			
Dept. Office	1	3			1000		
Faculty Offices	44				8050		
Teaching Fellows & Res. Assistants				60	3600		
Secretaries		14			2100		
Conference and Seminar Rooms					1400		
Shops		5					2500
			(classes) U & G	(res. spaces)			
Construction Lab.			70/wk.	0		900	
Geodesy Lab		1	100/wk	3		5400	
Hydraulics Lab		1	75/wk	5		2450	
Sanitary Eng. Lab.		3	50/wk	19		10932*	
Soil Mech. Lab.		2	100/wk	5		4000	
Structures Lab.		2	140/wk	9		8900**	
Traffic-Transp. Lab.		1	20/wk	4		2000	
Grad. Stud. Work Stations - 88							
					16150	34580	2500

Total Space 53230

* Proposed as a separate wing

**Required for teaching and Ph.D. thesis research - in addition to the proposed 20,000 ft^2 Structural Lab adjacent to the Michigan State Highway Department Testing Lab.

6/7/66

Table 18

Summary of Space Requirements for

The Electrical Engineering Department

	Number of People Involved				Space Required (1976) (square feet) New Building		
	Teaching Faculty	Academic Research Personnel	Non-Academic Personnel	Students	Office Conference Lounge	Lab	Other
Faculty Offices	90				14,310		
Teaching Fellows				45	2,640		
Dept. Admin., Student Counselling, Secretarial Offices including filing, reproduction and storage	3		20		4,700		800
Instructional Laboratory						22,250	
Faculty and Student Activities					4,600		
Shop and Services			6				5,400
Computation							1,200
Electronic Communication Lab.[2]		18	23	77	7,160	10,000	3,060
Electron Physics Lab		7	37	54	5,440	11,050	9,975
Electro-Optical Lab.		2	7	18	2,040	5,800	2,500
Radiation Lab.[3]		26	24	54	4,820	1,500	3,110
Space Physics Lab.[4]		35	30	60	3,000	3,900	2,030
Systems Eng. Lab.		2	9	80	6,100	2,400	1,560
Space Research Lab. Other than major units	—	—	—	10	600	1,800	
Total	93	90	156	398	55,410	58,700	29,635
Total space	143,745						

1. This does not include regular classroom space.
2. This laboratory will retain 5,780 sq. ft. at the Cooley Bldg. in addition to that required in the new building.
3. This laboratory will require a facility separate from the instructional bldg. This facility requires 12,433 of bldg. space and 10 acres of land for an Antenna Range.
4. This laboratory will retain its present space at the NASA Bldg. in addition to that required in the new building.

Table 19 - Summary of Space Requirements for Engineering Mechanics Department for Total Move to North Campus*

	Teaching and Research Personnel			Total No. Campus Space Required 1976			New Space Required on No. Campus 1976		
	Faculty	Non-Academic Personnel	Students	Office Conf. Lounge	Lab.	Other	Office Conf. Lounge	Lab.	Other
Faculty Offices	50			8210			7410		
Teaching Fellow Offices			14	1050			1050		
Academic Res. Offices			12	480			480		
Dept. Admin., Stu. Counselling, Secretarial, Filing, Repro., Storage	1	14		3075			3075		
Student-Faculty Activities						1600			1600
Shops & Services		5				1750			350
Computation						850			300
U/G Instructional Labs.					8720**			5360**	
Grad & Res. Labs									
General Fl. Dyn.			8	480	2200		480		
Dynamics and Solid Mech.			8	480	2000		480	2000	
Inhomogeneous Fl. Dyn.			6	360	4100		126		
Totals	51	19	48	14135	17020**	4200	13111	7360**	2250

Total Space 22721

*This does not include regular classroom space
**Reduce by 3360 if first two years stay on Central Campus

June, 1966

Table 20 - Space Needs for Industrial Engineering

Item	NUMBER OF PEOPLE INVOLVED					SPACE REQUIRED (1976) sq. ft. NEW BUILDING		
	Primarily Teaching Faculty	Primarily Acad Research Person.	Non-Acad. Pers.	Offices For Students	No. of Stud. Served Per Yr.	Office Conf. Lounge	Lab.	Other
Senate Rank Personnel	37					5670		
Lecturers & Emeritus Professors	3	10				1990		
Secretarial			25			3750		
Technicians			4			480		800*
Graduate Assistants and Fellows				110		6600		
TEACHING LABORATORIES:								
Work Measurement					170	1000		
Facilities Design					170	800		
Computation					500	1200		
Simulation					250	1000		
Systems (3 units)					150	2700		
Satellite Computer					400	2000		
RESEARCH AND TEACHING LABORATORIES:								
Environmental					60	1000		
Human Performance Testing					200	800		
Facilities Design					60	900		
Advanced Systems (6 units)					450	4800		
Ph.D. Research				20		2000	2000	
SPECIAL FACILITIES:								
Student Reading Rm.				40	700	2000		2000
Programmed Material and TV Instruc. (4 units)					300			2400
Conference Rooms (4 rooms)					100	2000		
Service Area								400
Reproduction Room								800
Totals	40	10	29	170	3510	40690	2000	6400

Total Space 49,090

*Assuming central shop facilities are available

Table 21 - Space Requirements for Mechanical Engineering by 1976

Item	Number of Persons			a. Space Required (sq. ft.)		
	Faculty	Non-Acad.	Students	Office Conference	Lab	Other
1. Administration secretaries, and allied functions	1	11		2650		
2. Teaching Faculty	56			6270		
3. Teaching Fellows			18	1080		
4. Graduate student and research assistant stations			63	3150		
5. Faculty & student activities				1600		
6. Thermodynamics, Heat Transfer, amd Fluid Mechanics labs and associated facilities		6	46	1500	5300	
7. Mechanical design labs and all facilities associated with this phase of Mech. Engineering		2	15	450	9000	
8. All facilities connected with the Manufacturing and Materials phase of Mech. Engineering		5	17	850	12700	1650
9. All facilities connected with Automotive, including Combustion Research		5	9	450	2750	1000
Totals	57	29	168	18000	29750	2650

Total space 50,400

a. This space is that which is over and above the space presently occupied by Mech. Eng. on North Campus. It is anticipated that present occupancy will be retained. Regular classroom space is not included herein.

Table 22 - Space Requirements for Meteorology and Oceanography by 1976

	Number of People					Space Required (sq. ft.)		
				Students				
	Faculty	Academic Research	Non-Academic	Grad.	Under-Grad.	Confer.	Lab.	Special
Faculty Offices	12					1850		
Lecturers & Teaching Fellows	2			3		420		
Dept. Admin. & Secretaries	1		3			750		
Dept. Library & Study Area			1			150		800
Special Classroom Conference Rooms						450		1200
Shops			3			250		2000
Research Assts				18		1080		
Assts in Research				18		720		
Lab A - Large - Scale Meteorology			1	5	15	15	1600	
Lab B - Air-Sea Interaction							600	
Lab C - Cloud & Precip. Physics		1		5	8	120	800	
Lab D - Hybrid Computer		1	3			400	1000	
Lab E - Meteor. Instrument (teach)							650	
Lab F - Meteor. Instrument (research)		1		2		120	900	
Lab G - Instrument store & repair			1			50	450	
Lab H - Wind Tunnel Room							600	
Lab I - Atmos. Chemistry		1		9	22	150	800	
Lab J - Rotating Fluids				5	15		600	
Storage Space								2000
Totals	13	6 12	1265	65	60	6660	8000	6000

Total Space 20,660

Revised 6/6/66

Table 23 - Space Requirements for Naval Architecture and Marine Engineering

	Staff			Students		Space		
Item	Academic	Research Academic	Non-Academic	Under-grad	Grad	Office	Lab.	Other
Total Personnel	16	4	8	170	40			
Staff Offices	16					2580		
Dept. Office						300		
Conference						300		
Secretarial			6			900		
Research Engr.	6					960		
Research Asst.	15					900		
Student Quarterdeck						300		
Design Rooms							4800	
Wet Labs							2000	
Shops								1000
						6240	6800	1000

Total Space 14040

Table 23a - A Summary of Space Requirements for the Department of Naval Architecture and Marine Engineering

June 6, 1966

Students and Staff

Undergraduate Students	170
Graduate Students	40
Academic Staff	16
Teaching Assistants	5
Departmental Secretaries	4
Research and Shop Personnel	20

Space

These staff and student members can be translated into the following space requirements for the year 1976:

1. Main Campus

	sq. ft.	
a) Shops and Model Basin	12,400	(existing)
b) Additional research staff space	1,000	(existing)
c) Counselling office	150	

2. North Campus

a) Four research staff offices	1,072	(existing)
b) Wave tank and water tunnel laboratory	6,000	
c) Academic staff offices (16)	2,400	
d) Graduate students and teaching assistants (13)	700	
e) Secretarial offices (3)	600	
f) Departmental office (2 rooms)	600	
g) Conference room and library	600	
h) Two or three small laboratories	3,000	
i) Model shop--primarily a wood working shop with some machining and instrumentation capacity	1,000	

j) Machine shop--in combination with other departments. Our work is light. A shop containing the normal machine tools would suffice. The only special piece of equipment we would need would be a profiling or computer controlled milling machine to make hydrofoil shapes and propeller models.

k) Instrument shop--in combination with other departments.

Table 24 - Summary of Space Requirements for Nuclear Engineering

Item	Faculty	Staff Non-Academic	Students	Space Office	Space Lab	Other
Faculty Offices	26			4070		
Secretarial		5		750		
Post Prelim. Grad. Stat. Offices			50	3000		
Dept. Adm.	1	2		1000		
Instructional Labs					5000	
Shops		4				2750
Student Shop						600
Computation						1000
Plasma Lab			8		2000	
Solid State & Mat.			8		2000	
Subcritical Lab			4		1200	
Scintilation Lab			3		800	
Reactor Coolant Lab			7		2000	
Mossbauer Lab			3		800	
Neutron Meas. Lab			5		1600	
Analog Comp. Lab					400	
Critical Lab			7		2000	
Vande Graaf Lab			10		3200	
Totals	27	105	11	8820	21000	4350

Total Space 34170

6/9/66

Table 25 - Space Requirements for English Department

Space to be used for	Number of People Academic	Non Academic	Square Feet Per Unit	Total Square Feet
Faculty Offices at One full-time, or Two half-time teachers per office	53 (full-time or equivalent)		120	6360
Chairman's Office			200	200
Secretaries, Mail, Reception		3	133	400
Conference Rooms - 2			200	400
Storage and Files - 1			100	100
Reproduction - 1			100	100
Recording Room - 1			100	100
Totals	53	3		7660 sq. ft.

ENGINEERING LIBRARY

The present Engineering and Transportation Library occupies the third floor and part of the fourth floor of the Undergraduate Library Building--a space of 26,170 square feet. On the North Campus, the Phoenix Library now housed in the Phoenix Building, with 810 square feet, should be included in the Engineering Library. Likewise, the Institute of Science and Technology collections should be considered for the Engineering Library, 4515 square feet.

The location of the Library is very important in its performing the intended function. Preferably, the Library for each group of people should be within no more than five minute walking distance within the same building. The use of the Engineering Library by the faculty in East Engineering Building decreased to a small fraction of its previous use when the Library was taken from the third floor of that building and placed in the new Undergraduate Library Building. The Department of Chemical and Metallurgical Engineering felt obliged to assemble their own collection for commonly used materials. It will be very difficult to place the Library within the above stated distance of faculties of the College, but every effort should be made to include as many faculty within this reach.

Libraries are undergoing a rapid change and are thought of as information storage and processing centers today. Within ten years, many library functions will be automated and it is quite possible that the use of the library can be carried out via a central computing facility. This service when established would remove part of the disadvantage of not having the library immediately at hand. It would, however, generate the need for a considerable amount of new space not now present in the Library.

Information Processing Services

With the automation of the Library, there will be need for space to carry out the initial processing of information which is sent to the central computer and information system. Also, there would be need for a group of consoles for students coming to the Library to make searches. Although such searches could be made by computer consoles scattered throughout the Campus, there would be students who would go to the Library to see the original works and they would need to have a console at hand in the Library facility.

Space Needs

The space needs for the Engineering and Technology Center Library are given on Table 26. The replacement of present services total 65,107 sq. ft. while the estimate for new information processing activities and carrels to serve research personnel total 8560 sq. ft. for a total of 73,667 sq. ft.

The Engineering Library should be integrated with the Center for Engineering and Technology to make it accessible to the largest number of faculty and students. Placement of the Library outside of the Center would be a great waste in that much time would be consumed in transit by students and faculty who do use it and the usefulness of the Library would be only a fraction of that which would be provided by a centrally located facility. It would be very desirable to be possible to go from the office and classroom areas to the library without going out of doors.

Table 26 - Space for a Library to Serve the Engineering and Technology Center in 1976

Seats	38,178 sq. ft.	
Stacks	22,651	
Administrative work	4,278	
Sub Total		65,107*
Carrels		
Faculty 12 at 80	960	
Student 100 at 40	4,000	
Information Processing		
Console Area 40 x 40	1,600	
Preparation	2,000	
Sub Total		8,560
Total		73,667 sq. ft.

* University Library Space Projections August 23, 1965

CLASSROOM SPACE

The classrooms in the College are in a common pool and every effort is made to obtain maximum utilization of space. It is estimated that on the average, a classroom is used 29 hours per week at peak enrollment, i.e., the Fall Term. Currently, there are 40 classrooms used for students beyond the first two years and 37 rooms used for the first two years. Some large lecture sections use space outside the College.

With almost a doubling of enrollment predicted at the 3rd and 4th year level and a doubling of graduate enrollment as well, some 75 classrooms will be needed. As each department moves, the classrooms needed to serve the teaching for the classes taught by their faculty should be provided. Table 27 gives the distribution of classroom sizes and total space indicated for the projected enrollment.

The estimate of needs is based on using the normal size classrooms 29 hours per week and the larger (>80) ones 20 hours per week. The average class enrollment will be 50% of seating capacity. In many classes, the blackboard space is the criterion for its size rather than the seating capacity. During examinations, under the honor system, students take alternate seats. Many classrooms are used for meetings and lectures. Such utilization does not appear in the usual report of degree of occupancy of the seats in classrooms.

Various departments have indicated special needs for services in classrooms such as computer conduit, electrical power, and demonstration units. Such facilities would be planned at the time the classrooms are allocated for construction to serve the several departments.

Table 27 - Classroom Needs for College

(Not including first and second year students)

Number of Rooms	Seating Capacity	Seats
36	40	1440
12	25	300
12	60	720
8	80	640
3	120	360
2	240	480
1	350	350
		4290

Total space computed at 12 sq. ft./seat = 51,480 sq. ft.

TYPES OF LABORATORY FACILITIES

Planning of engineering laboratories can be a time consuming effort, and even then the person who uses the room some 10 years after it was planned may not be satisfied. Also, great expense can be caused by providing maximum flexibility by providing every possible service, few of which are ever used. It is assumed that each department finally will specify the laboratories which they need. The reports herein are intended to give general specifications for all laboratories while some have given rather complete information.

An effort was made to establish three general types of laboratories which could be specified during this planning stage. The General Purpose Laboratory was one with both electrical facilities and water in one area of the laboratory. The Chemical Laboratory was intended to provide water and sewer throughout the room and such items as hoods. The Dry Electrical Laboratory was designed for electrical experiments, and did not include water and sink services.

The specifications for these three types of laboratories are given. Some of the departmental reports refer directly to these specifications while others do not.

Chemical or Wet Laboratories

This category might be described as a chemical laboratory in which typical chemical laboratory units can be installed, throughout the room. To service such laboratory units throughout the room, provision must be made for the following services to the units:

- Hot and cold water to all units
- Distilled water
- Acid Drains
- Compressed air (100 psi) to all units
- Gas to all units
- Sanitary sewer for multiple sinks
- An individual hood duct
- 110 and 220 volt power, 15 kva through laboratory distribution box
- Linoleum or tile floor
- Telephone line and data link to Computing Center

<u>General Purpose Laboratory</u>

This category is intended to describe a laboratory in which a combination of units for experimental work are involved. One chemical laboratory unit can be installed and other laboratory benches with electrical connections would be appropriate. Such a laboratory would have:

Normal electrical (110) and 220) power, up to 15 kva in individual distribution box
Sanitary sewer, hot and cold tap water, gas, and compressed air available in only one location in the laboratory
Telephone conduits and Data link to Computing Center
Linoleum or tile floors
A good electrical ground system

This laboratory differs from the chemical wet laboratory in that only one sewer connection is available instead of multiple connections, no hood duct is installed and no distilled water or acid drains are provided.

<u>Dry Electrical Laboratory</u> (2-21-66)

1. All power to the laboratory (except for normal lighting circuits and wall outlets) shall be supplied through a standard main distribution box located in the room and provided with proper thermal overload breakers. The type of distribution box shall be left to the discretion of those requiring it.
2. 115 and 230 volts, 60 cps, single and three phase with a 30 KVA capacity shall be available at the distribution box.
3. Workbenches shall be available. The type and arrangement of the workbenches shall be left to the discretion of the departments requiring them.
4. 4" x 4" ducts running the entire length of all walls and located at a height which provides convenient access at workbench level shall be provided. The type and number of connections between the main distribution box and other outlets in the room shall be left to the discretion of those requiring them.

5. The laboratory shall be provided with 3-prong, parallel-space, polarized wall receptacles for 115 volts, single phase, 60 cps with ground in the form of a plug mold or equivalent. The plug mold shall run the entire length of all walls and shall be at a height which provides convenient access at workbench level. The plug mold shall also be provided at the workbenches. Outlet spacing shall be 1 foot. Power to the plug mold shall be supplied through the distribution box and proper thermal overload breakers and a switch to activate the plug mold shall be provided. Loads shall be evenly distributed among the phases.
6. Total power capacity for the plug mold shall be approximately 18 KVA or 150 amperes. The plug mold shall consist of six separate sections and each section shall have a capacity of 3 KVA or 25 amperes. Each section shall have a thermal overload breaker.
7. The power to the lighting circuits shall be separate from that described above.
8. A blackboard shall be provided at one wall at the end of the room. It should not be on the wall facing the windows.

This laboratory <u>will</u> <u>not</u> have:

1. D.C. Voltages or 440 volts, 60 CPS.
2. Running water.
3. Compressed air.
4. Natural gas.
5. Electrical shielding.
6. Chemical sinks, hoods or exhausts.
7. Special air conditioning.
8. Dark curtains.
9. Projection screen.

<u>College-Wide Services</u>

Task groups were asked to consider college-wide services such as reproduction and photographic services, machine shops, electronic shops, dispensing services, etc. In general each department wishes to retain its own shops and their requests have included space for them. In some areas central facilities may be indicated, but until the arrangements of the departments are understood, little progress can be made in such consolidation.

To allow for such general service areas beyond space requested by departments the following items are included:

	Sq. Ft.
Photographic and Reproduction	1,000
Dispensing of supplies	1,000
General Machine and Electron Shops	2,000
Educational Aids, Projection, etc.	2,000
Total	6,000

FIRST AND SECOND YEAR STUDENTS

By 1976, the projected enrollment of first and second year students is 1800, substantially the same as at present. Although a sizable freshman class is contemplated, the growth of the College by 1976 is expected to occur via transfers from other colleges. Curriculum adjustments are under consideration to ease this transfer and the mood of the people is believed to indicate greater use of local colleges for the first two years.

In the Fall of 1965, a brief study was made of whether the first and second year students should be transferred to the North Campus. It was agreed that it would be highly desirable to have all of the undergraduates located on the North Campus, with every effort made to minimize the requirement that students go to the main campus for courses. It was also agreed that the first and second year students would transfer after the professional departments have relocated. Thus, it will be some time before plans for the transfer would take place. The summary and recommendations of this study are given here.

<u>Summary and Recommendations Relative to Transfer of First and Second Year Students</u>

1. There is no clear cut answer as to whether or not first and second year students should eventually be transferred to the North Campus for their primary instruction. Should first year students remain on the Main

Campus, it would be possible to have essentially all of their instruction there. Students in their first term of their second year would normally elect a few engineering courses, while students in their second term of their second year would be electing approximately half of their work from engineering departments. On the other hand, if students were transferred to the North Campus for their primary instruction during the first two years, a goodly amount of travel would be needed for these students to take courses on the Main Campus.

2. A review of instruction in Chemistry, Mathematics, Physics, and Engineering English indicates that all of this instruction could be carried out on the North Campus with current plans, excepting for students taking Chemistry, in which case it would be necessary for them to transfer to the Main Campus for a one-half day combined recitation-laboratory session.

3. While we, in this document, are addressing ourselves to first year and second year students, it should be appreciated that if students started their program on the Main Campus, some might well change their primary place of instruction to the North Campus at the end of three terms, others at the end of four, and possibly some at the end of five, depending upon their program and elections.

4. It is the consensus in the College that the transfer of first year and probably second year students to the North Campus for their primary instruction should await the moving of the professional departments to the North Campus with their third year, fourth year, and graduate groups. On a time scale, this means that planning for the moving of first and second year students would take place no sooner than six years and more likely some eight or ten years hence.

5. It is recommended that plans for the North Campus be developed with an allocation of a site which could be used for first and second year instruction and a gross square footage be included in the plan. However, it will be necessary to maintain space for the instruction of first and

second year students on the Main Campus until all of the departments have moved. A center should be maintained on the Main Campus for communication and administration of the programs for these students. As the space for the professional departments is constructed, the needs for the first and second year students should be reviewed for at that time new needs may have arisen.

The English and Engineering Graphics faculties in the College are interrelated to instruction of the first and second year students. To a lesser degree as a fraction of their total effort, the Department of Engineering Mechanics carries out instruction for second year students. Most departments give one or two courses for this group of students.

The space required for moving all instruction for the first two years to the North Campus would include classrooms, drafting rooms, and complete office space for all faculties. The space for classrooms and drafting is as follows:

37 classrooms at 40 seats at 12 sq.ft./seat	=	17,800
6 drafting rooms at 1100 sq. ft.	=	6,600
Office space for English and Engineering Graphics	=	10,200
total		34,600 sq. ft.

These classrooms include space for mathematics but not for physics, chemistry, or other courses in L.S. and A. In 1964-65, there were 750 student-course elections outside the College from the first and second year students beyond Chemistry, Mathematics, and Physics. Such elections would need to be studied to see how many sections of L.S. and A. courses might be held on the North Campus.

AUDITORIUM

There are several times a year when an auditorium with a seating capacity of 1000 to 1200 could be very useful in the program of the College of Engineering. The assembly of the several classes in the College, Honors Convocation, and an occasional outstanding speaker would provide the occasion when an auditorium of this capacity would be very useful. It is appreciated that the frequency of use by the College by no means provides the justification for such facilities. On the other hand, a statement concerning the proposed North Campus concert hall has been reviewed. It is believed that such a concert hall could serve the College needs for the above occasions in a fine manner and the use by the College would therefore be an added reason for its construction.

NEED FOR NEARBY COMMERCIAL ESTABLISHMENTS

When the faculty of the College of Engineering contemplate moving to the North Campus, and they have just returned from the bookstore, the bank, and the drug store on the corner of South University and East University, they are reminded that there are needs of a commercial nature near the North Campus which should be arranged or guided by the University. The establishments which are most frequently used are the bank, the drug store, the bookstore, the barbershop, and the photographic store. The North Campus planning group for the University no doubt has already considered land use to accommodate such establishments. The faculty of the College of Engineering consider such services to represent an important part of their daily needs. Such establishments should be close enough so that the travel time will be relatively small and hopefully trips to such stores can be made in transit to and from the University.

NEXT STEP

A summary of the square footage needs for the Engineering and Technology Center was given on page 8, showing some 700,000 net, 1,200,000 gross square feet.

With the included information, a general site plan should be prepared for housing the various groups. When the general location of the various departments has been established and the overall plans made, it would be well to refine the departmental requests in order of the priority given to erecting the buildings.

The first groups to move to the North Campus will be building facilities before the full demand predicted for 1976 is at hand. Therefore it may be necessary to build only 75 - 85% of the total space requested initially and plan some later additions or wings to complete the total. However, all facilities which are essential to operating the departments should be included, with extra faculty offices and research space the likely items to be delayed or used temporarily by others.

There should be an element of an adaptive system in the building plans. Both the enrollment figures in specific areas and the nature of the work will require a reconsideration of needs at the time each new addition to the Engineering and Technology Center is made.

Priority

Since several departments already have a considerable amount of activity on the North Campus, such departments are anxious to complete the moving of their department. It would be very helpful if a large block of funds could be made available within a relatively short period of 4 to 6 years so as to accomplish the move for all the professional departments. Possibly matching Federal grants will assist in such a plan. To take advantage of such funds, it is necessary that the full building program and space plans be ready for submission.

Preparation of the Report

Many persons have had a part in the preparation of this report. Dean Gordon J. Van Wylen in September 1965 asked Professor Donald L. Katz to assist him as coordinator for North Campus Planning and they jointly are responsible for this report. Individual portions and the departmental reports in the appendix were prepared by others.

DLK

6/16/66

Appendix

Departmental Reports

Individual reports have been prepared by the several departments and groups involved in planning. Some uniformity to space requests were directed, such as use of faculty office space no larger than 30% at 200 sq.ft., 50% at 150 sq.ft., and 20% at 120 sq.ft. Likewise, a uniform office size for teaching fellows, doctoral students, etc., at 60 sq.ft. was used. Secretarial offices at 150 sq.ft. per person are expected to include files and reception area.

These requests have been transmitted as submitted. The only control was in the setting of projected student enrollment for 1976 and in a general reviewing of the projected faculty.

Contents

11 February 1966
Revised June 1966

Aerospace Engineering Department - North Campus Planning Report

1. Program Statement

Aeronautical Engineering at The University of Michigan goes back to 1911 when the students constructed a small wind tunnel in the West Engineering Building and also constructed and flew their first glider. In 1915, the first course, "Theory of Aviation" was taught by Professor Felix W. Pawlowski. This was the first undergraduate course in Aeronautical Engineering in the United States. The first Bachelor's degree was awarded in 1916. The Daniel Guggenheim Foundation awarded $78,000. in 1926 for our first large wind tunnel and for the Daniel Guggenheim Chair of Aeronautics. The department was established in 1930. The work was broadened into space technology in the period after World War II and the alumni include Astronauts Edward H. White and James A. McDivitt. This department activated a Rocket Launch Site on the Keweenaw Peninsula and fired a series of five "Arcas" rockets in 1964.

The Department of Aerospace Engineering is concerned with the application of advanced concepts in science and mathematics to the further development of aviation and space technology. This application is laid upon a solid foundation of courses in mechanics, physics, mathematics, chemistry, thermodynamics and related areas. Its role includes education and research in gasdynamics, structural mechanics and aeroelasticity, flight mechanics, vehicular guidance and control, and in the application of this work to aerospace system design and engineering. The increasing speed range and complexity of aircraft and the increasing utilization of outer space have brought new and heavy demands upon the aerospace engineer and the instructional and research programs are responsive to these needs.

Graduate work in gasdynamics includes advanced work in compressible, viscous, high-temperature and low-density fluid flow, turbulence in fluids, magneto-fluid dynamics and plasma-dynamics, atmospheric and space propulsion, and combustion. This work relates directly to high-speed flight and space reentry systems. In mechanics of flight the performance and control of both aircraft and space vehicles are analyzed. Space vehicles are considered in both drag-free space and in planetary atmospheric entry. Guidance and control of aircraft and space vehicles utilize background material in automatic control and random processes. Structural mechanics includes advanced work in high-temperature effects, structural dynamics and matrix analysis of complex configurations.

Our research program is concentrated largely in the areas of atmospheric sciences, gasdynamics, flight mechanics, instrumentation, structural mechanics, and aeroelasticity. The major efforts in the atmospheric sciences are devoted to investigations in air composition and structure up to altitudes of 1000 kilometers, and to investigations of the meteorological significance of infra-red radiative processes in the atmosphere. In gasdynamics the program covers a wide area of specialties from subsonic to hypersonic flow, high temperature and low density flows, magnetogasdynamics and plasma dynamics, flow stability, turbulence, dynamic stability of bodies, air- and space-craft and missile control devices, and propulsion devices. The experimental facilities, in atmospheric sciences and in gasdynamics, are located in our present North Campus Laboratories. Research in mechanics of flight and control includes methods of trajectory optimization, vehicle control systems, guidance, space communication, manual-control, and simulation of flight. Current research in structural mechanics is concerned with the structural dynamics of large flexible satellite systems. In aeroelasticity, theories are being developed for the panel flutter of cylindrical shells.

Foreseeable future trends in aerospace education and research will be largely in the areas and will require continued updating of courses and laboratory equipment coupled with moderate staff expansion relative to our graduate work.

2. Number of Students, Faculty, Non-academic

Our present and projected personnel requirements are listed below. It should be pointed out that our present complex of laboratories and research personnel on the North Campus are independent of this study. We are concerned here with the staff and space on the main campus in the East Engineering Building which would have to be accommodated in the proposed new building.

Department Enrollment and Staff

	Present	Projected (1976)
Aerospace (undergraduate)	287	340
Aerospace (graduate	97	151
Information and Control (graduates)	44	74
Professors	25	43
Teaching Fellows	18	26
Secretaries (East Eng.)	6	12
Technicians	6	12

3. Departmental Offices

Chairman (office and conference room)			500 sq.ft.
Professors (43) with one office each			6750 sq.ft.
Secretaries (12) with six offices	6 x 300	=	1800 sq.ft.
Teaching Fellows (26)	13 x 120	=	1560 sq.ft.
Pre-doctoral students (40)	20 x 120	=	2400 sq.ft.
Conference rooms (2)	2 x 300	=	600 sq.ft.
	Total		13,610 sq.ft.

We have no special needs in the above office space but would prefer an arrangement whereby professors and secretaries and conference rooms are grouped for ready access. We plan to have desk space for some of the 76 pre-doctoral students in our existing laboratories and therefore have specified only 20 small offices in that category.

4. Laboratories and Special Facilities

Our needs here are primarily in small, flexible laboratory units as follows:

Small Laboratories

Structural Mechanics (3)	3 x 600 =	1800 sq.ft.
Propulsion (1)		600 sq.ft.
Aerodynamics (2)	2 x 600 =	1200 sq.ft.
Planetary and Space Science (1)		600 sq. ft.
Guidance and Control - Aero (2)	2 x 600 =	1200 sq.ft.
Information and Control Engineering (4)	4 x 600 =	2400 sq.ft.
	Total	7800 sq.ft.

The structural mechanics laboratories (3) are needed to carry on our undergraduate and graduate instruction and research work. They will contain small static and dynamic test set-ups for thin-wall, light-weight structural elements. One of the laboratories will be used for undergraduate instruction, one for graduate reserach, and one for faculty research. (Estimated use: ten sections of undergraduate students per term plus six graduate students.) We will also need 1000 sq.ft. in a "large structures" laboratory with high ceiling (16 ft.) and heavy walls for our large compression-tension testing machine and our drop test rig. This could be in some other building and combined with other departments, but would preferably be adjacent to these small laboratories.

The propulsion laboratory will be used primarily for undergraduate laboratory experiments such as fluid mass flow rates, friction effects on fluid flow, properties of gaseous combustion and the performance of small jet reaction devices. (Estimated use: ten sections of undergraduate students per term.) This small laboratory will supplement our existing Propulsion Laboratory Building on the North Campus.

The Aerodynamics Laboratories (2) will house principally our small table-top experiments in fluid mechanics (water tunnel, rotational flow, fluid mappers, and small wind tunnels). We estimate ten sections of undergraduate students per term. These two small laboratories will supplement our existing Aerodynamics Laboratory Building on the North Campus. We would also need a space of approximately 26 ft. x 100 ft. for our low-turbulence research tunnel on the fourth floor of East Engineering Building. Inasmuch as it requires the use of expensive measuring devices already available in our present North Campus Aerodynamics Laboratory, we suggest consideration of a small extension of the west wall for this purpose.

The Planetary and Space Sciences Laboratory will be primarily for graduate students working this area. It will include bench-size experiments on the evaluation of infra-red and ultra-violet sensors, electron density measuring devices, and a small computation area with electronics calculator. Estimated usage: 15 graduate students per term.

The six laboratories for "guidance and control" and "information and control" will be discussed as a group. These laboratories consist mainly of analog and hybrid computers to simulate the dynamic response of various systems. There will be both bench-top analog computers and larger console equipment of 5-6 ft. in height. There will also be control system hardware and test instruments. Estimated use: 24 laboratory sections per semester, of which 6 would be undergraduate students and the remainder graduate students. In addition, about 25 graduate students would be doing thesis work. These laboratories should also have a data link to the Computing Center.

All of the above laboratories should have approximately 600 sq.ft. of floor area. This will allow enough space for up to half a dozen laboratory experiments on benches or tables as well as room for 15 or more chairs and a blackboard so that laboratory lectures can be presented. The benches should be located around the perimeter of the room with separate stools at each bench, or, alternatively, small movable tables with suitable stools should be provided. At least 15 running feet of blackboard is needed. Windows are not necessary. Storage cabinets (preferably not under the benches) are needed in ample quantity.

The following services should be provided:

a. A sink with hot and cold water.
b. Compressed air (100 psi).
c. Gas and individual hood duct (for the aerodynamics and propulsion laboratories).
d. 115 volt line power consisting of six 20-amp systems with separate circuit breakers located in the laboratory for each system. Also, 220-volt power is desirable.
e. Either floor or overhead channels for additional power distribution.
f. A good electrical ground system.

The design room (1000 sq.ft.) should provide for 20 drafting tables (3 ft. x 6 ft.) for undergraduate design work. This is needed to handle 40 students per term on required undergraduate design courses.

A small departmental library room of 250 sq.ft. is needed to house journals, books, and Government publications being received by the department for staff use.

5. Services and Shops

Our shop requirements are as follows:

Area - 4000 sq.ft.
Power - 110 V. ac and 220 V. ac (overhead and wall)
Lighting - normal shop lighting, 100 f.c. minimum
Air-conditioned
Special facilities:
Ceiling height - 12 ft. minimum
Compressed air, gas, water (hot and cold)
Vented hoods (paint room and welding room)
Stainless steel double sink
Floor drains
Shop office for supervisor
Metal-working, wood-working and electronics areas

6. The above requirements comprising a total of 26,660 sq.ft. would allow us to release all of our present space in East Engineering Building (18,000 sq.ft.). We will need to retain all of our present North Campus space (42,000 sq.ft.). A careful study of these estimates will indicate that we plan a more efficient utilization of the total space. This is primarily due to having all of the available space in close proximity on the North Campus.

7. Site location. The department laboratories in aerodynamics and propulsion were among the first engineering buildings to be constructed on the North Campus. Since their erection in 1954 we have maintained a continuous program of undergraduate laboratory instruction, graduate thesis work and research on the North Campus. This complex was augmented by the Research Activities Building in 1961 (devoted completely to our High Altitude Engineering laboratories) and the Space Research Laboratory in 1965 (occupied in part by this department).

