COLLEGE OF ENGINEERING
THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

CONFIDENTIAL

EXECUTIVE COMMITTEE RETREAT

Supporting Materials

Fall, 1985

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EXECUTIVE COMMITTEE RETREAT

Fall, 1985
Tentative Agenda

Status of the College*

- Faculty
- Facilities
- Financial Resources
- Students

Status of Departments and Programs*

Major Concerns and Strategic Planning*

*Written materials will be provided prior to meeting.

Needs of the College of Engineering

[Our Christmas list for Uncle Billy...]

General Fund Support

- Solidification of REEDF appropriation in "base" ($8.5 M)
- Restoration of adequate base support for instructional programs ($9 M)
- GF budget line for research support indexed at 15% of research volume
  (department research administration, cost-sharing, ...)

Physical Facilities

- Dow-GGBL Connector: UM cost-sharing: $2 M
- North Campus Library: State + private: $14 M
- North Campus Commercial Center: Student fees + commercial leases
- Longer Term:
  - Aerospace Engineering Complex
  - Nuclear Engineering Laboratories
  - Engineering Research Projects Laboratory

University Policies

- "Research Agenda"
  - Department Research Administration
  - Research Incentives
  - Primary Research Staff
  - Cost-Sharing
- Intellectual Properties
- Federal Relations Support
- Admissions Policies

Actions Requested

IMMEDIATE (now...)

- Supplemental REEDF Appropriation ($2.36 M)
- Approval of Dow-GGBL Connector (UM cost-sharing: $2 M)

Near Term (within months...)

- Top Priority to JCOC Planning for North Campus Library
- Approval of North Campus Commercial Center
- General Fund growth (bridge) for support of instructional programs

Longer Term (during 1986)

- Support of state-wide effort for engineering education
- "Research Agenda"
    - Department Research Administration
    - Research Incentives
    - Primary Research Staff
    - Cost-Sharing
- Intellectual Properties
- Federal Relations Support
- Admissions Policies
- Cost *and Revenue* Control Centers

Challenges for the Years Ahead

1. "Liberalization" of the Undergraduate Engineering Degree Program

2. Responding to intellectual changes in engineering and applied science

   - Diffusing boundaries between engineering and science
   - Obsolescense of traditional engineering disciplines
     (importance of cross-disciplinary activities
   - Applied Sciences-->Subsystems-->Total Systems Integration
   - Accommodating and stimulating innovation and creativity
     (working in the "exponential" region of the knowledge curve)
   - Building new programs in "computational science and simulation"
     (Scientific research = theory + experiment + simulation)

   Key Question:

   UM Engineering ---???--> College of Engineering & Applied Science
   UM Engineering ---???--> College of Engineering Systems

3. Faculty

   - Rebuilding senior faculty leadership in key departments
     (EECS, MEAM, Chem Eng, Civil)
   - Staffing "hot" areas
     (computer science, computational sciences, manufacturing)

4. Physical Facilities

   - Dow-GGBL Connector
   - North Campus Library
   - North Campus Commercial Center
   - Aerospace Laboratories
   - Engineering Research Projects Laboratory

5. Rebuilding strength of basic sciences at Michigan

   - Applied Physics Program
   - Applied Mathematics Program
   - Center for Computational Science and Engineering
   - Earth and Planetary Sciences
   - Applied "biosciences" programs (biotech, bioengineering, etc.)
   - Chemistry-Engineering Interface

6. Massive Experimental Facilities

- Examples:
  - Materials Characterization and Surface Sciences
  - Solid State Electronics
  - Optical Physics and Optoelectronics
  - Intense Energy Beam Laboratories
- Challenges:
  - Capital funding and maintenance
  - Staffing and management

7. Information Technologies

- CAEN Financing and Management
- CITI Evolution
- Computational Science support
- CAEN-Phase III: Massive workstation deployment to all students

8. Administration

- Transition from "takeoff and climbing" to "cruising altitude"
- Strategic Budget Management
- Completion of cost-revenue control center structure
- Differential Tuition
- Completion of "MIT of the Midwest" Strategy

Major Accomplishments
1981-1985

Major Accomplishments of UM Engineering (1981-1985)

Key Accomplishment

The College of Engineering was reestablished as a top priority both of the University of Michigan and the State of Michigan.

Quality

Faculty Recruitment:

A major renewal of the College faculty occurred, with the hiring of move than 90 new faculty (corresponding to almost 30% of the faculty). The College has been successful in attracting an extraordinary group of new faculty members at all ranks.

Student Quality:

Student quality rose still further to the point at which the average student entering the College now ranks in the 98th percentile of high school graduates. This is all the more impressive in view of the fact that the College now ranks first nationally in the total number of degrees awarded (almost 2,000 per year, including Computer Science).

Environment for Excellence:

The College has been successful in establishing an intense, entrepreneurial environment in which initiative, achievement, and the quest for excellence dominate. Hiring, promotion, tenure, and salary policies have been modified to reflect this emphasis on achievement.

Faculty and Student Morale:

Faculty and student morale seem very high. We are beginning to achieve the level of intensity -- the "go for it" attitude, the unwillingness to settle for anything less that the best -- necessary to compete with our leading peers (MIT, Stanford, UC-Berkeley).

Environment

Completion of the North Campus Move:

The opening of Engineering Building I next spring will complete the move of the College to the North Campus. Over the past several years, the University and College have managed a complex sequence of construction, renovation, and space trade projects totalling $70 million and involving the relocation of 7 academic departments, 250 faculty, and 5,000 students.

Computer-Aided Engineering Network:

UM Engineering has managed to build what is generally regarded as the leading computing environment in engineering education. This is serving as a model for many institutions across the nation (including other components of the UofM).

Laboratory Equipment and Support:

The College has begun to make a major dent in the staggering laboratory equipment needs of its instructional and research programs (although we are still a long ways from where we need to be). We have also tripled technical support staff for laboratory activities.

Administration:

- A first-rate team of associate deans has been assembled.
- The administration has been structured to emphasis responsiveness.
- Equitable resource allocation policies (zero-base budgeting)

Ongoing program review and reallocation:

Review of all academic departments; discontinuance of 1 department, 4 academic programs, and 2 administrative units; achievement of equitable degree of General Fund support for all departments and programs

General Resources:

With the successful implementation of the Research Excellence Fund, the College will have managed to restore the base General Fund support of its programs lost during the 1970s. The "Engineering Gap" will have been eliminated.

Research

- Research Incentive Program
- Sponsored research increase from $16 M/y to $25 M/y
- Major increase in PhD enrollments
- Center for Research in Integrated Manufacturing
- Industrial Technology Institute
- Computing Research laboratory
- Computer Aided Engineering Network
- Department of Electrical Engineering and Computer Science
- Center for Advanced Electronics and Optics Technology
- Renovation of Ship Hydrodynamics Laboratory (Towing Tank)
- Civil Engineering Structures Laboratory
- Electron Microscopy and Surface Sciences Laboratory
- Advanced Computer Architecture Laboratory (NCUBE)
- Biomechanics Laboratory (Al Schultz)
- SPRL Expansion (HRDI)
- Nuclear Accelerator Laboratory
- Directed Energy Beam Laboratory
- MEAM CAD Facility
- Harris H-800 Facility
- Center for Machine Intelligence
- Applied Physics Program
- Materials Processing Research Laboratory
- Center for Scientific Computation (under development)
- Industrial Research Partnership program
- Michigan Research Excellence Fund

Instruction

- Student Computing Environment (CAEN)
- Freshman Computer Instruction Laboratories (Eng 103)
- Engineering Instruction Center (Dow)
- VLSI Design Laboratory
- Integrated Design and Rapid Prototyping Laboratory
- UM Videotape Instruction Program
- Co-operative Engineering Education Program
- Engineering Graduation Exercises

Development, State, Federal, and Alumni Relations

- National Advisory Committee
- Strong relationships established with Governor's team ("MIT of Midwest" strategy)
- Strengthening federal relationships
- Engineering Alumni Society

Challenges in the Years Ahead

1. "Liberalization" of the Engineering Undergraduate Degree Program

2. Responding to intellectual changes in engineering and applied science
    - Diffusing boundaries between engineering and science
    - Obsolescence of traditional engineering disciplines
      (importance of cross-disciplinary activities)
    - Applied Sciences --> Subsystems --> Total Systems Integration
      (new intellectual taxonomy of engineering)
    - Accommodating and stimulating innovation and creativity
    - Pushing the College back on the "exponential" part of the knowledge curve
    - Experiment, Theory, Computation & Simulation

3. Faculty

    - Rebuilding senior leadership in key departments
      (EECS, MEAM, Chem Eng, Civil)
    - Staffing "hot" areas
      (software engineering, manufacturing systems, computational science)

4. Physical Facilities

    - North Campus Engineering Library
    - Engineering Research Project Laboratory
    - North Campus Commercial Center
    - Aerospace Laboratories
    - Expansion of Nuclear Laboratories
    - GGBL-Dow Connector (MME/Chem Eng Labs)
    - Landscaping of North Campus complex

5. Rebuilding strength of physical sciences at Michigan

    - Applied Physics Program
    - Center for Scientific Computation
    - Applied Mathematics Program
    - Relationships with Chemistry
    - Applied "biosciences" programs (biotech, bioengineering, etc.)

6. Massive Experimental Facilities

    - Funding acquisition and maintenance costs
    - Staffing and management

7. Administration

- Transition from "takeoff and climbing" to "cruising altitude"
- Budget
  Indexing budget component to 15% of research activity
  - Elimination of "Engineering Gap"
  - Differential tuition
  - Completion of transition to cost-revenue control center
- Completion of "MIT of Midwest" Strategy

	A	B	C	D	E
1	Name	Rank	Dept	Institution	
2	1981-82				
3	Elta, Michael	aP	EECS	MIT (Lincoln Labs)	
4	Hansell, Greg	aP	EECS	MIT	
5	Hansen, Wil	aP	Civil	Illinois	
6	Hayes, John	P	EECS	USC (Illinois)	
7	Jain, Ramesh	AP	EECS	WSU	
8	Kannatey-Asibu, Elijah	aP	MEAM	UC-Berkeley	
9	Kapuscinski, Rich	aP	Civil	Harvard	
10	Liker, Jeffrey	aP	IOE	Cornell	
11	Perakis, Tosis	aP	NAME	MIT	
12	Shin, Kang	aP	EECS	RPI (Cornell)	
13	Smith, Douglas	aP	EECS	Cornell	
14	Stark, Wayne	aP	EECS	Illinois	
15	Stein, Jeff	aP	MEAM	MIT	
16	Yano, Candice	aP	IOE	Stanford	
17	Ziff, Robert	aP	Chem	Rockefeller	
18	1982-83				
19	Beier, Peter	aP	NAME	Berlin	
20	Bhattacharya, Pallub	AP	EECS	Oregon	
21	Breitenbach, Jeffrey	aP	EECS	UCLA	
22	Dillingham, Jeff	aP	NAME	UC-Berkeley	
23	Kabamba, Pierre	aP	Aero	Columbia	
24	Kelton, David	aP	IOE	Wisconsin	
25	Keyserling, W. M.	aP	IOE	Harvard	
26	Kravaris, Costas	aP	Chem	Caltech	
27	Naaman, Aantoine	P	Civil	Illinois (MIT)	
28	Schultz, Albert	P*	MEAM	Illinois (Yale)	
29	Slezak, Scott	aP	MEAM	Illinois	
30	Wallace, Jay	aP	MME	Stuttgart	
31	1983-84				
32	Abriola, Linda	aP	Civil	Princeton	
33	Bernal, Luis	aP	Aero	Caltech	
34	Brake, Mary	aP	Nuclear	MSU	
35	Brockett, Terry	AP	NAME	DTMB (UC-Berkeley)	
36	Compton, Karl	aP	EECS	Wisconsin	
37	Freudenberg, James	aP	EECS	Illinois	
38	Gibala, Ronald	P	MME	Case (Illinois)	
39	Hero, Albert	aP	EECS	Princeton	
40	Ioannou, Photios	aP	Civil	MIT	
41	Katehi, Pisti	aP	EECS	UCLA	
42	Kieras, David	AP	EECS	Arizona	
43	Lee, Y.	aP	EECS	Purdue	
44	Meerkov, S.	P	EECS	Moscow	
45	Palsson, Bernard	aP	Chem	Wisconsin	
46	Pan, J.	aP	MEAM	Brown	
47	Papanastasios, A.	aP	Chem	Minnesota	
48	Rao, R.	aP	MEAM	Carnegie-Mellon	

	A	B	C	D	E
49	Srinivasa, M.	aP	IOE	Northwestern	
50	Stout, Quentin	aP	EECS	SUNY	
51	Teneketzis, D.	aP	EECS	MIT	
52	Ulaby, Fawwaz	P	EECS	Kansas (Texas)	
53	Volakis, John	aP	EECS	Rockwell (OSU)	
54	Weinberger, Doreen	aP	EECS	Arizona	
55	Weymouth, Terrry	aP	EECS	U. Mass	
56	1984-85				
57	Barker, James	P	AOS	SRI (Carnegie-Mellon)	
58	Baru, C.	aP	EECS	Florida	
59	Bozer, Y.	aP	IOE	Georgia Tech	
60	Brown, Richard	aP	EECS	Utah	
61	Brown-Mishra, April	aP	EECS	Cornell	
62	Conway, Lynn	P	EECS	PARC (Columbia)	
63	Dahm, Werner	aP	Aero	Caltech	
64	Elkerton, J.	aP	IOE	VPI	
65	Faeth, Gerald	P*	Aero	Penn State	
66	Hryciw, R.	aP	Civil	Northwestern	
67	Jha, N.	aP	EECS	Illinois	
68	Kaviany, M.	aP	MEAM	Wisconsin (UCB)	
69	Miller, Warren	P*	Nuclear	LASL (Northwestern)	
70	Mishra, U.	aP	EECS	GE (Cornell)	
71	Olson, Linda	aP	MEAM	MIT	
72	Pavlidis, D.	P	EECS	Thomson (Newcastle)	
73	Pierre, C.	aP	MEAM	Duke	
74	Robertson, R.	P	MME	Ford (Caltech)	
75	Robinson, Andy	aP	EECS	GE (MIT)	
76	Saigal, R.	P	IOE	Northwestern (UCB)	
77	Schultz, William	aP	MEAM	Rutgers	
78	Singh, J.	aP	EECS	U. Chicago	
79	Steel, Duncan	AP	EECS	Hughes	
80	Talley, Douglas	aP	MEAM	Carnegie-Mellon	
81	Terry, Fred	aP	EECS	MIT	
82	Tryggvason, G.	aP	MEAM	Courant (Brown)	
83	Wakefield, Greg	aP	EECS	Minnesota	
84	Walker, Michael	AP	EECS	Clemson (Purdue)	
85	Wehe, David	aP	Nuclear	Oak Ridge (UM)	
86	Yagle, Andy	aP	EECS	MIT	
87	Yee, Albert	P	MME	GE (UC-Berkeley)	
88	Outstanding Offers				
89	Mai, Y-W	P	MEAM	Sydney (Hong Kong)	
90	Ruhle, Manfred	P	MME	Stuttgart	
91	Targets				
92	Ghosh, A.	AP	MME	Rockwell (Illinois)	
93	Vahala, Kerry	aP	EECS	Caltech	
94	Krumm, Charles	P	EECS	Hughes	
95	Wright, Paul	P*	MEAM	Carnegie-Mellon	
96	Hess, D.	P	Chem	UC-Berkeley	

	A	B	C	D	E
97	Alferness, R.	P	EECS	Bell Labs (UM)	
98					
99	Department	Hires		Institutions	Hires
100	Aero	4		MIT	11
101	AOS	1		Illinois	9
102	Chem	4		U. California	9
103	Civil	6		Caltech	4
104	EECS	36		Cornell	4
105	IOE	7		Carnegie-Mellon	3
106	MEAM	14		Northwestern	3
107	MME	4		Wisconsin	4
108	NAME	3		Ivy League	12
109	Nuclear	3		Big Ten	18
110		82		Foreign Universities	6
111				Industry	10