In order to make the most efficient use of our facilities and time we feel that this department should be one of the first to move to the North Campus. All of our instruction is done at the Junior year level and above, with the exception of Aero 200. We desire close proximity to our present laboratory facilities in order to alleviate or eliminate transportation problems for the staff and students. It is estimated that our overall productivity would increase at least 20% if a well-integrated arrangement of laboratories, offices and classrooms could be provided on the North Campus. A desired location for this department would be in the immediate vicinity of our present complex of laboratories.

Closely related departments are Engineering Mechanics, Electrical Engineering, and Mechanical Engineering, if several departments are considered for the same building.

8. Classroom Space. We have no special classroom requirements but would like to emphasize the importance of having each classroom adequately equipped for visual aids (pull-down screen, black-out curtains, convenient outlets).

9. Time schedule. As noted in item 7, we desire an early moving date due to the severe split in our present activities. We presently occupy more than twice the area on the North Campus as we do in East Engineering Building.

Submitted by: W. C. Nelson
Chairman

Summary of Space Requirements
for
Aerospace Engineering Department (1976)
North Campus Planning Report

Department Offices		
Chairman (office and conference room)	500 sq.ft.	
Professors (43) (12 x 200, 21 x 150, 10 x 120)	6750 sq.ft.	
Secretaries (12) (6 x 300)	1800 sq.ft.	
Teaching Fellows (26) (13 x 120)	1560 sq.ft.	
Predoctoral students (20 x 120)	2400 sq.ft.	
Conference Rooms (2) (2 x 300)	600 sq.ft.	
		13,610 sq.ft.
Small Laboratories		
Structural Mechanics (3) (3 x 600)	1800 sq.ft.	
Propulsion (1)	600 sq.ft.	
Aerodynamics (2) (2 x 600)	1200 sq.ft.	
Planetary and Space Sciences (1)	600 sq.ft.	
Guidance and Control - Aero (2) (2 x 600)	1200 sq.ft.	
Information and Control Engr. (4) (4 x 600)	2400 sq.ft.	
		7,800 sq.ft.
Supplementary Facilities		
Design Room	1000 sq.ft.	
Library	250 sq.ft.	
Shop	4000 sq.ft.	
		5,250 sq.ft.
	Total	26,660 sq.ft.

NOTE: The above summary is based upon this Department retaining its present space on the North Campus. The requirements listed are for the new building.

Department of Chemical and Metallurgical Engineering
1976 North Campus Requirements

S. W. Churchill
L. H. Van Vlack
February 1966
Revised June 1966

The Department of Chemical and Metallurgical Engineering has a long history and tradition as one of the outstanding departments in the nation. Not only was it among the first to offer a course in Chemical Engineering, but it was one of the pioneers in developing doctoral work. Provision for space in the East Engineering Building in 1923 permitted an already active department to develop one of the outstanding graduate programs in the nation. As early as 1932, The University of Michigan had 80 graduate students in Chemical Engineering, representing some 30 percent of all the doctoral students in the nation. In the decade of 1950-60, the Department granted about 10 percent of the doctorates in Chemical Engineering, with the Massachusetts Institute of Technology the only comparable school. The Department was one of only eight in the entire University rated as "distinguished" in the 1966 evaluation of the American Council for Education.

The Department has attracted unusual support from industry in the form of fellowships because of its outstanding reputation. In 1965, 20 industrial fellowships were awarded to our students. The textbook by Badger and McCabe and the later book on Unit Operations written under the leadership of the late Dean G. G. Brown demonstrated the leadership of the Department in undergraduate education.

Each of the chairmen of the Department has been elected to the presidency of the American Institute of Chemical Engineers--a unique record. The current faculty members are very active professionally and widely in demand as consultants.

The late Edward DeMille Campbell, the director of the Chemical Laboratory from which the Department of Chemical Engineering evolved, was a pioneer in metallurgy. The American Society for Metals has honored him with a lectureship in his name. The late Alfred E. White organized the American Society for Metals and was one of the outstanding metallurgists in the nation. An emphasis on metallurgy was always present in the Department, and in 1935 the name of the Department was changed from Chemical Engineering to Chemical and Metallurgical Engineering. In 1952, a degree in Materials Engineering was added. Thus, the Department's activities cover a full spectrum from purely Chemical Engineering, with many staff members having overlapping interests. All of these programs depend upon a background in chemistry, and thus differ from the other curricula of the College.

From this base of high-level activity over a long period of time, the Department does not expect its graduate program to grow as much as the newer programs in the College. Most faculty members in the Department are already supervising as many research projects and graduate students as they can handle. Only as the faculty expands with the gradual growth in the undergraduate enrollment does the Department expect to expand.

Both the graduate and undergraduate programs in the department provide a balance of theoretical and applied work. For example, our doctoral students are required to demonstrate their competence in solving a practical engineering problem involving design and economic evaluation, in addition to their course work and fundamental research. This additional competence of our doctoral students is widely recognized in industry.

I. Long-Range Trend

Although the Department of Chemical and Metallurgical Engineering does not foresee any drastic changes in its programs during the next decade, it does expect to push major trends which have been evolving.

Process dynamics and computer applications are currently receiving, and will continue to receive, special emphasis in Chemical Engineering. These, as well as other chemical engineering activities, require that we make a rapid advance in the incorporation of instrumentation and control procedures within our chemical engineering curriculum.

A similar advance must be made within the metallurgical area; specifically, in obtaining and using modern tools and equipment for analytical and research activities. Unfortunately, we are lagging behind our former position of pre-eminence in Metallurgical Engineering, primarily because other schools have overtaken us in space, equipment, and facilities for research and graduate instruction.

Our department has taken a position of leadership in undergraduate materials instruction and should continue to maintain this position. With its broad capabilities in chemical processing and materials engineering, our department has a unique opportunity to put the state of Michigan in a leading position in materials processing. This potentiality can be best realized with a strong Department of Chemical and Metallurgical Engineering.

II. Students and Staff

The growth in undergraduate enrollment in Chemical, Metallurgical, and Materials Engineering is expected to be proporational to the growth in undergraduate enrollment in the College. Based on an assumed College enrollment of 3900 in 1976 and a continuation of our present proportion of 12%, undergraduate enrollment (excluding freshmen) is estimated to be 355 within the Department in 1976. The division of students between these three curricula is not important at the sophomore and junior levels because all three curricula have nearly the same course and laboratory requirements. We must expect to handle 75 students each term in these common courses. At the senior level, however, there has usually been a split into about 70% Chemical, 20% Metallurgical, and 10% Materials Engineers. Thus, our senior laboratory courses in Chemical Engineering, which are seldom taken by other students, should be able to handle 50 students per term. There is a large overlap between the Metallurgical and Materials Engineering curricula so that most of the courses in these two areas are taken by 30% of the students. In addition, a number of Chemical Engineers take materials courses as professional electives, making it necessary for many of the metallurgy and materials courses to handle 25 or more students per term.

The growth of graduate enrollment is expected to be slightly less than that of the College as a whole since we already have an active graduate program. We predict that we will have 205 students by 1976, a 56% increase from 1966, compared with an estimated 100%

increase for the College. This is a shift from the Department's granting 11% of the College's M.S.E. degrees at present to approximately 8% ten years hence. Our current level of 30% of the College's Ph.D. degrees will drop to 20% in 1976 when the enrollment expands to more than 2100 graduate students. Despite this percentage drop, there will be an increase in actual numbers, and provision must be made for this increase.

Our current and projected academic staff are listed in the following table. Both the present and projected figures are consistent with national studies made by Professor A. X. Schmidt of N.Y.U. of faculty requirements to meet undergraduate and graduate enrollments in chemical engineering.

Projected Staff

	Present	1976
Full Professor	21	22
Associate Professor	7	9
Assistant Professor	8	10
Instructor	2	4
Emeritus	1	3
Visiting	2	3
Totals	41	51

Our department currently employs only 10 people in the category of research personnel. It is estimated that there will be need for about 15 in 1976. It should be noted that both of these figures are below typical numbers when the volume of research activity is compared with other departments. The Department of Chemical and Metallurgical Engineering has made the practice, however, of selecting research activities which are geared to faculty and graduate students participation, with a minimum of other research personnel.

The Department currently has 20 nonacademic employees. This number is insufficient to meet our current needs. Furthermore, we expect a student increase of more than 50% during the next decade. Therefore, it is anticipated that our 1976 requirements will be 38 nonacademic employees.

III. Department Offices

The faculty of the Department wants to avoid dispersion upon moving to North Campus. The strength and reputation of the Department has resulted in large measure from a high degree of interaction of teaching and research activities among the chemical, metallurgical and materials engineers. Thus, the Department wants to have its facilities contiguous. Within the Department, however, the faculty feels that its staff offices should be dispersed throughout the general laboratory areas in clusters of three, four or five offices. This dispersion has the advantage of placing the faculty member close to his research and his graduate student activities. Within this dispersion, however, there should be a clustering of three, four and five offices so that secretarial and related services may be available locally.

III-A. Faculty Offices — 7950 $ft.^2$

Clusters of 3, 4 and 5 dispersed throughout the Departmental area.

15 offices	200 $ft.^2$
25 offices	150 $ft.^2$
10 offices	120 $ft.^2$

III-B. Secretarial Offices (11) — 1650 $ft.^2$

1 office for each 3 Senate rank faculty member located with the clusters of 3, 4 and 5 faculty offices. Filing and student waiting space is included.

III-C. Central Departmental Office — 1200 $ft.^2$

Departmental records, accounts, duplicating services, and related activities. Five secretaries. Provision for movable partitions.

III-D. Conference Rooms — 1400 $ft.^2$

5 rooms of 200 $ft.^2$ dispersed within the department
1 room of 400 $ft.^2$ adjacent to the Central Department office.

III-E. Seminar Room — 1000 $ft.^2$

Folding doors to divide room in half, computer plug-in, built-in movie screen, dark curtains, public address system, air conditioning.

III-F. Student Society Rooms 800 ft.^{2}

The Department activities include two student professional societies which are active in providing their own professional programs and student leadership.

2 rooms, 400 ft.^{2} each connecting to seminar room (III-E.)

water and drain; 15 KVA each

III-G. Department Reference Room 800 ft.^{2}

Reference materials have been contributed to the Department for faculty use and form a very significant contribution to faculty study. To be located adjacent to the Central Department office.

Laboratory work has traditionally been considered one of the most important activities of the faculty and students of our Department. Past experience has shown that active participation in research work and in the teaching of laboratory courses contributes markedly to maintaining faculty effectiveness and competence. Likewise, laboratory courses and directed research work afford students an opportunity to learn of the stimulating and interesting aspects of current work in various subject areas, besides providing experience in actually doing significant engineering experiments. All of our faculty members are encouraged to conduct research programs, and many are nationally and internationally recognized for their accomplishments. All graduate students, including those at the Masters level, are required to do research or to teach. Undergraduate students who show interest and ability are encouraged to enroll in research or design-oriented laboratory courses or to work as student research assistants with individual faculty members or advanced graduate students.

Two types of laboratories are needed to fulfill our departmental requirements: small research laboratories which will be allocated to individual faculty members and their graduate student associates and undergraduate student assistants, and larger laboratories nominally designed for housing specific equipment and facilities needed for teaching particular laboratory courses. Since most of our faculty conduct research in the subject areas in which they teach, most of these latter laboratories will be used for research when classes are not acutally in session. In all cases, past experience indicates that it is highly desirable to have groups of laboratories and faculty office clusters intermingled so that faculty members can easily participate in their research programs and supervise the laboratories in which they teach.

Because of the particular nature and orientation of the laboratory work in our department, all our laboratories should have distilled water and rough vacuum lines besides the facilities specified above for the various types of laboratories (wet chemical, general purpose, dry electrical). Certain laboratories should have acid and/or floor drains, as indicated, and safety showers should be available within 50 feet of every laboratory. While the recommended 15 KVA of electrical power will be adequate for most of the small research laboratories, certain of these and many larger laboratories will require substantially more power. In general, it is recommended that 15 KVA be provided for each 200 $ft.^2$ of laboratory space, with provisions for concentrating it where necessary.

The specific laboratories needed by the department are described in detail in sections IV-A. through IV-LL. below.

IV-A. Faculty and Graduate Research Laboratories 29,100 $ft.^2$

Our department has been a national leader in graduate research, having graduated more than ten percent of the nations Ph.D.s in chemical engineering during the decade from 1950 to 1960. Most of our faculty members and graduate students, and a considerable number of our undergraduate students, are actively engaged in research work. A number of small research laboratories, ranging in size from 200 $ft.^2$ to 400 $ft.^2$, are needed to house this research program. In general, these laboratories will be assigned to individual faculty members and their graduate student, so that the specific type of research project carried out in any one of them may change from time to time. The specific requirements, allowing for growth projected to 1976, are as follows:

30 Wet Chemical Laboratories of 400 $ft.^2$ each	12,000 $ft.^2$
25 General Purpose Laboratories of 400 $ft.^2$ each	10,000 $ft.^2$
35 General Purpose Laboratories of 200 $ft.^2$ each	7,000 $ft.^2$

IV-B. Chemical Thermodynamics Laboratory 1200 ft.^{2}

This laboratory will be used in an undergraduate course which is required of all undergraduate chemical, metallurgical, and materials engineers. This course is the foundation of our departmental course structure, and introduces our students to the engineering applications of thermodynamics to material and energy balances, cyclic and flow processes, phase relationships, and chemical and physical equilibrium. This course also provides students with introductory training in the use of precision instruments, and in the methods of designing experiments, collecting, evaluating, and analyzing experimental data, and of reporting experimental results.*

Usage: Eight 3-hour sections of 9 students per week. Two half days for preparation of experiments. Minimal research use.

Facilities: Wet chemical laboratory with duct for one hood and floor drains. 15 KVA.

IV-C. Rate Processes Laboratory

This laboratory is now being established in the Fluids building and will not go into the new building.

IV-D. Separation Processes Laboratory 800 ft.^{2}

One of the most important functions of a chemical engineer is to design processes for separating valuable product materials from other components of chemical reaction mixtures. This laboratory will be used for required and elective undergraduate instruction and research on topics in this field, including: column crystallization, normal freezing, zone refining, and thermal diffusion, plus related graduate research.

Usage: Six 4-hour sections of 9 students each per week. Two half days per week for experiment preparation. Facilities used for research except when undergraduate laboratory sections are in progress.

Facilities: Wet chemical laboratory with ducts for one hood, floor drains, and volatile disposal. 15 KVA.

* It differs from other courses in thermodynamics in the College by its emphasis on chemical transformations.

IV-E. Unit Operations Laboratory

This laboratory has been established in the Fluids Building and will not go into the new building.

IV-F. Process Dynamics Laboratory 1200 ft.^{2}

The chemical and metallurgical industries are leaders in the use of instrumentation and automation for controlling manufacturing processes. This laboratory will contain equipment for instruction and research on the measurement, control, and analysis of process variables in hydrodynamic, pneumatic, heat-exchange, and chemical reaction systems, including analog computer facilities for process simulation and modeling, and digital computer connections for process control. This laboratory differs from other college facilities in the same general field by its emphasis on chemical transformations and on the complex processing operations characteristic of the chemical and metallurgical industries.

Usage: Six 3-hour sections of 8 students each, and one half-day for preparation of experiments per week. Research activities when classes are not in session.

Facilities: Wet chemical laboratory of 1000 ft.^{2} with floor drains and computer plug-in, plus an adjoining general purpose laboratory of 200 ft.^{2} for analog computers. 30 KVA.

IV-G. Polymers Laboratory 1200 ft.^{2}

Polymeric materials (plastic) are one of the three principal types of engineering materials, and this laboratory is essential for instruction and research at both the graduate and undergraduate levels in the chemical synthesis, physical properties, and engineering applications of these materials.

Usage: Three 3-hour sections of 12 students, plus two half-days for preparation of experiments per week. Used for research at other times.

Facilities: Wet chemical laboratory with one hood plus acid and floor drains. 30 KVA.

IV-H. Physical Ceramics Laboratories 1200 ft.^{2}

Ceramic materials are becoming increasingly important in electrical and high temperature applications as well as for more familiar uses. Adequate space and facilities are required for expanding graduate and undergraduate programs in this subject.

Usage: Three 3-hour sections of 8 students each per week. Two half-days for experiment preparation. Research activity except when the undergraduate sections are in progress.

Facilities: Wet chemical laboratory with ducts for one hood, acid and floor drains. 90 KVA.

IV-I. Furnace Room 1200 ft.^{2}

This is a necessary service facility for all undergraduate and many graduate courses in metallurgy and ceramics. In addition it is used on virtually all doctoral research programs, and on many sponsored research projects in materials and metallurgy.

Usage: 24 hours per day seven days per week.

Facilities: 200 KVA with flexible distribution services to various installations in the room. Floor drains. Gas air, water, and vacuum lines plus duct for hood at one location in the room.

IV-J. Physical Metallurgy Laboratory 1600 ft.^{2}

This facility is primarily for the physical property determination of metals and ceramics, including non-destructive testing, internal friction, damping capacity, hardness, etc.

Usage: Three 3-hour sections of 8 students each per week. One half-day for experiment preparation. Three days per week for research.

Facilities: General purpose laboratory Vacuum line. 30 KVA.

IV-K. Metal Preparation Laboratory 400 ft.^{2}

These facilities are essential to reduce engineering samples to a size for suitable examination by x-rays, metallography, electron probe, or any of the other examination method used to characterize materials.

Usage: Continuously.

Facilities: 30 KVA, water, floor drain, and hood duct. Vacuum line.

IV-L. Mechanical Metallurgy Laboratory 1200 ft.^{2}

This will house equipment for tensile, compression, and shear testing of materials, evaluation of their hardness, fatigue properties, wear resistance, and impact properties over a range of temperatures and other service conditions.

Usage: Two 3-hour laboratory of 8 students per week. Research activities except when the undergraduate sections are in progress.

Facilities: General purpose laboratory
Vibration pad for tensile machine. 120 KVA. Vacuum lines.

IV-M. Chemical Metallurgy Laboratory 800 ft.^{2}

Activities: Slag-Metal equilibria, Sieverts analyses, vacuum fusion analyses, spectrochemical analyses, wet chemical analyses.

Usage: Two 3-hour sections of 8 students each per week. One half-day per week for preparation of experiments. Research activities during the balance of the week.

Facilities: Wet laboratory with one hood. Distilled water, acid drain, and floor drain. 60 KVA. Vacuum lines.

IV-N. X-Ray Diffraction Laboratory 800 ft.^{2}

Crystal structure studies by x-ray diffraction methods are used for determining the arrangement of atoms and molecules in mettals, ceramics, and even polymers, and provide fundamental information for understanding the relationships between structures and properties of engineering materials. Courses in crystallography, x-ray techniques, and radiographic procedures are offered at both the graduate and undergraduate levels, and the facilities of this laboratory are used on most doctoral thesis and sponsored research projects in metallurgy and materials engineering.

Usage: Four 2-hour sections of 6 students each per week, plus two half-days per week for preparation of experiments. Used for research at other times.

Facilities: General purpose laboratory of 700 ft.^{2} plus a 50 ft.^{2} lead-lined room for radiographic equipment. 45 KVA with voltage regulated to 1% for x-ray diffraction equipment, plus 15 KVA general service. Air conditioning. Computer plug-in.

IV-O. Electron Microscopy Laboratory 1000 ft.^{2}

The mechanical properties of many modern alloy and ceramic materials are the result of structures which are so fine they cannot be resolved by optical microscopy. Our department's electron microscopes, which are capable of providing resolutions and magnifications up to 1000 times as great as optical microscopes, are used extensively in doctoral theses and sponsored research projects on such materials as well as in teaching a course on electron microscopy which is taken by students studying in other engineering departments and in departments of natural, biological, and physical sciences throughout the University.

Usage: Two 4-hour sections of 8 students each plus two half-days per week for servicing and maintenance of instruments. Available for research on 24 hour basis at other times.

Facilities: Three general purpose laboratories of electron microscopes. One general purpose laboratory of 300 ft.^{2} for general specimen preparation. One general purpose laboratory of 150 ft.^{2} for ultramicrotomy and special specimen preparation techniques. One darkroom of 100 ft.^{2}. Air conditioning in all rooms. Floor drains in electron microscope laboratories and darkroom. 30 KVA with voltage regulated to 1% for electron microscopes. 15 KVA for other uses.

IV-P. Metallography Laboratory 1200 ft.^{2}

This laboratory should be composed of two sections of 600 ft.^{2} each, not necessarily located adjacent to one another, which will house facilities for photographically recording the microstructures of materials.

Usage: One section of the laboratory will have four 3-hour classes of 6 students each per week, two half-days a week for preparation; research will occupy the balance of the week, including Saturdays and Sundays. The other section of the laboratory will be reserved exclusively for research and will be in use all days of the week.

Facilities: Each laboratory should be subdivided so that it has a dark room and a microscope room of 150 $ft.^2$ each. The remaining area will be for polishing and etching. The Metal Preparation Laboratory (IV-K. above) should be adjacent to the undergraduate Metallographic Laboratory. The polishing and etching rooms should have wet laboratory facilities plus hood ducts, vacuum lines, and acid drain. 30 KVA.

IV-Q. Biochemical Engineering Laboratory 800 $ft.^2$

Undergraduate and graduate instruction and research in fermentation and microbiology.

Usage: Two 3-hour sections of 10 students each per week. One half-day preparation time per week. Three days research time per week.

Facilities: Wet laboratory, distilled water, hood duct, acid drain, floor drain. Wash-down walls. Vacuum line. 30 KVA.

IV-R. Cast Metals Laboratory

Present facilities may be maintained in the East Engineering Building.

IV-S. Computation Rooms 1600 $ft.^2$

Instruction, discussion, and computation in the various laboratory sections which are in progress in adjacent laboratories.

Usage: Continuously available to various laboratory sections.

Facilities: Four rooms of 400 $ft.^2$ each, distributed among the other laboratories. Blackboard and computer plug-in.

IV-T. Computer Stations 1200 $ft.^2$

Usage: On call seven days a week as undergraduate and graduate students need the facilities.

Facilities: Four rooms of 200 $ft.^2$ each for individual student computation and problems. One room of 400 $ft.^2$ for group instruction and discussions in connection with computer problems. Computer connection, card punching equipment, a small analog computer, abacus, and blackboard in each room, plus video display in large room. These five rooms are to be distributed throughout the Department area.

IV-V. Precision Measurement Laboratory 800 ft.^{2}

Activities: Standardized and reference physical measurements. This laboratory is used as a service for the Chemical and Metallurgical Engineering Department, as well as for other units of the University.

IV-U. Mass Spectroscopy Laboratory 1200 ft.^{2}

Mass spectrometers are sensitive, versatile, accurate, analytical instruments that can be used to make qualitative identifications and quantitative determinations of most types of most materials by measuring accurately the masses of the atomic and molecular fragments produced when the material is volatilized and ionized, and the resulting ions passed through appropriate magnetic and electrostatic deflecting fields. Analyses can be made in major components as well as trace constituents of mixtures. Our department now has an analytical mass spectrometer suitable for use with petroleum products and other easily volatile organic materials, and an isotope ratio mass spectrometer used for comparing the relative abundance of different atomic isotopes. It is hoped to obtain a modern instrument for analysis of solids in the near future. These instruments are operated by a full time analyst with the help of student assistants, and their services are available to faculty and students throughout the University.

Usage: Full-time research.

Facilities: General purpose laboratory, with air conditioning, located adjacent to instrumental analysis laboratory. 45 KVA with voltage regulated to 1% for mass spectrometers. 15 KVA for general use. Connection to digital computer facility.

Usage: Full-time research availability.

Facilities: General purpose facilities, plus distilled water. Air conditioning. Vacuum line, 30 KVA.

IV-W. Instrumental Analysis Laboratory 1200 ft.^{2}

This laboratory will house apparatus for infra-red absorption spectrometry, gas chromatography, and similar analytical instruments used for faculty, graduate, and undergraduate research, and for the instruction of students in the operation, maintenance, and application of such instruments.

Usage: Full-time research availability.

Facilities: G neral purpose laboratory with duct for one hood and air conditioning. 15 KVA, with voltage regulated to 1% for instruments, plus 30 KVA for general uses.

IV-X. Vacuum Analysis Laboratory 400 ft.^{2}

Activities: An important factor affecting the properties of molten metals is their gas content (oxygen, nitrogen, and hydrogen in particular). Special equipment and facilities are required for their analysis. Related chemical metallurgy activities would benefit.

Usage: Full-time research.

Facilities: General purpose laboratory. 45 KVA. Adjacent to Chemical Metallurgy laboratory above.

IV-Y. Chemical Analysis Laboratory 800 ft.^{2}

Activities: Analytical chemistry for the research in chemical processing and materials engineering.

Usage: Full-time research availability.

Facilities: Wet laboratory with two hoods and two acid drains, plus vacuum line and floor drain.

IV-Z. Thermodynamic Properties Laboratory 800 ft.^{2}

Research on thermodynamic properties, such as heat capacities, enthalpies, vapor processures, etc. of fluorohydrocarbons.

Usage: Full-time research.

Facilities: Wet laboratory with one hood, distilled water, vacuum line, and floor drain.

IV-AA. Electron Probe Laboratory 800 ft.^{2}

An electron microprobe x-ray fluorescence spectrometer is an extremely versatile instrument capable of nondestructively making qualitative and quantitative chemical analyses of areas of solid specimens less than 1 micron in diameter. This instrument has been at the top of the priority list for equipment for our Department for the past two years, and will be available for research and instructional use to all departments of the University.

Usage: Full-time research.

Facilities: General purpose laboratory with air conditioning. 15 KVA with voltage regulated to 1% for probe, plus 15 KVA for general uses.

IV-BB. Electrochemical Research Laboratory 800 $ft.^2$

Fuel cells and related electrochemical systems are receiving increasing attention within the Department. Research would involve future energy conversion studies.

Usage: Full-time research.

Facilities: Wet laboratory with one hood and acid drain. 30 KVA.

IV-CC. Semiconductor Materials Research Laboratory 800 $ft.^2$

Activities: Chemical processing of semiconductor materials.

Usage: Full-time research.

Facilities: Wet laboratory, plus additional facilities available in an electrical laboratory, plus hood. Vacuum line. 60 KVA.

IV-DD. Liquid Metals Research Laboratory

To be located in the Fluids Building in a high bay area.

IV-EE. High Temperature Metallurgy Laboratory.

Should be moved to North Campus from the Argus Building when funds are available.

IV-FF. Multiphase Fluids Laboratory

Already established in Fluids Building.

IV-GG. Biochemical Research Laboratory

Already established in Fluids Building.

IV-HH. Heat Transfer Research Laboratory

Already established in the Fluids Building

IV-II. Plasma Research Laboratory

To be located in the Fluids Building when space is available.

IV-JJ. Enthalphy Measurement Laboratory

Already established in the Automotive Lab.

V. Services and Shops

V-A. Glass Blowing Shop 600 $ft.^2$

Activities: This will serve as a central glass blowing facility for North Campus. A glass blower is currently an employee of the Department.

Facilities: General purpose laboratory plus hood and gas booster. Air conditioned. 30 KVA.

V-B. Department Stock Room 1000 ft.^{2}

Activities: This stock room may be combined with stock room requirements of other departments. However, this space beyond the 1000 ft.^{2} required for the College.

Facilities: General purpose laboratory facilities in one corner of the stock room.

V-C. Instrument Maintenance 600 ft.^{2}

Activities: For maintenance of instruments and equipment in the Department. The Department currently employs one electronic technician in this area and should add two more. This facility could be combined with requirements of other departments; however, it should be readily available for the electronic technicians associated with this Department.

Facilities: Electrical laboratory plus water and drain.

V-D. Metals and Materials Shop 1000 ft.^{2}

Activities: Work space for shop and student personnel for maintenance of Departmental equipment and preparation activities which cannot be handled in the individual laboratories.

Facilities: Water and drain. 30 KVA. Vacuum line.

V-E. Chemical Engineering Shops 1000 ft.^{2}

Activities: Work space for shop and student personnel for maintenance of Departmental equipment and preparation activities which cannot be handled in the individual laboratories.

Facilities: Water and drain. 30 KVA. Vacuum line.

V-F. Graduate Student Shop 800 ft.^{2}

Activities: Shop facilities for graduate students so that they may perform some of their own sample and equipment preparation and avoid the necessity of employing a machinist for simple jobs. This shop could be combined with a similar facility for one or possibly two adjacent departments. It should be sufficiently close to our Department, however, so that it will be used.

Usage: Full-time availability for students (and for faculty members).

Facilities: Water and rain; power for medium size lathe, drill press, band saw, hack saw, etc. Located adjacent to the Metals and Materials Shop. 30 KVA.

V-G. Equipment Storage 1000 $ft.^2$

Activities: Occasionally used equipment and equipment with anticipated future use will be stored in this area. We find that it is mandatory that such storage space be made available so that equipment which is not in current usage is under control and not subject to deterioration in general laboratory space. This should be located adjacent to the Departmental Stock Room.

Facilities: Shelves for storage.

VI. Site Location and Special Requirements

As indicated earlier, the faculty of the Department wants to occupy continguous areas within any new building when they move to the North Campus. Within the Department, however, the faculty offices should be dispersed in clusters of three, four, or five among the laboratories of the Department. Laboratories IV-I through IV-Q plus IV-y, IV-AA and IV-CC should be in the same general vicinity. Laboratories IV-C, IV-E, IV-G, IV-H, IV-R, IV-V, IV-W, IV-X, IV-Z and IV-BB should be in the same general vicinity. The shops and service facilities should be located between the two general areas just cited.

F. E. Richart, Jr.
February 25, 1966
Revised 6/6/66

North Campus Facilities - Civil Engineering Requirements

1. Civil Engineering has been described as the research, planning, design, development, and responsibility for construction of facilities and systems in the public interest. Consequently, our attention will be focused on problems associated with a continual growth of the population and its requirements. This includes such specific problems of urban development as the transportation systems, the water requirements (fresh water to the population and polluted water disposal), flood control, highway design, structural design of bridges, buildings, and other shelters to protect people from the natural phenomena of rain, wind, and earthquakes. Because we must deal with the entire system, beginning with the preliminary surveys, through the basic concept of design and planning all the way to the final construction, it is necessary that our program be oriented towards thinking in terms of systems, and that we make increasing use of computers to obtain actual numerical solutions. The civil engineer must live in the real world and construct against the forces of nature in many instances where he has inadequate data or knowledge of the magnitude of the natural forces. Consequently, the judgment required in his daily activities must be based upon scientific principles, experience, and a thorough knowledge of the materials with which he must work.

The program in the Department of Civil Engineering is directed towards a strong graduate program, emphasizing the specific fields of hydraulics and hydrodynamics, structural dynamics, soil mechanics and soil dynamics, sanitary engineering and water resources engineering, and transportation engineering. Strong doctoral programs are being developed in these areas supported by M.S. programs in construction engineering, municipal engineering and geodetic engineering. The undergraduate program will necessarily have more required courses than some other disciplines because we feel it is necessary that a civil engineer have a broad background in the physical and mathematical disciplines upon which his future professional activities will be based. For example, our courses in hydrology, geology, soil mechanics, and reinforced concrete, just to name a few topics, are introduced to assure that the student has an appreciation of some elements of the physical environment in which he must conduct his activities.

Consequently, in order to improve our instruction in material behavior and our calculation of system responses, we will need additional and better laboratory facilities than are at present available.

2. Tables I and II indicate the approximate number of students and the Civil Engineering staff estimated for 1976.

TABLE I

ESTIMATED STUDENT ENROLLMENT IN CIVIL ENGINEERING-1976

Freshmen	64
Sophomores	58
Juniors	75
Seniors	68
Total undergraduate	265
Total graduate	150
Total students	415

TABLE II

ESTIMATED CIVIL ENGINEERING STAFF-1976

Section	Prof.	Assoc. Prof.	Asst. Prof.	Lect., Adj., Instr.	T.F.	Res. Asst.	Secy.	Techn.
Construction	2	1		3	1	4	1	
Geodesy	2	1		1	3	4	1	1
Hydraulics	3	1	1		3	10	2	2
Sanitary	3	2	1	3	4	16	3	3
Soils	2	2	1		2	8	2	3
Structures	4	2	2		2	16	3	3
Transportation	3	1	1	2	3	12	2	2
C.E. Dept.	1						3	1
Total	20	10	6	9	18	70	17	15

*Among the 15 technicians there will be one woodworker, three machinists, two electronics technicians, two computer technicians, and seven general technicians.

3. Departmental Offices. Senior staff members should have offices with a minimum size of 200 sq.ft. Table III indicates the suggested office size for the different categories of staff, the number of each category and the estimated total space requirements.

TABLE III

OFFICE SPACE REQUIREMENTS

	Space(ea.)	No. Staff	Total Space
Dept. Office		1 + 3 Secys.	1000
Professor, Assoc. Prof.	200 sq.ft.	29	5800
Asst. Prof., Lect., Instr., Adjunct Prof.	150 sq.ft.	15	2250
Teaching Fellow, Res. Assistant	60 sq.ft.	60	3600
Secretaries	150 sq.ft.	14	2100
C.E. Dept. Conf. Room	800 sq.ft.	Staff	800
2 Seminar Rooms	2 at 300 sq.ft.	Staff	600
		Total	16,150

(Note: Space for technicians included in shop and lab. areas.)

4. Laboratories and special facilities. The special utilities and equipment needed for all laboratories are summarized in Table V, and the description of each laboratory and its purpose are given under separate sub-headings.

TABLE IV

ESTIMATED LABORATORY SPACE REQUIREMENTS-1976
(net sq.ft.)

Laboratories	Teaching	Research	Supervised Design Lab.	Total
Soil Mechanics	1,200	2,800	--	4,000
Hydraulics	900	650	900	2,450
Structures	2,000	6,000	900	8,900
Sanitary				10,932
Traffic-Transportation	500	600	900	2,000
Geodesy	3,600		1,800	5,400
Construction			900	900
Shops	1,500	1,000		2,500
			Total	37,082

TABLE V
SPECIAL UTILITIES AND EQUIPMENT FOR LABORATORIES

	Soil Mech., Teaching	Soil Mech., Research	Hydraulics, T	Hydraulics, R	Hydraulics, Design	Structures, T	Structures, R	Structures, D	Sanitary, T	Sanitary, R	Transp., T	Transp., R	Transp., D	Geodesy, T	Geodesy, D	Construction, D	Shops
Hot and Cold Water	x	x	x	x		x	x		x	x	x	x		x			x
Compressed Air	x	x		x		x	x		(1)	(1)		x					x
Special Sewerage	x	x					x		x	x							x
Ventilating Hoods	x	x							x	x							x
Special Air Cond.		x								x							
Gas	x	x					x		x	x							x
Telephone		x		x			x	x		x		x			x		x
Data Link to Computing Center	x	x		x		x	x	x	x			x		x	x	x	
110 volt Power	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
220v. 3∅ Power						x	x		(2)	(2)							x
440v. 3∅ Power																	x
Crane							x										
Local Elevator										x							
Special Storage Tanks										x							
Constant Head Tank										x							

(1) Sanitary laboratory requires separate compressed air supply

(2) Sanitary laboratory requires precise voltage control on 220v. supply.

LABORATORY REQUIREMENTS IN NEW BUILDING

The Soil Mechanics Teaching Laboratory (wet laboratory) of 1200 sq.ft. will be designed to accommodate up to 25 students at any one time. It is anticipated that this laboratory will be occupied every afternoon of the week and that in the mornings it will be used in preparation for the laboratory sessions, and for some undergraduate student research. Consequently, these laboratories will handle about 140 students per week and will be used approximately 70% of the time.

The Soil Mechanics and Soil Dynamics Research Laboratory (wet laboratory), estimated at 2800 sq.ft., will be used for doctoral student research and sponsored research under the direction of the faculty. This space will be in use 100% of the time by approximately 12 doctoral students and at least four of the staff. Actually, a total of 4,000 sq.ft. for soil mechanics is a minimum size compared to other major universities doing comparable graduate teaching and research. Some schools have allocated up to 18,000 sq.ft. for this purpose.

Hydraulic Research - 650 sq.ft. This room is to take the place of Room 140 W.Eng. which is used to house three graduate students and the experimental apparatus for research dealing with pulsatile flow. This is the portion of our transient flow research program which has applications to blood circulation and thus enters into the area of bio-engineering.

STRUCTURES LABORATORY SPACE REQUIREMENTS-1976

A total of 8,900 sq.ft. of structure laboratory space will be required in 1976 exclusive of the 20,000 square feet that are proposed for an independent laboratory to be located adjacent to the proposed highway engineering laboratory.

Teaching Laboratory, 2,000 sq.ft.

The teaching laboratory will be used to give the students a basic understanding of structural behavior and to acquaint them with modern techniques employed in experimental analysis of structures. The principal equipment in the laboratory will be a universal testing machine and a structural floor system with provisions for anchoring loading abutments and loading jacks. This laboratory facility will be used for scheduled course laboratory sessions nearly every afternoon. The course sections using the laboratory will contain about twenty students each. Mornings will be used for setup time and for research use of the laboratory equipment.

Research Laboratory, 6,000 sq.ft.

The research laboratory will provide space and facilities for graduate students to conduct the experimental portions of their thesis research. The principal testing equipment will be fatigue testing equipment and dynamic loading devices. This laboratory will also be equipped with a structural floor system to provide anchorages for abutments and loading jacks for static tests. This laboratory must be large enough to permit occasional tests of sub-assemblies of structural components. Part of the floor system will be isolated from the main floor to minimize vibration transmission from dynamic experiments. The laboratory will be in more or less continuous use by doctoral students. On the average it is anticipated that eight or ten experimental investigations will engage the research laboratory.

Design Laboratory, 900 sq.ft.

The design laboratory facilities will be used for scheduled design courses every afternoon. Morning use of the laboratory will be for individual students working on design studies or design projects. The principal facilities required are desk calculating equipment and a computer terminal with graphical input-output equipment.

SANITARY ENGINEERING FACILITIES ON NORTH CAMPUS

Problems in water pollution are of mounting concern to many state and federal agencies and, indirectly, to all individuals. This is especially true in Michigan, where the water resources of the State have been the basis of much of the daily interest of large segments of the population.

Water supplies and disposal of waste waters, both domestic and industrial, are the major interest of sanitary engineers who need special training beyond the routine undergraduate engineering they all receive. The specialized work lies in areas of biology and chemistry of dilute aqueous solutions and in systems engineering. Unless competent research engineers are turned out in far greater numbers than ever before, our country will lose its present position in the pollution race, let alone make progress in improving the situation.

Our proposed North Campus facility has been designed with the thought of maximum efficiency and utility. This space was first designed as a separate building in 1946 and has been resubmitted in different forms over the past 20 years. Our objectives have never changed over the years. We desire to expand to the level where student competition, discussion of mutual problems, and productivity are sufficiently high to assure a constant flow of quality product (both graduates and research). This we feel will come only with four to five staff members, 15 doctoral students, and 25 to 30 master's students. This level we consider a critical mass.

Space Justification

(1) Doctoral Research (1500 sq.ft.) (Use 100%)

Ten doctoral research labs are envisioned. These will be shared by two men each. Fifteen doctoral students, three or four teaching assistants and one or two post-doctoral fellows.

(2) Office Space (720 sq.ft.)(Use 100%)(12 at 60 sq.ft./student)

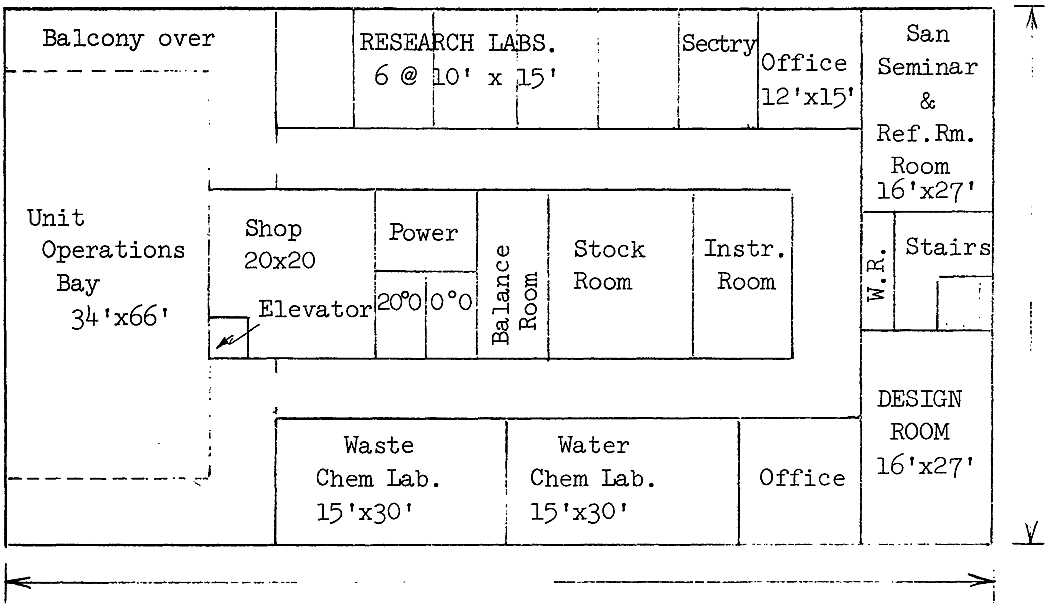
Four offices are asked for. This is extremely marginal but perhaps some flexibility is possible with one dry laboratory.

(3) Seminar Room and Laboratories

1 seminar and ref. room (432 sq.ft. - 60-70% use)
1 design room (432 sq.ft.) (50% use)
2 dry laboratories (864 sq.ft.) (60-70% use)
(One dry laboratory to be equipped with desk computers and data link to computer center.)
(One dry laboratory to be equipped for solids wastes work)

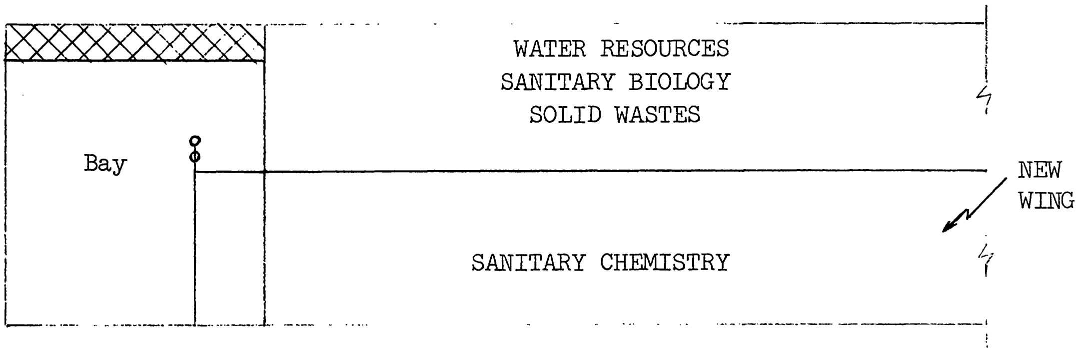
Appendix-Civil Engineering

SANITARY & WATER RESOURCES ENGINEERING FACILITIES



FIRST FLOOR PLAN

(Also Typical of 2nd Floor)



ELEVATION

SPACE REQUIREMENTS

4 - Offices @ 180	= 720	Unit op. Bay	= 2244
1 - Class Room	= 432	4 Wet Labs.	= 1800
3 - Dry Labs	=1296	Service Area Shops etc.	= 2640
2 - Sec. Offices	= 300		
10 - Doctoral Research Labs	=1500		
		total	=10932 sq.ft.

(3) Seminar Room and Laboratories (continued)

4 wet laboratories (1800 sq.ft.)(70 to 100% use)

(One Sanitary Chemistry
Sewage and Industrial Wastes)

(One Sanitary Chemistry
Water and exotic chem. analysis)

(One water bacteriology laboratory)

(One Plankton org. and limnology laboratory)

1 unit operations bay (2244 sq.ft.)(100% use)

This bay will be set up for treatment operations and also for full-time research projects)

(4) Service Area (2640 sq.ft.)(100% use)

This space will house all major equipment which can be used jointly by several groups. Spectrophotometers, gas chromatographs, balance rooms, walk-in incubators at 0°C, 20°C, and 37°C will be provided, stockrooms, desk space for three technicians, and a 20 x 20 tool room.

General Statement

The laboratory spaces and classroom spaces itemized above are intended to be an integrated operation serving 30 master's students and perhaps 20 visitors 50 to 70 percent of their time. The doctoral students and research will circulate around the teaching effort using the space in off-peak hours. The appendix of this report shows required services and a sketch of the space.

TEACHING, RESEARCH, AND DESIGN LABORATORIES FOR TRANSPORTATION ENGINEERING

Teaching Laboratory (500 sq.ft.)

This laboratory is used to demonstrate the currently used transportation design and control devices. It will be used an average of two afternoons each week by up to 20 students. Most equipment is electrical.

Research Laboratory (600 sq.ft.)

This laboratory is used for transportation engineering research. A dark cubicle is needed for photographic projection analysis. Up to 10 graduate students will use the facilities at a time. The usage will be primarily in the afternoon. Research equipment will be stored and calibrated in the laboratory. Computer console access is needed.

Design Laboratory (900 sq.ft.)

This laboratory is used for design by transportation engineering students. The class sizes will range up to 20 and formal class usage will be 3 afternoons each week. Students will work in designs individually during other hours. Drafting boards and storage space are needed.

LABORATORY REQUIREMENTS FOR THE GEODETIC ENGINEERING PROGRAM

The Geodetic Engineering program has three distinct phases:

1. Basic courses, required of all civil engineering students and service courses for architects and foresters.
2. Advanced courses, elected by undergraduate students taking the geodetic technical option. These courses may also be elected by graduate students in the master's program.
3. Research and special investigations, undertaken by graduate students for credit toward degrees, or for special projects for sponsored research.

Laboratories to cover these phases include:

a.	Equipment Storage and Issue Room (needs power, gas, compressed air)	1000 sq.ft.
b.	General lab for indoor assignments, drafting, computing, etc. Also to be used as briefing room for outdoor assignments	1800 sq.ft.
c.	Precision photogrammetric lab for stereoscopic plotting instruments, comparator, etc. Must be "clean" (air-conditioned) and vibration isolated	800 sq.ft.
d.	Small labs for special work assignments in connection with advanced courses or for research. Two required. No special equipment. Desk, large table	300 sq.ft.
e.	Cubicle for extended advanced or research computations, with one electronic desk calculator and large table	150 sq.ft.

Laboratories (continued)

f. Small photographic laboratory. For preparation of diapositive plates for stereo plotters, photo-theodolite, etc., and other operations incidental to photogrammetry. Requires temperature-controlled running water. 150 sq.ft.

g. Computing lab with 30 desk calculators and appropriate layout and working table space. Remote console for IBM/360. Also self-contained medium-sized electronic computer (IBM 1130?) and two small cubicles with one electronic desk calculator in each. 1200 sq.ft.

Total 5400 sq.ft.

Storage-Issue Room (a) and General Lab (b) will be needed to present Basic Geodetic Engineering (C.E. 262) to approximately 60 civil engineering and 30 forestry and architectural students in the fall term each year. Use 5 days a week (4 hrs. per day). Use for general photogrammetric lab (except precision instruments) and occasional field-associated operations for C.E. 263, 2 days a week in the winter term. (a) and (b) should be adjacent and (a) should have direct ground-level access to outside.

Precision Photogrammetric Lab (c) will be permanent location for high-precision stereoscopic plotters and micron comparator for advanced course-work and research in photogrammetry and geodesy. Estimated use several days per week by up to 10 students and research staff. Should be vibration-isolated (basement location) and "clean" as appropriate for high-precision optical-mechanical equipment. Air-conditioning required to maintain dimensional stability and calibration of micron comparator. Use photographic lab (f) in connection with this operation so it should be adjacent to lab (c).

Small labs (d) (10' x 15' each) required for special studies and research in geodesy and/or photogrammetry where material can be "laid-out" and remain undisturbed for extended periods. Use by 6-10 advanced students, full-time around the year.

Computation cubicle (e) to be used by all advanced students and research staff for great variety of non-production computations which are so varied as to be inefficiently solved on large computer or to make necessary numerical solutions of problems used to "de-bug" large computer programs. Use nearly full-time by students, faculty, research staff.

Computing Lab (g) to be computing center for C.E. Department, but with priority time for class and lab sessions as required for course in Basic Geodetic Computations (C.E. 263). Isolated remote console for IBM/360 and cubicles for individual computations by staff, advanced students, and research staff permits use of these facilities while class in session in large lab. Large lab in class use for 30 students 2 days per week, all year. Small facilities in use full-time.

SUPERVISED DESIGN LABORATORY FOR CONSTRUCTION
900 sq.ft.

This room is needed as work space for seniors and advanced students in Construction Engineering. Seniors will be working on assigned laboratory problems; advanced students will be doing research. The room should be equipped with two drawing tables, plan file, writing tables, two desk calculators, and an IBM time sharing console for the computing center computer. The lab would be opened 75 hours per week, would be supervised by a teaching assistant, and would serve 40 seniors and 30 graduates.

5. Services and Shops. The request of 1500 sq.ft. for shops associated with teaching and 1,000 sq.ft. for shops associated with research represent minimum working space for the 16 technicians anticipated ten years from now. This estimate is based on the assumption that there will be a central College of Engineering shop facility in the new building which will house machine tools and shop personnel for manufacturing special equipment. The shops for the Civil Engineering Department will be primarily for assembly, repair, and supervision of student projects. Several such shops will be distributed adjacent to the major laboratories.

6. The space now occupied which is to be retained is primarily the Civil Engineering space in the Fluids Building on the North Campus. We contemplate moving completely from East and West Engineering to the North Campus.

7. Site Location or Special Requirements. If it appears impossible* to secure a separate Structural Laboratory building adjacent to the proposed Highway Department Testing Laboratory building, then it would be necessary to locate the structures laboratory and related facilities on the ground floor of the proposed engineering building. The testing machines are necessarily heavy and bulky, and specimens to be tested require special handling equipment, overhead cranes, and easy access from the outside.

   A second requirement is that the Sanitary wing be constructed essentially as indicated in the drawing, for convenience of operation of the personnel involved in this activity.

   In general, it is anticipated that the new College of Engineering building will be located to the west of the present Fluids Building. This would make the activities of the Civil Engineering Department more accessible to the hydraulics personnel in the Fluids Building and to some of the highway materials people in the State Highway Testing Laboratory building.

   Generally, it would be preferable to have offices for the Civil Engineering Department near the structural laboratory which would necessarily be on the ground floor and not higher than the second floor.

8. Normal Classroom Spaces. It is estimated that we will need 13 classrooms in any one hour, and 42 classrooms in any one day.

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* 1. Alt. No. 1 - New separate Struct. Lab. - 20,000 sq.ft. + 2900 in new building.

2. Alt. No. 2 - "Make Do" in new building with 8900 + 6000 = 14,900 sq.ft. (to take care of concrete also)

3. Alt. No. 3 - "Make Do" in new building - 8900 sq.ft.

9. Time Schedule for Moving. At the present time there is no reason why the entire Civil Engineering Department couldn't be moved from East and West Engineering Buildings to a new facility at the same time. The entire Department could be moved during the first adjustment.

SUMMARY OF SPACE REQUIREMENTS FOR
CIVIL ENGINEERING DEPARTMENT

	No. of People Involved				Space (ft^2) Req'd (1976) New Building		
	Academic	Non-Academic	Undergrad Students	Grad. Students	Office	Lab	Other
Total Personnel	45	32	265	150			
Dept. Office	1	3			1000		
Faculty Offices	44				8050		
Teaching Fellows and Res. Assts.				60	3600		
Secretaries		14			2100		
Conference and Seminar Rooms					1400		
Shops		5					2500
			(classes) U and G	(res. spaces)			
Construction Lab.			70/wk.	0		900	
Geodesy Lab.		1	100/wk.	3		5400	
Hydraulics Lab.		1	75/wk.	5		2450	
Sanitary Eng.Lab.		3	50/wk.	19		10932*	
Soil Mech. Lab.		2	100/wk.	5		4000	
Structures Lab.		2	140/wk.	9		8900**	
Traffic-Transp. Lab.		1	20/wk.	4		2000	
	Grad. Stud. Work Stations			88			
			TOTAL SPACE		16,150	34,580	2,500
				TOTAL		53,230	

*Proposed as a separate wing.

**Required for teaching and Ph.D thesis research - in addition to the proposed 20,000 sq.ft. Structural Lab. adjacent to the Michigan State Highway Department Testing Lab.

6/7/66

PROGRAM AND SPACE REQUIREMENTS
OF
THE ELECTRICAL ENGINEERING DEPARTMENT

ELECTRICAL ENGINEERING DEPARTMENT
PLANNING COMMITTEE
March 4, 1966 - Revised 6/2/66

R. K. Brown
V. R. Burris
J. L. Cochran
B. A. Harrison
L. N. Holland
N. W. Navarre
G. I. Haddad, Chairman

I. PROGRAM STATEMENT

Electrical Engineering continues to be characterized by prompt utilization of the mathematical and scientific bases on which it has come to depend for advancing technology beyond the "obvious idea" stage. This need for advanced tools will expand as we move into new areas of research, development, and instruction involving the generation and control of information and energy, including computers, computation and data processing, communication and electronics, plasmas, solid-state devices and circuits, automation, instrumentation, radiation and propagation, space physics, electro-optics and indeed all facets of engineering systems.

Curricular changes are steadily evolving to embrace these many areas of relevant interest and concern. The influence of our large and growing graduate research program is constantly evident in our undergraduate offerings. The effect of this influence is to cause the bachelor's degree program to encompass more and more the invariants in electrical engineering education, with specialization in the frontier efforts coming at the graduate level.

Our graduates are in demand at all three degree levels and it is always stimulating to see the delivered performance of our "average" students on their chosen jobs. Graduate work is ever more important. Most of our doctoral recipients are going into teaching positions at other institutions. For these new engineering teachers it is particularly important that their standards be high, that they have been professionally indoctrinated and that their experiences as research assistants and teaching fellows be significant and substantial. This requires laboratory and classroom opportunities second to none and we propose that their inspiration should come from their meaningful experience in electrical engineering education at The University of Michigan.

II. CONCLUSIONS AND RECOMMENDATIONS

The space available at the present and its locations and the future space requirements of the Electrical Engineering Department are presented in detail in following sections of this report. Some general conclusions and recommendations are presented in this section.

Several problems exist at this time because of the lack of space and the location of the present space. It is shown in following sections that most of the research laboratories of the department where our graduate students are trained are scattered in various areas and are widely separated from one another and from the regular instructional facilities. This creates several problems which hinder the instructional process and make it less effective. These problems will become more severe in the future because of the anticipated increase in undergraduate and graduate student enrollment unless space is made available. The alternative of keeping student enrollment at its present level is not in line with the plans of this Department, the Engineering College and the University as a whole. Thus the only solution and the only way to prevent these problems from getting out of hand in the future is to provide adequate space.

It is the feeling of this Department that the most desirable, most efficient, and most economical way to satisfy its present and future requirements is to have a new facility, large enough to accommodate both teaching and research, and to have this facility located at the North Campus. The reasons for this are summarized below.

Appendix-Electrical Engineering

We feel that the research carried out by the Department is of fundamental importance to the teaching function, which is the education of engineers. Engineers are thinkers and doers and they must be trained in an environment of doing. Blackboards, offices and other areas are sterile in comparison to the stimulation and training given to students by an environment of research projects. Research is also of great importance to the faculty for it provides them with research opportunities for their scholarly development and enables them to stay abreast of new technical developments so that they may bring them to their classrooms. The present research space location detracts considerably from these objectives. An integrated research and teaching facility would provide this and would allow students to be exposed to and participate in many, not just one, aspect of the Department's research.

A single location would allow the usage for instructional purposes of equipment and facilities which are mainly available to the research laboratories at the present time. We feel that this alone would result in savings of hundreds of thousands of dollars in the long run, not to mention the great advantages gained for instruction.

Such a facility would bring about great savings in space and faculty time. At the present most members of the teaching faculty who are doing research occupy office space at the teaching and research locations. This is also true for teaching fellows. Because of the wide separation of these locations a great deal of time is spent commuting back and forth between them. A single facility would allow these people to occupy one office where they could always be found when needed.

An integrated research facility would allow sharing of equipment and facilities by the various laboratories and would result in great savings in space and equipment expenditures. It would provide an opportunity for the teaching and research faculty to work together for more effective cross fertilization. It would permit an effective joint effort on research programs requiring contributions from two or more department laboratories. The overlap in various research programs of the laboratories which presently exists may be ✓ eliminated by consolidated them. This would provide more depth in these areas and would place the Department in a much better position when competing for research funds with other universities. It would eliminate the competition among the laboratories themselves for space, equipment and research funds. Having an integrated facility would make it much simpler and more effective to tell the outside world about our research activities, and thus will enable us to recruit and retain outstanding faculty members and graduate students because the research activities of a department have a direct bearing on its image and reputation.

We feel that a new facility would be the most desirable and most economical way to satisfy the space needs of this Department. Because of its large graduate student enrollment this Department has and will continue to have a large research program. Since graduate enrollment will increase at a fast rate in the coming years our research space requirements will follow these trends and will also grow at a rapid rate. In order to maintain leadership in instruction and research we must have modern laboratory facilities. Because of the special requirements on space that may be used for our specialized laboratories many of our present buildings are completely inappropriate for this purpose and a great deal of expense is usually required to convert available space for such use. We feel that it is very unwise to spend money on old isolated buildings to provide the required space. For example, there has been some consideration given recently to relocation of a part of the Radiation Laboratory from one hangar at Willow Run Airport to another at an estimated cost of $100,000. We feel that this is an exorbitant price to pay to have one of the departmental laboratories, where several faculty members and students do their work, located fifteen miles away from the instructional facilities and twenty miles away from other parts of the laboratory. This is one example, and others like it have occurred and will most likely occur in the future because of our expanding program. We thus feel that it is in the best interests of the University, the Engineering College and this Department that any plans by the College for a move to the North Campus should consider moving departments with large graduate student enrollments and research programs first. Since the Electrical Engineering Department has and will have the largest number of graduate students who require a variety of modern research facilities for their training it should be the first department considered for such a move. As discussed in detail in a later section, our present space is not adequate for instructional purposes in many instances because of the large undergraduate student enrollment. This is even more reason for a new building which could be designed to satisfy these requirements.

The location of the building at the North Campus would place us in close proximity to the Institute of Science and Technology where several of our faculty members and students do their research and where many research programs are conducted which are of direct interest to the Department. This, we believe, would result in mutual benefits to both groups.

III. PRESENT AND FUTURE STUDENT ENROLLMENT

The present and future undergraduate and graduate student enrollment in the Electrical Engineering Department is summarized in Table 1, where it is compared to student enrollment in the entire Engineering College. It is shown that the percentage increase in undergraduates by 1976 will be approximately 51% and that for graduates will be 88%. The large increase expected for graduate students is due in part to a national trend for attainment of advanced degrees and in particular to the various graduate degree programs which are being planned by the Department. These graduate programs will certainly attract students from scientific disciplines other than Electrical Engineering.

The present ratio of graduate students is approximately 39% and this is expected to increase by 5% by 1976. The expected ratio of students in this department to the total college enrollment (excluding Freshmen) is 23% for undergraduates and 25% for graduates. The national average of Electrical Engineering graduate students as compared to the total Engineering students is approximately 35% and thus the expected number of students is certainly in line with the national trend.

IV. PRESENT AND FUTURE SIZE OF THE FACULTY AND NONACADEMIC PERSONNEL

The present and future size of the faculty and nonacademic personnel is shown in Table 2. This table does not include the academic research and supporting personnel of the various departmental research laboratories. These are presented and discussed in detail in a later section. It is expected that the increase in the professorial staff will be approximately 40% and that in the total faculty will be approximately 35%. These figures are certainly conservative when compared to the expected student enrollment.

Teaching fellows and assistants are and will continue to be a very important element in the instructional process. They are very capable and eager persons and contribute immensely to our undergraduate instruction. Since many of these students accept permanent teaching positions at other universities, this provides them with an excellent opportunity for self development and thus is an excellent form of training and instruction for them. There are presently 35 teaching fellows in the department and the expected increase is approximately 40% which is in line with the undergraduate student enrollment increase.

The supporting personnel consist of secretaries, instrument room supervisors, instrument maintenance and construction and shop supervision and maintenance. The departmental instruction relies a great deal on laboratory work, and design projects where students design and build various devices and systems. It is then essential that supporting personnel in these various areas be provided. Nothing needs to be said about secretarial assistance as this is fairly obvious.

Table 1.

Present and Future Student Enrollment

	1966	1976	% Increase	% of College* 1976
Undergraduate	449	680	51	23
Graduate	285	535	88	25
% Graduate	39	44	5	--

* Excluding Freshmen

Table 2.*

Present and Future Size of Electrical Engineering Faculty, and Nonacademic Personnel

	1966	1976	% Increase	% of College 1976
Professorial Staff	53	72	40	19
Total Faculty	69	90	35	19
Teaching Fellows	35	45	40	--
Secretaries	9	18	90	
Shop and Maintenance	4	6	50	

*The figures in this table do not include the academic research and personnel. These are given in Table 4.

V. NORMAL TEACHING SPACE REQUIREMENTS

The teaching space requirements are summarized in Table 3 and are discussed in detail below. This table includes the regular classroom and instructional laboratory space but does not include the research laboratory space requirements which, due to our large graduate student enrollment, are just as important as the regular instructional space. These space requirements are presented and discussed in a following section.

The regular instructional space requirements are divided into several categories and each category is discussed. The space requirements are based on the student enrollment and faculty size predictions shown in Tables 1 and 2. These are:

Appendix-Electrical Engineering

1. Office Space Requirements

The office space requirements are shown in Table 3. The way we arrived at this figure is consistent with the recommendation of the Engineering College, which we feel is well justified. Since our expected faculty size is 90 faculty members and 45 teaching fellows, the following are required,

27 offices at 200 sq.ft. per office	=	5,400
45 offices at 150 sq.ft. per office	=	6,750
18 offices at 120 sq.ft. per office	=	2,160
22 offices at 120 sq.ft. per office to accommodate two teaching fellows each	=	2,640
Secretarial offices including filing, reproduction, etc., for 18 secretaries	=	2,700
Total (Square Feet)		19,650

The increase in the office space required is due to the inadequate space available at the present and the increase in the size of the faculty. Our present faculty office space is very inadequate. Frequently three or more faculty members occupy the same office which is approximately 280 sq.ft. in size. This is not only inadequate as far as space is concerned but results in several inconveniences and waste of time for faculty and students. For example, a student finds it very difficult to talk to his instructor about a particular problem (academic or personal) when three other people are in the same office. When a student comes to talk to one of the instructors in this type of office the other instructors are interrupted. It is thus essential for both students and faculty members that each faculty member be located in a private office. Also, in order to keep men on our faculty of national stature and recruit such faculty in the future, we must be able to provide adequate office space for their library, files and many activities.

Since teaching fellows and assistants are and will continue to be a very important element in undergraduate instruction we must provide these people with adequate space. At the present time there is no office space available for them. This gives them a feeling of neglect, and more importantly, they are very hard to locate. It makes it very difficult for students to see them outside the classroom and for lecture and laboratory supervisors to find them when they are needed.

Appendix-Electrical Engineering

It is desirable that the offices be located in close proximity to the classrooms and laboratories. It is also preferable that the offices be located at outside walls of the building. The plan of having offices in clusters with adjacent secretarial space is desirable. The office doors should not be solid but have opaque glass windows. A blackboard in each office is desirable. It is also desirable to have a direct connection between the offices and the computing center.

Table 3.
NORMAL TEACHING SPACE REQUIREMENTS

	Available Space (Square Feet) 1966	Required Space (Square Feet) 1976	Number of People
Faculty Offices	5,000	14,310	90
Teaching Fellows and Assistants' Offices	0	2,640	45
Secretarial Offices including filing, reproduction, etc.	1,200	2,700	18
Classroom	15,250*	14,400	
Laboratory		22,250	
Department Administration and student counselling	1,220	2,800	5
Faculty Conference Rooms and Lounge	240	2,600	
Student activities study area and radio sta.	500	2,000	
Service areas, equipment storage and maintenance	2,470	4,800	5
Student and Faculty Shop	300	600	1
Computer Key Punch and remote control consoles	0	1,200	
Total	25,380	70,300	164

*At the present laboratories are also used for classroom instruction but they will be separate by 1976 since the laboratories will be used full time for laboratory instruction.

2. Classroom Space

The classroom space should be adequate to take care of the increased student enrollment. Our present space is particularly short on classrooms which can be used for large lecture sections. The larger rooms which are available are not suitable because of their design and result in severe acoustical and visual handicaps for the student. Thus we would like to have the following things taken into consideration in the design of classrooms.

a) Most of the classrooms should be of a size which will accommodate 30 - 40 students.

b) Some of the classrooms (3-4) should be large enough to accommodate 100 students.

c) Some of the classrooms (1-2) should be large enough to accommodate approximately 200 students.

d) All classrooms should have an adequate number of power outlets (especially at the front of the room) for convenient use of classroom demonstrations.

e) All classrooms should be provided with a movie screen and dark curtains.

f) The larger classrooms should have a built-in movie screen, projection booth and adequate electrical outlets and benches in the front of the room for lecture demonstrations.

g) Classroom and laboratory areas should be connected by a conduit to a Central Control and switching room to allow for the introduction of television input or output units whenever necessary.

h) It is desirable to have direct connections between the classrooms and the computing center.

i) It is desirable to have the classrooms with windows to the outside.

3. Instructional Laboratory Space

Laboratory space and equipment is of great importance to an Engineering Department. Aside from being thinkers, engineers must do and build things and thus they must be trained in such an environment. The laboratories do create such an environment and thus an engineering department such as ours must have adequate laboratory space to provide the best possible training for our engineers. Because of its nature, Electrical Engineering requires a great deal of laboratory work and we will be constantly revising our laboratories and introducing new ones in order to remain in the forefront and provide our students with the best possible training. The laboratory space available at the present time is inadequate and this hinders the instructional process in the existing laboratories and prevents the introduction of needed ones in new areas.

Because of the large number of students, laboratory instruction at the present time is performed mainly on a group basis, although some project-type laboratories do exist. With the increasing number of students it is anticipated that at the undergraduate level the group-type of laboratory instruction will continue to be employed. In this type of laboratory there are usually 12-16 students per laboratory section and these are usually divided into groups of 3-4 or more students per group. These four or more students perform an experiment on the same machine or setup. This policy of having four or more students trying to perform an experiment on one piece of equipment or the same setup is very ineffective and fifty percent of the students usually never have a chance to do any of the experimental work. One way of alleviating this problem would be to provide more equipment so that a maximum number of two students per group might be accommodated. This cannot be done at the present time because the space required to do this is not available. The laboratory instruction is usually carried out in 3-4 hour intervals and we would like to see our laboratory sections so arranged that we will have a maximum of 12 students in each one. Each section can then be divided into six groups of two students per group. We feel that this will aid the laboratory instruction immensely. Based on this a full-time use of the laboratory will accommodate 11 sections (including one on Saturday morning) or a total of approximately 130 students per semester. This is approximately the number of students that would have to be accommodated by 1976 by each of the required laboratory courses. For optional laboratory courses the laboratory room may be shared by two or more, unless the course is of the project-type where it would be in constant use for that particular course. Thus our laboratory space requirements are based on the above assumptions and on the assumption that the laboratories will not be employed for class instruction as is presently being done due to shortage of space. All of the laboratories cited below will be used 100% of the time.

A detailed description of the various instructional laboratories and their space requirements is given below.

a) EE-210, Circuits Laboratory

This is an introductory course that is taken by students in their sophomore year. It is mainly concerned with properties of Electrical Circuits and basic electrical instruments and measurements. It is a required laboratory.*

The space required for this laboratory in square feet = 1200

This should be a "Dry" Electrical Laboratory.

b) EE-316, Electrical Circuits and Electronics

This laboratory is a service course for nonelectrical engineering students. It is mainly concerned with properties of electrical and electronic circuits and is designed to satisfy the requirements of nonelectrical engineering students. The present number of students who take this laboratory per semester is approximately 150 and by 1976 this number will be approximately 230 and thus two laboratory rooms will be required.

The space required for this laboratory is two rooms at 800 square feet per room = 1600

The type of space should be a "Dry" Electrical Laboratory.

c) Science Engineering Laboratory

This laboratory will be used for the Electrical Engineering Laboratory courses offered to Science Engineering students. These include the Electromagnetics and Energy Conversion (EE-320) Electronic Circuits and systems (EE-337) and Electronics and Radio Communications (EE-438) courses. These are required laboratory

*A "Required Laboratory" is one which must be taken by students before they can graduate.

courses.

The space required for this laboratory in square feet = 800

This should be a "Dry" Electrical Laboratory.

d) <u>EE-330, Electronics and Communications Laboratory</u>

This is a required laboratory which is taken by Electrical Engineering students in their junior or senior years. It acquaints the students with various properties of electronic circuits and how they are employed in amplifiers, oscillators and other systems for the generation, amplification and detection of radio waves.