	A	B	C	D	E	F	G	H
1	FACULTY DATA (1980-1985)							
2	Faculty Hiring Activity							
3		80-81	81-82	82-83	83-84	84-85	85-86	5-Year Totals
4	Asst Prof	0	13	9	21	19		62
5	Assoc Prof	0	1	1	3	1		6
6	Prof	0	1	3	4	6		14
7	Totals	0	15	13	28	26	0	82
8								
9	Faculty Attrition							
10		80-81	81-82	82-83	83-84	84-85	85-86	5-Year Totals
11	Retirements							
12	Tenure							
13	Lost to Raids							
14	Other							
15								
16	Promotion Activity							
17		80-81	81-82	82-83	83-84	84-85	85-86	5-Year Totals
18	aP--> AP							
19	AP-->P							
20	Tenure							
21	Endow Chair		0	2	1	1		
22	Dept Chm							
23								
24	Faculty Appointments (Head Count)							
25		80-81	81-82	82-83	83-84	84-85	85-86	% Change
26	Asst Prof							
27	Assoc Prof							
28	Prof							
29	Total							
30								
31	Faculty Appointments (FTEs)							
32		80-81	81-82	82-83	83-84	84-85	85-86	% Change
33	Asst Prof							
34	Assoc Prof							
35	Prof							
36	Total							
37								
38	Salary Comparisons							
39		80-81	81-82	82-83	83-84	84-85	85-86	Tot % Change
40	Engineering		12.00%	9.50%	8.50%	8.50%	8.65%	56.86%
41	University		5.00%	5.00%	4.50%	5.00%	5.00%	27.02%
42	Difference		7.00%	4.50%	4.00%	3.50%	3.65%	29.84%
43								
44	FINANCIAL DATA (1980-1985)							
45	General Fund Budget							
46								
47	Gen Fund $	$11,300,000	$13,300,000	$15,500,000	$18,500,000	$23,800,000	$34,000,000	200.88%
48	GF$ (CPI)	$5,200,000	$5,600,000	$6,300,000	$7,300,000	$9,000,000	$12,480,000	140.00%
49	$/Student HC	$2,128	$2,419	$2,798	$3,112	$3,958	$5,762	170.77%
50	$/SCH (CPI)	$974	$1,024	$1,130	$1,204	$1,502	$2,116	117.25%
51								
52	Total Revenues							
53		80-81	81-82	82-83	83-84	84-85	85-86	% Change
54	State Appro	$21,300,000	$21,500,000	$21,700,000	$24,500,000	$28,700,000	$40,070,000	88.12%
55	Tuition	$13,100,000	$15,700,000	$19,700,000	$22,000,000	$24,800,000	$26,950,000	105.73%
56	Gifts	$3,500,000	$5,400,000	$7,600,000	$6,100,000	$6,710,000	$8,000,000	128.57%
57	Endow Inc	$600,000	$600,000	$800,000	$900,000	$1,000,000	$1,100,000	83.33%
58	Service	$1,000,000	$1,200,000	$1,100,000	$1,400,000	$1,700,000	$2,000,000	
59	Spon Res	$16,200,000	$16,200,000	$16,900,000	$19,600,000	$22,800,000	$25,600,000	58.02%
60	Totals	$55,700,000	$60,600,000	$67,800,000	$74,500,000	$85,710,000	$103,720,000	86.21%
61	Totals (-St)	$34,400,000	$39,100,000	$46,100,000	$50,000,000	$57,010,000	$63,650,000	85.03%
62								
63	College Expenditures							
64		80-81	81-82	82-83	83-84	84-85	85-86	% Change
65	Inst Sal	$10,200,000	$11,600,000	$12,900,000	$13,600,000	$16,400,000	$18,600,000	82.35%
66	Staff Sal	$8,200,000	$8,700,000	$9,600,000	$10,400,000	$11,700,000	$12,460,000	51.95%

	A	B	C	D	E	F	G	H
67	Staff Ben	$900,000	$1,000,000	$1,000,000	$1,200,000	$1,300,000	$1,400,000	55.56%
68	Sch/Fel	$1,100,000	$1,400,000	$1,800,000	$1,700,000	$1,900,000	$2,000,000	81.82%
69	Service	$1,700,000	$1,600,000	$1,800,000	$1,900,000	$2,000,000	$2,050,000	20.59%
70	Supplies	$1,200,000	$1,500,000	$1,900,000	$1,800,000	$1,900,000	$2,000,000	66.67%
71	Misc	$1,200,000	$900,000	$1,200,000	$1,700,000	$1,800,000	$10,400,000	766.67%
72	Travel	$700,000	$700,000	$900,000	$1,000,000	$1,200,000	$1,300,000	85.71%
73	Equipment	$1,400,000	$1,600,000	$2,800,000	$5,200,000	$6,100,000	$5,000,000	257.14%
74	Research IC	$4,800,000	$5,000,000	$4,400,000	$5,800,000	$7,000,000	$8,000,000	66.67%
75	Total	$31,400,000	$34,000,000	$38,300,000	$44,300,000	$51,300,000	$63,210,000	101.31%
76								
77	College-Imposed Expenditures							
78		80-81	81-82	82-83	83-84	84-85	85-86	% Change
79	Staff Benefits	$1,200,000	$1,300,000	$1,600,000	$1,500,000	$1,600,000	$1,700,000	41.67%
80	Instruction(-)	$1,900,000	$1,400,000	$1,600,000	$1,800,000	$1,900,000	$2,600,000	36.84%
81	Instruction…	($300,000)	$400,000	($500,000)	($500,000)	($600,000)	($650,000)	116.67%
82	Plant	$2,400,000	$2,700,000	$3,100,000	$3,500,000	$3,800,000	$4,000,000	66.67%
83	MTS	$500,000	$500,000	$700,000	$700,000	$900,000	$1,100,000	120.00%
84	ETL	$300,000	$400,000	$400,000	$400,000	$500,000	$500,000	66.67%
85	Finan Aid	$300,000	$300,000	$300,000	$300,000	$400,000	$450,000	50.00%
86	Cen Admin	$4,700,000	$4,900,000	$5,300,000	$5,900,000	$6,400,000	$9,500,000	102.13%
87	Total	$11,000,000	$11,900,000	$12,500,000	$13,600,000	$14,900,000	$19,200,000	74.55%
88								
89	Total Revenues and Expenditures							
90		80-81	81-82	82-83	83-84	84-85	85-86	% Change
91	Tot Revenue	$55,700,000	$60,600,000	$67,800,000	$74,500,000	$85,710,000	$103,720,000	
92	Tot Expen	$42,400,000	$45,900,000	$50,800,000	$57,900,000	$66,200,000	$82,410,000	
93	Rev-Expen	$13,300,000	$14,700,000	$17,000,000	$16,600,000	$19,510,000	$21,310,000	
94								
95	Sponsored Research Expenditures							
96		80-81	81-82	82-83	83-84	84-85	85-86	% Change
97	Direct Costs	$11,000,000	$11,200,000	$11,800,000	$14,300,000	$17,600,000		
98	Indirec Costs	$4,800,000	$4,800,000	$5,100,000	$6,000,000	$7,200,000		
99	Total	$15,800,000	$16,000,000	$16,900,000	$20,300,000	$24,800,000	$0	
100								
101	Private Fund Raising							
102		80-81	81-82	82-83	83-84	84-85	85-86	% Change
103	Corporations					$1,128,915		
104	Corp Fdns					$1,634,618		
105	Individuals					$2,206,274		
106	Bequests					$118,584		
107	Assoc					$125,389		
108	Family Fdns					$1,648,032		
109	Total					$6,861,812		
110								
111	Equipment (Base General Fund Support)							
112		80-81	81-82	82-83	83-84	84-85	85-86	% Change
113	Laboratory	$0	$200,000	$1,000,000	$1,300,000	$2,100,000	$5,500,000	
114	Computing	$0	$0	$500,000	$1,500,000	$1,500,000	$1,500,000	
115	Total	$0	$200,000	$1,500,000	$2,800,000	$3,600,000	$7,000,000	
116								
117	Computing Support							
118		80-81	81-82	82-83	83-84	84-85	85-86	% Change
119	MTS $	$498,000	$540,000	$684,000	$700,000	$800,000	$1,100,000	
120	Comp Equip	$0	$0	$800,000	$2,600,000	$2,300,000	$3,000,000	
121	Staff	$0	$0	$200,000	$400,000	$650,000	$800,000	
122	Total	$498,000	$540,000	$1,684,000	$3,700,000	$3,750,000	$4,900,000	
123								
124	Support Staff (Full-Time Equivalents)							
125		80-81	81-82	82-83	83-84	84-85	85-86	% Change
126	Tech Staff	27	30	44	44	57		
127	Comp Staff	0	0	0	6	12		
128	Clerical							
129	P&A							
130	Total	27	30	44	50	69	0	
131								
132	Research Agenda							

	A	B	C	D	E	F	G	H
133		80-81	81-82	82-83	83-84	84-85	85-86	% Change
134	Res Incen	$0	$0	$600,000	$600,000	$600,000	$720,000	
135	GSRA	$0	$0	$0	$0	$650,000	$685,000	
136	Computers	$0	$0	$0	$800,000	$300,000	$150,000	
137	Dept Admin	$0	$0	$0	$250,000	$500,000	$500,000	
138	Equip & R...	$250,000	$290,000	$0	$340,000	$350,000	$370,000	
139	Total	$250,000	$290,000	$600,000	$1,990,000	$2,400,000	$2,425,000	
140								
141	Graduate Student Support							
142		80-81	81-82	82-83	83-84	84-85	85-86	% Change
143	GF Sup							
144	Fellowships							
145	Indus Sup							
146	GSRAs							
147	Total							
148								
149	Discretionary Capacity							
150		80-81	81-82	82-83	83-84	84-85	85-86	% Change
151	Faculty	$0	$0	$600,000	$600,000	$600,000	$720,000	
152	Eq & Rehab	$250,000	$250,000	$0	$340,000	$350,000	$370,000	
153	Dept Admin	$0	$0	$0	$250,000	$500,000	$500,000	
154	REs Offset							
155	Flex Staff							
156	Curr Acct							
157	GSRAs							
158	Total	$250,000	$250,000	$600,000	$1,190,000	$1,450,000	$1,590,000	
159								
160	PRODUCTIVITY DATA (1980-85)							
161	Enrollment							
162		80-81	81-82	82-83	83-84	84-85	85-86	% Change
163	B.S. (Eng)	4,196	4,217	4,259	4,212			
164	B.S. (CS)							
165	M.S.	776	777	876	941			
166	Ph.D.	353	370	401	489			
167	Total	5,325	5,364	5,536	5,642	0	0	
168								
169	Degree Production							
170		80-81	81-82	82-83	83-84	84-85	85-86	% Change
171	B.S. (Eng)	917	997	970	1,081			
172	B.S. (CS)							
173	M.S.	410	475	500				
174	Ph.D.	51	57	95				
175	Total	1,378	1,529	1,565	1,081	0	0	

	A	B	C	D	E	F	G	H
133		80-81	81-82	82-83	83-84	84-85	85-86	% Change
134	Res Incen	$0	$0	$600,000	$600,000	$600,000	$720,000	
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144	Fellowships							
145	Indus Sup							
146	GSRAs							
147	Total							
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174	Ph.D.	51	57	95				
175	Total	1,378	1,529	1,565	1,081	0	0	

College of Engineering Activities
1981-1985

COLLEGE OF ENGINEERING ACTIVITIES

GENERAL STRATEGY:

Evaluation --> Planning --> Advocacy --> Action

YEAR 1 (1981-1982)

Robotics Institute Study (5/81)
Planning Document (5/81)
MME Analysis - Phase I (5/81)
Chairmen Replacement:
- NAME (5/81)
- Civil (5/81)
- MEAM (6/81)
- Humanities (6/81)
- IOE (6/81)

Chairmen's Advisory Council (6/81)
New Hiring Guidelines (6/81)
1981-82 Budget Negotiation (6% cut relief) (6/81)
General Motors Gift Proposal (6/81)
Deans Office Administrative Structure
- Vest (5/81)
- Atkins (8/81)
- Fogler (11/81)

Planning Document -- Draft 2 (7/81)
Indirect Cost Proposal to Shapiro (8/81)
North Campus Move Proposal to Frye (8/81)
First Faculty State-of-the College Assembly
Development activities restructured (9/81)
Space Wars settled (MME, ChE) (9/81)
Co-operative Engineering Education Program Study (9/81)
Michigan Research Corporation Study (9/81)
General Motors Institute -- Initial Contact (9/81)
Computer Policy Committee formed (9/81)
MTS Allocation Policy revised to meet needs (9/81)
Meeting with all junior faculty (9/81)
$1 million growth in base equipment support (State PRR) (9/81)
Dean's Office reconfiguration (9/81)
Control Data supercomputer project (10/81)
Review of manufacturing engineering (10/81)

Analysis of salary review policies (10/81)
Preliminary discussion of college --> school (10/81)
First proposal barrage to Frye (10/81)
Increased General Fund support
Market Adjustment needs
Flexible staff needs
North Campus move
Indirect Cost Return proposal
Development
Market Salary Adjustment Program (10/81)
(including analysis of faculty research activity)
Formation of CRIM (10/81)
GMI - Detailed proposal preparation (11/81)
Review of Ergonomics Center; director appointed (11/81)
Executive Officers Presentation (11/5/81)
ABET Visit (11/81)
Industrial Technology Institute (12/81)
Promotion and Tenure Review Policy Development (12/81)
NSF Computer Science (CER) Proposal site visit (12/81)
AFOSR CRIM Proposal (1/82)
GMI - FInal Decision (1/82)
Hit & Run Committees (2/82)
Chrysler Center / Instructional Television
College --> School, upper division admission
Equipment and support staff needs
Primary research staff
College Data Base formed (2/82)
Resource allocation models developed (with CAC) (2/82)
Detailed proposals for North Campus move prepared (2/82)
Revised Prospectus for Engineering Building I (3/82)
NAME Review (3/82)
Implementation of Co-operativeEngineering Education Program (3/82)
Development of Freshman Computer Course (Eng 103) (3/82)
All-Funds Analysis of College Expenditures (3/82)
Decision Chart preparation and submission to Executive Officers (3/82)
$2 million University commitment to research support (4/82)
Decision to transfer Records Operation to Registrar's Office (4/82)
Instructional Television reconfiguration (4/82)
MEAM Review; reappointment of chairman (4/82)
One-Year and Five-Year Budget Planning Document (4/82)
Review of HSRI relationship (4/82)
Computer-Aided Engineering Laboratory (4/82)
College 1-Yr Reallocation Requirement (2.5% internally) (4/82)

Junior faculty meetings (4/82)
Chrysler Center/Instructional Television Center reorganization (4/82)
DOD research issue first appears (stimulated by IST) (4/82)
Frye & Brinkerhoff approve Phase I of NC Move (4/82)
FY82-83 Budget Plan (4/82)
Superstar recruiting and chair policies (5/82)
ChE Review; chairman reappointed (5/82)
Development Plans -- Capital Campaign (5/82)
Executive Committee Retreat (5/82)
OSAT Review; transfer to UMTRI (6/82)
Automotive Laboratory Review (6/82)

YEAR 2 (1982-1983)

Preliminary discussion of Humanities strategy (7/82)
Review of CAD M.S. Program; decision to discontinue (7/82)
Second Year Merit Salary Program (8/82)
Start MSPE State Relations Program (8/82)
Move Engineering Administration to Chrysler Center (8/82)
ISDOS-PRISE negotiations begin (8/82)
Zero-base budget model for flexible staff funding implemented(9/82)
Merger of AOS and SPRL (9/82)
Second State-of-the-College Faculty Assembly (9/82)
Ketchum Survey of Development Potential(9/82)
Legislative meetings to save EBI (9/82)
Restructuring of Development (2nd Try) (9/82)
Aerospace Review; appointment of new chairman (9/82)
Implementation of "essential singularity" staffing policy (9/83)
"White Paper" to Alumni (10/82)
Environmental Sciences Discontinuance Decision (10/82)
Decision to Review Humanities Department for Discontinuance (10/82)
Continued negotiations on location and stucture of ITI (10/82)
Research Incentive Program-Phase I Implementation (10/82)
JCOC approves construction start for EBI (11/82)
DOD Research debate intensifies (11/82)
Ratings of PhD Program Effectiveness appear (11/82)
Benton Gift ($3.5 million) (and negotiations) (11/82)
Decision to eliminate Assoc Dean / Instruction position (12/82)
Analysis of internal candidates for chairs (12/82)
College Honors & Awards Assembly initiated (12/82)
General Motors Executive Briefing on Research Partnership (1/83)
Center for Scientific Computation proposal (1/83)

Tenure meeting with assistant professors
CICE Review (2/83)
    Preliminary decision to join ECE and CCS
    Negotiations on structure begin
JCOC Approval of EBI Schematics (3/83)
Regents approve of College Capital Campaign (3/83)
Transportation studies program in Civil Eng discontinued (3/83)
GM Research Partnership approved (3/83)
MSPE Engineering Laboratory Equipment Initiative (3/83)
Opposition to Overberger Patent Royalty Policy (3/83)
Capital Campaign Policy Committee gives College the go-ahead (3/83)
MCC Effort (Atkins, Gerson, Blanchard) (3/83)
Frye & Brinkerhoff approve Phase 2,3 of NC Move (3/83)
IBM Research Partnership approved (4/83)
VP Overberger steps down (4/83)
Recommendation to discontinue Humanities (4/83)
ECE Signs off on EECS Division structure (4/83)
First Engineering Graduation Exercises (4/83)
Calma CAD Partnership approved (4/83)
Visit to Silicon Valley (Xerox PARC) (5/83)
Michigan Engineer filmed (5/83)
JCOC approves EBI Preliminary Drawings (6/83)
Regents approve North Campus Instructional Center plan (6/83)
Negotiations with IBM begin (6/83)
Negotiations with Apple begin (6/83)
Negotiations with Apollo begin (6/83)
Phase 3 of Merit Salary Program (6/83)

YEAR 3 (1983-1984)

Decision to go with CAEN (7/83)
    Regents approve differential tuition (7/83)
    Decision to go with Apple-Apollo for student component (7/83)
    CAEN Administrative Structure (8/83)
MME Review; apppointment of new chairman (8/83)
MEAM moves into GGBL and AutoLab (8/83)
IOE moves into Res Admin (8/83)
JCOC authorization to proceed with EBI Final Drawings (8/83)
Restructure of Student Services (Anne Monterio as director) (8/83)
Colorado State Supercomputer Consortium (9/83)
MMPI Initiative begins (9/83)
Second year of research incentive program (9/83)

Decision to equip all faculty with computers (9/83)
First request for special State action (9/83)
Third State-of-the-College Faculty Assembly (9/83)
Regents approve Humanities Discontinuance (9/83)
Executive Committee meeting with Frye (9/83)
Re-initiated University-wide Research Incentive debate (10/83)
MSPE Equipment Initiative meetings with Legislature (10/83)
Chrysler Executive Briefing (10/83)
GM approves $2 M gift for CAEN (10/83)
Approval of Engineering Alumni Society (10/83)
First National Advisory Committee meeting (10/83)
Apple-Apollo Press Conference (11/83)
Appointment of new Ergonomics Director (11/83)
University approves Apple Resale Clause (12/83)
Detailed College equipment needs inventory (12/83)
Decision to merge CCS and ECE into EECS (1/84)
Apointment of new Civil Eng chairman (1/84)
AOS-GLMWC merger proposal (1/84)
Burks-Holland patent dispute (1/84)
Loss of State Engineering Excellence Fund initiative (1/84)
Appointment of third assistant dean (1/84)
JCOC approval of EBI Final Design (2/84)
Executive Officer Briefing (2/84)
College support of Physics MBE (2/84)
NSF Engineering Research Center Team formed (2/84)
Regents approve CCS-ECE merger into EECS (3/84)
Shapiro's approval of special State effort (3/84)
"MIT of the Midwest" plan underway (3/84)
Formal request to Frye to close IST (with LSA) (4/84)
Meeting with Medical School (4/84)
DOD Software Engineering Institute initiative (4/84)
NAME Review - chairman reappointment (4/84)
Nuclear Eng Review - chairman reappointment (4/84)
Faculty approval of EECS admission control (4/84)
ITI research interaction negotiation (4/84)
Blowup over Ford Capital Campaign decision (4/84)
Review of Placement Center (4/84)
Decision to move Placement Center to Stearns Building (4/84)
Recommendation to establish Applied Physics program (4/84)
Groundbreaking on EBI (5/84)
Decision to fast-track Dow Instructional Center (5/84)
Proposal to develop Applied Physics program (5/84)
Development of "MIT of Midwest" strategy (5/84)

Phase 2 of Research Incentive Program (5/84)
Cover all GSRA tuition (5/84)
FY84-85 Budget (6/84)
    $1.1 M increase in flexible staff funding
    $750 K increase in base equipment support
    $500 K allocation for department research administration
College emptys the cookie jar (6/84)
    Covering $800 K in year-end overruns in salary and equipment
    Advancing $1 M to begin Dow Instruction Center

YEAR 4 (1984-1985)

UM selects Engineering as priority in State budget req (9/84)
Research Excellence Fund Strategy (9/84)
Second Modine Chair established (9/84)
Fourth State-of-the-College Faculty Assembly (9/84)
SPRL Review -- Appointment of new Director (9/84)
NSF ERC Proposal (10/85) (unsuccessful)
NSF Supercomputer Center Proposal (10/85) (unsuccessful)
ABET Accreditation Visit - MME, MEAM (10/85)
UM develops "management incentive plan" (11/85)
MMPI-MMI negotiation (11/85)
Applied Physics Program negotiation (1/85)
Discussions on Washington presence commence (1/85)
Third story GGBL addition for MEAM completed (1/85)
GG Brown Chair (2/85)
Solid State Electronics Lab Review (2/85)
Appointment of Lynn Conway as Assoc Dean (3/85)
National Advisory Committee doubled in size (4/85)
NSF Visit (Erich Bloch, Nam Suh) (4/85)
Dialogue with LSA re Peace and National Security Center (4/85)
Joint MSE/MBA program approved (5/85)
Anderson Chair in Manufacturing Technology established (5/85)
Advanced Computer Architecture Laboratory (NCUBE) (5/85)
College receives permission to retain ITV tuition revenue (5/85)
Student Study Lounge completed (6/85)
Civil Engineering Facility in GGBL High Bay completed (6/85)
Civil Engineering completes move to North Campus (6/85)
Center for Machine Intelligence established (with EDS) (6/85)
Research Excellence Fund approved by Legislature (6/85)
4th year of differential salary program for Engineering (6/85)
Decision to proceed with Solid State Electronics Lab (6/85)
AOS Review -- reappointment of chairman (6/85)

Chemical Eng Review -- selection of new chairman (6/85)

YEAR 5 (1985-1986)

UM implements "management incentive plan" (7/85)
Appointment of Walt Hancock as director of CRIM and Assoc Dean (8/85)
SPRL Addition approved and started (8/85)
CAEN tuition differential increased to $150/term (8/85)
IST Review started (8/85)
Solid State Electronics Laboratory equipment ordered ($3.0 M) (8/85)
Renovation of GGBL for MEAM completed (9/85)
Additional parking lots for Engineering constructed (9/85)

EXPECTATIONS (and hopes) FOR 1985-86

College receives $6.6+ million/y increase in base budget (REF) (9/85)
Completion of REF goal ($8.5 million/y)
Engineering Gap is eliminated
Achievement of GF Base equipment target ($5.3 million/y)
Dow Instructional Center completed (and paid off)
Blue Ribbon Study of UG Engineering Curriculum
Space Physics Research Laboratory addition completed
EECS Laboratory (EBI) completed
EECS moves to North Campus
College of Engineering completes move to North Campus
College of Engineering Review
Research Agenda to 15% of sponsored research volume
Instructional Television System re-equipped and moved to North Campus
Aerospace Laboratory construction begun
Planning for Engineering Library begins
GGBL-Dow Connector planned
North Campus Commercial Center begun
Landscaping of North Campus diag begun
Strategy developed for Engineering Research Projects Laboratory
Computational Science facilities (H-1000s, Gould, FPS)
Megaprojects:
    ERC-II
    Biotechnology Centers of Excellence (with MBI)
    Center for Advanced Scientific Computation
"MIT of Midwest" Strategy-- Phase II
Engineering Laboratory Equipment Initiative

Department Challenges for 1985-86

Department Challenges for 1985-86

A&OS

Review (1985)
Challenges for 1985-86
- Decision on Oceanic Sciences
- Rebuilding of Meteorology
- SPRL Building Addition
- Remote Sensing Initiatives

Aero

Review (1983)
Challenges for 1985-86
- Acquisition of funding for Aerospace Laboratories
- Enrollment swings
- Intellectual thrusts of aerospace field
- Interaction with MEAM (combustion & fluid sciences)

Chem

Review (1983)
Challenges for 1985-86
- New chairmanship
- Senior faculty problems
  - Inactive faculty
- Recruitment of senior faculty
  - Electronics processing
  - Biotechnology
- Undergraduate teaching quality
- Laboratory space
- MME Interface

Civil

Review (1981)
Challenges for 1985-86
- Focusing activities of Department
- Settling into new facilities
- Junior faculty development
- Inactive faculty

Interaction with other programs
Attractiveness of undergraduate programs

EECS

Review (1985)
Challenges for 1985-86 -- Department-wide
- New Department Chairman
- Workable administrative structure for Department
- Moving into new facilities
- Providing adequate attention to new faculty
- Service teaching loads (both EE and CSE)

Mergen has worked in a formal sense.
Concern about circuits area
Concern about intellectual focus and research support of systems division

Challenges: EE
- Assimilating new faculty
- SSEL equipment and staffing
- Broadening and extending intellectual vision of division
- Inactive faculty

Challenges: CSE
- Leadership
- Attracting high quality junior faculty
- Overcoming insular attitude

IOE

Review (1981)
Challenges for 1985-86
- Faculty review
- Junior faculty development
- Intellectual thrusts of "industrial engineering"
- Weakening federal support of "operations research"
- PRISE evolution
- Ergonomics evolution
- Manufacturing interfaces

MME

Review (1984)
Challenges for 1985-86
- Faculty rebuilding
  - Achieving balance between junior and senior faculty
  - Effects of rapid acceleration
- Laboratory space
- Electron microscopy laboratory

Response to MMPI initiative
Maintaining intellectual focus during rapid rebuilding
Macromolecular Sciences interface
Chemical Engineering interface
MME 250 load

MEAM

Review (1978)
Challenges for 1985-86
- Continued faculty rebuilding
  - Key areas: manufacturing
  - Inactive faculty
- Intellectual focus of Department
- Broadening and extending vision of department
- Applied Mechanics
- Automotive Laboratory

NAME

Review (1984)
Challenges for 1985-86
- Assimilation of new faculty
- Stabilizing support for Towing Tank
  - Taking in laundry???
- Broadening and extending vision of department

Nuclear

Review (1984)
- Challenges for 1985-86
- Intellectual thrust of Department
  - Nuclear materials program
  - Future of Fission and Fusion programs
- Anticipating senior faculty retirements
- Engineering Physics accreditation
- Moving to larger scale research activities
- Applied Physics impact

COLLEGE-WIDE

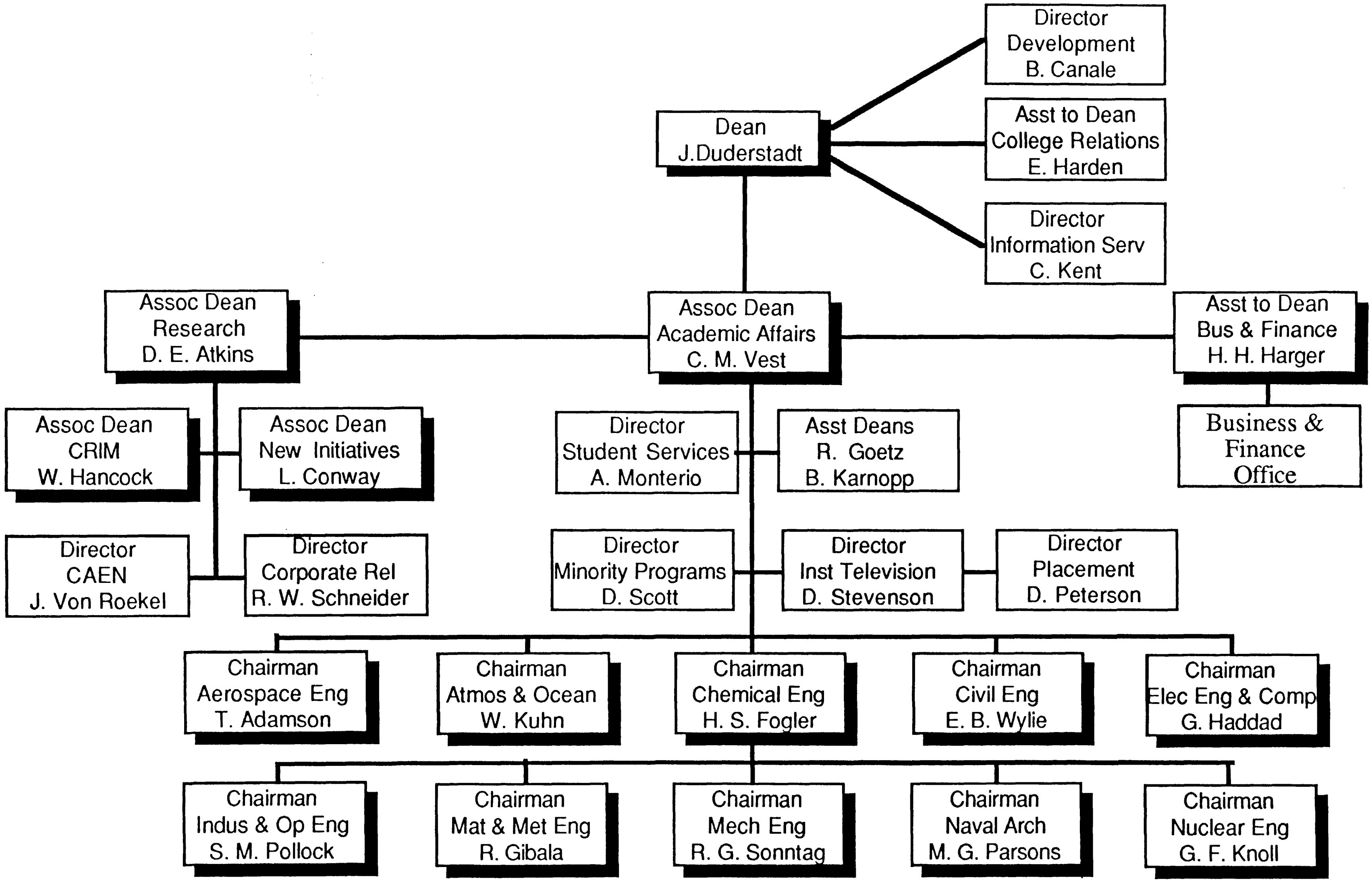
Review (1985???)
Challenges for 1985-86

- Evolution of leadership team
- Faculty
  - Assimilating new faculty
  - Handling inactive (and counter-productive) faculty
  - Maintaining high standards on promotion & tenure decisions
- Meeting needs of experimental research facilities
- Restore core General Fund support ($8.5 million)
- Completing move to North Campus
- Review of undergraduate curriculum