The space for this laboratory in square feet = 800

This should be a "Dry" Electrical Laboratory.

e) <u>EE-360, Basic Electrical Measurements</u>

This is a required laboratory that is taken by students in their junior year. It is concerned with precision measurements of various electrical parameters and acquaints the students with the various methods of precision measurements and the equipment used in these measurements.

The space required for this laboratory in square feet = 800

This should be a "Dry" Electrical Laboratory

f) <u>EE-381, Physical Electronics Laboratory</u>

This is a required laboratory and is usually taken by students in their junior year. Its purpose is to acquaint students with basic physical phenomena that are necessary in the understanding of vacuum tubes, display devices, plasmas and solid-state devices.

The space required for this laboratory in square feet = 800

This should be a "Dry" Electrical Laboratory.

g) <u>EE-421, Electromagnetic Fields Laboratory</u>

This laboratory was recently approved by the faculty and is scheduled to be given for the first time next fall. At the present, no adequate space is available for this type of laboratory. It is anticipated that this will be a required laboratory in the future. This laboratory will be concerned with experiments on Electrostatics, magnetostatics, time-varying fields, radiation, propagation and scattering. It will usually be taken by electrical engineering students in their senior year.

The space required for this laboratory in square feet	=	1200
Adjacent storage area	=	250
	Total	1,450

This laboratory should be a Dry Electrical laboratory with the following additions. One sanitary sewer, tap water, gas and compressed air. It should be located on the top floor of the building and have conduits and port openings for cable and wave-guide access to the roof. An area on the roof of the building, with convenient personnel access to this area, is required. This area should provide for lightweight antenna towers with 50-foot separation and a site free from nearby interfering scatterers.

h) EE-430 (Electronics and Communications) and EE-433 (Electra-acoustics and Ultrasonics) Laboratories

One laboratory room which when used on a full-time basis can accommodate these two laboratory courses. These are optional laboratories and are usually chosen by students in their senior year or by first-year graduate students. These are more of the project type and students taking them can come in and work on their own on various projects. The Electronics and Communications laboratory deals with information transmission and detection and includes such things as amplitude, frequency and pulse modulation and noise in electronic devices and circuits. The Electroacoustic and Ultrasonics laboratory deals with sound propagation, electro-mechanical and electroacoustical transducers such as loudspeakers and microphones and acoustic instrumentation and measurements.

The space required for this laboratory in square feet	=	800

This should be a "Dry" Electrical Laboratory

i) EE-442, Automatic Control, Electronics and Electromechanical Energy Conversion

This laboratory is given by the Electrical Engineering Department to students in other Engineering departments. It deals with automatic control systems, system stability, electromechanical energy conversion and a.c. and d.c. machines such as motors and generators. Because of the machines and equipment needed in such a laboratory the space required for it is greater than that for an average Electronics Laboratory.

The space required for this laboratory in square feet = 1600

This should be a dry electrical laboratory with the following additions: 120 and 240 volts D.C. with a capacity of approximately 30 KW. are required. Because of the rotating machinery and the floor loading required, it would be best to locate this laboratory in the basement.

j) EE-444, Energy Conversion and Control Laboratory

This is a required laboratory which is usually taken by electrical engineering students in their senior year. It deals with various means of energy conversion and control, such as transformers, d-c and a-c machines, direct energy conversion, feedback control systems and system stability. Because of the machines and equipment needed in such a laboratory, the space required for it is greater than that for an average electronics laboratory.

The space required for this laboratory in square feet = 2,000

This laboratory should be a wet laboratory with the following additions: Electrical power in the laboratory should be as that specified for Dry Electrical laboratory with the power capacity increased to 15 KVA per outlet box or 90 KVA total; 50 KW of 120 and 240 volts, D.C. should be provided. Because of the rotating machinery and floor loading required, it would be best to locate this laboratory in the basement.

k) Computer Laboratory

This laboratory will be used in conjunction with the present course offerings in computer technology. These include EE-465, 466, and 565. It will also be used in conjunction with an engineering intensive summer course in computer technology for practicing engineers. This laboratory will house digital and analog computers of some form. (It is not known as of this writing what kind of computers these will be by 1976.)

The space required for this laboratory in square feet = 3,000

This will be a dry electrical laboratory, but the power requirements for it may be different from those specified.

This laboratory will be used for both instruction and research.

l) EE-473 and EE-499, Analysis and Design Projects Laboratory

This is a project-type laboratory in which individual students or groups of students conceive, design and build various systems, devices and equipment. This is an optional laboratory which is presently limited to approximately 16 students per term. This may be increased in the future if enough space were available.

The space required for this laboratory in square feet = 800

This should be a wet laboratory and should be adjacent to a student shop.

m) Microwave Laboratory

This laboratory is for graduate student instruction. It deals with microwave measurements on circuits, electron beam devices, solid-state devices and plasmas. It is and will be offered in conjunction with courses such as EE530, 580, and 686.

The space required for this laboratory in square feet = 800

This should be a dry electrical laboratory plus running water and a sink.

n) EE-539, Electronic Circuit Design Laboratory

This is a graduate instructional laboratory and is of the project type. It deals with low-noise circuits, oscillator design, parametric amplifiers and converters, tunnel diode circuits and other electronic circuits.

The space required for this laboratory in square feet = 800

This should be a dry electrical laboratory and should be adjacent to a student work shop.

o) Solid-State Materials and Devices Laboratory

This laboratory does not exist at the present but is anticipated for the future. With the present and future importance of solid-state materials and devices such as employed in integrated circuits, it is very important that an electrical engineering department be well equipped for this. This will be mainly a graduate student laboratory of the projected type.

The space required for this laboratory in square feet = 800

This should be a wet laboratory

p) Power Systems Laboratory

This is a graduate student laboratory of the project type which will be used by students on an individual or group basis. It deals with power generation, transmission and control and power system stability. This laboratory will be used for instruction and research by graduate students working on a Ph.D degree in this area.

The space required for this laboratory in square feet = 1,000

This should be a dry electrical laboratory with special power capacity and distribution. The three-phase power capacities should be on the order of 15 KVA per outlet and 50 KW of 125 and 250 volts D.C. should be provided through the distribution panel. This laboratory should be located in the basement because of the floor loading required and the presence of heavy rotating machinery.

q) A Shielded Room

A shielded room is required. This will be employed in instrument calibration, and measurements on electronics circuits and devices where complete isolation from interfering signals and sources is required.

The space required for this room in square feet = 200

This should be of the dry electrical type.

r) Unspecified Laboratory Space

It is almost impossible to foresee all the laboratory space requirements for 1976. With new disciplines and fields developing in the department such as Bioengineering, and the constant change in Electrical Engineering courses, it is necessary to plan for unspecified space.

The space required for this purpose in square feet = 3,000

This should be of the general purpose laboratory type.

The total instructional laboratory space requirements for the Engineering Department are then approximately 22,250 square feet.

The following items should be included in all of the above laboratories:

i - Dark curtains
ii - Conduits for television input and output units
iii - Telephone conduits
iv - Conduits for direct connection to the computing center
v - Projection screen
vi - Antenna leads to the roof

4. Department Administration and Student Counselling and Classification

Adequate space should be provided for Departmental Administration and student counselling and classification. The space for the department administration should include, the Chairman's office, an administrative assistant's office, space for secretaries, supplies storage, and reproduction facilities such as Xerox and Ditto machines. There is no space available at the present for student counselling and preclassification, and the students mainly use the corridors at the present for this purpose. Space should be made available for this. The required space for these purposes is shown in Table 3.

5. Faculty Conference Rooms and Lounge

These facilities do not exist at the present time but are essential. Thus adequate space must be provided for them. We propose the following:

4 Conference rooms at 200 sq.ft. per room	=	800
1 Conference room (800 sq.ft.) which would be used for faculty meetings and Departmental lectures and seminars	=	800
Faculty lounge	=	1,000
Total (sq.ft.)		2,600

6. Student Activities, Study Area, and Radio Station

Space should be provided where students can meet for the various organizational activities such as Eta Kappa Nu and which students can use between classes to study and read available professional magazines. A space of this sort set aside for student use will be extremely beneficial to and welcomed by the students. There is presently a radio station which is operated and maintained by students. This is of great value to the students, as it gives them excellent experience in this field. We would like to see this retained and expanded. The space required for these activities is:

Student Activities area (sq.ft.)	=	1,500
Student Radio Station (sq.ft.)	=	500
Total (sq.ft.)		2,000

7. Service Areas for Laboratory Equipment Storage and Maintenance and for Dead Storage

Because of the large amount of equipment that is required in our instructional laboratories and because this equipment is shared by the various laboratories, it is necessary to have a central area for storing this equipment when it is not being used and for distributing it to the laboratories when it is needed. We must also have a standards laboratory for equipment calibration and a repair and maintenance area for our equipment. A dead storage area is also necessary for equipment that is not used frequently and is unwise to throw away because a future need may arise for it. The space required for these purposes is as follows:

Equipment storage	=	2,500 sq.ft.
Standards Laboratory	=	500
Equipment Maintenance Repair	=	500
Dead Storage	=	1,300
Total		4,800 sq.ft.

8. Student and Faculty Shop

Since several of our laboratories are project-type laboratories where students design and build various instruments and devices, it is essential that a shop which the students can use be available. Several faculty members have design projects of their own where shop use by them is necessary. It is then important that space for such a shop be provided. The shop area should be supervised by a full-time man who will assist the students and faculty and maintain the equipment in good working condition.

The space required for this area is approximately 600 square feet.

9. Computer Key Punch and Remote Control Consoles

Computers for problem solving is presently being employed in various courses. The usage of computers in various aspects of instruction will increase in the future. It is thus important that space for computer key punch and remote control consoles be provided for student faculty use. The space required for this purpose is approximately 1200 square feet.

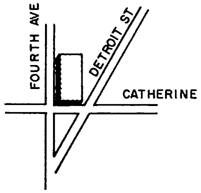
VI. RESEARCH LABORATORY SPACE REQUIREMENTS

A. Introduction

As mentioned in Section II of this report, research laboratories are an essential part of our educational program. Normal classroom and laboratory instruction must be supplemented by research programs in various areas in order to provide good training for our students. This is a "must" at the graduate level and several of our undergraduates participate in the various research programs of the Department. In the majority of the laboratories, the research staff mainly consists of faculty members, graduate students and supporting personnel such as secretaries, technicians and shop workers. Some of the laboratories also have a number of people whose main responsibility is in research. These people are very important to our educational program, however, for they provide guidance and support to many of our students who are working on their degrees and are an excellent source of flexible staff to assist in classroom teaching when a need arises, especially at short notice and in certain specialized areas, such as intensive summer courses for practicing engineers from industry and other universities. Many of these faculty members are outstanding and foremost in their fields and are certainly a credit to this Department, the Engineering College and the University. With the need for "continuing Engineering Education" rising rapidly in various specialized areas, the need for such people in our educational program becomes even more necessary.

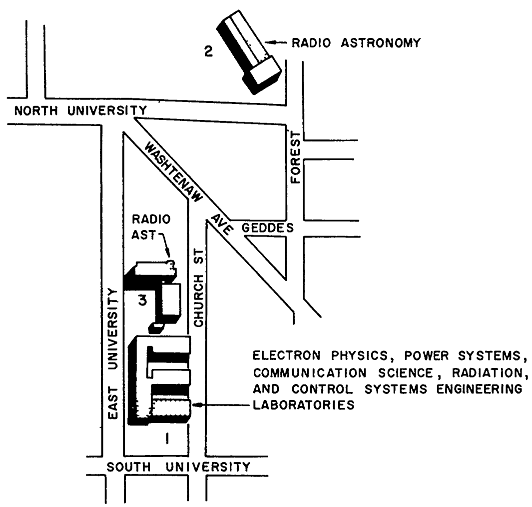
LOCATIONS OF ELECTRICAL ENGINEERING RESEARCH FACILITIES

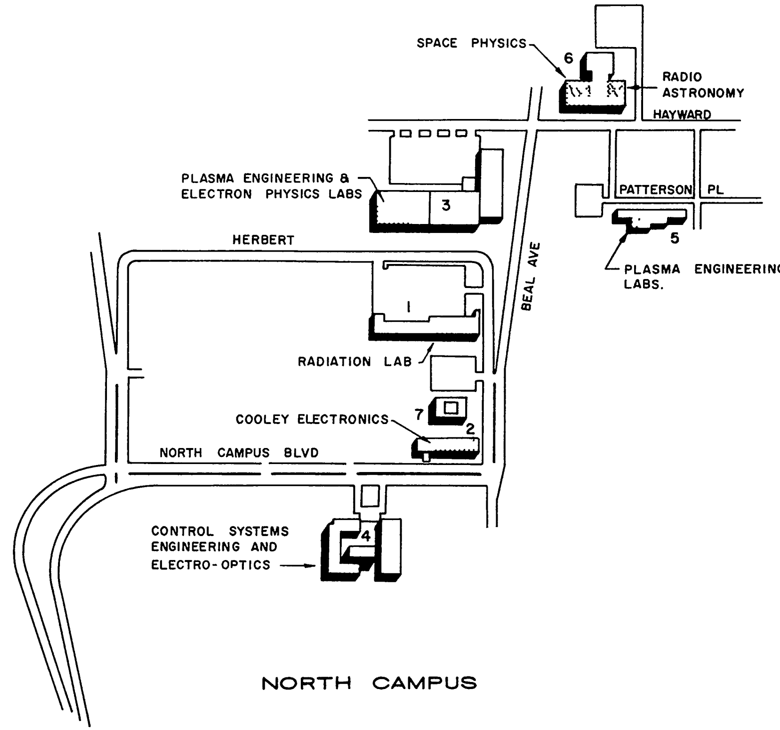
CATHERINE ST. RADIATION LAB.



CENTRAL CAMPUS

1. EAST ENGINEERING BLDG.
2. NORTH UNIVERSITY BLDG.
3. PHYSICS & ASTRONOMY

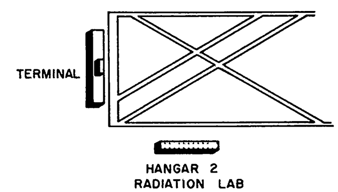




NORTH CAMPUS

1 AUTOMOTIVE LAB.
2. COOLEY MEMORIAL LAB
3. FLUIDS LAB.
4. INST. SCIENCE & TECHNOLOGY
5 PROPULSION LAB.
6 NASA BLDG
7 RES ADMIN. BLDG.

WILLOW RUN



Appendix-Electrical Engineering

This Department has a vast research program which covers almost every conceivable area relative to Electrical Engineering. This provides our graduate students with an excellent opportunity for self development and training and places them in great demand by industry and other universities.

We feel that the research carried by the Department is of fundamental importance to the teaching function, which is the education of engineers. The present location of the research laboratories detracts, however, from this objective.

As is shown in the following tables and in the map of Fig. 1, the research laboratories are widely scattered in the areas that are quite remote from the instructional facilities and from one another. Even some of the individual research laboratories are themselves located in widely separated areas. A prime example of this is the Department's Radiation Laboratory which as shown in a following table, is housed in a number of old, poorly designed buildings. This laboratory is situated at four locations, namely: Catherine Street in downtown Ann Arbor, Hangar II at Willow Run Airport, the East Engineering Building, and at North Campus. Another example, is the Department's Electron Physics Laboratory whose space is split between the East Engineering Building and the North Campus. This separation in research space location of the various laboratories creates several problems for laboratory heads and the department chairman for it becomes rather difficult to direct the research activities in an effective and efficient manner. The laboratories that are split in this manner cannot use some of their heavy, expensive and rare pieces of equipment at the various locations because of the time and expense required to move such equipment.

The separation of the space locations of the laboratories also prohibits any cooperation among them on research programs requiring contributions from two or more laboratories. It makes any sharing of equipment or facilities extremely difficult and in most cases impossible. Because of the overlap of some research programs, it leads to competition instead of cooperation among them for facilities, equipment and support.

The research programs of the various laboratories, their presently available space, their future needs and other pertinent information is given in detail in the following sections.

B. Research Laboratory Program Statements and Space Requirements

It is essential that the research laboratory space be integrated with the rest of the instructional facilities. The requirements set forth for the various research laboratories are divided into six major laboratories which represent the major areas of research related to Electrical Engineering. The space requirements for each of these major areas of research are described in detail below. As mentioned earlier, a number of supporting personnel in addition to the faculty and the students is necessary for effective operation of the laboratories. This includes full-time research personnel, administrative assistants, secretaries, technicians and shop personnel.

A typical graduate student would do both theoretical and experimental research during his enrollment in the Department. It is thus essential that he be provided with office space as well as space for his experimental setups. This also holds for the faculty and the full-time research personnel. The office space requirements for the faculty were presented in a previous section. In estimating the office space requirements for students and research personnel, an average of 120 square feet per research person and 60 square feet per student were employed. This office space should be adjacent to the experimental laboratory space.

A program statement for, and the kind of space required by the various research units are presented below. The number of individuals involved in each category is also given.

1. Electronic Communications Laboratory

a) Program Statement

The purpose of this laboratory is to provide research opportunities for faculty and students in the general areas of communication, acoustics, microelectronics, countermeasures, network synthesis, signal detection and processing and associated fields.

Table 4.

Space Requirements for the Electronic Communications Laboratory

Type of Space	Present Space (square feet) 1966	Space Location	Cooley Bldg.	Number of Persons	New Bldg.	Number of Persons
Academic Research Personnel Offices	1,544	Cooley Bldg. North Campus	480	4	1,680	14
Student Offices	3,093	Cooley Bldg. North Campus	600	10	4,020	67
Administrative and Secretarial Offices	640	Cooley Bldg. North Campus	200	2	1,100	9
Library	411	Cooley Bldg. North Campus	200		500	
Shop	1,062	Cooley Bldg. North Campus	0		500	4
Assembly, Maintenance - Stock Storage	1,766	Cooley Bldg. North Campus	500	1	1,200	4
Reproduction-Drafting	600	Cooley Bldg. North Campus	0		500	3
Computer	0	Cooley Bldg. North Campus	0		360	3
Conference	1,275	Cooley Bldg. North Campus	200		360	
Experimental Laboratories	6,466	Cooley Bldg. North Campus	3.600		10.000	
Total	16,842		5,780*	17	20,220	104

*This space at the Cooley Building will be retained.

b) Space Requirements

The space available at the present and its location and the future space requirements for this laboratory are shown in Table 4. The space requirements are divided into several categories and the need for such space in a research laboratory is self-explanatory. The number of people involved in each category is also given in Table 4. The kind of space under the category of Experimental Laboratories is given below. This will be required by the faculty and students for experimental setups and measurements.

4 Wet Laboratories of 900 sq.ft. each	÷	3,600
7 Dry Electrical Laboratories of 800 sq.ft. each	=	5,600
1 Room (Dry Electrical) with Vent and Antenna Leads to Roof	=	200
1 Clean Room	=	300
2 Dark Rooms	=	300
Total (square feet)		10,000

Because of the specialized facilities that are available at the Cooley Building and the expense that would be necessary to duplicate these facilities in a new building, 5,780 sq.ft. will be retained in this building. The rest of the space in this building will be vacated.

2. Electron Physics Laboratory

a) Program Statement

The principal purpose of the Electron Physics Laboratory is to provide an environment and facilities for faculty and graduate student research in the broad area of physical electronics. At the present time this research encompasses studies on electron beam devices, gaseous plasmas and solid-state material and devices. It is expected that many of these studies will continue for some time while other new studies will be initiated relative to material properties and their utilization to perform device functions. The emphasis is always on basic physical phenomena and their application. The laboratory staff will always be primarily composed of faculty and graduate students with a small number of full-time researchers to provide continuity and primary support in the experimental areas. The principal outputs of the laboratory group are graduate students and publications and it is desired that at least 25 percent of the total support be derived from Michigan industry whose work relates directly to the laboratory faculty interests.

The research programs currently active and the type of programs desired are of the non-mission-oriented variety. Long term general study programs are desired in which the direction of effort is to be determined by the senior laboratory staff and can be changed as frequently as deemed necessary. Classified contracts are not appropriate for this research laboratory and all research tasks should ultimately result in doctoral theses and/or scholarly publications.

b) Space Requirements

The space available at the present and its location and the future space requirements for this laboratory are shown in Table 5. The space requirements are divided into several categories and the need for such space in a research laboratory is self-explanatory. The kind of experimental and other laboratory space required is given in detail below.

Code

Title

a. No. of square feet
b. Type of laboratory
c. Special Facilities

i. Plasma Laboratory

a. 2000 square feet
b. General purpose, with exceptions.
c. Facility to be divided into three areas of 750, 750, and 500 square feet.
    1. High-power, High-density Plasmas - 750
    2. Low-power, Low-density Plasmas - 750
    3. General purpose and cold test measurements - 750

Power requirements are:

Laboratory No. 1

Minimum of 600 KVA of 480 volt, 3 phase 4 wire "Y"
60 KVA of 208 volt, 3 phase 4 wire "Y"

Normal 115 volt plug strip as in the dry laboratory.

Water requirements are for 200 gallons per minute.

Table 5.

Space Requirements for Electron Physics Laboratory

	Available Space (square feet) 1966	Space Location 1966	New Building Space Required (square feet) 1976	Number of Persons Involved
Academic Research Faculty Personnel Offices	660	260 at North Campus 400 at E.E.	840	7
Student Offices	1,800	620 at North Campus 1,180 at E.E.	3,240	54
Administrative and Secretarial	870	E.E.	1,100	9
Library	120	E.E.	500	
Shop	2,100	E.E.	2,500	9
Assembly, Maintenance, Stock and Storage	1,000	2,250 at E.E. 250 at North Campus	2,075	11
Reproduction and Drafting	200	E.E.	500	3
Computer Key punch, Remote Console and programmers	370	E.E.	600	5
Conference	130	E.E.	260	
Experimental Laboratories	7,970	3.370 at North Campus 3,100 at E.E.	11,050	
TOTAL	16,000	4,500 at North Campus 11,500 at E.E.	26,465	98

Maximum water temperature of 80 degrees F.
Additional water inlet and exhaust system along with compressed air shall be distributed around the perimeter of the room. This water is to be used for cooling purposes and will require a maximum of 65 degrees F and is not to be recirculated. Install one sink and cabinet.

Laboratories 2 and 3.

Normal 115 plug strip around the rooms.
60 KVA of 208 volt, 3 phase 4 wire "Y"
Water and compressed air around the perimeter of the rooms. Sink and cabinet in each room.
Normal ceiling heights and air conditioning load.
Sump for water drainage in each room.

ii. Solid-State Devices Laboratory

a. 2500 square feet.
b. General purpose, with exceptions.
c. Facility to be divided into a minimum of three rooms.

Rooms one and two at 800 sq.ft. each, will be devoted to Maser and Maser materials research. Room three will be devoted to Semi-conductor devices research with 900 sq.ft. All rooms will require 60 KVA of 208 volt 3 phase 4 wire "Y" each.
Water inlet and exhaust lines, and compressed air around the perimeter of the room. Water temperature maximum of 65 degrees F. Sump for water drainage in each room. Sinks and cabinets in rooms.
Year around air conditioning and humidity control in each room.
Humidity control to be positive and effective to 40 percent level.
Rooms one and two will require a high floor loading factor.

iii. Light Modulation and Detection Laboratory

a. 1250 square feet.
b. General purpose, with exceptions.
c. Facility to be divided into three areas.

Two rooms will be 500 sq.ft. each. Room one and two will require 30 KVA of 208 volt, 3 phase 4 wire "Y".
Water inlet and exhaust and compressed air around the perimenter of the room.
Water temperature not to exceed 65 degrees F
Sump required for water drainage.

Year around air conditioning and humidity control required.
Room No. 3, 250 sq.ft., is to be constructed as a typical dark room. 25 KVA of 208 volt, 3 phase, 4 wire "Y" and 115 volt plug strip around the room with controlled lighting.
Year around air conditioning and humidity control required.

iv. Laser Laboratory

a. 800 square feet.

b. General purpose with exceptions.

c. Room to have 60 KVA of 208 volt, 3 phase 4 wire "Y".
Water inlet and exhaust and compressed air around the perimeter of the room.
Water temperature not to exceed 65 degrees F.
Sump required for drainage.
Year around air conditioning and humidity control required.
Humidity to be controlled to the lowest possible level.

v. Electron Beam Devices Laboratory

a. 2000 square feet

b. General purpose laboratory.

c. Facility to be divided into three areas.

Area 1. Beam analyzer laboratory 500 sq.ft.
Area 2. Relativistic Electron Beam laboratory 750 sq.ft.
Area 3. General purpose 750 sq.ft.

The combined facility will require 300 KVA of 208 volt, 3 phase 4 wire "Y", 60 KVA of 120 volt, single phase, 150 KVA of 240 volt 3 phase delta, 10 KVA of 120 volt, 3 phase service, 60 amperes of 240 volt single phase service, 30 amperes of 125/250 volt DC service.

Water inlet and exhaust lines and compressed air on all walls. City gas on one wall in each room. Sumps for water drainage required. Sink and cabinet in Room 3. Water temperature not to exceed 65 degrees F. Year around air conditioning and reasonable humidity control required. The air conditioning load will be quite high in Rooms 2 and 3 because of large scale power dissipation. Room 2 will require a minimum ceiling height of 15 feet in the clear and a high floor loading factor. = 2,000

vi. Thin Film Laboratory

a. 1200 square feet.

b. Room 1, General purpose.
   Room 2, wet, both with exceptions.

c. Room 1 will require 60 KVA of 208 volt, 3 phase 4 wire "Y" 60 amperes of 240 volt, 3 phase delta will also be required. Water inlet and exhaust lines, compressed air and city gas around the perimeter of the room. Water temperature not to exceed 65 degrees F. Year around air conditioning and humidity control required. Humidity must be maintained at a very low level.

Exhaust lines shall be installed to service several vacuum systems. Floor covering shall be vinyl in sheet form as opposed to tile. Consideration should be given to epoxy wall finishes for ease of cleaning and maintenance. The air conditioning system shall be balanced to keep the room under pressure. All air inlets shall be adequately filtered.

Room 2, wet type laboratory, will not require additional electrical power although a power distribution outlet box should be installed. Facilities for two fume hoods and associated chemical benches shall be provided. Fume hoods will utilize 70 percent make-up air and the air conditioning system shall be balanced accordingly. All air inlets shall be filtered.

Floor shall be ceramic tile and the wall covering or finish is to be compatible with this type of facility.

vii. <u>Analog Computer Laboratory</u>

a. 500 square feet.

b. General purpose, with exceptions.

c. Room to have 25 KVA of 230 volt 3 phase delta, year around air conditioning and humidity control = 500

viii. <u>Materials and Techniques Laboratory and Device Final Assembly</u>

a. 2800 square feet.

b. General purpose and wet with exceptions.

c. Facility will be divided into seven areas.

Area 1.	Furnace Room	700 sq.ft.
Area 2.	Welding	200 sq.ft.
Area 3.	Glassworking	250 sq.ft.
Area 4.	Materials Storage	225 sq.ft.
Area 5.	Chemistry Room	500 sq.ft.

Area 6. Clean Room 375 sq.ft.
Area 7. Materials Preparation 500 sq.ft.

Room 1.

Furnace room will require 50 KVA of 208 volt, 3 phase 4 wire "Y", 100 KVA of 440-480 3 phase power and 25 KVA of 240 volt 3 phase delta. Water inlet and exhaust lines on two walls. City gas and compressed air on all walls. High volume, controlled flow rate, water lines shall be installed in at least two locations. Water temperature shall not exceed 65 degrees F and line surges cannot decrease the pressure below 60 psi at any time. Sumps for water drainage required. Exhaust hood canopies shall be installed in at least Two locations. Canopies to be designed utilizing low volume fans specifically to remove heat from resistance furnaces. One canopy shall have explosion-proof motors and controls to handle hydrogen residue. Provide an exhaust line for several vacuum systems.

Room 2.

Welding room will require 20 KVA of 230 volts 3 phase delta or 208 volts "Y". Install an exhaust or fume hood to exhaust welding fumes. Provide water inlet and exhaust lines, compressed air and city gas.

Room 3.

Glassworking will require 20 KVA of 230 volts 3-phase delta or 208 volts "Y". Install water inlet and exhaust, compressed air and city gas on all walls.

Room 4.

Materials storage. No special facilities required.

Room 5.

Chemistry room, wet laboratory, does not require extra electrical power except as noted in Room 5. This room shall be designed as a class I or class II clean room. It is recommended that the design be based upon the modular air-flow principal and walls, ceiling and floor be compatible with this approach.

Provide for one fume hood designed to utilize 70 percent makeup air.

Room 7.

Materials research will require 30 KVA of 208 volt, 3 phase 4 wire "Y" and 30 KVA of 230, 3 phase delta.

Water inlet and exhaust, compressed air and city gas on all walls. Provide exhaust line to handle several vacuum systems.

Floors in Rooms 1 and 3 shall be covered in vinyl sheet as opposed to tile.

Provide emergency showers and eye rinse fountains in Room 5, Chemistry room. Manifolds shall be located outside the building for the storage of at least hydrogen and nitrogen. Gases will be piped into designated areas with proper safety controls. All air conditioning inlets in the seven areas shall be filtered. The air conditioning will have to be zoned or balanced to suit the individual area. Year around air conditioning and humidity control required. Maintain minimum humidity in Rooms 1, 6 and 7. Room 3 shall have a drop-pan ceiling with the incoming air diffused through the ceiling so as to prevent drafts. Fume hood exhaust ducts shall be independent of other systems so as to prevent cross-contamination of materials.

ix. Model Shop

a. 2500 square feet.

b. General purpose with exceptions.

c. Facility to be divided into five basic areas: General Machining, Grinding Room, Welding Room.

60 KVA of 230 volt 3 phase delat and 20 KVA of 440 volt power will be required as well as extra 115 volt single phase circuits. Overhead lighting shall be dropped to approximately nine (9) feet from the floor level and the light intensity shall be compatible with accepted practice. Floors are to be left bare and finished with an acceptable grade of oil and grease proof enamel. Compressed air shall be installed in all areas. Water inlet and exhaust and city gas shall be installed in the grinding and welding areas. Provide sink and cabinet in the welding room. Provide facilities for exhaust ducts in the welding and grinding areas. This facility shall be located adjacent to a receiving dock with provision for an overhead crane to move raw materials from the dock to the materials storage area.

Heavy floor loading factors required.
If the shop is to be located on the ground floor, an outside window well shall be installed so as to provide outside lighting.
Year around air conditioning and humidity control required.

x. Instrumentation and Maintenance Laboratory

a. 1700 square feet.

b. General purpose with exceptions.

c. The facility will be divided into four areas:

Area 1.	Office	125 square feet
Area 2.	Work area	700 square feet
Area 3.	Active storage and supplies	500 square feet
Area 4.	Dead Storage	375 square feet

Provide 25 KVA of 230 volt, 3 phase delta, 25 KVA of 208 volt, 3 phase 4 wire "Y" and extra capacity 115 volt service to the work area. Provide compressed air and city gas. Install one sink and cabinet.

In general the foregoing is based upon the premise that the building will be air conditioned with sufficient capacity to provide for zoned control as required.

The electrical power requirements are such that we must have both Delta and "Y" to operate present laboratory experiments. This should not present a problem since we have been informed that all primary power available on the North Campus is 4 wire "Y".

The power requirements listed are based upon having distribution panels and outlet boxes as specified under the heading of "Dry Laboratories". This also applies to the 115 volt plug strips on all walls in each room.

3. Electro-optical Laboratory

a) Program Statement

The purpose of this laboratory is to provide facilities and support for faculty and student research in the area of Electro-optics. This includes work on coherent and noncoherent optics and their applications to holography. Work on advanced and sophisticated ruling engines is also performed in this laboratory.

b) Space Requirements

The present space and its location and the future space requirements of this laboratory are summarized in Table 6. The special space requirements of this laboratory are as follows:

4 rooms at 1000 sq.ft. per room	=	4,000
4 dark rooms at 200 sq.ft. per room	=	800
Ruling Engine Laboratory	=	1,000
		5,800

This space should be of the General Purpose laboratory type with the following additions. Because of the nature of the experiments carried out in this laboratory, acoustical isolation, vibration isolation which may be attained by using piers, low-velocity air conditioning to avoid optical turbulence, good temperature (± 1 degree) and humidity control)40% ± 2%) are required. It is best to locate this space in the basement where several of the above factors can be controlled best.

4. Radiation Laboratory

a) Program Statement

The purpose of this laboratory is to provide support and research facilities for faculty and students in the general area of electromagnetic fields. This includes propagation through free space and anisotropic media such as plasmas and ferrites, antennas, radiation and scattering of electromagnetic waves and other associated subjects.

b) Space Requirements

The present space and its location and the future space requirements for this laboratory are summarized in Table 7. Because of the nature of its work, this laboratory requires space in instructional facility as well as a separate facility for an Antenna range. A detailed description of the requirements for special facilities is presented below. These are divided into two categories as follows:

Category 1: Laboratory Space in the Instructional Building

1.1 Plasma Laboratory

This is a laboratory for the study of the interaction of electromagnetic waves with plasmas and of plasma devices. The laboratory is primarily for research but it would also be used for instructional purposes. It has the following requirements:

1.1a Size: 1000 square feet

1.1b Dry electrical laboratory

1.1c Running Water

1.1d Natural gas and oxygen

1.1e Hooded sink and exhaust

1.1f DC voltage, desirable but not necessary

1.1g Compressed air

1.2 Small Anechoic Room

This laboratory is for the purpose of instruction in aspects of electromagnetic theory involving reflection and diffraction by physical obstacles.

1.2a Size: 8x8x14 ft. room with 6-foot space above ceiling for access to probe positioning equipment.

1.2b Dry electrical laboratory

1.2c Special air conditioning

1.3 Impedance and Field Probe Measurements Laboratory

This laboratory is for research. It will be used for the study of impedance characteristics, operation and construction of equipment used with the anechoic room, and for the design and construction of probes for the measurement of fields induced by electromagnetic waves on objects.

1.3a Size: 400 square feet

1.3b Dry electrical laboratory

1.3c 2 KVA single phase 400 cycle, 115 volts

1.3d 1000 watts of 28 volt DC

1.3e Special air conditioning

1.4 Roof Facilities

These facilities are for the study of antenna theory. It is to be used for both instruction and research. See specification under instructional laboratories.

1.4a Elevator access to roof

1.4b Two antenna towers

1.4c Single phase 60 cycle 115 volts

Category 2: Laboratory Space in Separate Experimental Facility

This research facility is for the study of electromagnetic scattering and diffraction, the study of electromagnetic fields induced on objects and study of antenna theory and measurements.

Table 6.