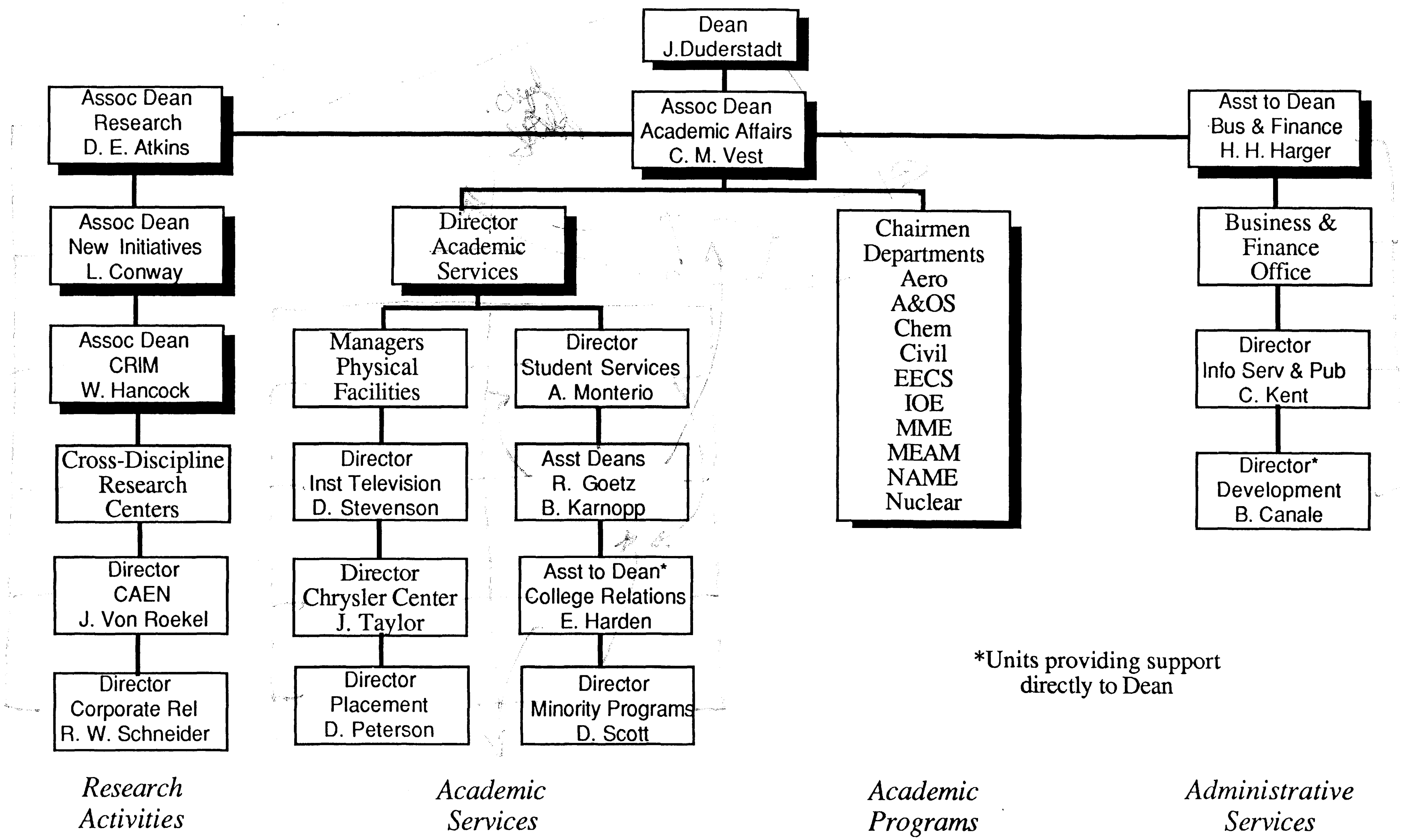
Specific Goals

- Facilities (near term)
  - SPRL Expansion: construction
  - GGBL Parking Lot: construction finished
  - Dow Instructional Center: construction finished
- Facilities (long term)
  - Aerospace/Nuclear Laboratory: project start
  - Engineering Library: continued fund-raising efforts
  - Research Projects Laboratory: federal/state funding analysis
  - GGBL-Dow Connector: University commitment
  - NC Commercial Center: Brinkerhoff commitment
  - NC Landscaping: Shapiro commitment
- Experimental facilities:
  - Solid State Electronics Laboratory: $3.0 M startup
  - Electron Microscopy Lab: $1.2 M startup
  - Instructional Television System: $1 M equipment
- Budget goals:
  - $6.6 + 0.5 base increase (REF)
  - $2.3 REF supplemental appropriation
  - Major special equipment support
  - 15% Research Agenda
- Federal initiatives:
  - ERC proposal
  - Biotechnology proposal
  - Computational science and engineering proposal
  - SDI initiatives
- Other MEGAProjects:
  - Review of undergraduate curriculum
  - CAEN: Phase II
  - Applied Physics

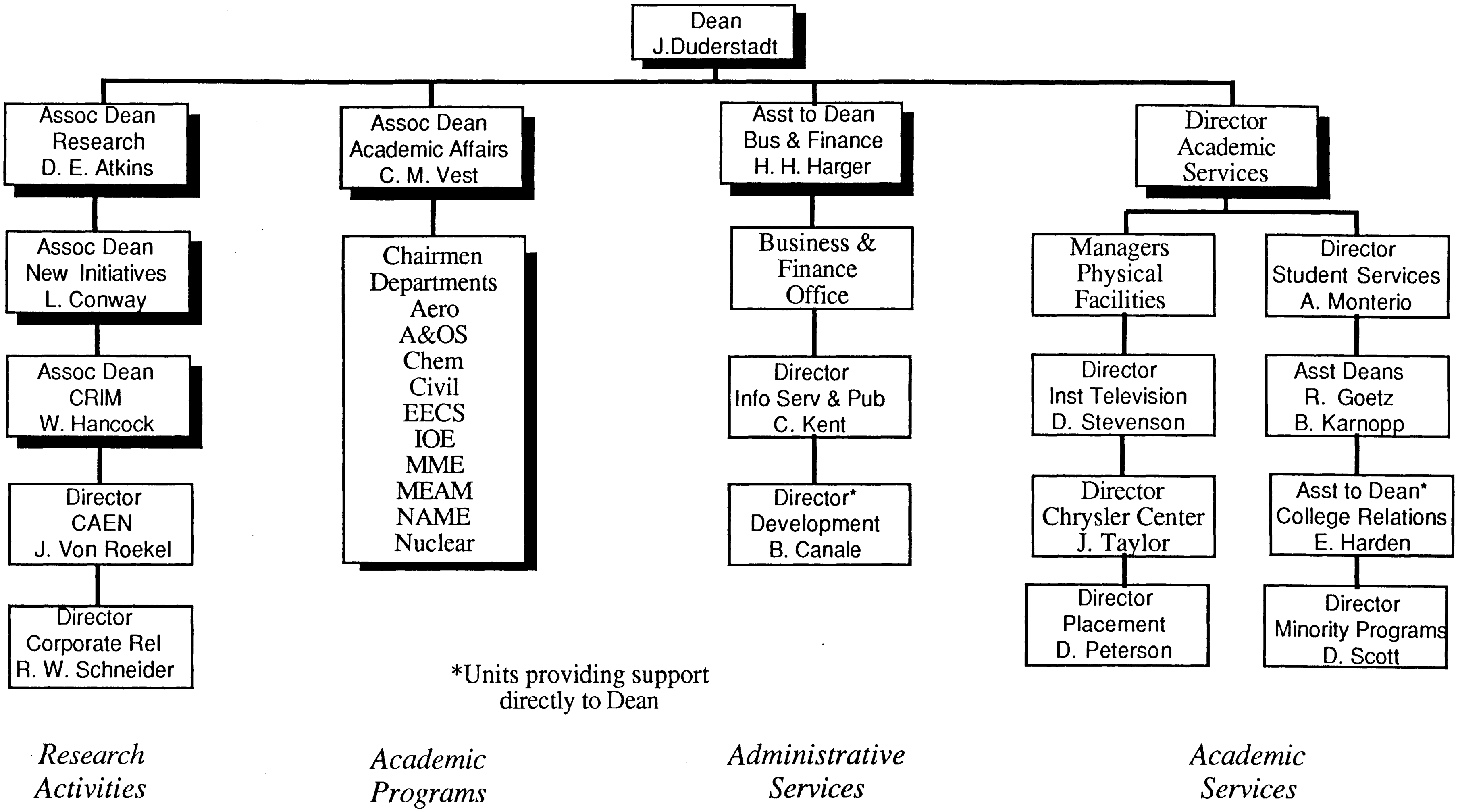
College Administration Structures



College Administration
Line Reporting Structure
Present Model



College Administration
Line Reporting Structure
Model 1



College Administration
Line Reporting Structure
Model 2

Dean
J.Duderstadt

Assoc Dean
Research
D. E. Atkins

General Fund Resources:
- Research Incentive Funds
- Research Development Funds
- CAEN Tuition Revenue
- CRIM GF support (Hancock)
- New initiatives (Conway)

External Funds:
- Cross-discipline sponsored research support
- Industrial affiliates programs
- Industrial equipment grants
- Special federal programs

Research Support
(Both federal and industrial)

Assoc Dean
Academic Affairs
C. M. Vest

General Fund Resources:
- Equipment
  - Instructional Laboratories
  - New Faculty Startups
  - Cost-Sharing
- Flexible staff
- Dept Res Admin
- GSRA Tuition Grants
- Current Account
- Student Financial Aid
- New Support Staff

External Funds:
- Physical Facility Projects
- Off-Campus Tuition Revenue
- ITV Revenue
- Chrysler Center Revenue

General Fund Support

Asst to Dean
Bus & Finance
H. H. Harger

General Fund Resources:
- Base faculty appointments
- Base support staff appointments

External Funds:
- Endowment & FFE
- Expendible Restricted

Monitor and approve all expenditures and staffing appointments

Private Support

College Administration
Resource Control Responsibilities

Appendices

The University of Michigan

College of Engineering

Fact Book

Draft 4

August 27, 1985

THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING

FACTSHEET

KEY POINTS

1. The University of Michigan College of Engineering has consistently ranked among the leading engineering schools in the world, whether measured by the quality of its instructional programs, its research accomplishments, or the impact of its graduates. Each of its 22 degree programs is generally ranked among the top 10 nationally.

2. The 6,000 students enrolled in the College rank among the 98th percentile of high school graduates.

3. The College leads the nation in total degree production, awarding over 2,000 degrees in engineering and applied science each year.

4. The 1980s are a period of rapid change and renewal for the College, with the completion of $70 million of new facilities and the replacement of over 40% of its faculty (140 positions).

TRADITION

- 7th oldest engineering school in nation (founded in 1853)
- 3rd in total number of degrees awarded (>50,000)
- A pioneer in new disciplines:
  - Metallurgy (1854)
  - Naval Architecture (1881)
  - Chemical Engineering (1897)
  - Aeronautical Engineering (1917)
  - Nuclear Engineering (1953)
  - Computer Engineering (1965)

ACADEMIC STRUCTURE

- Instruction:
  - 10 academic departments
  - 22 degree programs (B.S, M.S, Ph.D)
- Research:
  - 540 sponsored research projects
  - Matrix management (across department lines)
  - Research projects, laboratories, centers, institutes

CAPACITY

- Enrollment (4th in nation):

Undergraduate	4,312
M.S.	1,016
Ph.D.	677
Total	6,005

- Degree Production (1st in nation):

B.S.	1,310
M.S.	680
Ph.D.	93
Total	2,083

- Research Activity:

College Units	
Federal	$20 M/y
Industry	5 M/y
Affiliated Units	12 M/y
Total	$32 M/y

RESOURCES

• Faculty:	320
• Research staff:	1,100
• Physical plant:	1,000,000 nsf
• Equipment inventory	$30 million
• Computer inventory	$15 million
• Operating budget (FY 1985-86)	$80 million
• Revenue:	
Tuition:	$29 million
Research:	$25 million
Private Gifts:	$10 million
Total	$64 million

QUALITY

- Students
  - Entering Freshmen:
    - 3,500 applications for 750 positions
    - 98th percentile of high school graduates
    - 1280 SATs, 3.8 GPAs
    - 27% are straight 4.0 students
  - Graduates: 3rd in Who's Who alumni

- Faculty:
  - 8 National Academy of Engineering
  - 2 National Academy of Sciences
  - 2 National Medal of Science Winners
  - 85 new faculty added in past 4 years
- Programs:
  - Traditionally ranked 5th nationally
  - All 22 degree programs in top 10

BASIC STRATEGY

To focus resources on those areas in which UM has the tradition, the mission, or the opportunity to achieve national leadership.

OPPORTUNITIES

The UM College of Engineering has been identified as a key factor in the economic future of the Great Lakes area. As a result, it has benefited from several major commitments:

- Major base budget growth
- Competitive salary structure
- New faculty capacity (20 - 30 per year)
- $70 million building program
- Growth in equipment and support staff
- Entrepreneurial environment

EXAMPLES OF THRUSTS

- Advanced electronics and optics
- Aeronomy and planetary atmospheres
- Biotechnology
- Catalysis and surface sciences
- Combustion sciences
- Composite materials
- Construction management
- Ergonomics
- Information technology
- Integrated manufacturing systems
- Directed energy beam technology
- Machine intelligence
- Materials processing
- Polymer science and processing
- Remote sensing
- Ship hydrodynamics
- Structural engineering

OTHER POINTS OF INTEREST

- UM Engineering is a leading source of engineering manpower:
  - Produces 40% of the B.S., 60% of the M.S. and 80% of the PhDs in Michigan
  - Largest supplier of engineers to the automobile industry
  - One of the nation's leading sources of aerospace engineering (including 8 astronauts)
  - Supplies 80% of all naval architects in U.S.

Moreover, the College presently ranks first nationally in the total number of degrees awarded each year.

- Over the past three decades the College and its affiliated research laboratories have spawned over 100 new companies employing 40,000 and generating over $2 billion per year in sales.

- To meet the needs of American industry, UM Engineering has formed major new research programs such as its Center for Research in Integrated Manufacturing, the Center for Machine Intelligence, and the associated Industrial Technology Institute.

- UM Engineering is committed to building the leading information technology environment for engineering education and research. Through its Computer Aided Engineering Network, the College has developed a sophisticated distributed computing environment consisting of over 1,100 computer workstations, communication networks, and network servicers. The associated EPIC Industrial Affiliates program has provided industry with an opportunity to access and participate in this exciting R&D project.

- The College faces the opportunity (and challenge) of replacing almost 40% of its faculty (140 faculty positions) during the 1980s. Through the first half of this decade, UM Engineering has already added over 90 new faculty members from the leading institutions throughout the world.

INTRODUCTION

To prepare for the increasingly complex society of the future, universities must make strong commitments to build and sustain high-quality programs in engineering and applied science. The University of Michigan, through its College of Engineering, is fulfilling such commitments and advancing its role as a leader in intellectual creativity and technological innovation.

The College has consistently ranked among the leading engineering schools in the world, whether measured by the quality of its instructional programs, its research accomplishments, or the impact of its graduates. The College's combination of disciplinary breadth and depth of quality across the full spectrum of instruction and research make it unusual among the nation's engineering schools.

Because the College is one of the few leading engineering schools imbedded in a world-renowned university with strengths across all academic and professional disciplines; it has had a unique opportunity to develop new academic programs and research areas that interact strongly with other disciplines. The presence of other strong programs of study has also provided students of the College with an unparalleled breadth of educational opportunities and experiences.

The 1980s have been a period of unusual challenge, opportunity, and change for the College. At the beginning of this decade, the University of Michigan and the State of Michigan clearly established UM Engineering as a leading priority in Michigan higher education. They provided the College with the resources and flexibility necessary to replenish its physical and human capital.

During the past five years, UM Engineering has completed a $70 million building program aimed at providing the high quality environment necessary for leadership in engineering education and research. In addition, over this period the University increased the base General Fund (instructional) budget of the College from $11.5 million to $34 million per year. Major investments in laboratory equipment, information technology, and support staff were made. Most important, during this period the College recruited more than 100 new faculty members, corresponding to almost one-third of its faculty complement.

To respond to these extraordinary opportunities, UM Engineering has established an intense, entrepreneurial environment in which individual initiative, achievement, and the quest for excellence are dominant elements. Key in this new spirit has been the College's commitment to focus resources, to stress the quality rather than the breadth or capacity of its programs, and to settle for nothing less than the best in the accomplishments of its students and faculty.

Today the UM College of Engineering is continuing to change rapidly. Even as it changes, however, the College reaffirms its long tradition of excellence and leadership in engineering education and research.

The UM College of Engineering

The UM College of Engineering is one of the nation's leading sources of high-quality graduates in engineering and applied science. Although the mere fact that the College currently ranks first nationally in the total number of degrees awarded annually (2,083 degrees in 1985, including 1,310 B.S., 680 M.S., and 93 Ph.D.) is impressive in itself, even more significant is the *quality* of the roughly 6,000 students enrolled in its 22 degree programs.

Undergraduate students attending the College rank in the 98th percentile of high school graduates with average grade points of 3.8 and SAT scores of 1280. Graduate students are selected from an applicant pool representing the finest institutions in America and abroad.

Associated with the College are some 320 faculty members and 1,100 research and support staff. UM Engineering occupies roughly one million square feet of modern laboratories and classrooms on the University's North Campus. The College's total annual expenditures for instruction and research exceeded $85 million in FY1985-86.

Graduates of the College are widely known and respected for their broad education, their strong background in fundamental science, and their ability to apply this knowledge to engineering practice. They move easily and rapidly into positions of leadership in industry, government, and academe. At the present time, the College counts among its alumni more than

50,000 engineers, scientists, and executives throughout the world.

The College has a long tradition of leadership in the development of new academic and research programs. For example, UM Engineering established the earliest programs in the United States in areas such as naval architecture, aeronautical engineering, and nuclear engineering. This heritage of leadership continues today as the College moves to establish major new programs in computer-integrated manufacturing, robotics and machine intelligence, advanced electronics and optics, materials processing technology, and computer science and engineering.

Research activities of the College have increasingly been broad, cross-disciplinary efforts involving teams of engineers and scientists. To support such programs, the College has moved to a matrix management structure to coordinate and administer an array of research laboratories, centers, and institutes. Of particular note are major research units such as the Center for Research on Integrated Manufacturing, the Space Physics Research Laboratory, the Center for Ergonomics, the Center for Advanced Electronics and Optics, the Gas Dynamics Laboratory, and the Ship Hydrodynamics Laboratory.

Industry and government are turning increasingly to the College in their efforts to rebuild American productivity and strengthen national security. They seek the talented engineering graduates so critical to our society, the intellectual creativity of engineering faculty essential to technological innovation, and the leaders and entrepreneurs of tomorrow.

To respond to these needs, the College has developed numerous mechanisms for interacting more closely with industry. A variety of Industrial Affiliates programs draws together companies with common technical interests to sponsor and participate in research or instruction in particular areas. In the more intensive Industrial Research Partnerships, the College works closely with a particular company to develop a major research relationship involving faculty-led teams of PhD students working side by side with industrial scientists and engineers. In addition, to better facilitate industrial research interactions, the College has spawned several research organizations that are separate from the University. Examples of such organizations are the Industrial Technology Institute, the Environmental Research Institute of Michigan, and the Center for Machine Intelligence . Of course, the College continues to provide assistance to industry through cooperative engineering education programs, continuing engineering education, its Instructional Television System, and a variety of consulting relationships.

The College has strongly encouraged its faculty, students, and staff to become involved in the transfer of intellectual properties from campus laboratories into the private sector. Working closely with the University and State government, it has streamlined conflict-of-interest regulations to facilitate the establishment of spinoff companies. It has also worked closely with venture capital groups, financial institutions, State government, and other units of the University to stimulate this important activity.

The University of Michigan

The University of Michigan, one of the world's most distinguished academic institutions, is an international resource of learning, research, and service. Its 2,400 faculty members, 34,500 students, and 12,000 staff members study, teach, and conduct research in a modern environment that includes more than 250 research units equipped with advanced analytical and data processing facilities.

The quality of the academic programs at Michigan places it among the leading universities nationwide. On undergraduate, graduate, and professional levels, in a wide variety of degree programs, the University of Michigan maintains a caliber of academic excellence unsurpassed by other institutions of higher learning.

Michigan consistently ranks as a national leader in total research expenditures. Annual research volume at the University totals more than $130 million, of which approximately $95 million is sponsored by the federal government, $10 million by private industry, and $25 million by private foundations, professional societies, agencies, and associations.

The University Library system contains more than six million volumes in libraries spread throughout the campus. The Law, Business, Art History, Architecture, Engineering, Medical, Graduate and Undergraduate Libraries are regarded as major national resources. The Gerald R. Ford

Presidential Library, the William Clements Library, and the Bentley Historical Library contain particularly significant collections.

The University's unusually talented and diversified pool of undergraduate and graduate students is one of the nation's most valuable resources. Out of interaction of such students with faculty and researchers comes new knowledge, techniques, and solutions to the important problems of our times.

Mission and Philosophy

Mission

The profession of engineering serves the needs of society through the application of science and technology. The UM College of Engineering is maintained for the purpose of serving both the State of Michigan and the nation. Its charter identifies its mission as:

i) providing instruction in engineering and applied science,

ii) conducting scholarly investigations and research in those branches of knowledge that form the basis of modern culture, professional practice, and leadership in our business and industrial society, and

iii) applying the knowledge of the physical, biological, social, and engineering sciences to the solutions of the problems of our society.

As our society has become ever more dependent on science and technology, the missions of engineering schools such as UM Engineering have become increasingly critical. In a very real sense, technology has become the major determinant of the nature of modern society and of the quality of life within that society. The security of our nation, in the broadest sense, and the achievement of the aspirations of its citizens ultimately will depend on our technological leadership.

Philosophy

The objective of the College is quite simple: to achieve excellence in teaching, research, and the professional accomplishments of its students, faculty, and graduates. Indeed, the College believes that it must achieve the level of excellence necessary for national leadership if it is to respond to the responsibilities, challenges, and opportunities before it.

In this quest it has accepted two fundamental premises: first, the College stands firm in its belief that the key to the achievement of excellence lies in its people--in their abilities and their commitments. From this premise it follows that the College's primary goal must be to establish an environment that not only allows for excellence, creativity, and initiative, but actively stimulates, rewards, and demands such qualities. Only in this way can the College continue to attract and retain the outstanding faculty and students necessary to continue its long tradition of leadership in engineering education and research.

Equally important is our second premise that the future of the College will depend not on the capacity or the breadth of its academic programs, but rather on the quality of these programs. The College refuses to yield to pressures to maintain its breadth, size, or tradition at the expense of quality, to do simply an adequate job across the board. Rather, UM Engineering is committed to being the best in certain key areas, and it has taken steps to focus its resources accordingly. It has developed policies that subject all programs to ongoing reviews for relevance, excellence, and cost-effectiveness. Programs that fail to meet these tests are reduced or eliminated to provide the resources necessary to strengthen areas of higher priority or potential for excellence. In this way, the College has sought to maintain its flexibility to respond to changing needs, priorities, and opportunities.

These two premises--a fundamental belief in the importance of individual achievement and a willingness to focus resources to build excellence--form the cornerstones of the College's efforts to achieve and sustain leadership in engineering education and research in the years ahead.

Tradition

For more than a century, the UM College of Engineering has consistently ranked among the leading engineering schools in the world. Founded in 1853, the College is the seventh oldest engineering school in the nation. It ranks third among all engineering schools in the total number of degrees awarded and claims more than 50,000 alumni throughout the world.

The College has long been a leader in the development of new academic programs at the forefront of technology. It pioneered in the introduction of programs in metallurgical engineering (1854), naval architecture (1881), chemical engineering (1898), aeronautical engineering (1917), nuclear engineering (1953), and computer engineering (1965).

In addition, through the years, the College has been a major factor in the technological strength of this nation. Major technological discoveries, such as holography and synthetic aperture radar, were developed by Michigan engineers. Furthermore, UM Engineering has contributed heavily to the space program, counting eight astronauts among its graduates, and continue to be one of the major suppliers of engineers to the nation's aerospace industry. Throughout its history, it has been the leading source of naval architects for our nation (currently graduating 70 percent of the nation's supply each year).

Organization

Administrative Structure

The organization of the College is aligned along its three primary missions: instruction, research, and service.

Instructional activities and degree programs are conducted through traditional academic departments (e.g., Civil Engineering, Aerospace Engineering) and report through the Associate Dean for Academic Affairs. At the present time, the College has 10 academic departments conducting degree programs in 22 different disciplines at the B.S., M.S., and Ph.D. level. These departments range in size from smaller units, such as Nuclear Engineering and Atmospheric and Ocean Sciences, each with roughly 12 faculty members and 120 students, to massive "super departments" such as Electrical Engineering and Computer Science, with more than 100 faculty members and 1,800 students.

Research activities are conducted through a variety of units, ranging from the research projects of individual faculty members to major research laboratories, centers, and institutes. Many of these units report to the departments. However the trend toward multi-investigator, cross-disciplinary research has led the College to a "matrix" management structure in which research units spanning several departments report directly to the Associate Dean for Research. In addition, faculty, staff, and students of the College participate in a number of University-wide research centers and institutes that report directly to the Vice-President for Research.

The development of new research and instructional programs that span several College or University units is the responsibility of the Associate Dean for New Initiatives. Examples of such programs include the Center for Machine Intelligence and the Integrated Design and Rapid Prototyping Laboratory.

Service activities are conducted by a variety of special units reporting directly to the Dean's Office. Examples include the Chrysler Center for Continuing Engineering Education, the UM Instructional Television System, the Office of Student Services, Development and Alumni Relations, and the Engineering Placement Center.

A key element in the administration of the College is an Executive Committee, comprised of four faculty members elected to four-year terms by the faculty at large plus the Dean of the College. The Executive Committee is charged with key responsibilities for staffing decisions, such as faculty hiring, promotion, tenure, and salary determination. The Committee is delegated the authority for major policy decisions within the College (although these may also require approval by direct vote of the entire faculty of the College).

Other groups playing key roles in policy development, strategic planning, and implementation include the Chairmen's Advisory Council and the deans of the College. In addition, the College has numerous faculty standing committees to address specific issues, such as curriculum, scholastic standing, and computer policies.

The management of the College tends to flow in a highly interactive, participatory fashion involving faculty, students, and administrative units such as the deans, Executive Committee, and Chairmen's Advisory Council. Strategic planning and policy development are generally stimulated by faculty and student concerns. Policies are then refined through dialog involving deans, department chairs, and various ad hoc faculty committees. Finally, policies are approved by the faculty of the College or their elected Executive Committee and implemented by the College administration.

Intellectual Taxonomy

Modern technology has evolved new ways of thinking, analysis, and synthesis which are profound intellectual pursuits in and of themselves. In engineering, the generation and dissemination of knowledge are intertwined -- we learn and teach through our research and design activities. The distinction between "basic" and "applied" knowledge has virtually disappeared.

Similarly, the intellectual boundaries between traditional engineering disciplines have also vanished. A knowledge of software engineering, systems engineering, and materials structure is frequently as important to a mechanical engineer as are traditional areas such as thermodynamics, kinematics, and fluid dynamics. The electrical engineer of today requires a firm understanding of quantum mechanics and condensed matter physics in addition to circuit analysis and control theory.

As the boundaries between disciplines blur, the traditional methods for characterizing and describing research and instructional activities in engineering and applied science lose their relevance. The intellectual activities of the College simply cannot be classified in terms of the traditional disciplines (e.g., mechanical engineering, civil engineering, electrical engineering).

A somewhat different taxonomy involves distinguishing the level of "systems integration" involved in a given research or instructional area. One view of the activities of the College involves a three-tiered classification: total systems integration, subsystems, and scientific base. For example, the College's activities in manufacturing fit well into such a taxonomy, ranging from fundamental scientific investigations such as tribology and expert system development to subsystems such as robots and flexible manufacturing cells to total systems integration at the plant, company, or industry level.

We have attempted to provide such a taxonomy of several key thrust areas of the College, including materials research, advanced electronics and optics, manufacturing, transportation systems, and biotechnology in the accompanying figures.

Instruction

Degree Programs

Instruction in the College of Engineering is offered at the undergraduate, graduate, and professional levels through ten academic departments:

Aerospace Engineering
Atmospheric and Oceanic Science
Chemical Engineering
Civil Engineering
Electrical Engineering & Computer Science
Industrial and Operations Engineering
Materials & Metallurgical Engineering
Mechanical Engineering & Applied Mechanics
Naval Architecture and Marine Engineering
Nuclear Engineering

In addition, the College conducts a number of interdisciplinary programs, such as:

Bioengineering
Applied Physics
Environmental Sciences

At the undergraduate level, 12 programs lead to ABET-accredited B.S.E. degrees. Two programs in applied science lead to the B.S. degree. At the Master degree level, 16 M.S.E. and 11 M.S. programs are available. At the Professional Degree level, 11 programs in engineering are offered. Doctoral studies leading to the Ph.D. degree are offered in 14 engineering disciplines and 4 fields of applied science.

Enrollment

Enrollment in the degree programs conducted by the College has stabilized at roughly 6,000 students: 4,300 undergraduates, 1,000 M.S. students, and 700 Ph.D. students. (Note that these numbers include some 400 computer science students who are registered in the College of Literature, Science, and Arts but who elected the Computer Science degree program offered by the Department of Electrical Engineering and Computer Science.)

Although total enrollment in the College has been stable, focus has shifted toward upperclass and graduate programs. Furthermore, graduate instruction has shifted somewhat to stress Ph.D. programs in an attempt to respond to the serious national shortage of engineering doctorates.

The distribution of students among degree programs is similar to that found in many engineering schools. Roughly 1,800 students, almost one-third of the College student body, major in Electrical Engineering, Computer Engineering, or Computer Science. Some 950 students major in Mechanical Engineering, while Aerospace Engineering, Chemical Engineering, Industrial Engineering, and Civil Engineering each enroll 400 to 500 students. To better adapt to shifts in enrollments, the College has implemented selective enrollment control for high demand programs such as Electrical Engineering and Computer Engineering.

Degree Production

Each year the College graduates more than 2,000 students from its degree programs, including 1,300 B.S., 600 M.S., and 100 Ph.D. graduates in engineering and computer science. This degree production ranks the College first nationally (tied with Illinois) in the total number of degrees awarded. Moreover, UM Engineering contributes 30% of the B.S., 60% of the M.S., and 80% of the Ph.D. engineering graduates produced in the State of Michigan.

Student Demographics

Roughly 62% of the students enrolled in the College (and 74% of the undergraduates) are Michigan residents. Other students come from most states and many foreign countries.

Women students comprise 20% of the present enrollment. However, freshman enrollments (25% women) and secondary school surveys suggest that the representation of women students will increase to 40% or higher over the next decade.

Minority students comprise 7% of the College's enrollment (3% black). The College has developed an aggressive minority recruiting and retention program through its Minority Engineering Projects Office.

Approximately 11% of the students enrolled in the College are foreign nationals. These students are concentrated at the graduate level where they comprise 30% of the student body (and 40% of the Ph.D. students).

Research

The UM College of Engineering places major emphasis on research and graduate education. Perhaps more than any other factor, the quality of the research and graduate education performed by the College determines its reputation, the quality of its faculty and students, the quality of its instructional programs, and its contributions to society. Research also plays the key role in determining the resources available to the College.

Importance

This is a rather sweeping statement, but there is ample evidence to support it. Those institutions we regard as our peers -- MIT, Stanford, Berkeley, Illinois, Caltech -- are distinguished by the quality of their research. Furthermore, it has become apparent that the quality of the research environment offered by an institution probably plays the most significant role in attracting and retaining outstanding faculty members and graduate students. There is little doubt that research also has a major impact on the resources of an academic institution. At the present time, more than 50% of the $80 million annual budget of the College is provided through research grants and contracts.

Moreover, research and graduate education play positive and major roles in determining the quality of the instructional programs offered by the College. Certainly research activities play a major role in providing the resources for quality undergraduate education (e.g., laboratory equipment and facilities). Research also provides the intellectual thrust for new academic programs. Beyond this, however, we have found time and time again, through careful evaluation of both the teaching and research activities of our faculty, that our most outstanding scholars are also seen by our students to be our most outstanding teachers. Furthermore, in an era of ever more sophisticated technology, faculty members must remain active to remain technically relevant, to keep on top of their field.

The research activities of this nation's leading engineering schools are of critical importance. Universities continue to perform the majority of the basic research in the United States and to provide the catalyst for America's scientific and technological strength. Furthermore, the production of advanced-degree engineers is essential to maintaining the technological leadership of this nation.

Challenges

University-based research is an exceptionally demanding activity. Not only does it require long hours of work and intense concentration within an environment of competing demands (instruction, counseling, committees), but in today's intense world of sponsored research, it requires the additional skills of an entrepreneur and an administrator. To achieve excellence in research, one must first attract and sustain faculty with the ability to define, develop, direct, and attract funding for major research programs. Unlike their colleagues in industrial or government research laboratories, university faculty members are generally expected to be capable of conducting independent research programs. To be sure, many engineering faculty members work as members of research teams. However, each member of the team is expected to be able to function independently in the development, funding, and conduct of research.

Although research performed in the traditional mode by single investigators in narrow disciplines continues to be the core of academic research, many university research programs have been shifting to problem-focused research, which better addresses national needs in areas such as industrial productivity. Such research activities tend to be cross-disciplinary in nature, involving teams of investigators drawn from a variety of fields. They frequently are concerned with engineering *systems* rather than simply with engineering science. Such cross-disciplinary, problem-focused research activities require a quite different style of management and support.

The costs of the modern laboratory equipment and computing environment required to support engineering research have presented major challenges for most universities. Of comparable significance are the support staff and maintenance costs associated with such facilities. Both the acquisition and maintenance of such environments have required new approaches in the administration, funding, and conduct of research.