SPACE REQUIREMENTS FOR
ELECTRO-OPTICAL LABORATORY

	Available Space (Sq.Ft.) 1966	Space Location	Space Required (Sq.Ft.) New Building 1976	Number of People Involved
Part-Time Teaching Faculty	130	North Campus IST Building	0	
Academic Research Personnel Offices	0	North Campus IST Building	240	2
Student Offices	800	North Campus IST Building	1,140	18
Administrative and Secretarial	200	North Campus IST Building	400	3
Library	200	North Campus IST Building	400	
Shop	400	North Campus IST Building	800	1
Assembly, Maintenance, Stock and Storage	400	North Campus IST Building	800	1
Reproduction and Drafting	150	North Campus IST Building	300	1
Computer, Key Punch and Remote Console	100	North Campus IST Building	300	1
Conference	200	North Campus IST Building	260	
Experimental Laboratories	2,000	North Campus IST Building	4,000	
Ruling Engine Lab. and Dark Rooms	1,150	North Campus IST Building	1,800	
Total	5,930		10,340	27

Category 2: (continued)
The facility requires about 12,000 sq.ft. of building space and about 10 acres of land to accommodate the antenna ranges. It is recommended that the metal reinforcing material in the building be connected to a common ground. In addition to a small shop area, and office areas, it would have the following facilities.

2.1 Anechoic Chambers

Three chambers would be required, each having 25-foot ceilings.

Table 7.

Space Requirements for Radiation Laboratory

	Available Space (square feet) 1966	Space Location 1966	Space Required (square feet) 1976 New Building	No. of People Involved	Separate Facility*	No. of People Involved
Academic Research Personnel Offices	2,947	1,917 at 201 Catherine 1,030 at Willow Run	1,560	13	1,560	13
Student Offices	2,234	1,760 at 201 Catherine 474 at Willow Run	2,160	36	1,080	18
Administrative and Secretarial	871	741 at 201 Catherine 130 at Willow Run	1,100	9	200	2
Library	325	at 201 Catherine	500			
Shop	1,049	At Willow Run			500	1
Assembly, Maintenance, Stock and Storage	1,982	211 at 201 Catherine 1,571 at Willow 200 at North Campus	500	1	2,000	4
Reproduction and Drafting	461	318 at 201 Catherine 143 at Willow Run	360	3	150	1
Computer	616	at 201 Catherine	800	3		
Conference	710	473 at 201 Catherine 273 at Willow Run	800			
Experimental Laboratories	6,973**	5,459 at Willow Run 1,140 at E.E. 374 at North Campus	1,500		6,943	
Vault	112	201 Catherine	150			
Total	18,279	10,129 at W.R.; 1,520 at E.E. 574 at N.C.; 7,298 at Catherine	9,430	65	12,433	39

* See requirements for Separate Facility in text. This facility also requires 10 acres of land for Antenna ranges.

** Does not include roof-top antenna range at North Campus.

2.1a Sizes: 25x100 ft., 25x50 ft., and 12x46 ft.
2.1b Dry electrical laboratory
2.1c 28 volt DC, 1000 watts
2.1d single phase 400 cycle, 115 volts, 2 KVA
2.1e Special air conditioning
2.1f Compressed air
2.1g Running water
2.1h Antenna towers and cabling to towers

2.2 <u>Shipping, Receiving and Storage Areas</u>

This area is to be used for receiving, shipping and storage of antennas, models, electronic equipment, instruments, miscellaneous absorber materials, general supplies, etc.

2.2a Size: 1290 sq.ft.

2.3 <u>Backscatter Range Control Room</u>

This area will be used for the instrumentation for the large anechoic room.

2.3a Size: 18x30 ft.
2.3b Dry electrical laboratory
2.3c 28 volt DC, 1000 watts
2.3d Single phase 400 cycle, 115 volts, 2 KVA
2.3e Special air conditioning

2.4 <u>Antenna Laboratories</u>

This area is used for the study of antenna characteristics.

2.4a Size: Two laboratories; 13x25 ft. and 13x30 ft.
2.4b Dry electrical laboratory
2.4c Natural gas
2.4d 28 volt DC, 1000 watts
2.4e Single phase 400 cycle, 115 volts, 2 KVA
2.4f Special air conditioning
2.4g Compressed air
2.4h Cabling to towers and to roof.

2.5 <u>Microwave Testing and Repair Laboratory</u>

This laboratory is for the testing of sensitive instruments and the general testing and repair of equipment.

2.5a Size: 8x12 ft. with 12-foot ceiling
2.5b Dry electrical laboratory
2.5c Shielded enclosure of entire room

2.5d Natural gas

2.5e Special air conditioning

2.5f 28 volt DC, 1000 watts

2.5g Single phase 400 cycle, 115 volts, 2 KVA

2.5h Compressed air.

5. Space Physics Laboratory

a) Program Statement

The purpose of this laboratory is to provide support and research facilities for faculty and students in the general area of space physics. Experimental and theoretical research on the interaction between the Earth's atmosphere and the solar energy input is carried out. Specifically, studies on the composition, density and temperature of the charged particles which constitute the Earth's ionosphere are presently being conducted.

b) Space Requirements

The present space and its location and future space requirements for this laboratory are summarized in Table 8. This laboratory is presently housed in the NASA Building at North Campus. Due to its rapidly expanding research program, additional facilities are required at the present and will be required by 1976. This additional space and its type are shown in Table 9. It is expected that the present space at the NASA Building will be retained. The kind of laboratory space required in a new building is given below:

4 General purpose Laboratories at 900 Sq.ft. each	=	3,600
Clean Room (sq.ft.)	=	300

The clean room must satisfy NASA specifications

Computer room with special air conditioning and power requirements (sq.ft.)	=	680

6. Systems Engineering Laboratories

a) Program Statement

The purpose of these laboratories is to provide support and facilities for faculty and student research in the area of Systems Engineering. This includes Information and Control Systems, Communication Systems, Computer Technology, and Energy Conversion Systems.

b) Space Requirements

The present space and its location and the future space requirements for these laboratories are summarized in Table 9. The laboratory space required is as follows:

3 rooms of 800 square feet each of the Dry Electrical laboratory type = 2,400

Table 8.

Space Requirements for Space Physics Laboratory

	Avail.Space* (sq.ft.) 1966	No. of People Involved	Space Location 1966	New Bldg. Space Reqd. (sq.ft.) 1976	No. of People Involved
Academic Res. Personnel Offices	2,290	24	NASA Bldg. N.C.	1,320	11
Student Offices	900	42	NASA Bldg. N.C.	1,080	18
Administ. and Secretarial	250	2	NASA Bldg. N.C.	400	3
Library	0		NASA Bldg. N.C.	300	
Shop	800	2	NASA Bldg. N.C.	0	
Assembly, Mainten., Stock and Storage	700	3	NASA Bldg. N.C.	800	5
Reproduction and Drafting	950	4	NASA Bldg. N.C.	250	2
Computer	320	2	NASA Bldg. N.C.	680	4
Conference	210		NASA Bldg. N.C.	200	
Experimental Laboratories	4,100	4	NASA Bldg. N.C.	3,900	
Miscellaneous	200		NASA Bldg. N.C.		
Total	10,720	83		8,930	43

*This space will be retained.

Table 9.

Space Requirements for Systems Engineering Labs.

	Available Space (square feet) 1966	Space Location 1966	New Building Space Required (square feet) 1976	Number of People Involved
Academic Research Personnel Offices	330	North Campus	240	2
Student Offices	3,000	1,000 at North Campus 1,000 at E.E.	4,800	80
Administrative and Secretarial	200	100 at E.E. 100 at North Campus	700	5
Library	0		360	
Shop	0		500	1
Assembly, Maintenance Stock and Storage	300	150 at North Campus 150 at E.E.	500	2
Reproduction and Drafting	100	at North Campus	200	1
Conference	0		360	
Experimental Laboratories	800	at E.E.	2,400	
TOTAL	6,570	1,870 at North Campus 6,130 at E.E.	10,060	91

7. Other Research Laboratory Space

Since some faculty members and students carry out experimental research on an individual basis and separate from the major research units it is necessary to provide space for this purpose. The amount and type of space required for this purpose is

Office space for 10 students at 60 sq.ft. each (5 offices)	=	600
2 general purpose laboratories at 900 sq.ft. each	=	1,800
Total (sq.ft.)		2,400

VII. SUMMARY OF TOTAL SPACE REQUIREMENTS

A summary of the total space requirements of this Department and the number of people involved is given in Table 10. Even though, it is most desirable to have all the research laboratory space located in the instructional building, some of the present facilities will be retained because of their specialized nature and the expense that would be required to reproduce them in a new building. The space that would be retained is indicated in Table 10. Because of the nature of its work, the Radiation Laboratory requires a facility separate from the instructional building. The type of facility required for this purpose was discussed in detail in a previous section.

Table 1 indicates that the graduate student enrollment by 1976 will be approximately 650, while Table 10 indicates that provisions for only 435 of them have been planned. There is really no discrepancy here since some of the graduate students will do their research work at other research units of the University such as IST and some may be employed part-time with local industries. This is of great benefit to these industries. It is also worth mentioning here that several undergraduate and first-year graduate students will be involved in the research programs of the Department, who have not been included in the table because they do not require regular office space and can be accommodated in the research laboratory space.

Table 10.

Summary of Space Requirements for The Electrical Engineering Department

	Number of People Involved				Space Required (1976) (square feet) New Building		
Item	Teaching Faculty	Academic Research Personnel	Non-Academic Personnel	Students	Office Conference Lounge	Laboratory	Other
Faculty Offices	90				14,310		
Teaching Fellows				45	2,640		
Dept. Admin., Student Counselling, Secretarial Offices including filing, reproduction and storage	3		20		4,700		800
Instructional Laboratory						22,250	
Faculty and Student Activities					4,600		
Shop and Services			6				5,400
Computation							1,200
Electronic Communication Lab.[2]		18	23	77	7,160	10,000	3,060
Electron Physics Lab		7	37	54	5,440	11,050	9,975
Electro-Optical Lab		2	7	18	2,040	5,800	2,500
Radiation Lab.[3]		26	24	54	4,820	1,500	3,110
Space Physics Lab.[4]		35	30	60	3,000	3,900	2,030
Systems Eng. Lab.		2	9	80	6,100	2,400	1,560
Space Research Lab. other than major units				10	600	1,800	
Total	93	90	156	398	55,410	58,700	29,635
Total space	143,745						

1. This does not include regular classroom space.
2. This laboratory will retain 5,780 sq. ft. at the Cooley Bldg. in addition to that required in the new building.
3. This laboratory will require a facility separate from the instructional bldg. This facility requires 12,433 of bldg. space and 10 acres of land for an Antenna Range.
4. This laboratory will retain its present space at the NASA Bldg. in addition to that required in the new building.

VIII: SPACE NEEDED ON MAIN CAMPUS FOR 1st and 2nd YEAR STUDENTS

The only Electrical Engineering courses that are taken by first and second year students are EE210 and 220. It is estimated that approximately 50 percent of the students take EE220 in their fifth rather than fourth semesters. Thus, the space needed on the Main Campus after the move would be that necessary to accommodate 130 students in EE210 and 65 students in EE220. These can be accommodated by providing a lecture room which can seat 65 students for 5 hours on three days of the week and two rooms which can accommodate 25-30 students for all hours of the week. Part-time office space for 5 faculty members and 10 teaching fellows will also be required.

ENGINEERING MECHANICS DEPARTMENT
Projections for Space Needs in 1976

J. W. Daily
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1. PROGRAM STATEMENT

The Department of Engineering Mechanics is concerned with instruction and research in the broad field of mechanics for application to modern engineering science problems. It differs from other departments of the College in being organized around a particular discipline rather than around a special field of application. In carrying out its responsibilities the Department has multiple roles. It provides basic courses in the discipline for students of the other departments; it conducts degree programs for undergraduate and graduate students concentrating in the discipline; and it conducts a program of research seeking to generalize and simplify the laws of mechanics and to extend them imaginatively to the treatment of complicated physical phenomena. In the application of mechanics principles there is often the need of analysis and applied mathematics is the natural tool. On the physical side experimentation is the tool. The programs of instruction and research use these tools widely.

The field of the discipline is wide. It applies the principles of mechanics to the static and dynamic behavior of rigid and deformable solid materials and bodies and of fluids, all as they compose structures, vehicles and other devices or form natural systems. It treats elastic, plastic and viscoelastic phenomena; continuum, particulate and crystalline materials; Newtonian and non-Newtonian fluids; waves mechanics in solids and fluids. Graduates trained in the discipline are found in many branches of engineering and science, and perform important roles in industry, research and education. Dynamics of structures and vehicles, space travel dynamics, materials and their behavior, fluid mechanics of atmospheric and ocean masses, seismic waves, ground water flow, dynamics of insterstellar spaces and biomechanics are a few of the many and diverse subjects of their pursuits.

Graduate: 1.7 (See Table I-A)

This is goal of growth to 80 students over the average number of 47 students during the past five years.

Undergraduate 1.58 (See Table I-B)

This is the planned growth of the total of Sophomore, Junior, and Senior students in Engineering Mechanics undergraduate courses over average of past five years.

Table II gives staff requirements. The instructional staff is based on the above student population projections. The Senate rank faculty projection is according to a prorated division of effort between undergraduate and graduate instruction and thesis supervision. The projection of other instructional staff is based solely on undergraduate numbers. Research Assistants are projected in proporation to graduate student growth.

An important need for more effective output of the faculty is an adequate supply of secretarial help. Staff projections include secretaries on the basis of department general administrative needs plus one for each four instructional staff of Senate rank and one for each twelve below Senate rank.

3. DEPARTMENTAL OFFICES

A. Administration and General Operations

Table IV gives space requirements for administering the Engineering Mechanics Department in 1976 compared with existing space. Included are space for departmental headquarters and space for some special facilities for the general operation of the academic program. They are as follows:

North Campus

General administration (Item 1, 2, 3; Table IV)

Office and work areas, secretarial and reception, records, conference room

Staff: 5 persons (Chairman, Administrative Assistant, and three secretaries)

Area: 1315 sq.ft. in suite arrangement distributed as in Table IV.

Academic program operations (Items 4, 5, 6; Table IV)
Counseling and registration area, seminar room, study-lounge area
Staff: 1 secretary (also serving general needs of faculty assigned to counseling)
Area: 800 sq.ft. distributed as in Table IV.
Counseling office and seminar room desirably located adjacent to administrative suite. Student study-lounge should be separately located with some isolation.

Central Campus:

Academic program operations (Item 5; Table IV)
Counseling and registration
Staff: 1 secretary (also assisting with general needs of faculty teaching on Central Campus)
Area: 150 sq.ft.
This space is needed only if class and laboratories for the first two years remain on the Central Campus.

The personnel and space projections for general administrative needs are based on a total department staff of 106 persons Table II) which will provide counseling and instruction for 50 undergraduate and 80 graduate students in the Department's degree programs and instruction for over 2000 students per week in an estimated 90 to 100 sections. The space requirements would be met by an adaptation of the suite arrangement proposed by Professors Bunning and Harris (memo of 11/22/65).

The counseling, seminar and study-lounge facilities are to serve the students in the Department's programs. The study-lounge primarily for the undergraduate students; the counseling and seminar areas for both undergraduate and graduate. The seminar room will serve both administrative and academic purposes in providing space for staff meetings and large committee meetings as well as for seminar classes, doctoral examinations and general purpose uses.

B. Teaching and Research Personnel

Table V gives the projections for space needs for the teaching and research staff and secretarial support. Table III shows the basis of the projections and the number of offices.

It will be noted that there are provisions for regular faculty and for Teaching Fellows and Research Assistants. Both of the latter require office space in the discharge of their duties. Additionally, provision is made for a few offices (4) to be assigned to graduate students who are engaged in thesis research but who do not hold Teaching Fellow or Research Assistant appointments. The proper pursuit of a thesis program requires an adequate work space. Moreover, there is special educational value in conducting the study and work in association with other students similarly engaged and at a location of easy access to needed facilities. Consequently, this provision is considered especially important.

In summary the office needs for teaching and research staff on North Campus excluding secretarial space is for 72 offices totalling 11,060 sq.ft. distributed as follows:

22 offices of 200 sq.ft.	30.5% of total
22 offices of 150 sq.ft.	30.5% of total
28 offices of 120 sq.ft.	39.% of total

Additionally it is proposed that secretarial space totaling 1260 sq.ft. be provided in connection with reception areas to above offices arranged in suites. The total North Campus office space for teaching and research including secretarial area is 12,320 sq.ft. to serve 97 regular staff and up to 12 thesis students who do not hold staff appointments.

Additionally, if all classes and laboratories for the first two years remain on the Central Campus it will be necessary to retain a certain amount of office space in West Engineering for teaching staff which will divide its time between the two Campuses. This is estimated to be approximately 2000 sq.ft. and is in addition to the North Campus space. The equivalent will not be needed if all classes and laboratories move to the North Campus.

Projections for the future indicate:

1) Increased emphasis on the unusual materials and fluids, and on the more complicated phenomena of systems involving them. Examples are:the current interests in composite and fibrous reinforced materials for extreme loadings; plastic, visco-elastic materials and solid-liquid mixtures having special rheological properties; new fluids having low friction characteristics.
2) Increased importance of dynamical aspects of fluid and structures systems, and the interactions between structures and the materials and fluids composing them. Hydrodynamic and mechanical stability, response of elastic and visco-elastic materials to wave propagation, random vibrations and stochastic processes are examples.
3) Broader applications to all the engineering areas as we have known them and continued extension to those areas undergoing new and renewed coupling with engineering, such as bio-mechanics and geophysical mechanics.

The clear call of these trends is for new advanced programs with enlarged graduate instruction. They forecast expanded research, both theoretical and experimental. Implementation will involve extended capabilities, of which physical facilities for the support of instruction, for laboratories and for offices are highly important.

2. STUDENT ENROLLMENTS AND STAFF REQUIREMENTS

The Engineering Mechanics Department's faculty is responsible for degree programs at the undergraduate and graduate levels and for service courses for the College as a whole at Sophomore, Junior, and Senior levels. Consequently, its staff requirements are related to both the numbers of students enrolled with the department and the College enrollment totals.

Past enrollment data and future projections are given in Tables I-A and I-B. The enrollment growth rates taken from these tables are:

4. LABORATORIES

A. Undergraduate Laboratories and Demonstration Area

A central goal of the Department's undergraduate laboratory program is to bring each student into direct contact with physical phenoma and into personal involvement in organizing and conducting experiments that are meaningful beyond a simple demonstration. This is an added and important facet to the traditional purposes of merely illustrating principles and providing laboratory practice. It requires special flexibilities in equipment and space to permit a succession of varied experiments. The current trend of this Department in implementing this goal is to emphasize the project-type experiment with individual participation supplemented by wide use of audio-visual and demonstration presentations to larger groups of students.

The scheduling of project-type laboratory work can be done from lesser to greater degree depending on the student level and student numbers. For Sophomore laboratories with high enrollment a restricted program is possible. For Junior and Senior laboratories with smaller enrollments increasingly more emphasis is possible and desirable. Concomitant with the increased educational value of this approach is the requirement of more equipment and more space so that laboratories of the same size will handle fewer students. The laboratory space projections (Table VI) consider the above as well as the number of students to be served and the different types of equipment in different laboratory areas. Nevertheless, the gains are so great that it is essential to follow this course.

Fundamental Solid Mechanics

This is a basic laboratory in mechanics of materials taken by the majority of the Sophomore engineering students. It requires some heavy equipment and multiple stations for student experiments.

Estimated enrollment: approx. 200 students/week
Estimated time use: 40 hrs./week
Area: 3360 sq.ft. on Central Campus. If first two years moves to North Campus, this space will be required on North Campus.

Fundamental Fluid Mechanics and Dynamics Projects Lab.

These areas are to serve Junior and Senior level students with a major stress on project-type work. They are considered together because of this similarity of approach and the fact that much instrumentation is common to both. An actual combination is a future possibility. The kinds of equipment desired for the fluids laboratory occupies more space than for the dynamics experiments. This is reflected in the area breakdown in Table VI. It is also planned that these areas be used in conjunction with the corresponding graduate laboratories listed in Table VII. The present trend and future goal in this Department is to increase the contacts of undergraduates with graduate research projects which will be encouraged by joint uses of space.

Estimated enrollment: 60 students/week
Estimated time use: Goal of operation is for afternoon scheduled sessions (20 hrs/week) with the laboratory continuously available throughout the week for conducting experimental projects.
Area: 3960 sq.ft. on North Campus

Audio-Visual Demonstration and Laboratory Briefing

This space will include provisions for housing visual aid devices and demonstration equipment for the broad range of fluid and solid mechanics subjects. It will also include an area to serve students at all levels for presentations supplementary to classroom work and in preparation for laboratory work. An objective of the Department is to increase the use of such aids and demonstrations in connection with its various courses.

Estimated use of a presentation area for 40 students is up to 20 hrs/week.
Area: 800 sq.ft. on North Campus

B. Graduate Laboratories and Other Facilities for Advanced Work

Table VII lists graduate laboratories and other related facilities for support of advanced work at graduate and undergraduate levels. The facilities are for instruction via experiment and computation and for student thesis research. They provide for the Department's graduate experimental interests in the general areas of fluid mechanics and of solid mechanics and for computational equipment and services for both experimental and theoretical work at various levels. A laboratory for photoelasticity and experimental stress analysis is a facility bridging graduate and advanced undergraduate activities. A darkroom is included as a necessary adjunct to an experimental program. Finally, provision is made for a graduate student work-study area.

The Work-Study Area for Graduate Students is a highly important and needed facility. It is part of the effort to have graduate students work and study in an environment fostering discussions and exchanges with fellow students and faculty. Those students who are teaching fellows, research assistants and engaged in thesis projects should be assigned to shared office space as already discussed. A general work-study area with suitable work spaces is the provision for the remainder of the graduate student group estimated to be 40 persons. This space would have near continuous use. Requested area is 1200 sq.ft. on the North Campus.

The other facilities listed in Table VII will have uses as follows:

Fluid Dynamics Research and Instruction

For advanced experiments and research in general Newtonian and non-Newtonian fluid mechanics. Will house specialized equipment for instruction and thesis projects.

Estimated use:

For advanced laboratory: 6 hrs/week

For research: Occupation by staff projects and up to 10 doctoral thesis projects.

Area: 2200 sq.ft. on North Campus

Dynamics and Solid Mechanics

For advanced experiments and research in areas of elastic and inelastic mechanics including structural dynamics, random vibrations, reactive structures, time-temperature properties, general material behavior.

Estimated use:

For advanced laboratory: 6 hrs/week

For research: Occupation by staff projects and up to 10 doctoral thesis projects.

Area: 2200 sq.ft. on North Campus

Dynamics and Solid Mechanics

For advanced experiments and research in areas of elastic and inelastic mechanics including structural dynamics, random vibrations, reactive structures, time-temperature properties, general material behavior.

Estimated use: Primarily for research with occupation by staff projects and up to 10 doctoral thesis projects.

Area: 2000 sq.ft. on North Campus

As already noted, it is planned that the above laboratory areas be used in conjunction with the corresponding undergraduate laboratories in order to foster contacts of undergraduates with advanced research projects.

Photoelasticity and Experimental Stress Analysis

This laboratory houses special equipment for experimental determination of stress and strain. It is a basic facility for support of experiment and research in the general area of solid mechanics. In addition, it is used for instruction in techniques and for research using these techniques. Beyond an estimated 12 hrs/week for scheduled classes, its use will be variable but critically important in its supporting role.

Space: 600 sq.ft. on North Campus

Darkroom

Many physical events and certain types of data can only be recorded by photographic means. The darkroom is a necessary supporting facility for all types of photo-processing in this important connection. Its use by student and staff is variable with intensity depending primarily on the type of research projects in progress.

Space: 200 sq.ft. on North Campus

Analog Computer

The analog computer is an important adjunct to modern analysis and experimental work. The Department's interests in dynamical problems of all types is served by a laboratory equipped for analog computation and modelling. This laboratory not only supports the research program but it is used for undergraduate instruction and demonstration. In the latter role it is expected to serve

ENGINEERING MECHANICS DEPARTMENT

TABLE I

A. DEGREE PROGRAM ENROLLMENTS

	Avg. 1961-65	Current	Goal 1976
Undergraduate	22	26	50 (1)
Graduate	47	45	80 (2)

(1) Based on expected continuation of increasing Sophomore elections to EM degree program (from 4 in 1961 to 11 in 1965) and an increase in Junior level transfers.

(2) Based on 70% increase of 5-year average.

B. PROJECTIONS OF STUDENT COUNTS AND COLLEGE ENROLLMENT

	Student Count in EM Courses			College Enrollment Goal		
Course Level	Avg. 61-65	Estimated 1976	Incr. %	Avg. 61-65	Estimated 1976	Incr. %
Soph.	536	655 (3)	22	756	850	12
Junior	553	1020	84	693	1100	59
Senior	139	263	89	651	1000	54
Totals	1228	1938	58	2090	2950	41

(3) Includes an estimated 15% of Junior transfers taking 2nd year deficiencies.

TABLE II

STAFF REQUIREMENTS

ENGINEERING MECHANICS DEPARTMENT

Staff	Current In Force	Current Desired*		1976 Estimated
Active Faculty (Senate Rank)	18	20	(8 x 1.58) +(12 x 1.7)=	33(1)
Faculty on Temporary Assignment	2	2		2
Emeritus Faculty	6	6		3
Instructors	5	6	(8 x 1.58) =	13(2)
Lecturers	2	2		
Teaching Fellows	12	9	(9 x 1.58) =	14(2)
Research Assistants	12	12	(12 x 1.8) =	22(3)
Administrative Assts.	0	1		1
Secretaries	3	4		13(4)
Technicians	3	3		5
Total	63	65		106

*On the basis of preferable distribution of instructional staff.

(1) Based on an average increase of 58% in the number of students taking EM undergraduate subjects (See Table I) and a 90% increase in graduate enrollment applied to prorated effort of staff.

(2) Based on an average increase of 58% in the number of students taking EM undergraduate subjects (See Table I).

(3) Based on a 90% increase in graduate enrollment.

(4) Dept. Admin. 3
Senate Rank Faculty 8
Jr. Staff 2

Projections are:

Precision Machine Shop and Supply Area

Central Campus

Staff: 1
Space: 400 sq.ft.

North Campus

Staff: 3
Space: 1200 sq.ft.

Electronics Repair and Equipment Design

North Campus

Staff: 1
Space: 350 sq.ft.

6. SPACE TO BE RETAINED

Space to be retained in West Engineering provided that all classes and laboratories for the first two years remain on the Central Campus is the following:

(1) Rooms 101, 101A, 102

For Sophomore Laboratory in Mechanics of Material (Fundamental Solid Mechanics)

(2) Rooms 104, 106

For Shop and Supply area. (These rooms are formed by a subdivision of a larger room which has direct access to Room 102.

(3) Office space for staff serving classes and laboratories on Central Campus totaling an estimated 2000 sq.ft.

(4) Office space for counseling and registration of the Central Campus students, approximately 150 sq.ft.

7. SITE LOCATION REQUIREMENTS

The Department now operates laboratories in the fluids Engineering Building, most of which require the special services available only in that building. It is desirable that other laboratory needs be located adjacently to maximize the efficient use of shops and technicians services.

It is desirable that Department offices be located in the same area as other mechanics-related departments, particularly Aerospace.

approximately 250 students enrolled in dynamics classes. The intensity of its total use will be variable with near full-time use during certain periods in the term.

Space: 550 sq.ft. on North Campus

Auxiliaries to Digital Computer

The present wide use of the digital computer in instruction and research makes it important to have keypunch equipment convenient to the students and staff. The space projections in Table VII are in anticipation of a departmental terminal for time-sharing and associated equipment. Present keypunch usage is nearly 30 hours per week by 10 to 15 persons. It is estimated that 2 to 3 times as many persons will use a time-sharing terminal facility in 1976. The intensity of use cannot be forecast at this time.

Space: 300 sq.ft. on North Campus

C. Nonhomogeneous Fluid Dynamics Laboratory

This laboratory presently houses special equipment for research in the dynamics of nonhomogeneous and rotating fluids. It is anticipated that research in these and related areas will be continued on a long-term basis. Current research investigates problems of importance in many areas, including geophysics, meteorology and atmospheric pollution. Additional space needs for this purpose are not anticipated at this time.

5. SHOPS

The Department's programs of instruction and research are heavily dependent on machine shop and electronics shop capabilities. Currently small shops are maintained on the Central Campus and the North Campus which minister to the day-to-day requirements of laboratory courses and research. These units and the technicians attached to them operate in direct co-ordination with the instructional laboratories and in effect are attached to them.

The projections are for approximately the same facilities with a small increase in North Campus total space for shops and supplies. If all College operations move from the Central Campus the shop space in West Engineering would be released without need for further increase in the North Campus space.

ENGINEERING MECHANICS DEPARTMENT

TABLE III

OFFICE SPACE NEEDS FOR NORTH CAMPUS

(Teaching and Research Only)

	Persons Estimated 1976	Area Unit $ft.^2$/person	Total Area	No. of Offices
Active Faculty	21 12	200 150	4200 1800	21 12
Emeritus Faculty	3	150	450	3
Visiting Faculty	2	100	200	1
Instructors and Lecturers	13	120	1560	13
Teaching Fellows (TF)	14	75	1050	7
Research Assistants (RA)	22	60	1320	11
Thesis Research Offices (Graduate Students other than TF and RA)	12	40	480	4
Secretarial (Instructional Staff)	10	140*	1260**	9***

In addition to the above, approximately 2000 sq.ft. will be needed on the Central Campus for instructional staff if all classes and laboratories for the first two years remain on Central Campus.

*Includes filing space.

** Allows for one secretary to be housed in counseling-registration office (Table IV).

***Incorporated into secretarial-reception areas if faculty offices are arranged in suites.

TABLE IV

SPACE REQUIREMENTS FOR ADMINISTERING THE ENGINEERING MECHANICS DEPARTMENT

Type of Space	Present Space			Estimated Space Requirements 1976	Estimated Total Space Requirements on N.C. 1976	Estimated Requirements For Additional Space on N.C. 1976	Estimated Space Requirements on Central Campus 1976
	Current (Ft^2)	Room Nos.	Desired				
1. Chairman Adm. Ass't.	300	203 W.E.	300	400 150	400 150	400 150	0
2. Secretarial Reception Records Area	364	201 W.E.	400	500	500	500	0
3. Conference Room			215	215	215	215	0
4. Seminar Room			400	400	400	400	0
5. Counseling and Registration			90	300	150	150	150**
6. Student Study Lounge			300	400	400	400	0
TOTALS	664		1705	2365	2215	2215	150**

* Desired space for present enrollment and program.
** Provided classes and laboratories for first two years remain on Central Campus.

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TABLE V

SPACE REQUIREMENTS FOR OFFICES

FOR THE ENGINEERING MECHANICS DEPARTMENT

TEACHING, RESEARCH AND SUPPORTING SECRETARIAL

Type of Space	Present Space			Estimated Space Requirements 1976	Estimated Total Space Requirements on N.C. 1976	Estimated Requirements For Additional Space on N.C. 1976	Estimated** Space Requirements on Central Campus 1976
	Current (Ft^2)	Room Nos.	Desired*				
Active Faculty	2820	See Accompanying Listing in Table IX	3500	6000	6000	5200	Breakdown of Faculty not assessable but based on 20 persons at 100 Ft^2 per person
Emeritus Faculty	458		600	450	450	450	
Visiting Faculty			200	200	200	200	
Instructors & Lecturers	758		600	1560	1560	1560	
Teaching Fellows	903		540	1050	1050	1050	
Research Assts.	1042		1080	1320	1320	1096	
Secretarial				1260	1260	1260	
Thesis Res. ***				480	480	480	
Central Campus				2000**			
TOTAL	5981		6520	14320	12320	11296	2000**

* Desired space for present enrollment and desired faculty and staff distribution.
** Provided all classes and laboratories for the first two years remain on Central Campus.
*** Offices for graduate students engaged in research (other than Teaching Fellows or Research Assistants).

TABLE VI

ENGINEERING MECHANICS DEPARTMENT UNDERGRADUATE SMALL LABORATORY SPACE REQUIREMENTS

Type of Space	Present Space			Estimated Space Requirements 1976	Estimated Total Space Requirements on N.C. 1976	Estimated Requirements For Additional Space on N.C. 1976	Estimated Space Requirements on Main 1976
	Area	Room Nos.	Desired*				
Fundamental (1) Fluid Mechanics	3360	2221 F.E.B.	3360	3360	3360		
Dynamics (2) Projects Lab.	250	Part of 111 W.E.	600	600	600	600	
Fundamental (3) Solid Mechanics	1634	102 W.E.	2400	3360			3360**
Audio Visual (4) Demonstration & Laboratory Briefing	630	Portion of 101 W.E.	630	800	800	800	
TOTALS	5874		6990	8120	4760	1400	3360**

* Desired space for present enrollment and program.

(1) This lab. will require a sink, hot and cold water, air gas, 110 and 220 or 440 volts (up to 40 kva), high head room, access to water supply sump and constant head tank storm sewer connections.

(2, 3, 4) General purpose plus hot water.

(2, 3) Require heavy floor load rating.

** Provided all classes and laboratories for the first two years remain on Central Campus. Otherwise this space is needed on North Campus.

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ENGINEERING MECHANICS DEPARTMENT REQUIREMENTS FOR SMALL LABORATORY SPACE
TO SUPPORT ADVANCED INSTRUCTION AND RESEARCH

TABLE VII

Type of Space	Present Space			Estimated Space Requirements 1976	Estimated Total Space Requirements on N.C. 1976	Estimated Requirements For Additional Space on N.C. 1976	Estimated Space Requirements on Main 1976
	Area(Ft^2)	Room Nos.	Desired*				
Fluid Dynamics (1) Res. & Instr.	2200	Part of 1119 F.E.B.	2200	2200	2200		
Dynamics and (2) Solid Mechanics Res. & Instr.	250 630	Part of 111 W.E. 101 W.E.	1000	2000	2000	2000	
Photoelasticity & (3) Exp. Stress Anal.	264	415 W.E.	350	600	600	600	
Darkroom (4)	216Ft^2	108 W.E.	216	200	200	200	
Analog Comp. (5)	550	2260 F.E.B.	550	550	550		
Aux. to Dig. (6) Computer	100	Part of 111 W.E.	100	300	300	300	
Grad. Student Work-Study Area			600	1200**	1200**	1200**	0
TOTALS	4210		6016	7050	7050	4300	0

* Desired space for present enrollment and program.

** For graduate students not assigned to thesis or research projects. Estimated at 40 students x 30 ft^2/student.

(1) Laboratory for special studies in dynamics of Newtonian and non-Newtonian fluid phenomena. Requires high head room, access to water supply sump, constant head tank, storm sewers, hot and cold water, sanitary sewers, gas, compressed air, 110 and 220 or 440 volt (up to 100 kva), heavy floor load rating.