Research Environment

The UM College of Engineering has attempted to build an environment appropriate for high quality research in engineering and applied science. To provide the resources necessary for stimulating and sustaining high research momentum, the College has negotiated with the University a key component in its budget for research development. At the present time, this budget line is indexed to 15% of the College's annual sponsored research activity (presently $25 million).

These funds are used, in part, to provide support for graduate research assistants, technical support staff, and clerical staff so essential for large-scale research efforts. They also provide the seed funds, the "venture capital", necessary to initiate new research efforts. And, perhaps most significant of all from the faculty's viewpoint, a significant fraction of these resources are returned directly to individual investigators and research projects to serve as strong incentives for research. For example, the typical engineering faculty member has received roughly $3,000 per year in such discretionary funds.

The College has responded in other ways to the needs of its research community. To address the challenge of cross-disciplinary research, it has implemented a matrix style of research management in which many research projects, laboratories, and centers that span departments report directly to the Associate Dean for Research rather than to a given department. Because administrative responsibilities and authority follow budget lines, this management structure parallels that for the instructional programs that report through departments to the Associate Dean for Academic Affairs.

Research Activity

In FY1985-86 the College of Engineering conducted $25 million of sponsored research through College laboratories, centers, and institutes. In addition, the faculty of the College played key roles in University-level research units, such as the Transportation Research Institute, the Macromolecular Research Center, and the Great Lakes and Marine Waters Center. Such units affiliated with the College conducted an additional $12 million of research. The sponsored research volume per full-time-equivalent faculty member in the College was $125,000.

Although federal funding still provides the dominant source of sponsored research, industrial support is growing rapidly ($5 million or 20% of such funding). As the College becomes more heavily involved in cross-disciplinary, systems-focused research, industrial support is expected to grow.

Quality

The primary objective of the College is the achievement of excellence in teaching and research. It stands firm in its belief that the key to the achievement of excellence lies with its people, with their abilities and their commitments. And in the human resources represented by its faculty and students, the College benefits from a level of quality that is extraordinary.

Student Quality

The University of Michigan has long been distinguished by the outstanding quality of its students, generally regarded as among the highest of all public institutions in this nation. However, today the students enrolled in the UM College of Engineering stand at the forefront of even this extraordinary group, partly because of the unprecented demand for admission to the College. Applications for admission to all degree levels of the College have shown sustained growth for more than a decade. For example, the College received more than 3,500 applications for the 750 positions in its 1985 freshman class. An additional 1,500 students applied for roughly 400 transfer positions as juniors in the College.

The median freshmen entering the College now rank among the 98th percentile of high school graduates. The average UM Engineering freshman graduated from high school with a 3.8 grade point average and scored 1280 on the Scholastic Aptitude Test. More than 25% of the freshman class were straight 4.0 students in high school; essentially all achieved a grade point average of at least 3.5.

But perhaps equally impressive is the fact that the attrition rate among students enrolled in the College has now dropped to 10%. Not only are UM Engineering students characterized by unusual academic abilities, but they also have the determination and drive to meet the challenge and rigor of an engineering education.

Industry apparently shares our respect for these exceptional students. Essentially all UM Engineering graduates seeking immediate employment are placed prior to graduation, with most receiving several offers of employment. Furthermore, more than 50% of the B.S. graduates of the College will continue on to graduate or professional schools in fields such as engineering, science, business, law, and medicine.

Faculty Quality

The size of the instructional faculty of the College has remained relatively stable over the past several years, growing slightly from 225 full-time-equivalent in 1972 to 250 FTEs (320 head count) in 1985. However, the composition of the faculty has changed dramatically. Because of a period of rapid hiring in the late 1950s and early 1960s, followed by a decade of hiring constraints in the 1970s, the College entered the 1980s with a bimodal age distribution. A significant fraction of its faculty were clustered in the 50-to-60 age range and will approach retirement during the 1980s. In fact, during the 1980s, UM Engineering is facing the challenge -- and the opportunity -- of replacing almost 40% of its total complement of 320 faculty members.

To respond to this challenge, the College took several important steps to better position it for this massive recruiting effort. First, it set high standards for hiring, promotion, and tenure. Next, it implemented an aggressive, merit-based salary program that provided strong rewards for exceptional achievement. Finally, to better accommodate those faculty members who were uncomfortable with the more intense, achievement-oriented environment that was being developed, the College simultaneously developed a flexible and responsive early retirement program. These three actions have been used to significantly upgrade both the level of achievement and the expectations of the existing faculty.

To assist in its recruiting efforts, the College next persuaded the Provost to allow it to decouple its salary program from the rest of the University in order to achieve highly competitive offers, funded in part from private sources. In this way, the College has been able to increase its salary levels for junior faculty (assistant and associate professors) to among the highest of any engineering school in the nation. It took additional steps to provide junior faculty with ample startup funding for laboratory equipment and computers, reduced teaching loads, access to high-quality graduate students, discretionary resources, and strong guidance and support from senior faculty.

As a consequence of these actions, during the past five years the College has been able to hire more than 100 new faculty members from the leading institutions in the nation. In recent years, its success rate in acceptances of offers has run in excess of 80% -- a remarkable achievement in view of the intense competition for these scholars.

To achieve a more uniform faculty age distribution, the College established a flexible policy to encourage departments to recruit faculty at all levels, from assistant professors to full professors and endowed chairs. This has led to the addition of a number of distinguished senior faculty in recent years who have assumed positions of intellectual leadership in the College.

In a very real sense, the faculty of the College is being renewed at a dramatic pace during the decade of the 1980s. Roughly 20 to 30 new faculty members are being added each year. This has provided UM Engineering with an extraordinary opportunity to attract outstanding scholars, to move rapidly in building momentum in high priority areas.

Program Quality

The rating of academic programs is always a dangerous and controversial matter, usually generating far more heat than light. However, over the past two decades in most surveys, the UM College of Engineering has generally been ranked fifth or sixth nationally in overall quality -- usually trailing somewhat behind the three leading institutions MIT, Stanford, and Berkeley, but well within the next tier of institutions such as Illinois, Purdue, Cornell, Princeton, Caltech, and Wisconsin.

Each of the College's 22 individual degree programs is generally ranked among the top ten such programs in the nation, whether evaluated with respect to the quality of undergraduate or graduate instruction, research, or faculty. In surveys conducted during the past decade, several of these programs including Industrial Engineering, Nuclear Engineering, Naval Architecture, Atmospheric Sciences, and Aerospace Engineering were clearly identified as national leaders.

The achievements of alumni are key factors in determining the reputation of an academic institution. Michigan stands third nationally in the number of its graduates listed in citations such as *Who's Who*.

Resources

Financial Resources

Annual expenditures of the UM College of Engineering were $66 million in FY1984-85. Of this, $51.3 million was under the direct control of the College. An additional $15 million of expenditures was imposed on the University by College activities (indirect costs). Instructional and research activities were budgeted at roughly equal magnitudes; each accounted for $30 million in expenditures.

The College generated $60 million in revenue from a variety of sources including student tuition and fees ($25 million), sponsored research grants and contracts ($25 million), service activities such as off-campus instruction ($3 million), and private gifts ($7 million). In addition, the enrollment of the College generated roughly $28 million in State allocation to the University's General Fund.

The University of Michigan has long been characterized by a highly decentralized form of administration in which each academic unit assumes an unusual degree of budget responsibility and authority. In recent years the University has moved increasingly to local cost-revenue control centers at the unit level (an "every tub on its own bottom" style of financial management).

Each year UM Engineering receives a single negotiated budget line from the University's General Fund ($23.5 million in FY1984-85). In addition, it retains direct control over revenue from the direct-cost component of research grants and contracts, service income, private gifts, and differential tuition charged to engineering students for special programs such as the computing environment. The College negotiates one-time funding with the University or State government for special equipment or facilities needs. More recently, the College has benefited from special line item support from the State of Michigan for key research programs (e.g., integrated manufacturing, machine intelligence, advanced electronics and optics).

The College benefits from an unusual degree of autonomy and flexibility in the deployment of these resources. With the exception of base faculty budget lines and restricted funds (e.g., research and service contracts), most resources of the College are allocated to academic units utilizing a zero-base budgeting philosophy in which allocations are determined by the level of activity (enrollments, research volume, etc.), needs, and priorities. In addition, the College provides several sources of discretionary funds to faculty and departments to stimulate new research and instructional programs or to respond to unusual needs.

Because of this autonomy in financial management, UM Engineering has developed independent capabilities for generating resources. The College staffs both an Office of Development and an Office of Corporate Relations to conduct fund-raising from the private sector. The University has enabled the College to interact directly with the Governor and State Legislature to obtain support for both major facilities and base budget needs. Furthermore, the College maintains a significant Washington presence to track and respond to major opportunities at the federal level.

Physical Facilities

During the period from 1980 to 1986, UM Engineering completed $70 million of new facilities construction and renovation to move all of its programs into modern facilities on the North Campus of the University. This massive and complex sequence of projects, funded from both private ($40 million) and public ($30 million) sources, has provided the College with superb facilities for the conduct of engineering research and instruction. Most of the academic departments of the College are located in distinct buildings and laboratories, connected by corridors, walkways, and tunnels.

The North Campus engineering complex contains a number of unique facilities for research and instruction: the Solid-State Electronics Laboratory (with over 10,000 square feet of clean room facilities), the Center for Research on Integrated Manufacturing, the Phoenix Memorial Laboratory (and associated nuclear reactor), the Intense Energy Beam Laboratory, the Gas Dynamics Laboratory (and associated wind tunnels), the Large-Scale Structures Testing Laboratory, the Computer Aided Engineering Laboratory and Instructional Center. In close proximity to the Engineering campus are the affiliated laboratories of the Industrial Technology Institute, the Environmental Research Institute, the UM Transportation Research Institute, and the Center for Machine Intelligence. In addition, the

Schools of Architecture, Art, and Music are located on the North Campus, along with other facilities such as the University Computer Center, the Bentley Historical Library, and the Gerald R. Ford Library.

Although the College benefits today from outstanding facilities, the North Campus site will continue to evolve to meet changing needs. The next focal point of the campus will be the Engineering Library, scheduled for completion in 1988. Also planned is a major Experimental Projects Laboratory. In addition, a University-owed commercial complex will be constructed along the west boundary of the Engineering campus.

Laboratory Equipment

The serious deterioration in the laboratory equipment inventories of our nation's engineering schools over the past decade have been well documented. This crisis arose as most universities responded to a retrenchment in the support of higher education by cannibalizing equipment budgets. This happened during a period in which the federal government methodically canceled or decreased most of its support for instructional laboratory equipment. Compounding this situation was the increasing sophistication of modern instructional and research equipment, which led to sharp increases in both acquisition and maintenance costs. As a result, most engineering schools are now forced to conduct their instructional and research activities with obsolete, inadequate equipment that lags far behind modern professional practice.

To respond to this challenge, UM Engineering set as one of its highest priorities the restoration of adequate support for laboratory equipment (estimated in 1985 to have resulted in a backlog of equipment needs in excess of $30 million). Through a series of complex internal reallocation programs, coupled with initiatives to obtain special support from the public spector, the College succeeded in increasing its (General Fund) support for laboratory equipment from $200,000 per year in 1980 to $5,300,000 per year in 1985. This corresponds to a sustained investment from University funds of roughly $2,500 per engineering graduate per year.

When these internal funds are leveraged through grants from industry and federal agencies and deep discounts from suppliers, they provide UM Engineering with the capacity to build and sustain a laboratory environment suitable for high-quality engineering education and research. Perhaps the most vivid testimony of the success of this program has been the College's ability to recruit and sustain a significant number of outstanding experimentalists among its new faculty members in recent years.

Computing Environment

One of the major challenges facing academic institutions in general and engineering schools in particular involves the impact of modern computers and communications technology. New fields, such as computer-aided design, computer integrated manufacturing, and knowledge engineering, are not only revolutionizing engineering education and research, but they are imposing extraordinary challenges to academic institutions in providing the environment suitable for such activities.

The UM College of Engineering is committed to building the leading information technology environment for instruction and research. Technology now dictates that this environment be geographically distributed, but richly connected. The major physical components of a modern distributed information technology environment are computer workstations, communications networks, and network servers. Each of these elements has an associated hardware and software component. The total environment available to our students, faculty, and staff will be a complex composite of College, university, and national technology resources.

The College has assumed the responsibility for the acquisition, deployment, and maintenance of workstations and the associate College-level communications networks and servers. The vehicle for this effort is the Computer Aided Engineering Network (CAEN), a sophisticated information technologies network integrating the College's instruction, research, and administrative activities together with both on-campus users (students, faculty, and administrators) and off-campus participants (industry and government). CAEN is a distributed intelligence, hierarchical computing system linking personal computer workstations, superminicomputers (and "mini-supercomputers"), mainframe computers, function-specific machines (CAD, simulation, artificial intelligence), and gateway machines to national networks. The network is designed to support not only general scientific computing, but computer-aided engineering, computer-aided instruction, and administrative services (word processing, electronic mail, database management). It also provides access to technical and bibliographical databases and serves as a test bed for research and development in computer and communications engineering.

In a sense, one can think of CAEN as an environment in which each student and faculty member has open (unlimited) access to powerful ("5M" class) computer workstations, integrated into local area networks with appropriate servers (file, print, computation), and connected through high-speed data links and networks to more powerful resources, such as supercomputers, libraries, and application servers (VLSI fabrication, flexible manufacturing cells, simulators). Although CAEN is based primarily on UNIX operating systems, it has been designed with shells to support a variety of user interfaces (including MS-DOS, Apple-Mac, and VMS environments).

CAEN has grown rapidly in scope until today every faculty and staff member has at least one personal workstation (most also have similar workstations at home). Students presently have access to open clusters of roughly 600 workstations, ranging in power from IBM and Apple personal computers to Apollo, Sun, and MicroVax engineering workstations. We are closely tracking technology and at some point within the next one to two years expect to identify workstations with sufficient power at low enough cost to justify equipping all 6,000 of our students (on a lease-purchase plan) with personal workstations. The student's personal machine will be an intimate part of the educational process. Students will build a storehouse of algorithmic knowledge to take with them into professional practice. It is expected that the workstation, used with national networks, will enable continued electronic membership with the University community after graduation.

Challenges, Responsibilities, and Opportunities

Challenges

There is growing recognition of the critical role that this nation's leading engineering schools play in providing the engineers necessary for America's industrial strength and military security. Through their research activities these schools also provide the intellectual creativity and innovation necessary to sustain our technological leadership.

The need for engineers is intensifying, both because of the increasing sophistication of technology as well as the growing importance of engineering in meeting other societal objectives, such as the protection of public health, safety, and the environment. Although it is true that the quality of life and the economic well-being of our society depend on many factors, it is also true that these cannot be maintained, much less improved, without an adequate supply of highly skilled engineers. Yet, even as our society becomes increasingly dependent on science and technology for its prosperity and security, we face an engineering manpower crisis of unprecedented proportions.

Most engineering schools simply do not have the capacity to respond to the national needs for engineering graduates, particularly in critical areas such as electrical, computer, and manufacturing engineering. This shortage is particularly acute at the graduate level and poses a serious challenge to the continued health of this nation's research capabilities, not to mention its engineering schools.

At the same time that engineering schools are straining to respond to national needs, they are also deluged by an unprecedented demand on the part of our nation's most outstanding high school graduates to pursue engineering careers. Most engineering schools have seen both the quantity and quality of applications for admission rise sharply in recent years. The leading engineering schools, such as Michigan, can accommodate fewer than 20% of those students who apply -- despite the fact that roughly 80% of these applicants are well qualified for studies in engineering. This intense demand and selectivity yields a student body of extraordinary quality. This situation has arisen, however, because of the limited capacity of the leading engineering schools, which is caused by inadequate funding from state, federal, and industrial sources.

UM Engineering faces the challenge of responding to both the demands of the talented students seeking admission to its programs and the needs of our nation for its engineering graduates at all degree levels. At the same time, it must maintain the high-quality research programs so vital to our industrial strength and national security.

Responsibilities

To the Nation

Strong evidence suggests that America's leading engineering schools serve as primary catalysts and necessary ingredients in technology-based industrial development and national security. Such institutions provide the technological innovation and entrepreneurs necessary to build new industry. Furthermore, these schools furthermore provide the outstanding engineering graduates necessary to sustain and strengthen the competitiveness of existing industry.

It is reasonable to expect that the role of leading engineering schools will be even more critical in a future increasingly dominated by science and technology. There seems little doubt that our nation's ability to strengthen industrial competitiveness, to build the new industries necessary for economic prosperity, and to preserve its military security will depend on its ability to sustain these critical institutions.

To the State

The presence in the State of Michigan of one of the nation's leading engineering schools, the UM College of Engineering, is of critical importance to the state's future economic prosperity. Michigan requires a massive infusion of new technology if it is to regain its traditional industrial and economic leadership and become the nation's leading source of emerging industrial technology. The state must use technology to revitalize and diversify its present industrial base to protect existing jobs, even as it seeks to spawn and attract new industries over the longer term to create new jobs for Michigan citizens.

The UM College of Engineering is in an excellent position to achieve national leadership in areas of major importance to

Michigan's future, including complex manufacturing technology, machine intelligence, materials-processing technology, advanced electronics and optics technology, computer science and engineering, biotechnology, and information technologies.

The UM College of Engineering provides Michigan with both a vehicle and an extraordinary opportunity for investing in the long-term economic health of the state.

To Industry

The College acknowledges a special responsibility to respond to the needs of American industry. This mission is quite natural for an engineering college. In a very real sense, industry represents a major reason for the existence of the College. If one recognizes that engineering is the application of science and technology to meet the needs of society, then it is apparent that industry is the manifestation of this activity. Moreover, the students and the research provided by the College can be viewed as the lifeblood of industry and the key to the future of American productivity.

The College has set as one of its primary objectives the development of close ties with industry. It is working closely with industry to learn of needs and concerns. UM Engineering has developed special academic and research programs to respond to these needs.

To Our Students

The 6,000 students enrolling each year in the academic programs of the College represent one of this nation's greatest resources, drawn as they are from the top 2% of high school graduates. These students will continue on to a wide range of career opportunities, including engineering, scientific research, business, law, and medicine, but one thing is certain: they will become the leaders of our society and our nation.

For this reason, the College acknowledges a special responsibility -- a stewardship -- to provide its students with an outstanding education. This requires a commitment to attract and sustain world-renowned faculty with deep commitments to education and to build and equip the modern facilities required for high-quality instruction and research in engineering and applied science.

However, we also believe that the extraordinary quality of the students enrolling in UM Engineering demands something beyond this. These students deserve -- and demand -- a broad-based liberal education in the classical sense. It is not enough simply to provide them with outstanding instruction in the technical areas of engineering and science. Rather, the College is committed to drawing on the greater resources of the University to provide our students with a deep understanding and appreciation of the other critical areas of man's intellectual activities, ranging from literature and philosophy to art and social science. We believe that our students deserve an education befitting the future leaders of America.

Opportunities

As federal and state leaders have recognized the importance of world-class engineering schools to economic strength and national defense, public policy has begun to stress special attention and support for engineering education. This has occurred during a period in which the University of Michigan has also acknowledged the special role that the College of Engineering must play in the future of the institution. As a result, UM Engineering has benefited from a number of unusual opportunities:

• Because of natural faculty attrition, the College faces the challenge (and opportunity) of replacing roughly 40% of its faculty during the 1980s -- over 140 positions, occurring at the pace of 20 to 30 positions per year.

• To assist in this activity, the College has been allowed to decouple its salary program from the rest of the University to achieve market competitiveness with peer institutions and industry.

• The base instructional budget of the College has grown from $11.5 million to $34 million over the past four years.

• The College has benefited from the establishment of nine fully-funded ($1 million) endowed chairs for senior faculty and two endowed chairs for junior faculty.

• A $70 million construction program, funded from both public and private sources, has provided superb facilities for engineering instruction and research.

• Base (General Fund) support for laboratory equipment has been increased to $5.3 million per year. In addition, the College is now investing roughly $5 million per year in its computing environment (in addition to University-wide investments in networking and mainframe support).

• Technical support staff has been increased from 22 full-time equivalents (FTEs) (1981) to 85 FTE (1985).

• Conflict-of-interest regulations and patent policies have been streamlined to stimulate and encourage faculty to transfer intellectual properties to the private sector. The College is building an environment that encourages entrepreneurial activities on the part of its students, faculty, and staff.

Perhaps the most important opportunity arises from the unusual flexibility the College has been provided in its financial management, resource generation, personnel policies, and the administration of its academic and research programs. It has been provided with essentially complete control over its destiny, with the ability to move rapidly to respond to needs and opportunities.

Hence the final -- and most significant -- challenge faced by the UM College of Engineering is that of deploying its considerable financial, capital, and human resources to achieve leadership in engineering education and research.

Strategic Planning

The basic objective of the UM College of Engineering is simple: the achievement of excellence and leadership in engineering education and research. However, the strategy necessary to pursue this objective requires a bit more explanation.

Quality versus Breadth

Throughout most of their histories, the leading public institutions of higher education, such as the University of Michigan, have benefited from continually increasing levels of public support. These institutions could afford to be all things to all people. They could afford to place equal emphasis on the breadth, capacity, and quality of their programs. They attempted to do a great many things, with a great many people, and to do them all very well.

Today, however, public education faces a much different future. It has lost much of its ability to compete with other social services such as health care and welfare for continually increasing levels of public support. Furthermore, the decline of high school graduates over the next six years (projected to be as large as 25% to 30% in the northeastern United States) poses additional challenges.

For this reason, the University of Michigan, and more specifically the UM College of Engineering, has accepted the premise that in a future of level or perhaps even declining public support, its success will depend not on the capacity or breadth of its academic programs but rather on their *quality*. In such a future, only the best programs will be able to attract the resources necessary to sustain their excellence.

Hence, the underlying premise of UM Engineering's strategic planning is the belief that the College must identify those areas in which it has the tradition, the mission, or the opportunity to become the best, and then to focus resources to build and strengthen these areas. It must build peaks of exceptional excellence that stand high enough to acquire the national recognition, to attract the outstanding students, faculty, and resources, necessary to sustain quality. In UM Engineering's future, we believe that only the best will do.

Of course, such a strategy poses several challenges. First, the College must choose carefully those areas which have the potential for excellence and which, furthermore, are relevant to the particular mission of UM Engineering. Having chosen these areas, the College must then take the sometimes painful actions necessary to shift resources away from lower priority areas, decreasing or perhaps eliminating entirely activities in which we cannot hope to be national leaders.

Criteria for Areas of Focus

To date, we have utilized three criteria to determine areas of focus: tradition, mission, and opportunity.

There are several areas in which the College has a long tradition of excellence. For example, in areas such as aerospace engineering, industrial engineering, naval architecture, nuclear engineering, remote sensing, and atmospheric sciences, UM Engineering has built programs that are widely recognized as national leaders. Because these programs are already at the top, the investment required to sustain excellence and leadership is frequently modest (at least in comparison with building entirely new programs). Hence, we have frequently chosen to sustain and enhance those programs characterized by a strong tradition of national leadership.

We have chosen to stress some disciplines because we believe Michigan has a unique mission to achieve leadership in these areas. For example, because more than 80% of the manufacturing capacity of both the United States and Canada is within a 700 mile radius of Ann Arbor, we believe we must make the commitment to build leading programs in manufacturing (including all aspects of the "factory of the future"). A similar concern has stimulated major commitments to build high-quality programs in materials science and engineering, with a particular focus on materials-processing technology. And, because the infrastructure of industry in the midwest will increasingly be built on sophisticated information technologies, we have made massive commitments to the areas of advanced electronics and optics, computer science, and computer engineering.

Finally, the College has chosen to invest in certain areas simply as opportunities. Because of a unique confluence of outstanding faculty and unusual facilities, several of our programs have strong potential for national leadership. For example, over the past several years we have managed to recruit several outstanding young scholars in modern mechanics. Faculty in our Departments of Civil Engineering, Industrial Engineering, and the School of Business Administration have formed one of the nation's leading programs in construction management. By coupling the activities of several new faculty members in our electrical sciences program with a strong group in the Department of Physics, we have the opportunity to build a major program in modern optics (femtosecond optics, nonlinear optics, optoelectronics). Similarly, recent additions to the faculty from several leading industrial research laboratories have provided us with an strong capabilities in polymer and composite materials processing technology. Each of these areas represents an opportunity with a strong potential for excellence, and the College has responded to each with a major commitment of resources.

Resource Reallocation

To obtain the resources necessary to build and strengthen areas of high priority, it is inevitable that we must develop the capacity to reallocate resources away from other areas. Yet this requirement, so familiar to our colleagues in industry, is a relatively recent fact of life in academic institutions long accustomed to ever-increasing resources.

Part of our challenge has been to develop administrative structures and policies to facilitate reviews and resource allocation. To this end, UM Engineering now reviews on a regular basis all academic programs, even as it looks for opportunities for new program development. Programs that fail to meet the tests of centrality to the mission of the college, quality, and cost-effectiveness are candidates for program reduction or discontinuance. To assist in this effort, we have attempted to develop within the College a "zero-base budget" philosophy that stands in sharp contrast to the "incremental budgeting" so prevalent in university environments.

There is broad-based faculty and student participation in all aspects of such review and reallocation decisions. The effectiveness of this effort is demonstrated by the fact that even during a five-year period in which the General Fund resources available to the College increased by a factor of three, one academic department, four academic programs, and two administrative units have been eliminated.

Associated with this strategy of focusing resources has been an effort to develop a more efficient and decentralized style of administration. Working closely with the Chairmen's Advisory Council and Executive Committee, the College has developed fair and effective policies for resource allocation. These return primary responsibility for cost management to the units most directly responsible for expenditures. The College has also stimulated ongoing long-range planning and program review at both the local and College level.

Other Specific Strategies

The UM College of Engineering has set a number of other important objectives that have played major roles in determining its long range strategy:

1. The College has sought to improve the quality, achievements, and reputation of its faculty by implementing policies concerning hiring, promotion, tenure, and salary that strongly emphasis excellence in scholarship.

2. Research activity in the College has been increased substantially (60% over five years) through strong research incentives and increased College support of sponsored research activities.

3. To respond to serious national needs for advanced degree engineers while recognizing the strengths and interests of its faculty, the College has shifted its focus somewhat to stress upperclass and graduate-level instruction.

4. The College made major commitments of resources to increase both the quality and size of its Ph.D. programs.

5. The College has taken a number of steps to provide the environment necessary for high-quality engineering education and research, including massive commitments for physical facilities ($70 million), laboratory equipment ($5 million per year), and computing technology ($6 million per year).

6. The College has set as a leading priority the strengthening of its interactions with industry and has made major commitments of resources to build new programs for this purpose (for

example, Industrial Affiliates programs, Industrial Research Partnerships, the Center for Research on Integrated Manufacturing, the Center for Machine Intelligence, the Industrial Technology Institute).

7. A major goal of the College for the next several years will be a thorough review of the nature of undergraduate engineering education with the intent of exploring other options that provide students with the intellectual breadth and depth necessary to become leaders in our society.

Longer-term Strategy

The ability of the College to maintain its tradition of national leadership will depend, in part, on its ability to attract the sustained flow of resources necessary to support world-class programs. To this end, it has been working closely with both University and State officials to develop a plan that will provide UM Engineering with the base level of support necessary to compete effectively with the leading public and private engineering schools for outstanding students and faculty.

The first phase of this strategy involved a major reallocation of resources within the University of Michigan to restore the erosion that occurred in the base General Fund support of the College during the 1970s. This internal reallocation yielded the major increase in the College's General Fund budget that occurred during the period from 1981 to 1985 ($11.5 million --> $34 million).

The second phase of this strategy has involved special action by the State of Michigan to single out the UM College of Engineering as the key academic institution for the state's future. Several major studies conducted by state government have led to major policy actions that will provide the College in 1985 with special line item funding starting at a base level of $9 million per year for programs in the important areas of manufacturing, machine intelligence, and advanced electronics and optics. Further, such targeted appropriations are expected to increase this special funding for key College programs to $18 - $20 million per year over the next several years.

The third stage of the strategy is built around the unusual flexibility the College has been provided in its financial management. As the University has moved to decentralize cost and revenue control, the College has benefited from the ability to develop new sources of funding. For example, the College now has firmly established the precedent of differential tuition for engineering students, arguing that the increased cost of the facilities and instruction required for engineering education, along with our graduates' enhanced earning capacity, support such actions. (Of course, major increases in student financial aid must accompany any such actions.) A second source of non-traditional income involves activities in the private sector, such as patent development and licensing and equity interest in spinoff companies, both allowed by University policies. Finally, we have significantly increased our efforts to attract major gifts from individual donors, corporations, and foundations.

It is our belief that the strong priorities given the College by the University and the State, coupled with our unusual flexibility in resource generation and management, should provide the resources necessary to achieve our objectives of national leadership.

Relationships with Industry

UM Engineering acknowledges a special responsibility to respond to the needs of American industry. A major thrust of the College has involved a focusing of its efforts toward building stronger relationships with the private sector.

University-Industry Partnerships

It is important to recognize that the relationship between industry and academe is symbiotic -- an association between two unlike organisms for the benefit of one other. Although both industry and universities have a "service to society" component in their mission, the fundamental goal of industry is to make a profit. The fundamental goal of a university is to create and maintain knowledge and to impart it to its students. In a university-industry partnership, it is important that each partner do what it does best.

The traditional forms of interaction between universities and industry have been through the education of students who then take positions in industry and through open publication of research results in scholarly journals that are then read in industry. Although these modes of technology transfer continue to be necessary, an emerging consensus indicates that they are not sufficient.

The time required for technology transfer from university to industry must be reduced dramatically to meet the needs of existing companies and to spawn new industries. Academic institutions are ill equipped to respond to the highly focused, immediate needs of industry without considerable disruption of on-campus responsibilities. Furthermore, if universities are to acquire the capacity to respond more effectively to the industrial needs, then industry must develop mechanisms to provide more direct support for these institutions through financial assistance, equipment donations, and visiting staff.

It is generally agreed that both industry and academe desire stronger, more sophisticated, and more sustained relationships between each other, relationships that are better able to respond to the needs and capabilities of each group.

Mechanisms of Interaction

Traditional Modes: The traditional -- and most important -- mechanism for interaction between the College and industry is through the placement of engineering graduates. Each year the UM Engineering graduates more than 2,000 engineers and scientists, drawn initially from among the top 2% of high school graduates, and educated within the leading academic programs in the nation. The attractiveness of the College's principal "product" in the industrial "marketplace" is readily apparent to those who have experienced the crowds of company recruiters in our Engineering Placement Center.

Co-operative Engineering Education: The College has a comprehensive Cooperative Engineering Education Program in which strong students are allowed to alternate periods of study with work experiences in participating companies. Generally such cooperative programs do not begin until the junior year. Furthermore, the College requires that participating companies work closely with faculty counselors to develop a work experience that will complement the student's academic program. Participating companies are expected to provide financial support for the student's salary while on work assignment as well as the administrative costs of the program.

Continuing Engineering Education: To keep pace with changing technology and to maintain competitiveness, most companies find it essential to provide their engineering staff and management with ongoing exposure to state-of-the-art engineering and technology management methods through access to graduate-level instruction. The College conducts a comprehensive curriculum of on-site courses and seminars through its Continuing Engineering Education Center and its Engineering Summer Conference Program. In addition, the College has an extensive Instructional Television System that utilizes both live transmission (microwave and satellite-based) and videotape to provide remote site instruction.

Research: Yet another traditional mechanism involves on-campus research. In most cases, the results of College research programs are published in the open literature and are readily available to industry. When more specialized assistance is needed, companies sometimes directly sponsor the activities of College faculty and students in investigating a particular problem area. Such work can even be of a proprietary nature, as long as the basic results (although perhaps not the specific details) can eventually be published.

Consulting: Industry frequently uses faculty consultants to help solve near-term, specific problems. Such activities offer faculty valuable industrial experience to carry back into the classroom, as well as supplementary income. Although consulting is encouraged, it does not replace the need for more active institutional partnerships between industry and universities. Consulting generally does not include the involvement of students, nor does it directly support the basic, generic research that our society expects of universities.