(2) Laboratory for elastic and inelastic mechanics including structural dynamics, random vibrations, reactive structures, time-temperature properties, general material behavior, heavy floor load General purpose plus hot water.

(3) General purpose plus hot water, temp. and humidity control. Divide into two areas, one of which can be darkened.

(4) General purpose plus hot water; less air, gas, telephone, data link.

(5) General purpose

(6) Requires 110 and 220 or 440 volt, telephone, data links, tile floor.

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TABLE VIII

ENGINEERING MECHANICS DEPARTMENT REQUIREMENTS FOR SPACE FOR SPECIAL FACILITIES AND SHOPS

Type of Space	Present Space			Estimated Space Requirements 1976	Estimated Total Space Requirements on N.C. 1976	Estimated Requirements For Additional Space on N.C. 1976	Estimated Space Requirements on Main 1976
	Area (Ft²)	Room Nos.	Desired*				
Nonhomogeneous Fluid Dynamics Laboratory (1)	4100	First Floor Orig. Fluids Bldg.	4100	4100	4100	0	0
Precision Machine Shop and Supply Area (2)	1400	101A W.E. Part of 1119 F.E.B.	1400	1600**	1200	0	400**
Electronics Repair and Equipt. Design (3)	200	Part of 1119 F.E.B.	200	350	350	150	0
TOTALS	5700		5700	6050	5650	150	400**

* Desired space for present enrollment and program.

** Provided all classes and laboratories for first two years remain on Central Campus.

(1) Requires high head room, access to water supply sump, constant head tank, storm sewers, sanitary sewers, 110 v. service, 440 v. power (up to 300 kva) heavy floor load rating.

(2) Requires hot and cold water, sanitary sewer, gas, compressed air, 110 v. service, 440 v. power (up to 30 kva), telephone, grease resistant tile floors, access to air exhaust ducts, heavy floor load rating.

(3) Requires telephone, grease resistant tile floors, 110 v. service (thoroughly grounded), 220 v. power (up to 10 kva).

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TABLE IX

The following space is currently occupied by the Engineering Mechanics Department

Room	Size (Sq.Ft.)	Occupants
101 WE	1260	50% AudioVisual, Demonstration and Laboratory Briefing - 50% Research
101 A	430	Shop
102	1634	100% Solid Mechanics Laboratory
103	319	100% Instructors (I)
104	244	64% Faculty (F)-36% Res. Assts.(RA)
105	271	100% Lecturers (L)
106	220	55%F-45% Emeritus Faculty (EF)
107	335	50% Teaching Fellows (TF)-50% I
108	216	Dark Room and Storage
109 + 109A	220 + 32	100% TF
111 + 111A	554 + 45	Dynamics and Analogue Computer Lab.
200	187	100% F
201	364	100% Department
201C	209	100% F
201D	104	100% F
201E	170	100% F
201F	156	100% F
202	150	100% F
203	300	100% Department
204	280	100% F
205A	311	100% F
205B	375	100% F
206A	296	68% F - 32% EF
309	264	100% EF
415 + 415A	264 + 32	100% Photoelasticity Laboratory
2319 EE	242	100% TF
2327	330	100% RA
2331	242	100% TF
1052	112	100% RA
1119	3360	33% Shop-67% Research Laboratory
1176	112	100% RA
2221	3360	100% Undergraduate Fluids Lab.
2260	550	100% Undergraduate Lab. and Analog Computer

TABLE IX (continued)

Room	Size (Sq.Ft.)	Occupants
2272	200	100% RA
2274	200	100% RA
2276	200	100% F
2278	200	100% F
Open Laboratory Space	4100	100% Research and Graduate Studies

	Totals
Faculty	2820.44
Emeritus Faculty	457.72
Instructors and Lecturers	757.50
Teaching Fellows	903.50
Research Assistants	1041.84
Department Administration	664.00
Laboratories	14,298.00
Shops	1538.80
Grand Total	22,481.80

The above room sizes were taken from the data supplied by Mr. K. McAdam.

Revised 6/6/66
T. M. Sawyer

ESTIMATES OF SPACE NEEDS FOR ENGLISH DEPARTMENT

1. Program Statement

It seems apparent that undergraduate engineering education at The University of Michigan by 1976 will include a larger proportion of the Humanities and Social Sciences. One of the common methods in the better Engineering College of introducing scientifically and technically oriented freshmen students to these disciplines is to provide courses in the historically significant works of philosophy, history, political science, and the arts. Such courses are often entitled Great Books and are usually taught by the staff of the English Department.

The English Department of the College of Engineering expects to be asked to teach two such courses to freshmen in place of the present three required courses of freshman composition and speech. While considerable writing will be required in these courses, a course devoted entirely to composition and specifically tailored to the requirements of the scientific and technical student will be needed at the senior level. The existing sophomore and junior literature courses will probably continue.

Therefore, the English Department expects that by 1976 engineering undergraduates will be required to elect the same number of courses from the English Department, but that these courses will be differently arranged.

Moreover, there is a growing sentiment in favor of a 3-credit hour standard in non-laboratory courses in place of 1 or 2-credit hour courses. Our introductory and advanced literature courses, some of which are now 2-hour courses, will probably be expanded slightly to 3-credit hours. And since a 9-hour teaching load is the standard for professorial staff of English departments across the country, especially when composition is one of the courses to be taught, we expect that each full-time staff member would be assigned three, 3-hour sections.

2. Number of Students to be Served

If the program described above proves to be an accurate forecast, the English Department will expect in any one term to enroll 100% of the freshmen and 50% of each upper level undergraduate class; that is, freshmen will be asked to take Great Books in both

Fall and Winter Terms, Sophomores will be asked to take a literature course in one of the two terms, juniors the same, and seniors the same except composition rather than literature will be required.

Thus, in 1976 the English Department enrollments in any one term should be:

	Estimated College Enrollment		English Department Enrollment
Freshmen	950	x 1.00	950
Sophomores	850	x 0.50	425
Juniors	1100	x 0.50	550
Seniors	1000	x 0.50	500
Totals	3900		2425

This means that in any one term we will enroll about 62% of the total college undergraduate enrollment; a slight decrease from our 63% in the Fall Term 1965-66.

Staff - Since we presently provide individual instruction in composition in each course we teach, and since we expect to offer an intensive course in composition at the senior level, we need to keep our sections small. Over the years we have managed to provide this individual instruction by professorial staff in sections averaging about 15 students. We hope to maintain that average.

If this is possible we predict the number of sections to be taught by the English Department in any one term to be:

	Estimated English Enrollment 1976		Estimated Number of Sections
Freshmen	950	/15	63
Sophomores	425	/15	28
Juniors	550	/15	36
Seniors	500	/15	33
		Total	160

At the standard 9-hour, or 3-section, load for English Department professorial staffs, we will need 53 full time staff members or their equivalent. (160 sections/3 = 53 full-time staff)

Offices - We do not need large offices, but we do need individual offices in order to consult with students. We would be content with 120 square feet per man and we could assign two, one-half time teaching fellows to an office this large. Thus our office space requirements should be 6360 square feet. (120 square feet x 53 = 6360 square feet).

Non-Academic Personnel - We employ no non-academic or research personnel other than secretaries. We need one secretary for every 20 staff members. Thus by 1976 we will probably need 3 full-time secretaries.

3. Departmental Office Space Required

At present we have about 900 square feet divided into an administrative office and mail room with room for two secretaries, the chairman's office, a combined staff library and conference room, and storage closets.

We will need another conference room and space for a third secretary by 1976, bringing the departmental office space required to 1200 square feet.

Chairman's office	200 sq.ft.
Secretaries, reception, mail	400
Conference rooms	400
Storage and files	100
Reproduction facilities	100
Total	1200 sq.ft.

4. Laboratories and Special Facilities

We use recordings, both tape and disk, in a number of our literature courses and attempt to tape record students in our speech classes. However, we are considerably hampered by the necessity of carrying portable tape recorders or record players from our offices to our classrooms. It would be far more convenient to have classroom loudspeakers and microphones connected to a central, remotely operated, recording room. Such a room need not be very large; about 100 square feet should be sufficient.

We also believe that video-tape might eventually be used. At present General Motors Institute of Technology video-tapes students in their speech classes so that students cannot only hear but see how they perform. Video-tape recorders are becoming relatively inexpensive; the Zoology Department is planning to install one for use with Zoology 101 laboratory classes.

It appears that the only special facilities required for such equipment would be conduit connecting the recording room to the various remote classroom outlets.

5. Services and Shops

We require nothing in this category.

6. Space to be Retained

None

7. Site Location

We believe that there is a possibility that the faculty of the School of Music and of the College of Architecture and Design may become interested in the courses proposed for the Humanities and Social Sciences portion of the Engineering College curriculum. The School of Music must now send its students back to the Central Campus for English courses in the Literary College. The College of Architecture may have to employ the same procedure. Both might find an English Department located on the North Campus an attractive alternative.

If this is true, it would be wise to locate the offices and classrooms of the English Department, and commuting staff from the Humanities and Social Science departments of the Literary College, where they are readily accessible to other units.

8. Normal Classroom Space

Except for the addition of conduit connections to provide microphone, loudspeaker, and remote control outlets from a recording room, we foresee no need for modifications of normal classrooms. The number of sections we expect to teach indicate that we would keep 14 classrooms in constant use.

9. Time Schedule for Moving

If the first two years of Engineering remain on the Central Campus at the start, we would expect to teach 91 sections there and 69 on the North Campus. It would then make relatively little difference on which campus we were housed, about one-half of our classes would be taught by commuters. If we asked the commuters to use half an office for half a day on the remote campus, we could get by with 8 to 9 offices and about 8 classrooms on the remote campus.

January 28, 1966

To: Dr. D. L. Katz
North Campus Planning

From: H. T. Jenkins, Engineering Graphics

Engineering drawing and descriptive geometry are basically important and necessary to engineering. Engineering drawings are the means of communicating vital information to all concerned, and virtually the only way that an engineer can convey or develop creative designs. The concise theories of engineering expression, engineering analysis, and engineering design are fundamental to the complete understanding of modern computer concepts, linear programming and systems engineering.

In view of the expanding classroom and service area needed in the near future, the following space is proposed for the Engineering Graphics Department at the North Campus:

2 classrooms	1,800 sq.ft.
10 drafting rooms	11,000 sq.ft.
15 offices	2,000 sq.ft.
Department office, secretary	800 sq.ft.
Conference Room	400 sq.ft.
Service Department (Duplicating)	3,000 sq.ft.
	19,000 sq.ft.

The space now occupied by the Engineering Graphics Department may be summed up as follows:

	Drawing	Office	Storage
Room 407	880 sq.ft.		
409		480 sq.ft.	
412		190	
414		270	
417		560	
418	800		
419	680		
420		460	
421	1,000		
424	740		

	Drawing	Office	Storage
Room 426		150 sq.ft.	
425		290	
427-429			1,300 sq.ft.
428			400
430	350		
432	800		
435		300	
436	780		
437	600		
438	670		
439	680		
441		260	
445	1,050		
444-446			400
326		250	
Totals	9,030 sq.ft.	3,210 sq.ft.	2,100 sq.ft.

The Department of Engineering Graphics anticipates the enrollment of freshmen to level out in the next few years to from 650-700 students per semester. The proposed area at the North Campus required to accommodate these students and the staff is 19,000 sq.ft.

The space allocated to Graphics is as follows:

	Sq.Ft.
10 faculty	1540
2 Secretary	300
Conference	300
Communication, files and display	400
Total	2540

The drafting rooms, classrooms, and duplicating department are accommodated elsewhere.

FUTURE PLANS OF THE INDUSTRIAL ENGINEERING DEPARTMENT

W. M. Hancock
3-2-66
Rev. 6-6-66

I. Departmental Program Statement

Industrial engineering is concerned with the design and control of work. Classic examples include organizing the flow of work in a factory, improving the performance of the individual artisan, routing and scheduling of men and materials, balancing assembly lines, and determining the work loads of man-machine operators. In addition, industrial engineering now includes organizing the work performed by today's much larger systems such as supply distribution systems, transportation networks, communication and information handling systems, service systems (hospitals, etc.), and protection systems (policy, military, etc.). The design and control of these systems requires the use of scientific methods of measurement to analyze the demands on them, to represent the spectra of their work capabilities, to solve problems of complicated flow of traffic through them, and to measure their cost and effectiveness as a whole. The term "Operations Research" is commonly used to designate these industrial engineering activities.

The Industrial Engineering Department at The University of Michigan offers programs of instruction for these activities and conducts both basic and applied research programs in the areas discussed. The programs include methods of measurement (which are quite significant when dealing with large systems), methods of representing the performance of work in quantitative terms, theories which contribute to the design of efficient work systems, and experiments in testing the results of theoretical predictions. The areas in which theory (and consequently teaching) is most fully developed are those that, ten years ago, were fast-growing research topics, i.e., production, inventory, traffic, and material control.

The fastest growing areas now, in terms of laboratory requirements and research activity, are those involved with human factors--the measurement of human work capability--and with social systems.

Because these areas are gaining an increasingly large share of importance in our society today, industrial engineering is expected to experience rapid growth during the next decade. At present the rate of growth of the industrial engineering profession is restricted only by the shortage of qualified educators.

II. Students and Faculty--Present and Future

The following table contains our present enrollment and our anticipated enrollment ten years from now.

	Present	1976
Sophomore	77	89
Junior	90	130
Senior	90	116
Master	67	140
Post Master and Ph.D.	34	65

The following is the faculty and staff that we presently have and expect to have in ten years, based on the enrollment predictions indicated above.

	Present	1976
Senate Rank	16	37
Lecturers and Emeritus Professors	8	13
Secretarial Personnel	9	25
Technicians	1	4
Graduate Assistants and Fellows	40	110

These predictions indicate that there will be a 30% increase in undergraduate enrollment and a 103% increase in graduate enrollment. This growth rate is conservative compared with recent tendencies; the undergraduate growth rate has been approximately 10% per year over the last four years while the graduate growth rate has been 30% per year, with a very large shift towards Ph.D. enrollment.

The proposed staff figures are determined as follows:

A. Senate Rank Staff

1. The enrollment increases predicted justify increasing the staff from 16 to 25 members.

2. Enrollment of students from outside the department is increasing. Students from the other departments of the College of Engineering, as well as the Business School and School of Public Health, are enrolling in increasing numbers in both the graduate and undergraduate courses. Two additional faculty are estimated as being needed for this increased enrollment.
3. The proportion of faculty participating in research must increase. Technology is increasing at such a rate in our field that more active research participation will be required in order for the staff to retain a leadership role. In addition, the increase in the number of Ph.D. students will require more active staff participation in research in order to guide theses work effectively. Four of the increase in faculty will be needed for this purpose.
4. Continuing Education Commitments. The department has adopted the policy that continuing education, which exists presently in the form of extension teaching, will be supported by increased staff additions. The increasing demand in this direction can be met only by the addition of two staff members.
5. The present faculty is undermanned primarily because of recent shifts in Ph.D. enrollment. In order to provide for this situation, four additional staff are needed.

B. Lecturers and Emeritus Professors

The present lecturers in the department are primarily full-time research employees. Our current thinking is that the research budget of the department should be about the same as the academic budget in order to provide the best environment for students and faculty. Six lecturer positions are in this category, and we anticipate the need for four more.

We have two emeritus professors now and anticipate space needs for one more.

C. Secretarial Personnel

This category includes departmental and research secretaries as well as editorial assistants. Our present ratio of secretaries to full-time employees is approximately 1:2.8. This ratio is not considered satisfactory for the amount of work load imposed by the faculty and research staff. A ratio of 1:2 appears to be a better basis for prediction. Therefore, our estimate is that a predicted full-time staff of 50 will require 25 secretarial personnel.

D. Technicians

We anticipate that our laboratory needs will substantially increase even if enrollment is not permitted to increase. The additional laboratories that are proposed later in this report will require personnel to maintain and equip them. Four people will be adequate to maintain the laboratory additions we will need in the future.

E. Graduate Assistants and Fellows

The policy is to provide space for all of the Ph.D. students and a small number of the master's students who are grading papers and otherwise assisting professors. The predicted increases will allow us to continue this policy.

III. Departmental Offices

The following are the predicted office needs.

A. Senate Rank Personnel

1. Nine offices at 206 sq.ft. for the very active professorial staff. All of these offices should be equipped with data links to the Computing Center. Seven of the offices should have satellite computer installations with high speed input-output. Sq.Ft. needed------------------- 1800
2. Seventeen offices at 150 sq.ft. for the staff that do not require extra space for their activities. All of these offices should be equipped with data links and approximately ten with high speed input-output satellite stations to the central computer facility. Sq.Ft. needed------ 2550
3. Ten offices at 120 sq.ft. These offices would be for the faculty that have need for minimum office space only, for example, because most of their research activity is located in one of the laboratories. Sq.Ft. needed---------------- --------- 1200

4. Department Chairman's office at 300 sq.ft. Additional space is primarily needed so that small meetings can be conducted and so that a large number of guests can be seated when the occasion arises. Sq. Ft. needed----------------- 300

Subtotal 5670

B. Lecturers, Visiting, and Emeritus Professors

1. Four offices, 2 at 200, 2 at 150 sq.ft. These offices would be for full-time research personnel who need this type of space. All offices should have data links and three of them should have satellite computer stations with high speed input-output. Sq.Ft. needed-------------------------- 700
2. Seven offices at 150 sq.ft. The space would be for full-time research personnel. All offices should have data links. Four should have computer satellite stations. Sq.Ft. needed--------- 1050
3. Two offices at 120 sq.ft. These offices are for research personnel and/or emeritus professors. No special requirements. Sq. Ft. needed--------------------------------------- 240

Subtotal 1990

C. Secretarial Peronnel

1. Twelve offices at 120 sq.ft. These offices would contain the basic needs of a secretary as well as a minimum number of files and records. Sq.Ft. needed-- 1440
2. Ten offices at 150 sq.ft. These facilities would contain, in addition to those of the basic office, room for filing cabinets and small equipment such as stapling, hole punching, and adding machines. Sq.Ft. needed------------ 1500
3. Three offices at 180 sq.ft. These offices would be for the secretarial personnel of the department chairman, the graduate program advisor, and the undergraduate program advisor,

3. (continued)
who have a much greater than average need for filing space. Sq.Ft. needed--------------------- 540
(Ed: Note alternate 25 Sec. x 150 = 3750 sq.ft.)
Subtotal 3480

D. Technicians
The needs are for small offices for the four technicians at 120 sq.ft. plus a general work area of 800 sq.ft. to permit local assembly and construction of laboratory and experimental equipment. Sq.Ft. needed----------------- 1280

E. Graduate Assistants and Fellows
Space will be needed for 110 personnel in this area. Assuming two students to an office and 120 sq.ft. per office, sq.ft. needed--------------- 6600

Total space needs for the departmental offices------------- 19,830 sq.ft.

IV. Laboratories and Special Facilities

A. Laboratories

Since many of the laboratories can be considered as general purpose, the following is needed in each of the laboratories in addition to the special facilities indicated in each specific laboratory:

Normal electrical (110 and 220) power, up to 15 kva in individual distribution box
3 phase available at distribution box
Sanitary sewer, tap water, gas, and compressed air available in only one location in the laboratory
Telephone conduits and data link to Computing Center and between laboratories
Linoleum or tile floor
Air conditioning
Remote T.V. jacks
Telephone jacks

For purposes of this presentation, the laboratories are grouped into two general categories: those that are to be used for teaching only and those that are to be used for research and teaching.

1. Teaching Laboratories
   a. Work Measurement Laboratory. The purpose of this laboratory is to provide space and equipment where students can run experiments in the measurement and prediction of the performance of man-machine systems. Desks and work benches are required for 20 students along with an area for a conveyor system and demonstration equipment. Each desk should be equipped with high speed timing devices. Number of students to be served--170 per year. Use per week--30 hours. Sq.Ft. needed-- 1000
   b. Facilities Design Laboratory
      An undergraduate laboratory where students will perform experiments on the layout and work flow of various facilities. Room for 20 large tables as well as substantial locked space for the storage of equipment. Number of students to be served--170 per year. Use per week--40 hours. Sq.Ft. needed-------------------------- 800
   c. Computation Laboratory. Primarily a facility where small mechanical computation devices can be housed. Computations are required by many courses on such equipment. Special requirements: sound deadening materials in floor and ceiling and sound barriers between machines in room. Desk space for 30 students. Number of students to be served--500 per year. Use per week--80 hours. Sq.Ft. needed--------------- 1200
   d. Simulation Laboratory. A facility that can be used to demonstrate and experiment with basic characteristics of many types of systems such as waiting lines, Monte Carlo processes, and the characteristics of sampling from many distributions. Laboratory will contain analog and digital computation equipment with cathode

ray input and output. Room will require substantial amounts of air conditioning plus humidity controls and a seating capacity for 30 students to be served--250 per year. Expected use per week--60 hours. Sq.Ft. needed-- 1000

e. Systems Laboratories. Three of these facilities will be needed where portions of actual operating systems can be set up, instrumented, and observed. Systems involving the flow of work or material which involve man-machine interactions will have to be observed in the absence of the sociological and experimental constraints found in industry. Number of students to be served--50 students per laboratory. Frequency of use--20 hours per week per laboratory. No special purpose equipment needed except adequate floor space. Space should also be provided for a satellite computer station in each laboratory. Area needed--900 sq.ft. per laboratory. Total sq.ft. needed-------------------- 2700

f. Satellite Computer Laboratory. This facility will consist of 20 satellite computer stations for student use. It is anticipated that students will be asked to solve problems as a normal part of their classroom assignments, using this facility. Special needs: extra amounts of air conditioning and humidity controls and sound proofing in walls, ceiling, and between machines. Frequence of use--80 hours per week. Number of students to be served--400 per year. Sq.Ft. needed---------------- 2000

2. Research and Teaching Laboratories

a. Environmental Laboratory. This facility will be used to demonstrate and perform research to determine the performance of humans under abnormal conditions such as heat and cold and in the presence of certain gases. Special equipment needed: temperature controls for 40 to 125°F, humidity controls, closed air circulation system, and special construction for the test chamber portion of the room so that the desired conditions can be maintained with minimum losses through the walls. Number of students served--60 per year. Frequency of use--20 hours per week. Size of test cell--10' x 15. Total size of laboratory assuming separate air conditioning, ventilation and heating equipment--1000 sq.ft.

b. <u>Human Performance Testing Laboratory</u>
The facility will house the numerous test equipment needed for determining individual abilities to perform as part of man-machine systems. No special equipment needed except sound proofing on the walls and ceilings. Frequency of use--25 hours per week. Number of students to be served--200 per year.
Sq.Ft. needed-- 800

c. <u>Facilities Design Laboratory</u>. This laboratory will house various types of research being done on the optimum design of work flow and material flow that occur in many types of systems. Number of students served--60 per year. Frequency of use--40 hours per week. No special equipment needed. Sq.Ft. needed--------------------- 900

d. <u>Advanced Systems Laboratories</u>. Six such facilities will be needed to house the data and to provide adequate working space for students and faculty to work together with immediate access to stored data. The areas of inventory, scheduling, and hospital systems are in need of such space now and it is anticipated that this need will grow. No special facilities are needed except humidity controls, adequate work tables and chairs, and projection equipment. Frequency of use--50 hours per week per laboratory. Students served per year--75 per year per laboratory. Each laboratory to be 800 sq.ft. Total sq.ft. needed---------------- 4800

e. Ph.D. Research Laboratories. These will be small laboratory areas where Ph.D. students can undertake thesis research. Number of students served--3 per year per laboratory area. Rate of use--25 hours per week per area. Twenty laboratories at 200 sq.ft. each. Total sq.ft. needed-------------------------- 4000

B. Special Facilities

1. Student Reading Room

Space will be needed within the department for references to documents and the necessary tables and space for students to read and study. Forty alcoves will be needed including desks and chairs as well as adequate space for the storage and maintenance of documents. Number of students served--700. Amount of use--60 hours per week per alcove. Sq.Ft. needed-------------------------- 4000

2. Programmed Material and T.V. Instruction Rooms

Changes underway in the educational processes will require student consoles to be available for the effective use of these methods of instruction. It is predicted that four such rooms will be needed which will require sound proofing of walls and ceiling as well as carousels with associated equipment for 20 students in each room. Number of students served--300. Frequency of use--60 hours per week per room. Sq.Ft. needed-------------- 2400

3. Conference Rooms

Provisions should be made for four conference rooms that would be used for conferences between faculty and students as well as informal discussions between all parties involved. Frequency of use--20 hours per week per room. Number of students served--100 per room. Four rooms at 500 sq.ft. Sq.Ft. needed---------------------------- 2000

4. Service Area

Space will be needed for service functions such as coffee-making for seminars and meetings and, upon occasion, light lunches. Sq.ft. needed-- 900

5. Reproduction Room

This area will house the reproduction facilities: ditto, collating, Xerox machines, etc., and storage facilities for supplies. Sq.Ft. needed-- 800

Total area needed for laboratories and special facilities-- 29,800 sq.ft.

V. Service and Shops

As noted on page 7, 1280 sq.ft. will be needed for the technicians. No shops will be needed, on the assumption that central facilities will be available.

VI. Space to be Retained.

No space presently occupied is to be retained. This includes the space on the main campus as well as the 1328 sq.ft. now occupied in the Fluids Building on North Campus.

VII. Site Locations or Special Requirements

No special requirements are foreseen except that all of the space proposed be located in the same area of the building.

VIII. Time Schedule for Moving

Because of the shortage of space on the main campus, the Department of Industrial Engineering would like to move as soon as possible and preferably the entire department at the same time.

TOTAL SPACE NEEDED 49,090 square feet

DEPARTMENT OF MECHANICAL ENGINEERING
NORTH CAMPUS PLANNING REPORT

R. M. Caddell
A. G. Hansen
February 1966
Rev. 6/1/66

I Introduction

The Mechanical Engineering program at The University of Michigan ranks as being among the largest and most well-developed programs of its kind in the nation. Without a doubt the breadth of the program tends to make it almost unique in character. Topical areas of study treated in the curriculum and encompassed in research activities range from extremely sophisticated topics in engineering science such as determining the thermodynamic properties of substances to very applied topics such as the determination of tool life in metal cutting machinery.

The program in the Mechanical Engineering Department has been evolving at a rapid pace during the last five years. The nature of course offerings has steadily become more basic and yet a balance has been kept between theory and application. All students, for example, are required to take laboratory courses in numerous areas as this proposal will show.

The professional qualifications of the staff have grown along with the changes in program format. Whereas only a few incoming professors had attained the Ph.D. degree in years past, current staff acquisitions have all attained this rank. This development in staff capability has been reflected in a rapidly growing graduate program. In 1956 the number of graduate degrees in Mechanical Engineering numbered 44. In 1966 it is expected that the number of degrees will exceed 65. In the decade ahead, an even more rapid growth is expected.

The Mechanical Engineering program is the second largest in the College of Engineering. There are approximately 350 undergraduate students and 130 graduate students enrolled. The graduates of the program are employed in a wide number of industries. Significantly, the broad background of mechanical engineers does not restrict them to any one particular engineering activity. Positions are found in the aerospace industry as readily as in the more consumer oriented industries. It is felt that in the immediate future the program of the department through the research it conducts and the students it graduates will make an even greater contribution to the state, nation, and world community. The growth of computer technology, new material development, exotic sources of energy will all serve to provide input to the program and through incorporation, continue to make the program one of the very best.

Program expansion and development in the next decade will require facilities and space requirements commensurate with that expansion and development. The following text will outline in detail the precise nature of the needs.

II Students and Personnel Requirements

A. Present and Estimated Student Enrollment

At the present time there are approximately 360 undergraduate and 130 graduate students registered in the Mechanical Engineering program. During the next decade, it has been predicted that these numbers will increase to 435 and 225 respectively.

In addition, this department offers several service courses which satisfy both the requests and needs of others; these courses are presently required by other departments as a part of their undergraduate curricula. There is no reason to assume that these demands will be lessened in the future. As several of the larger departments request service courses, the number of non-mechanical students taking mechanical engineering courses will increase significantly. At this time, over 300 undergraduate students from other departments are being taught by members of the Mechanical Engineering faculty. Based upon projected enrollments, this number should increase to over 400 within the next decade.

B. Faculty Requirements

At the present time there are 30 full time faculty members of Senate Rank in Mechanical Engineering. Another 10 fall in the Emeritus and Visiting Professor categories. To assist in the teaching function an additional 13 teaching fellows are presently active in this department.

To satisfy the expected enrollment increases, especially on the graduate level where only experienced and well-qualified staff can fulfill such demands, full time faculty of Senate Rank will be required during the next decade.

C. Full Time Non-Academic Requirements

Some of the truly essential functions that must be handled properly in any well run department are those performed by non-academic persons. Too often these functions are either overlooked or taken for granted, but unless they are carried out efficiently, the entire program suffers. With the numbers of papers, reports, student tests, letters, equipment requests, etc. that must be processed, an adequate and efficiently trained secretarial staff is essential. The value of such service to the academic staff, in allowing the staff to more effectively pursue their primary concerns of teaching and research, is clearly obvious. A number of laboratories in this department are devoted to both formal instruction and research. It is essential to provide proper non-academic assistance in the form of laboratory technicians for building, maintaining, and servicing all aspects of a laboratory program. Some of these persons are highly skilled machinists and electronic technicians. Without their help, the quality and quantity of laboratory instruction and research would be severely restricted.

At the present time there are 8 secretaries and 15 other non-academic personnel connected with this department on a full time basis. To reasonably accommodate the expected increases in the student body and faculty, as specified in A and B above, these non-academic persons should increase to 11 secretaries and 18 other non-academic personnel respectively.

Research assistants currently number 31. The number anticipated in the future is 45.

III Departmental Offices

In contrast to full time faculty, teaching fellows, and secretaries, certain research assistants and doctoral candidates require very modest office-type space inthe vicinity of their research projects. Full time faculty needs for office space vary. This is especially true for senior men who may require space for their personal libraries and reference files. Based upon the estimated size of this department as stated in parts II-B and II-C, the breakdown of office needs is included in Summary Table I.

In addition to individual offices there is a pressing need for modest sized rooms to be used for seminars, conferences involving groups of staff members or visitors, and small meetings involving staff persons. Four such facilities from 350 to 400 square feet are needed.

IV Laboratories, Service Facilities, and Special Facilities

The Department of Mechanical Engineering can be nominally subdivided into six broad areas of instruction of roughly equal importance. Current trends are such as to make for greater interplay among areas of instruction. For the purposes of this proposal however, program statements and space needs might be more clearly understood by presenting requirements of each of these areas independently. The specific programs are centered in the areas of thermodynamics, heat transfer, fluid mechanics, mechanical design, manufacturing and materials, and automotive engineering.

A. Thermodynamics Program

At the heart of any curriculum in Mechanical Engineering is the subject of thermodynamics, the study of energy and its transformation. A thorough knowledge of thermodynamics is as essential to the mechanical engineer as a knowledge of mathematics. Two courses in thermodynamics are required of all students and on this foundation a number of courses are built.

Labcratory facilities are used for both undergraduate instruction and for experimental research dealing with thermodynamic properties of substances and in evaluating the behavior of thermodynamic systems over a wide range of conditions. Emphasis is placed upon the fundamental laws to provide a sound foundation for fields of application and for the related areas of fluid mechanics and heat transfer.

1. Undergraduate Laboratory

The experiments performed by students are closely coordinated with classroom instruction and are designed to demonstrate and reinforce the theoretical concepts through exposure to physical situations. With the use of modern equipment and instrumentation, students obtain measurements necessary for the thermodynamic analysis of various systems. An area of 2600 square feet is required and will serve 125 students who will use this laboratory for 20 hours per week.

2. Research Laboratory

This facility is utilized for both undergraduate and graduate experimental research projects. Among the studies pursued are those dealing with thermodynamic properties of pure substances and mixtures plus system phase behavior over a wide range of temperature and pressure variation. Such projects not only expose students to realistic and important experimental methods but provide added experience by requiring individual responsibility for the design, fabrication, and operation of specialized system components.

Departmental needs require an area of 2900 square feet; this space will be used continuously by as many as 14 students and several faculty members.

Of the total required 5500 square feet listed above, approximately 5000 square feet presently exists and is being used, thus, the necessary increase is modest. The full laboratory area is located in the Fluids Engineering Building and the requested expansion would be most desirable in a region contiguous with these existing facilities. Since the laboratory needs regarding accessory items such as water, power, etc., are presently satisfactory, no additional qualification is necessary.

B. Heat Transfer Program

The science of heat transfer builds upon the basic laws of thermodynamics and utilizes them to emphasize the concepts which underlie rate processes associated with the transfer of heat and mass. The foundations of heat conduction, convection, and radiation are heavily emphasized. Although often treated as an appendage to the course work in thermodynamics, especially in years past, this subject has developed rapidly in recent times. It now stands as a full-fledged major area of study within mechanical engineering. Applications of heat transfer technology range from those found in space sciences to simple heating devices so commonplace in our working environment.

Laboratory facilities are designed to provide a variety of modern engineering applications in which heat transfer plays a dominant role.

1. Undergraduate Laboratory

The experiments conducted in the undergraduate heat transfer laboratory not only serve to strengthen the students' theoretical background but also permit a direct comparison of the behavior of actual phenomena with results based upon idealized conceptual models. In pursuing the objectives of these experiments, students make much use of a number of modern instruments in order to obtain those measurements directly relevant to heat transfer studies.

It is estimated that no expansion in the present laboratory size of some 1200 square feet will be required. This facility will handle 105 students using this laboratory for 20 hours per week.

2. Research Laboratory

Research laboratory space and equipment is required for graduate research studies on the doctoral or predoctoral level. Other research, under the direction of faculty members, is performed on specific problems for governmental agencies, industry, or in areas of general interest. These research efforts not only unfold new knowledge but provide the specialized training and exposure necessary for students to conduct the type of research essential in this field.

3. Instrument Room

An area of 385 square feet is presently devoted to this function and no increase in size is necessary. This room is used for storage of portable instruments that are too delicate to be left unattended when not in direct use. Another use of this space is as a maintenance area for the servicing and repair of instruments associated with this laboratory. Expendable items such as thermocouple wire, small electrical accessories, and hand tools are kept in this room.

Since the present facilities are considered adequate and are now occupied, no further qualifying comments seem necessary.

C. Fluid Mechanics Program

The study of the flow of fluids is a basic area of study within the department. The course work builds on and extends previous material in thermodynamics. Students are thoroughly grounded in the analysis and use of the basic laws of thermodynamics and mechanics as they apply to the solution of fluid flow problems. Laboratory facilities are utilized for formal instruction and research studies involving fluid properties, fluid behavior, and fluid handling devices such as control systems and turbo-machinery. The intention of the laboratory program is to reinforce the students' technical competence by the introduction of the analyses of modern engineering systems in which the flow of fluids plays a major role.

1. Undergraduate Laboratory

This laboratory contains experimental devices that are employed to correlate classroom instruction with actual physical phenomena and to demonstrate the application of the basic laws of energy, mass, and momentum conservation to engineering problems. The student is exposed to experiments involving turbomachinery, fluid systems, and fluid measuring devices. In addition, the use of modern instrumentation is stressed wherever applicable.

An area of 4000 square feet is required for this function and will be used by 115 students for 20 hours per week. Some of the more specialized equipment will also be used for individual research studies. At the present time other departments occupy space adjacent to this laboratory and it is requested that such space be reassigned to this department so that the necessary expansion is contiguous with existing facilities. The physical makeup of the laboratory space is completely adequate, thus a further classification seems unnecessary.

2. Research Laboratory

Doctoral studies and sponsored research activities will be handled in a fluids research laboratory. Subjects such as fluid amplifiers, compressible flow, boundary layer phenomena, and design of various fluid flow devices comprise the type of problems to be studied. With the aid of sensitive instrumentation, such studies not only result in producing useful information but develop the students' research capabilities by requiring a composite approach of design, experimentation, and analysis.

Space needs here are 3000 square feet and will be used on a continuous basis by as many as 13 students. As in the case of the undergraduate laboratory discussed above, it is desired that the necessary expansion be contiguous with existing facilities.

3. Lubrication and Wear Laboratory

Lubrication and wear research is a new but extremely active area in the departmental structure. Laboratory facilities will be used primarily by graduate students working on research studies. Although the existing facility came into being a short time ago, eight different research projects utilizing both graduate and undergraduate students plus two doctoral students use the laboratory on a full time basis. Industrial interest in this area is significant and is reflected by the contributions of equipment, research funds, and fellowships. Expansion is now a necessity.

Space needs are 2000 square feet and full time use of this area is expected. Existing facilities are presently contained in three separate rooms in the Automotive Laboratory and it seems most reasonable to consolidate facilities into one area.

Expansion in the present building is most unlikely in view of the needs of others in the Automotive Laboratory.

The Lubrication and Wear facility is a "general purpose" laboratory.

4. Special Facilities

Associated with the laboratory programs in fluid mechanics are a number of special facilities which provide the maintenance and service necessary for the numerous experiments and research conducted in this area. Although these facilities are all in existence, they are presently available to all occupants in the Fluids Engineering Building. It is requested that both the space and equipment involved be assigned to the Department of Mechanical Engineering and that the services now provided by these facilities be maintained by the College for the benefit of all departments except Mechanical Engineering.

An area of 3000 square feet is occupied at the present time; no expansion is necessary. Included in this area are an instrument room and shop, welding room, student shop, and a pipe room.

D. Mechanical Design Program

The design function in any phase of engineering provides the essential vehicle by which the student's previous background is finally united and applied to problems that typify his future professional activity. Mechanical design is concerned with such specific topics as power transmission, physical displacements and motions utilized for specific control purposes. Basic physical laws are illustrated with the aid of such devices as cams, brakes, clutches, and levers. The application of theoretical concepts to the solution of engineering problems encountered in industry is stressed. Laboratory studies provide experience in applying modern instrumentation to obtain accurate measurements and a richer understanding of principles that help to advance the art of machine design.

1. Mechanical Analysis Laboratory

This facility contains modern equipment and instrumentation that are used in experimental projects which relate dynamic theory to practical situations. Numerous physical devices are instrumented to reflect and study current industrial problem areas and to indicate how and why certain approaches to these problems should be followed.

Formal undergraduate and graduate instruction is carried out in this laboratory and involves 105 students for 24 hours per week. Since additional use will be made of this area by doctoral students and research students, the facility will be occupied on a full time basis.

An area of 4000 squqre feet is required and this fits the "dry" laboratory category.

2. Analog Computer Laboratory

The use of analog computers for solving many problems of a mechanical engineering nature has increased tremendously. Certain distinct curriculum changes have resulted because of the need to unite this theory with direct application in such areas as heat transfer, mechanical vibrations, vehicle dynamics, and mechanical analysis. Thus this laboratory is an inter-disciplinary type that will serve the needs of specialized groups within this department. Besides containing analog facilities, computers of hybrid analog-digital nature will probably be housed here. In addition, remote terminals for direct access to the University Computer Center will provide an extremely important accessory for this department.

A number of undergraduate and graduate courses, plus individual research projects will make use of this laboratory. It will be operated on a full time basis and will serve as many as 35 individuals per week. An area of 1200 square feet is needed and may be classified as a "dry" laboratory. Since it will be shared by numerous departmental functions, it should be centrally located with respect to other laboratories.

3. Automatic Control Laboratory

Recent modernization in the mechanical design phase of departmental activity resulted in the introduction of a new undergraduate course entitled Automatic Controls. A laboratory for this area of study will be used to support the concepts presented in the classroom. All undergraduates in mechanical engineering must take this course and the need for adequate space is truly pressing. Experimental studies are based on linear control theory. Applications of that theory to the control of motion, and the flow of heat, liquids and gases are stressed. Experience in the laboratory enables the student to compare and judge the results predicted by analytical methods with those obtained by actual measurement.

This facility required 1400 square feet and may be classed as a "general purpose" laboratory. In addition to its use by 105 undergraduate students for 20 hours per week, a graduate course involving the dynamic behavior of thermal and fluid systems will utilize this laboratory for research studies.

4. Vibration Laboratory

A problem of major importance confronted in engineering design is the isolation and control of mechanically induced vibrations. This subject is introduced in the undergraduate curriculum of students in this department. An advanced, theoretical course is offered at the graduate level. Again, the need to correlate theory with actual engineering problems can only be met by providing adequate laboratory facilities. Experiments involving dynamically excited structures such as suspension systems and instrument packages provide typical illustrations of theory and practice. The use of measuring devices such as accelerometers, frequency analyzers, and optical oscillographs enable the student to analyze and confirm those mathematical models employed in theories.

The space required is 1200 square feet and may be classed as a "general purpose" laboratory. Between undergraduates, who number 105, and individual research studies, this facility will be used for 30-40 hours per week.

5. Graduate Research Laboratory

Used exclusively by doctoral students, a graduate research facility will provide an isolated area where students may assemble, instrument, and check components of their overall experimental unit. A desk calculator and work tables will be available to aid in making pilot checks and initial calculations.

An area of 600 square feet is needed and except for 110 and 220 volts lines, no special provisions are required.

6. Undergraduate Design Laboratory

An undergraduate design laboratory is exclusively used for a number of undergraduate design courses. This area will contain the facilities needed to complete large-scale design projects. It might be viewed as a combination classroom-laboratory since the nature of design work involves professor-student discussion as well as individual student effort. In addition to the necessary tables, stools, and standard design equipment, part of this laboratory will contain a modern display area in which a variety of up-to-date mechanisms will be available for student observation and study.

Space needs are 2200 square feet and may be classed as a "general purpose" area. Facilities will be used for 30 hours per week by 115 students.

E. Manufacturing and Materials Program

In the spectrum of mechanical engineering, students are initially schooled in particular fundamental laws and concepts which are then employed in the area of design. Finally, the conversion of such designs into physical components must inevitably take place and it is in this realm that the course-work and research efforts of manufacturing are concerned. The problems which arise in the various production methods are truly engineering in nature; this can no longer be seriously challenged. Many industries require engineers to fulfill positions of manufacturing responsibility. Whereas for much of the past decade many schools have de-emphasized or eliminated those efforts directed specifically towards manufacturing, the University of Michigan has continued to support and expand this important facet of mechanical engineering. The justification of this confidence can now be measured by the resurgence of interest by other schools in such programs. Perhaps the single factor most responsible for this position of leadership was the deemphasis, about ten years ago, of the traditional descriptive and trade-school courses. This was replaced by a philosophy that is based upon the premise that the materials being processed and the method used to process cannot be divorced; rather the effects of each upon the other truly pose the engineering problems that must be solved.

To accommodate the many technological advances made in recent years, the entire curriculum in this area has recently undergone extensive revision following an intensive study. Although essential traditional subject matter has been retained, newer areas such as numerically controlled machine tools, electrical machining methods, and advanced studies in the mechanical behavior of solids have been added. It is especially in these newer areas where the need for space and allied facilities is acute--especially if meaningful research is to be carried out concomitantly with course development.

The numerous laboratories listed below are used either for formal instruction or research. The formal experiments stress process capabilities, the application of fundamental concepts dealing with the control of mechanical properties of solids, and the competitive and economical aspects of the basic manufacturing processes. Research efforts can best be explained under each individual laboratory.

Three important points must be stressed here. First, most staff persons connected with this departmental activity utilize several of these laboratories both in teaching and research. Secondly, the majority of physical equipment is quite heavy and requires special design consideration regarding floor loading capabilities. Thirdly, this group is physically separated from the rest of this department which is highly undesirable. For these reasons it is recommended that these facilities be transferred to the North Campus into a unified area that is reasonably close to other departmental laboratories with special attention being devoted to the problem of floor loading.

1. Manufacturing Processes Laboratory

The Manufacturing Processes Laboratory is used to conduct experimental studies and to provide realistic demonstrations related to the basic processes of casting, welding, plastic working, and machining. These activities provide the necessary physical experience that relates directly to classroom discussions and permits behavioral studies of material processing under realistic conditions.

To house the physical equipment an area of 4500 square feet is required; although this is less than the present space allotted to these processes, it is felt that by consolidating equipment that is presently separated, a more efficient use of space will result.

Two undergraduate courses, involving 200 students, will be conducted in this area; the facilities will be used for 24 hours per week. This is a "general purpose" laboratory but will require several 440 volt lines.

2. Plastic Working Research Laboratory

The facilities in this laboratory will be used primarily for graduate student and faculty research studies; a modest amount of undergraduate research effort will also be conducted. Although the two graduate courses concerning the plastic forming of metals utilizes analytical analyses of problems, it is only be experimentation that the accuracy of such analyses can be investigated. A large universal testing machine and specialized equipment with associated instrumentation for investigating such processes as drawing and extruding will be housed in this laboratory.

An area of 600 square feet is required to satisfy this need. Six graduate students plus two faculty members will utilize these facilities for 40 hours per week. It falls under the "general purpose" type of laboratory.

3. Metal Removal Laboratory

The Metal Removal Laboratory serves a dual purpose. It is used for undergraduate and graduate instruction plus specific research studies. The experimental studies for instructional purposes are geared to stress two things. First is the significant individual characteristics of metal cutting equipment which involves three major topics, namely, adaptive control, numerical control, and metrology. The second broad concept pursued is the interdependency of the work material, process, and equipment; this has been traditionally called machinability.

Research studies related to residual stresses, vibratory finishing, tool wear and surface finish, ultrasonic machining, and tool chatter are actively pursued. Modern recording equipment, force and displacement pickups, and accurate temperature sensing devices are used extensively throughout this laboratory.

To accommodate the existing equipment an area of 3500 square feet is required. It will be used by 40 students in four different undergraduate and graduate courses for 15 hours per week. Additionally, faculty and student research projects will utilize this area and facilities on a continuous basis. This is basically a "general purpose" laboratory but will require some 440 volt lines. A modest portion of this laboratory, 600 square feet, is used for computation purposes and the projection of film and slides; it should be isolated soundwise from the remainder of the laboratory.

4. Solids Research Laboratory

The experimental studies conducted in this area are broadly related to the mechanical behavior of solids. Such subject areas as brittle fracture, aging, and strain hardening are investigated. These programs are geared basically for graduate student projects and an occasional undergraduate study. The specific studies are intended to provide appropriate research experience to interested students as well as to unfold new information and knowledge in these areas that are discussed conceptually in the classroom.

A number of items such as a small testing machine, heat treatment furnaces, and electrolytic thinning equipment will be housed in this space. This provides a reasonably complete package for the needs involved.

An area of 550 square feet is required and will be used on a full time basis by 5 students. The basic classification of this facility is a "wet" laboratory and it is desirable that it be located reasonably close to the Electron Microscopy Laboratory in the Department of Chemical and Metallurgical Engineering.

5. Mechanical Testing and Heat Treatment Laboratory

The Mechanical Testing and Heat Treatment Laboratory has facilities for analyzing and measuring the mechanical properties of materials. Devices for mechanical testing, heat treating, and metallography are deployed herein. The principal use of this laboratory is for undergraduate instruction. Additionally, it finds use in research studies concerned with the control of mechanical properties by mechanical and thermal means.

Formal laboratory experiments performed by undergraduates are intended to provide such students with direct experience in applying the principles of materials science by using and treating real materials. In this way, the verification of those principles discussed in the classroom can be ascertained. Through this experience, the ability of students to select and specify structural materials for mechanical designs is greatly enhanced.

Space needs here are 2300 square feet. Three undergraduate courses, involving 270 students, use this laboratory 24 hours per week. Research studies, added to formal class usage, raise the use of this area to a full time activity. Of this total area, 600 square feet are devoted to metallographic work which fits the "wet" laboratory category while another 600 square feet is used exclusively as a furnace room and fits the "dry" category. The remainder of this area falls into the "general purpose" classification.

6. Acoustic Emission Research Laboratory

The Acoustic Emission Research Laboratory is the most recent facility developed for the study of material behavior. As contrasted to other efforts in this general area, the problems pursued deal with attempts to correlate the macroscopic behavior of materials with measurements of nearly atomic origin. As an example a metal under mechanical loads gives off bursts of noise. It is hypothesized that this noise may be due to the movement of dislocations or other defects in the lattice structure. Theoretically, such measurements may possess definite significance in relation to such properties as fatifue life. This is a rapidly expanding area and several doctoral students have already conducted thesis work on this subject. Because of the background required to pursue such problems, this facility is used exclusively for faculty and graduate student research problems.

An area of 800 square feet is devoted to this function which will be used for 30 hours per week by five graduate students. Part of this facility is in the form of a soundproof room that must be isolated from building vibrations. Other than this special need, it may be classed as a "general purpose" laboratory.

7. Special Facilities

Included in "special facilities" are two distinct types of areas; material storage and service functions. Raw material in the form of metal bar stock is used in such quantities, (both for formal experiments and research projects) that a reasonable supply must be maintained. Except for the necessary floor space, no special provisions are required. The service areas provide the needed support that is essential to maintain and operate efficient laboratories. The various requirements are listed individually as follows:

a. Material Storage Area

This region will house the necessary raw stock and finished test specimens that are used inthe operations previously described under the Manufacturing Processes and Metal Removal Laboratories. An area of 250 square feet is needed and should be located in the immediate vicinity of these two laboratory areas.

b. Material Storage Area

Space needs here are 200 square feet and this area will be used in conjunction with the Mechanical Testing and

Heat Treatment Laboratory; as such it should be contiguous with that facility. Experience has shown that this area should be physically separated from the one described previously since the physical items to be stored are of a different nature. Planning and inventory checks can both be conducted more reasonably if the two storage areas are distinct. Except for adequate floor space, no special provisions are required.

c. Machine Tool Service Area

Total space needs here are 1150 square feet, 300 of which is occupied by a tool crib that houses all hand tools, measuring accessories, cutting fluids, etc., used in the Metal Removal and Manufacturing Processes Laboratories. Such items are also available to others in this department. It should be located near the aforementioned laboratories and other than 110 volt outlets, has no special requirements.

The remaining 800 square feet houses a variety of standard machine tools that are used by skilled technicians to satisfy the service needs of the department. It has been found to be highly beneficial to physically separate this equipment and this function from the formal laboratory areas. Besides caring for all laboratory needs, such as the preparation of specimens, this area is employed to satisfy the machining needs of research projects, doctoral students, and routine maintenance. Except for 110 volt and 220 volt power sources, no special requirements prevail.

d. Electronic Service Area

Perhaps the largest single change in the experimentation conducted in this department has been in the improvement in accuracy and capability of measuring devices. Modern and sophisticated electronic devices are now commonplace; some are commercial items but many have been designed and constructed by members of the staff with assistance from highly skilled technicians. To realistically and economically keep pace with these needs, a full time electronic technician provides the required assistance. To accommodate departmental needs regarding the calibration, maintenance, and construction of this specialized equipment, an area of 500 square feet is required. This space, which is classed as a "dry" laboratory should be centrally located with, but physically separated from, all laboratories in this department.

All of the space presently devoted to the Manufacturing and Materials effort, including faculty offices, is located in the East Engineering Building. Although the above estimated needs involve over 2000 square feet of space less than that presently occupied, consolidation of these facilities will undoubtedly lead to more efficient space usage. These laboratories are now separated over three floors of one building; this is not desirable. By moving to the North Campus, not only would this department function be unified but direct contact with the remainder of the departmental laboratories would result. Additionally, this would free a large amount of space to help satisfy the pressing needs of other schools that remain on the Main Campus.

F. Automotive Program

Facilities for the departmental program related to automotive engineering are used for both formal instruction and research at the undergraduate and graduate levels. Mechanical and thermodynamic design features, operating characteristics, and basic combustion phenomena are analyzed using a variety of engine types. Increased activities in conventional and new propulsion systems have taken place and the problem area of air pollution is being attacked with a major increase in effort.

1. Automotive Engineering Laboratory

Experiments involve the use of modern instrumentation for analyzing the performance, efficiency, and other operating characteristics of various engines. Through such experiments, understanding of the fundamental laws of thermodynamics is reinforced. In addition, the proper application of basic design principles is stressed.

Space needs are 4250 square feet and will serve the senior-graduate level courses handled in this area. Thirty-five students will use this laboratory 20 hours per week. Individual undergraduate and graduate level research studies will be conducted with these facilities at other times during the week. This is a "general purpose" laboratory.

2. Combustion Research Laboratory

Doctoral thesis studies, sponsored research projects and individual student research studies are performed in the combustion research laboratory. Some studies are of a fundamental nature involving such areas as flame propagation and temperature distribution in combustion chambers. A large part of this program is now being directed towards air pollution research which is quite broad in scope. The expanded efforts in this field require additional facilities in excess of those that now exist.

This function requires 4250 square feet and will be used steadily for the aforementioned research categories. In regard to classification, this is a "general purpose" laboratory.

3. Special Facilities

"Special facilities" provide the necessary storage and supporting functions for conducting the experiments and research studies in this facet of departmental activity. A modest instrument and shop area, garage space for laboratory vehicles and chassis displays, a dark room for photographic needs, a nitrogen machine, a fuel-blending area, and storage space comprise the full list of these facilities. At the present time, some of these areas are used to service specific needs of other departments.

The total laboratory area required here is 8500 square feet. The expansion envisioned beyond the space presently being utilized for all functions in the Automotive Program is about 4000 square feet. Most of this increase is in the Combustion Research Laboratory and arises from the increased efforts in the field of air pollution. At the present time, other departments and other areas of mechanical engineering occupy much of

Summary Table III

Summary of Space Requirements for Special Facilities - Mech. Eng. Dept.

Item	Present space occupied (square feet)		Projected needs by 1976 on North Campus	Additional space (sq ft) required on North Campus
	Main Campus	North Campus		
1. Instrument room for heat transfer and thermodynamics	0	385	385	0
2. Instrument room, pipe room, shop in fluid mechanics	0	3000	3000	0
3. Service area for all labs connected with manufacturing processes	1150	0	1150	1150
4. Electronic service area	350	0	500	500
5. Storage, garage area, nitrogen machine, shop and instrument room connected with the automotive and combustion labs	0	11000	12000	1000
Totals	[2]1500	[3]14385	17035	[1]2650

[1] This is the total increase in space needed by 1976 over and above that which is presently occupied on North Campus by the Mechanical Engineering Department.

[2] This will be released by Mechanical Engineering when this department moves to North Campus.

[3] This space will be retained by Mechanical Engineering.

SUMMARY TABLE I

Summary of Space Requirements for Offices, Conference Rooms, and Student Stations - Mech. Eng. Dept.

Item	Number of Persons Involved			Space (sq ft) required by 1976 above that which i presently occupied on N. Campus
	Teaching Faculty	Non-Acad. Personnel	Students	
1. Dept. Chairman and Administration, student counselling, secretarial offices including filing, storage and reproduction	1	11		2650
2. Faculty offices	56			6270
3. Teaching Fellows			18	1080
4. Graduate students and research assistants not stationed in a specific laboratory.			63	3150
5. Faculty and Student activities				1600
6. Thermodynamics, Heat Transfer, and Fluid Mechanics Laboratories (includes lubrication and wear)		6	46	1500
7. Mech. Analysis, Auto. Control, Analog Computer, Vibration and Design Research Labs		2	15	450
8. Manufacturing Processes, Plastic Working, Metal Removal, Solids Research, Mech. Testing and Heat Treatment, and Acoustic Emission Labs.		5	17	850
9. Automotive and Combusion Research		5	9	450
Totals	57	29	168	[1]18000

[1] This is the space required over and above that which is presently occupied by the Mechanical Engineering Department on North Campus.

Breakdown of Faculty Offices

Persons/Office	No. of Offices	Sq. Ft.	Staff Rank	Total Space Needed-sq. ft.
1	18	200	Senior	3600
1	27	150	Senior	4050
1	11	120	Junior	1320
Totals	56			*8970

* Of this total, 6270 square feet is required since present office space on North Campus, occupied by Mech. Eng. Faculty, totals 2700 square feet.

Summary Table II

Summary of Laboratory Space Requirements

for the Mechanical Engineering Department

Laboratory	Present space occupied (square feet)		Proj. space needs by 1976(sq ft)	[6]Add. Space Required on North Campus (1976)
	[3]Main Campus	North Campus		
[1]Thermodynamics U.G.	0	2600	2600	0
[2]Thermodynamics Res.	0	2400	2900	500
Heat Transfer U.G.	0	1200	1200	0
Heat transfer Res.	0	3800	4000	200
Fluid Mechanics U.G	0	2100	4000	1900
Fluid Mechanics Res	0	1300	3000	1700
Lubrication & Wear Res.	0	1000	2000	1000
Mechanical Analysis	0	1600	4000	2400
Analog Computer	500	0	1200	1200
Automatic Control	0	0	1400	1400
Vibration	0	0	1200	1200
Design Res.	0	0	600	600
Design U.G.	3500	0	2200	2200
Manufacturing Processes	4500	0	4500	4500
Plastic Working Res	620	0	600	600
Metal Removal	4300	0	3500	3500
Solids Res.	540	0	550	550
Mechanical Test & Heat Treat	2300	0	2300	2300
Acoustic Emission	1100	0	800	800
Material Storage	850	0	450	450
Automotive	0	3900	4250	350
Combustion Res.	0	1850	4250	2400
Totals	17710	[5]21750	51500	[4]29750

1 U. G. is an undergraduate laboratory.
2 Res. is a research laboratory (primarily graduate students).
3 All of this space will be released by Mechanical Engineering when this department moves to North Campus.
4 This is the estimated space needs over and above that which this department presently occupies on North Campus.
5 This space would be retained by Mechanical Engineering.
6 This does not include regular classroom space.

the Automotive Laboratory Building. It is requested that such activities be relocated so the expansion requested here can be accommodated in this same building. Present laboratory facilities and makeup are perfectly satisfactory thus, no changes beyond the space reassignments are needed.

V. Final Summary

At the present time over 60% of the laboratory space assigned to the Department of Mechanical Engineering is located on the North Campus in the Automotive and Fluids Engineering Buildings. It would appear most economical and efficient if all of that space were retained and the requested expansion of those functions be accommodated within those buildings. Of the remaining present laboratory facilities, practically all are located in the East Engineering Building. In proposing the removal of these facilities to the North Campus, it is urgently requested that they be housed in an area adjacent to the other departmental activities. At this time it would seem as if the Fluids Engineering Building might provide adequate space if interdepartmental reassignments are feasible.

It appears unlikely that all functions of this department will be located in one building, therefore, sufficient office space should be provided in each building that houses departmental laboratories. No special considerations are necessary in regard to classroom needs except that these rooms, laboratories, and offices should be interspersed rather than segregated. Care should be exercised here as experience has shown that high noise level laboratories must be isolated from adjacent classrooms.

The Department of Mechanical Engineering requests that consolidation of its facilities on the North Campus be effected as early as possible relative to a time schedule for the College as a whole. A complete breakdown of the number of pieces of equipment to be moved, weight of each, and other such information will be available well in advance of moving.

DEPARTMENT OF METEOROLOGY AND OCEANOGRAPHY

SPACE REQUIREMENTS IN NORTH CAMPUS CLASSROOM AND LABORATORY BUILDINGS

A. C. Wiin-Nielsen

1. Program Statement

Any fully developed scientific field has gone through a number of stages which may be described in general terms by: observation, description, prediction, and control. The first stage can be thought of in terms of the gathering of observations, the second stage is the analysis and description of the observations, the third stage is prediction based on understanding of physical laws, and the fourth stage consists of controlling the natural phenomena to such an extent that we can modify nature. The fields of meteorology and oceanography have be now developed to such an extent that we in many branches of our science are well into the stage of prediction, and at the same time we, in almost all areas, barely have reached a stage where our understanding is sufficient to conduct intelligent, nonhazardous experiments in control and modification of the natural environment. It is nevertheless of paramount importance to develop a program which will give us the penetrating understanding which will enable us to make such experiments in the future. The well recognized problems of air and water pollution, of cloud and weather modification, and perhaps even climate control are of sufficient basic importance for society in general and for the State of Michigan in particular to form a central theme around which we want to build our educational and research program.

The areas mentioned above should however not be considered as immediate goals but rather as broad problems which may be solved through basic research giving significant contributions to our understanding of the physical processes of the atmosphere and the oceans. In many fundamental respects, an earlier era of speculation and description has gradually been superceded by the present period in which rational and systematic explorations of the potentialities have become possible. Several changes stand out as factors causing this shift:

1. Increasingly complete and elaborate theories of atmospheric and oceanic processes have been advanced.

2. The advent of high-speed computers has radically changed our ability to test the theories and draw useful conclusions from them.

3. Man's ability to measure and to observe the atmosphere and the oceans including almost all parameters has been growing steadily.

The crucial uncertainties in our knowledge cannot be removed without basic research leading to a more refined predictability of the state of the atmosphere and the sea. We see it as our goal to contribute to such understanding through education and research in certain key areas which are suited for research in the university environment and which will be beneficial to our local and state problems as well as our national program. The educational program and our research efforts will be concentrated in the following areas:

A. Large-scale (global) dynamical processes.
B. Air and water pollution problems.
C. Cloud and precipitation physics.
D. Air-sea interaction.
E. Physical, geological and chemical aspects of Great Lakes oceanography.
F. Development of instrumentation for all programs.

All programs are in the forefront of research on the national level and they are also, with the possible exception of program A, of urgent importance to the Great Lakes region and in particular to the State of Michigan. The air and water pollution problem and the problems connected with air-sea interaction are of specific urgency to the industry of the State.

2. <u>Personnel in the Department</u>:

If significant contributions are to be made to the program outlined very briefly in the preceding section and of such great importance for the State and the Nation, it will be necessary to plan for considerable expansion in the efforts by our Department. An estimate of the personnel by 1976 including students in various categories is provided below in Table I.

Table I

Personnel Projection (1976)

A.	Undergraduate students	60
B.	Graduate students	65
C.	Professors	8
D.	Associate Professors	3
E.	Assistant Professors	2
F.	Lecturers	2
G.	Teaching Fellows	3
H.	Research Associates	4
I.	Technicians	5
	Total personnel	159

It has been assumed in Table I that the Department will be authorized to make a number of appointments on the professorial level. Table I reflects furthermore that we have assumed that a major fraction of the research personnel in oceanography will continue to be located in space provided by the Great Lakes Research Division (GLRD) of the Institute of Science and Technology. While the Department takes full responsibility for the educational program in meteorology and oceanography it will probably continue to be true that some aspects of the research program in our sciences will be done in laboratories in units other than the Department. Personnel and space for these efforts are not included in the present document.

3. Departmental Offices:

Office space should be provided for the professional staff listed in Table I and for a fraction of the undergraduate and graduate students who participate in the research program in the Department. The offices which function as departmental headquarters should include space for the office of the department Chairman, his secretarial staff (3) and a conference room which can be used for faculty meetings in the Department (16 people). There is an additional requirement for a somewhat smaller conference room (6-8 people). Table II provides for concreteness, a listing of the space requirements for offices including working space for graduate student research assistants and assistants in research (mostly undergraduate students).

Table II

Departmental Office Space (1976)

1	Office, Department Chairman	300 sq.ft.
3	Departmental Secretaries	450 sq.ft.
1	Conference room (Staff meetings)	300 sq.ft.
1	Smaller conference room	150 sq.ft.
10	Professors and Associate Professors	1590 sq.ft.
2	Assistant Professors at 130 sq.ft.	260 sq.ft.
2	Lecturers at 120 sq.ft.	240 sq.ft.
3	Teaching Fellows at 60 sq.ft.	180 sq.ft.
4	Research Associates	540 sq.ft.
5	Technicians at 50 sq.ft.	250 sq.ft.
4	Secretaries at 150 sq.ft.	600 sq.ft.
18	Research Assistants (grad. students) at 60 sq.ft.	1080 sq.ft.
18	Assistants in Research (undergrads) at 50 sq.ft.	720 sq.ft.
	Total	6660 sq.ft.

The arrangement of offices for the professorial staff, lecturers and teaching fellows should preferably be in office suites containing 5-6 persons together with the secretarial assistance, room for filing cabinets, and in some cases a smaller conference room.

We would hope that a different arrangement can be made to handle the office requirements for research associates, research assistants and assistants in research. Research associates should be located in separate rooms immediately adjacent to the small scale laboratories mentioned in the next section of this planning document. While separate offices are necessary for the research associates. we propose to locate the research assistants and the assistants in research in larger rooms with movable partitions. Each room should probably house 5-6 assistants.

4. Laboratories and Special Facilities:

The requirements for small scale laboratories in the Department are summarized in the following Table III.

Table III

Small Scale Laboratories (1976)

A.	Laboratory for large-scale meteorology	1600 sq.ft.
B.	Air-sea interaction laboratory	600 sq.ft.
C.	Laboratory for cloud and precipitation physics	800 sq.ft.
D.	Hybrid computer laboratory	1000 sq.ft.
E.	Meteorological instrumentation (Teaching)	650 sq.ft.
F.	Meteorological instrumentation (Research)	900 sq.ft.
G.	Instrument store room and repair facility	450 sq.ft.
H.	Wind tunnel room	600 sq.ft.
I.	Laboratory for atmospheric chemistry and chemical oceanography	800 sq.ft.
J.	Rotating fluids laboratory	600 sq.ft.
	Total	8000 sq.ft.

The purpose and use of each of the laboratories mentioned in Table III are given below.

A. Laboratory for Large-Scale Meteorology

The laboratory will be used for two purposes. It will serve as a teaching laboratory for courses in analysis of meteorological and oceanographic data. As such it will be used for two 3 credit hour courses per term with approximately 20 students in each class. It will in other words be occupied for teaching purposes for 18 hours per week. Secondly, the laboratory will be used in connection with the research program in large-scale dynamical processes. Large amounts of data are plotted and analyzed in this program together with a preparation of complicated computer programs. A special section of the laboratory (approximately 250 sq.ft.) should be equipped to house a weather map facsimile machine, Automatic Picture Transmission (APT) machine for communication with the University's central computer facility.

The laboratory must be equipped with relatively large work tables (light-tables, if possible) but can otherwise be a "general purpose" laboratory.

B. Air-Sea Interaction Laboratory

The program in Air-Sea Interaction is concerned with the turbulent transfer of momentum, heat and moisture between the ocean surface and the atmosphere. Data are collected in field programs. The program of the laboratory is therefore mainly to design instrumentation and to process data gathered in field work. No classroom teaching will be conducted in this laboratory except for occasional demonstration. The laboratory is used on a full time basis in the air-sea interaction program, and it will serve as laboratory for one research associate and three graduate students. It should be a "general purpose" laboratory.

C. Laboratory for Cloud and Precipitation Physics

The laboratory will serve as an experimental laboratory in physical meteorology. The program consists of simulating natural processes in clouds by laboratory experiments and by designing equipment which will be used in field programs. The laboratory will be used in connection with demonstrations in introductory courses in meteorology and oceanography and graduate courses in physical meteorology. It is estimated that it will serve as a laboratory for 10 students using it approximately 10 hours per week. In addition it will serve as the laboratory for one professor, one research associate and three graduate students. It should be a "general purpose" laboratory, but should be equipped with a small exhaust booth.

There is a special need for a 20 foot clearance in a small area (4 x 4 feet) in connection with this laboratory, but this area need not be directly in the main laboratory.

D. Hybrid Computer Laboratory

The program for this laboratory is to serve the teaching and research program by providing analog and digital computing facilities. The laboratory is used on a full time basis by all programs, and it should be centrally located in the space assigned to the department. A research associate is heading this facility and he is assisted by two technicians. The technicians should have work space adjacent to the computing laboratory. The room should have a humidity control, but can otherwise be a general purpose laboratory.

E., F., and G. Meteorological Instrumentation

The program of these laboratories is to provide space for the laboratory exercises in connection with our courses in meteorological instrumentation, and to provide space for the design, construction and testing of meteorological instrumentation in general. The teaching laboratory will be used two days a week as a laboratory for about 10 students, while the research laboratory will be used on a full time basis by one professor, one research associate and two graduate students.

The three laboratories should be located close to each other, and it is a definite requirement that they are located on the top floor of the building with easy access to roof mounted instruments. They must furthermore be equipped with 110 volt, 60 cycle, 1 phase, 60 ampere service with outlets back of all benches, gas, 90 p.s.i. air, ducts to roof area (connecting cables to roof mounted instruments), built in laboratory benches with drawers.

H. Wind Tunnel Room

The program of this laboratory is to provide facilities for testing and calibration of wind sensors used in the teaching program as mentioned above. It will house two lowspeed wind tunnels, one used for calibration, and the other for simulation of stratified flow over uneven terrain and heated ground. The laboratory is used on approximately half-time basis in the teaching and research program. It should be equipped with 110 volt, 60 cycle, 60 ampere, 220/440 volt, 3 phase service, and should have a 60 ampere exhaust fan, 3000-5000 c.p.m.

I. Laboratory for Atmospheric Chemistry and Chemical Oceanography

The program of this laboratory is to analyze chemical processes in the atmosphere and the sea. It will be used about 2 days a week in connection with courses in atmospheric chemistry and chemical oceanography, and will be used the remaining time by one professor and two or three graduate students.

The laboratory should be a typical "wet" laboratory.

J. Rotating Fluids Laboratory

The program of this laboratory is to provide facilities for experimentation with rotating fluids heated at the outer rim and cooled at the center in order to simulate large-scale wave motions in the atmosphere and the ocean. It will be used as a demonstration laboratory (approximately twice a week) in connection with courses in dynamic meteorology and oceanography, but will be used the remaining time in the research program. The program of this laboratory is very important as a supplement to the program in large-scale meteorology because it provides us with the only opportunity to simulate some of the gross aspects of atmospheric circulations including the general circulation, flow over barriers, different wave phenomena and large-scale convection.

The laboratory should be a "general purpose" laboratory.

5. Services and Shops

The general experience in the Department is that it is advantageous to have small shops which will satisfy the special requirements of the teaching and research staff. The service which can be obtained from centralized machine shops has turned out to be less than satisfactory. The shop activities in our department are probably so specialized that there is no reason to expect that a general machine shop can satisfy our needs. It is furthermore a fact that our department specializes in several aspects of applied and engineering meteorology and oceanography. Table IV summarizes our shop requirements.

Table IV

Shop Facilities (1976)

A.	Machine Shop		
	Woodworking area	200 sq.ft.	
	Precision shop	100 sq.ft.	
	Storage	200 sq.ft.	
	Main Machine shop	1100 sq.ft.	1600 sq.ft.
B.	Electronics Shop		300 sq.ft.
C.	Darkroom facility		100 sq.ft.
		Total	2000 sq.ft.

The program of the shops is to serve all teaching and research programs in the Department. They are used on a full-time basis by a laboratory machinist and a laboratory mechanic, but students may also work in the shops under proper supervision by the machinist.

The shops should be located in the neighborhood of the instrumentation laboratories, and should be equipped with 220/440 volt, 3 phase power in addition to 110 volt; gas; high pressure air in Main Machine Shop; hot-cold water; spray booth with exhaust fan and hood in machine shop; floor loading 200 lb./sq.ft.

The darkroom facility is used for counting work, microfilm reading and simple photographic work. It should contain 110 volt, 60 cycle and an exhaust fan.

6. Present Space:

No space presently occupied by the Department should be retained in connection with the move to the North Campus area.

7. Site Location and Special Requirements:

In connection with the relocation of the College of Engineering to North Campus one should give the most serious consideration to the possibility that the University should concentrate its effort in meteorology and oceanography in a single building. While the teaching in the two sciences is the main responsibility of our department, we find that the research efforts of the University are scattered in several units. In addition to the research program in our department meteorological research is presently going on in the High Altitude Laboratory of the Department of Aerospace Engineering, in the Space Physics Laboratory of the Department of Electrical Engineering and in the Great Lakes Research Division of the Institute of Science and Technology. The research program in oceanography is divided in a similar way between our department and the Great Lakes Research Division. While the unification of all these efforts into a single department may be undesirable, one should nevertheless try to design the building plans in such a way that the Department of Meteorology and Oceanography is located as close as possible to the laboratories and divisions mentioned above if it turns out to be impossible to locate all the units in a single building. It is anticipated that the Great Lakes Research Division will have moved to the IST Building (or a building adjacent to the present IST Building) when the College of Engineering is ready to move. Should it be impossible to locate all units in a single building, we shall prefer to be located between the IST complex on North Campus and the Research Activities Building.

Our department has now and will most likely continue to have a deep interest in the experimental aspects of meteorology and oceanography. While the oceanographers necessarily will have to travel long distances to do their field research, it is possible to conduct a large number of experiments of an educational and scientific nature if the department has direct access to the roof of the building. We will therefore prefer to be located on the top floor of the building with easy access to a horizontal roof area.

A research tower mounted on top of the East Engineering Building and equipped with meteorological instrumentation of different kinds is now being used on several research programs and also in the teaching program. It is essential that a similar tower is mounted on the new building. The possibility exists that the present tower can be moved to North Campus. It will extend 70 feet above the roof of the building. Special reinforcement is required. The weight of the tower is 5000 lbs.

8. Special Classrooms:

Since instruction in meteorology and oceanography to a very large extent depends on demonstrations and other visual aids, it is essential that a special classroom containing mounted geographical maps, boards for display of weather maps, facilities for classroom demonstrations and permanent screen and slide projectors is constructed for the use of the Department.

If the room can be large enough to seat about 80 people it can at the same time serve as the seminar room for the Department.

There is furthermore a requirement for a departmental library and student work area, and finally a need for storage space. The latter space can be located in the basement of the building, preferably with adjacent dock facilities.

The special requirements listed in this section are summarized in Table V.

Table V

Special Requirements

A.	Special classroom	1200 sq.ft.
B.	Departmental library and student work area	800 sq.ft.
C.	Storage space	2000 sq.ft.
	Total	4000 sq.ft.

9. Time Schedule for Moving

The Department of Meteorology and Oceanography has a requirement to move to the North Campus area as early as possible. The present operations in the Department are hampered by the widely scattered facilities to which we presently have access.

Table VI

Summary of Space Requirements (1976)

Offices (Table II)	6660 sq.ft.
Laboratories (-III)	8000 sq.ft.
Shop Facilities (-IV)	2000 sq.ft.
Special Rooms (-V)	4000 sq.ft.
Total	20,660 sq.ft.

G. L. West
February 10, 1966

PROGRAM OF THE DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING

I. The Department of Naval Architecture and Marine Engineering is one of the unique departments in The University of Michigan and one of only three schools in the U. S. with complete programs in Naval Architecture and Marine Engineering. The others are M.I.T. and Webb Institute, with the University of California, Berkeley, having a small graduate school in naval architecture. Furthermore, Michigan has one of the largest schools of naval architecture in the world. It is without doubt the most important school in the U.S. and is rapidly becoming so in the world. In the past several years more than half the graduates in these fields in the U.S. have come from The University of Michigan. Clearly, it is a school of national responsibility as well as to the State of Michigan.

The demand for graduates by the marine industry and the navy is very high and far exceeds the supply. Changes in technology, the development of hydrofoils, air supported craft, growth in oceanography and undersea exploration, etc. account for much of the industrial needs. The outlook is for a continuing high demand.

In the past ten years there has been a very large increase in enrollment in this department, most of it occurring during the middle of this period. The total enrollment has more than doubled, with particular growth at the graduate level. In the past three years this increase has leveled off and the prospects are that future growth will be gradual. There is one factor which may change this picture, however; in recent discussions with the Chief of the Bureau of Ships, Navy Department, the possibility of transferring the graduate training of engineering Navy officers from M.I.T. to the University was proposed. It appears that the shift of at least fifteen to twenty officer students may soon occur. The total number at M.I.T. is about seventy. These students are in a three-year program of naval architecture leading to a professional degree.

A new program is being developed within the department which will prepare students for work in ocean engineering. It is not anticipated, however, that this will have a great impact on enrollment.

The faculty and students of the department have been engaged in hydrodynamic research activities since the hydrodynamics laboratory came into existence in 1904. New facilities are being completed at North Campus and others are planned; thus the research accomplished by the students and staff is expected to grow greatly in the near future.

The long range objectives of the department are to meet the changing needs of the industry, to continue to improve the level of courses taught, and broaden the base of the overall curricula. Greater emphasis on graduate education is being applied.

II. A. Students and Academic Staff

Based on the college predicted enrollment figures of 3900 undergraduates and 2100 graduate students, the Naval Architecture Department predicts 170 undergraduate and 40 graduate students by 1967. In order to have adequate personnel we believe that the Department staff should number as follows:

16 full-time staff

- 8 full professors
- 2 associate professors
- 4 assistant professors
- 2 instructors

The above numbers provide 2 additional full professors, two additional associate professors, one additional assistant professor, and one additional instructor over the present number of staff members.

The staff additions are intended to accommodate an increase of 38 students at the undergraduate level (present undergraduates 142) and an increase of 20 graduate students (present graduate students 21).

Staff additions will be needed, not only to meet expanding enrollment, but to strengthen and increase graduate course offerings. This is especially true for the subjects of ship structures, systems analyses, and control systems. Beginning next Fall there will be a course in ocean engineering. This is an attempt to cover the broader expanding field of engineering associated with the sea. Eventually it is planned that the Department will be teaching several courses in this field. By 1976 at least two of the additional staff should be involved in a program in ocean engineering. This leaves four additional staff to take care of the increase in student enrollment and expanded graduate program.

B. Research and Non-Academic Staff

At the present time the non-academic staff in direct support of departmental activities consists of

2 secretaries
2 laboratory technicians

This is insufficient staff for the current 1966 operation. Therefore, we anticipate at least a doubling of the non-academic staff for direct departmental support. That is a total of

4 secretaries
4 laboratory technicians

by 1976. The increase in secretaries will be needed to accommodate our expanded staff and facilities. It is pointed out that we will be one of the few, if not the only, department to continue to occupy space on the main campus. This split in facilities means some increase in support personnel over a consolidated arrangement.

By 1976 we expect to have the North Campus laboratories, now under construction, in full operation. This will mean added laboratory classes and student research. The two additional laboratory technicians are for the operation of the new North Campus laboratories.

The departmental research staff currently numbers

2 research engineers
3 model makers
1 lab technician
3 research assistants
1 research secretary

We expect the dollar value of our research to rise beyond the $200,000 level. On this basis it is expected that the research personnel will increase to about 20. These will be broken down about as follows:

6 research engineers
4 model makers
3 lab technicians
5 research assistants
2 secretaries

III. Departmental Offices

The Department has two requirements for a satisfactory office arrangement. We strongly recommend single occupancy for assistant professors and above. Secondly, because we do some design work in our offices, we would like adequate space to accommodate a 6-foot drawing board in addition to the normal office equipment. 200 square feet is recommended as a suitable size while we believe 150 square feet to be a minimum.

Instructors can be doubled up. Teaching assistants and doctoral candidates should each have a desk. Our best prediction is that the number of teaching assistants and doctoral candidates would be about thirteen. (We now have eight).

We require a combination Quarterdeck Society (student honorary) office and interview room. It should be close to the design and drafting rooms which are outlined in the next section. The Quarterdeck Office should have at least 300 square feet to provide for the student library and files, and sufficient space for work and study.

IV. Laboratories and Special Facilities

A. We require a design and drawing laboratory. The primary purpose of these rooms is to provide drawing space for student design work. Our present drawing room has 48 - 72" x 30" drawing boards. This is not enough for the present number of students. That is, we are not able to provide drawing boards for all the students who need them. Briefly, then, our requirements for a satisfactory drawing and design laboratory are as follows:

1. The laboratory in one or more rooms should accommodate 75 - 72" x 30" drawing boards plus space for 75 - 18" x 18" x 15" lockers.
2. The laboratory should have good lighting and air-conditioning. The present space is especially uncomfortable in the summer.

3. Each room should have a sink. In this respect these could be called wet laboratories.
4. The laboratory should have a normal electrical supply.
5. Space and sufficient electrical outlets to operate six desk type calculators should be provided.
6. Since this laboratory will be used for drawing and design, the floor should be wood or as near to it as possible. The floor should be designed for comfort during long periods of standing.

In addition to student design, the above facility serves for graduate student and staff research whenever a drawing board is needed. Five boards are currently being used in this way.

As in the past, we expect these laboratories to be used virtually twenty-four hours a day, seven days a week. The Department drawing and design room has always been open to students, and especially toward the semester end it will be well occupied until midnight with a few students remaining all night. Traditionally, the room as served as a gathering point for the students of the Department. Past experience indicates that the room is rarely completely full and almost never empty. If at all possible, we should like to have our drafting and design rooms arranged so that our students can enter them at all hours without any need of issuing keys to all students.

B. Conference Room and Library

The Department requires a conference room which can double as a library. The library (primarily technical papers) is housed in the Chairman's office at present.

C. New Towing Tank

The Ship Hydrodynamics Laboratory located on the first floor of West Engineering has been an integral part of the department for more than sixty years. It is the most important facility of the department and is in continual use for student laboratory classes, graduate student research and faculty research. The move to North Campus will require that the towing tank in West Engineering and the related spaces, Rooms 113 and 128 to be retained until such time as a new laboratory of this kind be constructed in the North

Campus area. A new laboratory is badly needed because of the age and limitations of the West Engineering tank; such a tank is expensive, however, and requires a great deal of space. Until funds for a new laboratory can be raised the West Engineering tank must be retained. In the meantime plans for a new research facility are being developed and means of financing it are being investigated.

D. Wet Laboratory

A new wet laboratory for the set-up and demonstration of various small flow facilities is required. It will also be used for research in hydrodynamics and marine engineering. The occupancy is expected to be from two to fifteen students and faculty. It is expected that it will be occupied essentially all of the normal day hours and possibly occasionally at night. This laboratory should have a large sink, AC and DC outlets, gas and air supplies. Several large general purpose workbenches should be furnished.

V. Services and Shops

Model shop -- primarily a wood working shop with some machining and instrumentation capacity: 1000 square feet. The shop should have

1. 15 KVA, 110, 220, 440 volt electrical supply.
2. A sink and drain.
3. High pressure air and gas.
4. An exhaust hood and paint spray booth.

Machine shop -- in combination with other departments. Our work is light. A shop containing the normal machine tools would suffice. The only special piece of equipment we would need would be a profiling or computer controlled milling machine to make hydrofoil shapes and propeller models.

Instrument shop -- in combination with other departments.

VI. Space to be Retained

A. Shops and Model Basin

This space consists of Rooms 128 and 113 in West Engineering Building. We also anticipate the need for about an additional 1200 square feet for added research staff and a counselling office.

B. Four research staff offices in the Fluids Building Annex on North Campus Rooms 2310, 2312, 2314 and 2316.

C. Wave tank laboratory in the Fluids Building Annex.

VII. We have no special requirements for location, but would like to be as close to the Fluids Building as possible. Also, as mentioned earlier, the location should reflect our students' need for all-hour access to the design rooms.

William Kerr
2-18-66
Rev. 6-9-66

DEPARTMENT OF NUCLEAR ENGINEERING

A. Nuclear Engineering - Program Statement

Nuclear engineering is concerned with the release, control and use of energy from nuclear reactions. The principal source of nuclear energy for peaceful uses today is the nuclear fission reactor. However, sufficient understanding of the fusion process exists to allow the production of high yield nuclear explosives. Development work, now far advanced, indicates that controlled release of large quantities of energy using controlled fusion devices is not far in the future. Present basic scientific work in high energy physics, leading to a fuller understanding of the fundamental nature of matter, may lead to methods of energy release, such as annihilation of matter, which could virtually eliminate the problem of providing primary sources of energy. The nuclear engineer must have an understanding of basic nuclear processes sufficient to make use of the rapidly evolving fundamental developments as well as engineering training of sufficient depth to incorporate them into devices and systems.

He must be a specialist in those areas peculiar to nuclear energy sources. These include the large quantities of high energy radiation that accompany nuclear processes, the high temperatures and pressures necessary for successful operation of many nuclear energy devices, and the behavior of both conventional as well as new, exotic materials in environments which may include the corrosive effects of liquid metal coolants, the degrading effects of high energy neutrons and gamma rays and high temperature stresses.

He must have a knowledge of the more conventional engineering principles such as thermodynamics, heat transfer, fluid flow, stress analysis and electric circuit theory, and in addition must have a thorough grounding in basic low energy nuclear reactions, nuclear structure and the interactions of nuclear radiations with materials.

Today's nuclear engineer participates in the design of nuclear fission reactors for central station power plants and in the development of new types of reactors for propulsion ofmerchant ships. He may be part of a design group developing a new submarine power plant or he may be responsible for testing a portable power package for use in remote or inaccessible locations. He may be involved in the evaluation of a nuclear rocket engine for deep space exploration or the design of a radioisotope power supply for a weather satellite. Applications of nuclear radiation as diverse as the sterilization of surgical supplies, the use of radioisotopes to power a heart pacing device, or the irradiation of fresh water fish to increase its shelf life occupy his interest.

Research in nuclear engineering extends from studies of basic nuclear structure needed in the design of advanced reactors, to investigations of high temperature plasmas for controlled thermonuclear reactors, to evaluations of the effects of nuclear explosives used for large excavations, to properties of materials subject to extremes of temperature and radiation exposure.

Direct conversion of nuclear energy to electrical energy, already for low power specialized applications, is an exciting challenge for the future in large scale power plants as well. Here the problems of high temperature liquid metal coolants in a high intensity radiation environment pose special problems for the nuclear engineer in the areas of materials, of two phase flow and of reactor core design.

The Department of Nuclear Engineering at The University of Michigan now has a research program which includes active studies of reactor kinetic behavior with emphasis on measurement and interpretation of neutron fluctuations in reactors, investigations of neutron transport theory, and of reactor core design. There is an extensive research program in neutron optics and in inelastic scattering of low-energy neutrons with applications to the determination of the structure of liquids. Active investigations also exist in plasma and thermonuclear theory, with current emphasis on development of plasma diagnostic techniques including line broadening as a measure of plasma parameters, the use of lasers in optical scattering studies, the absorption of microwaves in plasmas, and the development of probe techniques.

Recent activities have included theoretical and experimental investigations of both gaseous and solid-state lasers. These have led to construction of special models of each type for use in the current research program. Research in the measurement of fast neutron spectra has led to the development of techniques for preparing very thin silicon surface barrier detectors for particle detection in a proton-telescope neutron detector and to the development of methods for producing thick silicon particle detectors using the lithium drift technique.

In addition, there are fundamental studies of fluid flow and heat transfer with particular applications to reactor systems, e.g. the study of natural convection in closed cells with internal heat source, studies of bubble formation and growth in connection with basic studies of the cavitation process, detailed investigations of material behavior and failure during cavitation, use of radiation from radioisotopes in timing fast events such as the motion of a projectile in a rifle barrel, the use of radioactive gases in detection of leaks in rocket fuel systems, and the use of radiation in measuring moisture content of wood, and local density of two-phase flow.

Studies in the area of materials and solids include extensive use of electron spin resonance as a method for studying structure and composition of solids. This technique has also been used as a measure of radiation effects, especially those which produce dislocations in crystal structure. Research designed to provide new types of radiation detectors and to add to the understanding of the basic mechanisms in existing detectors is in progress. Studies of thermoelectric effects have included extensive measurements of thermoelectric coefficients aimed at possible direct conversion applications. The correlation between photoconductivity and microwave absorption has been studied. Current work includes the correlation of EPR measurements with hydrostatic pressure in certain solids.

In addition to these areas, the department has begun work to develop the use of neutron diffraction and neutron scattering to study the structure of large molecules in biological systems. We have plans to begin work on accelerator design problems. And the area of materials research continues to be one of growing interest.

The existence of the Ford Nuclear Reactor and the Phoenix Memorial Laboratory gives the department access to one of the finest university research reactors now operating and provides an excellent research facility. The leadership provided by the Detroit Edison Company in developing the Enrico Fermi fast breeder reactor and the recently announced plans of the Consumers Powers Company to add a second nuclear power plant to their system provide an important local interest in nuclear engineering development.

The University of Michigan is in an unusually favorable position to maintain one of the top nuclear engineering programs in the country.

B. Enrollment and Staff Projections

(See memorandum dated December 20, 1965.)

Because nuclear engineering is a new and rapidly changing discipline, forecasting space needs of the department ten years from now involves much uncertainty. For the same reasons, assigning specific programs to laboratory space carries with it a large probability that the activities now forecast may be replaced by others. However, considering the rapid growth taking place in applications of nuclear energy and the primitive stage of development in which much of the field still resides, the projected space needs are likely to be conservative.

It is assumed that graduate enrollment in 1976 will be 155. Undergraduate enrollment is assumed to be 195.

It is estimated that 27 staff members will be required.

C. Faculty Office, Conference and Seminar Needs

(Associated floor space is assumed to conform to the Buning-Harris report of November 12, 1965.)

1. One departmental office with space for two secretaries is needed.
2. Staff offices - Space for 26 faculty members is needed. We favor a grouping of three to five staff with a secretary in a suite arrangement which would also include a conference room. In addition to two secretaries associated with the departmental office, we anticipate needing an additional five secretaries based on one secretary for five staff members.
3. Seminar rooms - We assume that small classrooms can also be used for small seminars, but that for larger colloquium type meetings there will be several available for the use of more than one department. We would expect to need one room once or twice a week which would seat 60 to 80 people.

D. Classrooms

We anticipate no unusual requirements in classrooms. We expect that some classrooms will be equippedto show slides and movies, and that there will be electrical outlets available in sufficient number to handle some reasonable amount of demonstration equipment.

E. Office Space for Teaching Fellows and Advanced Graduate Students, 3000 square feet

We estimate 50 post-prelim doctoral students and teaching fellows. We request 60 square feet of office space per man and would prefer an arrangement which puts three men in an office. We need 3,000 square feet for this purpose.

F. Laboratories

Our needs for laboratory space will be divided into several categories. With the exception of those laboratories to be used for formal laboratory instruction, we prefer a module of 400 square feet as a basic unit. Except for special laboratories which will be indicated, the specification for the General Laboratory will be appropriate to our needs. We would prefer that those laboratories used for formal instruction be 1,000 square feet. These should also be equipped as General Laboratories.

1. Laboratories for Formal Instruction, 5,000 square feet

We require five laboratories each of 1,000 square feet. This is based on the assumption that 150 juniors and seniors will be enrolled for an average of 1.25 laboratory courses per semester and that 60 pre-M.S. graduate students will enroll for 0.75 courses per semester. The laboratory section is assumedto be ten people and laboratory periods are taken as four hours. With these assumptions, the five laboratories required will be used eight hours per day by students. It is assumed that one day per week must be reserved for setting up experimental equipment and performing maintenance. Hence, each laboratory will be used five days per week by a group of ten students plus one or two instructors, and an additional day per week will be reserved for maintenance and laboratory set up.

These five laboratories will be used at the junior-senior-first year graduate level to perform several types of experimental investigations. The first type will be basic measurements of nuclear radiations. Topics will include the study of radiation detectors, determination of characteristics of radiation sources, the study of radiation dosimetry, analysis of systems of radiation detection and data computation, examination of interaction of radiation with materials, and evaluation of the characteristics of industrial measuring devices using radiation and radioisotopes. These experiments will provide students with a basic introduction to measuring and handling radiation in both laboratory and industrial applications. Because radiation sources will be used, the amount of space per student is somewhat greater than might otherwise be required.

In addition to measurements involving nuclear radiation, experiments of a more general type will be carried out. Emphasis here is on introducing students to modern principles and techniques used in engineering measurements, with second emphasis on nuclear engineering aspects. Topics to be covered include Rutherford scattering of charged particles in solids and gases, determination of charge and mass of heavy multiply charged particles such as fission fragments, and statistical analysis of fluctuations in systems as a measure of system performance (sometimes called "noise" analysis). Other topics to be covered are measurement of luminescence of solids, liquids and gases, determination of charged particle trajectories in electric and magnetic fields, the use of Mossbauer effect to study the structure of solids, and investigation of space quantization of atomic magnetic moments as a practical demonstration of the need for quantum mechanical concepts in explaining physical phenomena. Additional topics include the use of magnetic resonance techniques, measurement of semiconductor properties such as Hall resistivity and magneto-resistivity, basic measurements of plasma phenomena, and measurement of heat transfer in high intensity radiation environments.

A third type of laboratory experiment will put emphasis on industrial applications of radiation. Such topics as thickness, level and velocity measurements using radiation sources will be examined. Industrial process control methods will be studied. Special techniques for high level dosimetry will be examined. Stress here will be on existing and potential new applications.

In order to maintain maximum flexibility, the five laboratories used for formal teaching will be used interchangeably for the purposes described above. Experiments and equipment will be transferred from one to the other in many cases. Thus, all of the laboratories should be in the same general area.

2. Research Laboratories

Insofar as possible, the Department of Nuclear Engineering integrates its research program with the teaching of students. The research program carried on by a staff member, although it may be partially supported by outside funds, is one in which student participation is a principal consideration. Thus, in the following, although space allocations will be indicated in terms of staff and students separately, it should be recognized that most of the research is directly related both to the professional interest of a staff member and to the education program of a student.

a. M.S. Problem Research, 2,000 square feet

The department requires that all M.S. students carry out an individual problem. Experience would indicate about 20 M.S. students working on experimental programs at one time. Considering a use factor of about 50 percent, we allocate 100 square feet per student. Thus, 2,000 square feet are required for experimental work of the general type listed in the department's research program description. Typically, the student will design and build some equipment and use some commercial instruments. While his problem is being carried out, usually during one or two terms, the experimental setup must stay relatively intact. This experience is unusually valuable both to the man going directly into industry and to the man who will do further graduate work.

It is typically his first venture into carrying out an investigation on his own. He may make many mistakes, but he usually learns enough not to repeat them.

b. Doctoral Research, 7600 square feet

It is assumed that half of the estimated 50 post-prelim students will be doing experimental theses. Typically, the student at this level spends 12 to 16 hours per day in his laboratory. We estimate an average of 300 square feet per student. Thus, on the average four students could be accommodated in three of the 400 square feet laboratory modules.

Experimental work will include topics such as measurement of electron density and temperature of plasmas, scattering of laser generated light by high temperature plasmas, measurement of non-linear optical phenomena using laser sources, and investigation of two-phase fluid flow behavior in geometries appropriate to liquid metal direct conversion systems. Additional areas are the use of electron spin resonance to determine radiation effects in semiconductors, use of solid state detectors for precision measurement of nuclear radiations, use of pulsed neutron techniques to measure nuclear reactor behavior and investigations of the Mossbauer effect as a tool in studying the structure of solids. Included also will be studies of bubble formation stimulated by laser beams, as well as investigations of cavitation damage to materials and of the basic cavitation process itself. These are indicative of the basic problems which require solutions in order that development of nuclear energy sources may proceed. If developments of the last ten years are any indication, the next ten years will produce many additional problems. For example, location in the Ann Arbor area of the 200 Bev accelerator now being planned by the Atomic Energy Commission could provide a powerful stimulus not only to fundamental work in high energy physics, but to applications of this new knowledge to practical purposes as well. The research of the Department of Nuclear Engineering will reflect this and other similar developments.

A total of 7,600 square feet is required for this program.

c. Faculty Research Laboratories, 5,200 square feet

The space needs indicated here, although designated as faculty, will typically be used by students as well. Typically the doctoral student who does an experimental thesis begins learning experimental techniques by working as an apprentice with a staff member or an advanced graduate student. Hence, although program and continuity of work in this laboratory space are determined primarily by staff interest, student participation will be high It is estimated that 13 staff members and 30 graduate students will be involved. Space of 400 square feet per staff member is needed, for a total of 5,200 square feet.

The research programs are similar to those described under "b" above and will not be repeated. Typically the occupancy will fluctuate. But with one staff member and two graduate students assigned to one of the 400 square feet modules, probably two of the three will be present most of the time during any 10 to 12 hour day.

d. Postdoctoral Laboratories, 800 square feet

We anticipate two postdoctoral fellows carrying on experimental work. An allocation of 400 square feet for each for a total of 800 square feet should provide both the office and research space needed. The research program here is geared closely to that of the department described above. The occupancy here is expected to be full time.

e. Analog Computer Laboratory, 400 square feet

The department has and expects to continue to use a medium size analog computer. The computer and its associated input-output equipment requires 400 square feet of space. It will be used for both formal laboratories and research. Occupancy is expected to be about

75 percent by either one or two students carrying out individual problems or by a laboratory section of six to eight students.

f. Student Shop Space, 600 square feet

This is placed under the category of laboratory space because it will be used by students who are building equipment for research. Hence, it will contain no heavy equipment and for convenience should be located near the research laboratories. A room of 600 square feet is requested. Since no large equipment is anticipated, it can be furnished as a general laboratory. This would be used by about 30 Ph.D. students and 20 M.S. students.

The above allocation of research laboratories has been in terms of people who use them. An alternative allocation in terms of program can be made. It should be recognized, however, that the nature of research programs is such that this allocation is only meaningful in a general way.

3. Research Laboratory Allocation by Activity

a. Plasma Laboratories, 2,000 square feet

Five 400 square feet modules are allocated to research in plasmas as described in more detail above. As indicated, these would be used by staff and students on an almost continuous basis.

b. Solid State and Materials Laboratories, 2,000 sq. ft.

Radiation effects on materials, semiconductors as detectors, laser and maser materials, combined high temperature and radiation effects are some of the areas that would be studied as described in more detail earlier. Five 400 square feet modules are required. Again use is by staff and students as above.

c. Subcritical Reactor, Exponential Pile, and Pulsed Neutron Sources, 1,200 square feet

This set of three modules would house one or more subcritical reactors and one or several exponential reactors. Several pulsed neutron sources would be used to investigate reactor parameters and material characteristics. The neutron sources will also be used to provide bursts of neutrons for spectrum studies, for timing studies and for detector investigations. Use by staff and students as above.

d. Scintillation and Luminescence Phenomena, 800 sq. ft.

Two 400 square feet modules for studying scintillation and luminescence phenomena in liquids, gases and solids will be needed. The phenomena can be used to detect nuclear radiation, to elucidate structure of materials and to provide energy conversion. Use by staff and students as above.

e. Reactor Coolant, Liquid Metal MHD, Two Phase Flow Phenomena, Cavitation, 2,000 square feet

This class of problems is generally related and the five modules required should be contiguous. Water, liquid metals, and organic materials used as reactor coolants are all important in further development. Liquid metal MHD shows promise as a method of direct conversion of reactor generated heat to electrical energy. Use by staff and students as above.

f. Mossbauer Phenomena, 800 square feet

This process apparently has many possible applications from studying structure and internal fields of solids to precise measurements of velocities. Two 400 square feet modules for use by staff and students as above.

g. Neutron Measurements, 1,600 square feet

These four modules would be used to study neutron detection, neutron dosimetry, measurement of neutron spectra, determination of source characteristics. Studies of neutron absorption and shielding would be carried out. Staff and student use as above.

h. Analog Computer Laboratory, 400 square feet

(Same as F.2.e above)

i. Critical Facility Laboratory, 2,000 square feet

This space would be used to house a critical facility of essentially zero power. Experiments that otherwise need to be carried out on a research reactor can be made here. In some cases because of the high background radiation associated with the research reactor, a critical assembly is necessary for experimental research.

j. Van de Graaf Accelerator, 3,000 square feet

An accelerator of this type is an absolute necessity for fundamental studies of nuclear structure, for shielding research, for cross section measurements, and for many other areas in which neutrons, or protons, of precisely controlled energy are needed. This space should be open and needs to be two stories high to accommodate the accelerator and its associated equipment. It should probably be below ground level to minimize radiation shielding problems. Use by staff and students as above. (Since this is a generally useful machine, it might be an Engineering College facility.)

G. Computer Facilities, 1,000 square feet

Space for ten satellite stations is required. Since this will be used by staff and by both graduate and undergraduate students, it is estimated that the use factor will be almost 100 percent. Since at least some of these stations may be associated with a University-wide data retrieval system, this space should be located near the departmental office.

H. Departmental Shops, 2,750 square feet

At present the department shares shop space with the Phoenix Memorial Laboratory. As the program expands more space will be needed. It is estimated that 2,750 square feet will be needed for a small machine shop and an electronics shop.

I. Reassignment of Existing Space

(See section H of Nuclear Engineering Department report of December 20, 1965.)

J. Summary

Departmental office with space for two secretaries.

Office space for twenty-six (26) staff with five secretaries.

Office space for fifty (50) advanced graduate students and teaching fellows, 3,000 square feet.

Laboratory space = 21,000 square feet.
Computer facilities = 1,000 square feet.
Shop space = 3,350 square feet.

October 18, 1965

MEMORANDUM

To: Dean Gordon J. Van Wylen

From: Glenn V. Edmonson
Associate Dean

Subject: Laboratory for Bioengineering

Although the need to understand and use a limited portion of the biological sciences has been recognized by certain engineering specialties for many years, the requirement that a larger, more diversified group of engineers have an expanded understanding of the biological and medical sciences is of rather recent origin. This expansion accompanies the engineer's acceptance of a continually greater responsibility for extending his philosophical approach to problem solution to the most important social problems of his generation. Examples will illustrate.

The lack of knowledge about the interaction of the human in the man-machine system is one of the most pressing problems of the present advanced technology. The design of many of the machines, intended to satisfy the needs of the human, is deficient because of the absence of formulated information concerning the probable action of the human in the man-machine system. Designing for the broad human need for transportation in an increasingly complex living environment requires the engineer to give consideration to such basic questions, "How does the normal human operator respond to an environment?" - "What does he really see and hear?" - "Under stress how and at what rate does he respond?" Quantitative answers to these and a host of other physiological questions need to be generated. There are many other technological-physiological interactions of increasing importance.

Success in bringing about conservation of air and water resources requires closer interlocking of present technology and the biological sciences. The design knowledge that is needed to provide an earth environment for space exploration must include not only the most advanced technology of materials, telemetry and power but an intimate understanding of the physiology of the human for whom equipment is being developed.

The University of Michigan is in the forefront of a national effort to provide an educational opportunity for the engineer through which he may gain an advanced understanding of the biological sciences as he prepares for a career in engineering. The Horace H. Rackham for Graduate Studies offers both the M.S. and Ph.D. degrees in Bioengineering.

The faculty interested in this program have been unusually successful in providing a broad, diversified opportunity for graduate students due to the many resources available to the program on our Campus at The University. Within the four years since the program was announced, one of the larger, more widely represented student groups in the country is enrolled in the Bioengineering Program at The University of Michigan. Its growth has, however, uncovered weaknesses that need to be overcome. These weaknesses center around the need for a type of laboratory now available in any one of the participating schools and colleges of the University.

The activity in a Bioengineering laboratory should be strongly oriented to the engineering approach to problem solution. Analysis requires the continuing interaction of thos knowledgeable about the latest contributions in mathematics, the physical and natural sciences and the engineering sciences and a special kind of laboratory where this knowledge may be brought to focus on the main biological systems problems of interest to the engineer. Practically, existing engineering laboratories are not suited to the requirements of an engineering student group who are also interested in the biological sciences. The present biological science laboratories are likewise not suited to the needs of the engineering-oriented student.

It is further important that the Bioengineering student group, now a minority group, have a physical place where they may pursue separate, however, related interests and have the opportunity by virtue of geographic location to interact with their counterparts. In the foreseeable future it appears that those faculty members working with the Bioengineering Program from mathematics, the natural and physical sciences and engineering will also find a well-equipped laboratory and the special group of students important to the task that lies ahead of them in this new, rapidly developing interdisciplinary, inter-college effort.

Since the predominant number of students enrolled in the Bioengineering Program are now and probably will continue to be engineers by undergraduate training, it seems that the College of Engineering might take a great step forward by more closely identifying itself with this national effort. An excellent method for accomplishing this goal would be by providing a suitable laboratory. Because this program in a major way touches the needs for specially trained people for the future, this proposed laboratory might have significant appeal to prospective donors.

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It is difficult to anticipate needs for an emerging program such as Bioengineering. Accordingly, an arbitrary allotment of 5 staff, 3 non-academic persons, 3000 square feet of office and conference and 15,000 square feet of laboratories (wet and general purpose) were made for this activity. This assignment should not be considered a limit for the activity should the need for more staff or space arise.

10/18/65