Entreprenurial activity: The origins of many technology-based companies can be traced back to universities -- to individual faculty and staff or research laboratories. Indeed, UM Engineering has spun off more than 100 such companies over the past two decades. Although in the past such companies were sometimes viewed as conflicting with academic duties, the College today views such entreprenurial activities very positively. It has taken a number of steps to both encourage and facilitate the formation of spinoffs. Of course, there will always be the potential for possible conflict-of-interest problems, as there will also be for the loss of faculty to the private sector should they become too heavily involved in spinoff activities. Nevertheless, UM Engineering believes that these risks are well worth the payoff, both in terms of the College's ability to attract outstanding faculty and students who seek such entrepreneurial activities, and in terms of its social responsibility to transfer technology from the campus into the private sector.

Industrial Affiliates Programs: Recent years have seen a strong growth in the various Industrial Affiliates programs of the College. These programs generally focus on a specific contemporary technical area, and in exchange for an annual subscription fee, the industrial participants receive special treatment in accessing the research results of a group of faculty and graduate students. They may participate in the setting of research directions, and -- perhaps most important to industry -- they establish early tracking of the brightest students...hopefully their future employees. UM Engineering currently has more than a dozen such Industrial Affiliates programs.

Industrial Research Partnerships: The College has also developed a more sophisticated and sustained type of relationship known as the Industrial Research Partnership. In such partnerships, the College works closely with a single company on common research problems. Typically, teams of Ph.D. students led by senior faculty work side by side with industrial engineers and scientists, both in company facilities and on campus. Such partnerships have already yielded significant progress in critical areas of technology. Establishing such mutual interactions usually requires extended visits between both sides at both sites. It usually involves hard work. The success of such partnerships requires a prior commitment and degree of coordination from the highest levels of industry and the universities. Busy administrators, such as deans, CEOs, vice-presidents, and their staffs, must make time to define the program together and take specific action to make it happen. There must be a new willingness for give and take on both sides with respect to patent rights, open publication policies, and the minimum duration and continuity of such support. The College sees such relationships as involving signficant levels of commitment on both sides. Therefore, the number of Industrial Research Partnerships is, of necessity, rather small.

The Office of Corporate Relations:

To assist in building and coordinating relationships with industry, the College has established an Office of Corporate Relations reporting to the Associate Dean for Research. The Director of Corporate Relations can provide assistance in making the necessary contacts within the College across the entire range of its research and instructional activities.

The National Advisory Committee:

For many years the College has made use of visiting committees from industry to provide evaluation and advice concerning its various programs. It has also benefited from an ongoing Industry Committee, comprised of representatives from key midwestern companies.

To better address its breadth of intellectual activities and geographical responsibilities, in 1982 the College broadened its Industry Committee into a National Advisory Committee. This Committee, comprised of 50 leaders of industry, government, and academe, has provided the College with guidance and support for its instructional and research programs. Members of the Committee typically spend time on campus each fall to focus on major challenges facing the College. Subsets of the Committee take on more specialized assignments throughout the year.

ECONOMIC DEVELOPMENT

The UM College of Engineering believes it has a major responsibility to respond to the needs of the State and the nation:

...through the attraction of outstanding engineers and scientists and the establishment of national research centers of excellence capable of technological innovation,

...through the transfer of this technology to industry through its graduates, continuing engineering education, research partnerships, and the formation of spinoff companies,

...through direct participation in economic development by attracting companies and national R&D centers and encouraging faculty and graduates to build new companies.

The Strategy

The College probably has its largest impact on economic development through the more than 2,000 engineers it graduates each year and the research achievements of its faculty and staff. In recent years, however, UM Engineering has gone beyond these traditional mechanisms to initiate a number of new programs aimed at regional economic development. The College has developed its strategy in close cooperation with leaders of state government, industry, and business.

The basic strategy can be grouped into three areas:

Technological innovation:
- Outstanding engineers and scientists
- National research "centers of excellence"

Technology transfer:
- Traditional mechanisms (graduates, publishing)
- Research partnerships with industry
- Continuing engineering education
- Formation of spinoff companies
- Industrial consortia

Job creation:
- Formation of spinoff companies
- Attraction of new companies
- Attraction of major national R&D centers

Technological Innovation

Of course, the key to technological innovation involves the creative activities of outstanding engineers and scientists. Certainly in its 6,000 students and 320 faculty, the College benefits from one of the largest concentrations of such talent in the state.

To assist in attracting the people and resources necessary to stimulate intellectual creativity and technological innovation, the College has sought to establish nationally-recognized centers of excellence in areas of technology that are key to Michigan. Among these are:

- Center for Research on Integrated Manufacturing
- Industrial Technology Institute
- Air Force Center of Excellence in Robotics
- Computer-Aided Engineering Network
- Center for Ergonomics
- SRC Center in Semiconductor Manufacturing

A number of additional major research centers are under development:

- Center for Machine Intelligence
- Center for Electronics & Optics Technology
- Center for Scientific Computation
- Applied Physics Program

Technology Transfer

Traditionally, leading engineering schools such as UM Engineering have transferred technology to the private sector in the following ways:

- Placement of graduates in industry
- Cooperative engineering education
- Continuing engineering education for industry
- Publication of research results
- Faculty/industry exchange programs
- Faculty and staff consultation with industry
- Special research projects conducted for industry

Recently, however, the College has gone beyond these traditional mechanisms to develop new ways to transfer technology. One of the most important mechanisms involves Industrial Affiliates Programs in which 10 to 20 companies work with the College in areas of specific technological interest. Ongoing Industrial Affiliates programs include:

- Solid-State Electronics

Robotics
Ergonomics
Flow Reaction and Porous Media
Colloidal and Surface Phenomena
Machine-Tool Wear and Sensing
Information Systems Engineering
Computer-Aided Manufacturing
Construction Engineering and Management
Off-shore Engineering
Computer-enhanced Productivity (EPIC)

The College has also developed a more sophisticated and sustained type of relationship known as the Industrial Research Partnership. In these partnerships, the College works closely with key companies on common research problems. The College forms teams of Ph.D. students led by faculty; these teams then work side by side with industrial engineers and scientists (both in company facilities and on campus). Such partnerships have already yielded dramatic leaps progress in critical areas of technology. Existing research partnerships have been formed with the following companies:

General Motors: "factory of the future"
Ford: ergonomics, electronics
IBM: robotics, supercomputers
Intel: computer science
SRC: automation
General Dynamics: computing networks
EDS: knowledge engineering
Chrysler: automotive engineering

Job Creation

The UM College of Engineering is also involved in a number of activities aimed at direct job creation. One of the most important such mechanisms is through the formation of new "spinoff" companies by faculty, staff, and students. This has always been an active area, as evidenced by the more than 100 companies formed by the College and its affiliated research laboratories over the past two decades. However, strong steps are now being taken to encourage and facilitate this activity, and the rate of spinoffs is increasing rapidly.

Considerable activity has also been directed toward attracting industry to Michigan. Through close coordination with state and local government, the College has used its extensive industrial contacts to identify and interact with prospective companies. During the course of a typical academic year, faculty and staff of the College will conduct 50 to 60 day-long briefings both on campus and at industrial sites with the intent of exploring the opportunities for locating new installations in Michigan. The College has also been an important partner in efforts to develop several research parks in the southeastern Michigan area.

Finally, the UM College of Engineering has frequently played a key role in attempts to attract major R&D centers to Michigan. For example, the College provided the principal technical component of the State of Michigan's proposal for siting the Microelectronics and Computer Corporation. It has also taken the lead in other efforts, such as the DOD Software Engineering Institute and the NSF National Supercomputer Center. Similar efforts are now under way for other national centers.

The Computer-Aided Engineering Network - EPIC Project

Engineering education and practice are entering an era of unprecedented change. Already, new developments in computer and communications technology strongly affect engineering practice through applications in computer-aided design (CAD), computer-integrated manufacturing (CIM), knowledge engineering (applied artificial intelligence), and computer and communications networks -- fields referred to generically as computer-aided engineering (CAE). The disciplines of computer science and engineering are now focused on enhancing the productivity of people rather than simply the productivity of operations. As a result, engineering education faces a twofold challenge: to undertake creative research and development in these fields and to integrate the resulting technologies into academic programs.

The UM College of Engineering has set as its objective the development of the leading academic computing environment in the world. The vehicle for this effort is the Computer-Aided Engineering Network (CAEN), a sophisticated computer communications network that integrates the College's instruction, research, and administrative activities with on campus users (students, faculty, and administrators) and off campus participants (industry, government). CAEN is a distributed-intelligence, hierarchical computing system linking personal workstations, superminicomputers, mainframe computers, function-specific machines, and gateway machines to supercomputer installations. The network is designed to support not only general scientific computing but also computer-aided engineering, computer-aided instruction, and administrative activities (word processing, electronic mail, database management). It also provides access to technical and bibliographical databases and serves as a test bed for research and development in computer and communications engineering.

The Center for Research on Integrated Manufacturing

The College's Center for Research on Integrated Manufacturing (CRIM) addresses not only the elements of complex manufacturing technology but especially their integration. CRIM's activities focus on the development and integration of complex manufacturing systems in four interrelated areas: product design, cell-level production, plant-level production, and strategic management. Activities in each of these areas are tightly coordinated to address industrial needs for improving productivity, quality, and the worker environment to enhance the competitiveness of American industry.

The Center is designed to take full advantage of UM's unique strengths: the Computer-Aided Engineering Network (an advanced distributed computing environment), the Industrial Technology Institute, and the Center for Machine Intelligence. The Center has close ties with a number of different industries including manufacturing (e.g., General Motors, Ford, Chrysler, General Electric, TRW), information technologies (e.g., EDS, IBM, Harris, Apollo, Apple, AT&T), aerospace (e.g., General Dynamics, Grumman), and electronics (e.g., Intel, Hewlett-Packard, Hughes, Semiconductor Research Corporation). It also has strong ties with numerous federal agencies, including NSF, AFOSR, DARPA, and NASA.

A key feature of CRIM is technology transfer through a variety of mechanisms, including placement of engineering graduates, continuing engineering education, formation of spinoff companies, and the formation of major new research units.

The Center for Advanced Electronics and Optics Technology

Sophisticated electronic and optical devices will be the key to industrial automation, information processing and communication, sensors, management -- essentially all of the activities involved in complex manufacturing processes. Virtually every machine, instrument, and tool manufactured by the year 2000 will be computer-controlled. Already the automobile industry has become not only the largest consumer but also the largest manufacturer of electronic components.

Of similar importance is the closely related technology of applied optics: the use of lasers, electron beams, and ion beams as the machine tools of the factory of the future for processing, sensing, diagnostics and mechanical measurement. Furthermore, the exciting new field of integrated optoelectronics, "optics on a chip", has the potential of revolutionizing the electronics, computer, and communications industry in much the same manner as the solid-state transistor did in the 1960s.

UM Engineering is building on strong programs in these areas, working closely with the strong industrial infrastructure that is already present in the midwest, to build a world-class center in advanced electronics and optics technology. Components of the Center include:

- Solid State Electronics Laboratory
- Femtosecond Optics Laboratory
- Quantum Optics Laboratory
- Directed Energy Beam Laboratory
- Neutron Depth Profiling Facility (Phoenix Memorial Laboratory)
- Condensed Matter Physics Laboratory
- Optical Processing Laboratory

The Center brings together engineers and scientists from a wide array of disciplines in state-of-the-art facilities for research in these critical areas.

The Center for Machine Intelligence

The convergence of computer, communications, and control technology induced by microelectronics, together with advances in software engineering and the application of artificial intelligence, is leading to a new field of application known as machine intelligence. Extending beyond the realm of traditional robotics, this field includes a wide variety of "animate systems" that are capable of perceiving their environments, reasoning about and planning the accomplishment of complex goals, and then operating in their environments to carry out goal-seeking activity.

Leaders in manufacturing technology now view machine intelligence as central to the evolution of more productive management, design and manufacturing processes that yield products of higher quality. Machine intelligence will provide managers and engineers with active, intelligent tools to manage the complex enterprises and produce the high-technology designs of the future. As the "eyes, brains, and hands" of smart robotic assembly and processing machines, machine intelligence will be a major component of the complex manufacturing technology of the future. Eventually, machine intelligence will be integrated into final manufactured products themselves. The consensus of most leaders from the manufacturing, computer, and automation industries is that the economic impact of machine intelligence will greatly exceed that of the more limited field of robotics.

Michigan's industrial base in areas such as machine vision and robotics, coupled with UM Engineering's strong programs in automation, microelectronics, and artificial intelligence has provided an excellent opportunity for the College to become the nation's leader in this emerging technology. The UM Center for Machine Intelligence is intended to become the key catalyst to stimulate this activity, drawing together world-class engineers and scientists in the critical areas of machine vision, robotics, knowledge engineering (applied artificial intelligence), animate technology, computer engineering, and information systems integration.

To lay the foundation for this effort, the necessary relationships with key industrial partners and key government agencies are now being formed. Electronic Data Systems (EDS), the information management subsidiary of General Motors, has already joined with UM Engineering as a partner in founding CMI. In addition to the direct involvement of major industrial partners, this UM Center has the mission of stimulating and nurturing the growing infrastructure of small machine intelligence companies now building in southeastern Michigan (in the Ann Arbor-Detroit corridor known as "automation alley") through further spinoffs, technical interactions, and the provision of the necessary technical manpower.

Materials Research

The foundation of the American manufacturing industry rests upon materials processing technology. Although this industry has traditionally been based on metal processing, there are strong indications that a shift is occurring to advanced materials such as polymers, ceramics, and composites. Furthermore, the rapid growth of the use of microelectronics and computer technology will place comparable emphasis on electronic materials. Finally, there is strong interest in biological materials for a host of applications.

UM Engineering has made a major commitment to building world-class programs in materials science and processing research. Key in this effort is the development of state-of-the-art analytical facilities to support research in a wide range of areas, including metals, ceramics, polymers, composites, electronic materials, and biological materials.

The principal materials research facility contains an array of instruments for materials characterization including a high voltage, high resolution transmission electron microscope, a dedicated scanning transmission electron microscope, an electron microprobe analyzer, an Auger spectrometer, an X-ray photoelectron spectrometer, as well as standard instruments such as scanning electron microscopes and 100 kV transmission electron microscopes. This facility is augmented by several other major facilities, including instruments for ion implantation and Rutherford backscattering measurements. The Solid State Electronics laboratory is equipped with an array of instruments for the study of electronic materials and electrical devices, including several molecular beam epitaxy instruments, ion implantation, electron beam lithography, and plasma processing facilities. The nuclear reactor facility in the Phoenix Memorial Laboratory is being equipped with modified beam ports capable of producing neutron beams suitable for neutron depth profiling.

The UM Engineering Television Network

American industry faces a major challenge in keeping pace with changing technology as it strives to compete in the world marketplace. As companies become ever more dependent on advanced technologies such as microelectronics, computer science and engineering, and integrated manufacturing, they find it essential to provide their engineering staff and management with ongoing exposure to state-of-the-art engineering and technology management through access to graduate-level instruction. They require, in addition, a window on the most recent research results across a broad range of fields.

To respond to this growing need, UM Engineering has embarked upon a major effort to make available through television broadcasts its entire range of graduate coursework, research seminars, and internal conferences. The intent is to expand its ongoing Instructional Television System effective with the 1986-87 academic year to begin broadcasting a full schedule of graduate-level courses, seminars, and conferences in engineering, applied science, and management science (in collaboration with the UM Graduate School of Business Administration). More specifically, the Michigan Engineering Television Network (METN) will broadcast 60 hours (8 am to 6 pm each weekday) of programming in engineering and related subjects consisting of:

- Graduate-level courses
- Research seminars and lecture series
- Workshops and short courses
- Special industrial briefings
- International conferences

Programming will originate from the Ann Arbor campus of the University of Michigan (although selected off-campus conferences will also be scheduled). Programs will be relayed via microwave and satellite links to subscribers.

Companies wishing to participate in METN will become members of the METN Industrial Consortium. Payment of a single annual fee (based upon company size) will allow company members unrestricted access to METN broadcasts throughout all company sites (although reception and internal distribution will be the responsibility of each Consortium member). In addition, company staff qualifying for admission to the University as degree or non-degree candidates will be allowed to receive credit for courses taken through METN, subject to normal tuition charges.

The UM Engineering Television Network can be a major resource to industry. It will provide companies with a cost-effective mechanism for strengthening and sustaining their technological and management capacity. The METN Consortium will provide members with sustained access to world-class faculty, visiting engineers, scientists, and business leaders. In addition, METN will provide a window on advanced research and development through the broadcast of programming produced by major research centers such as the Center for Research in Integrated Manufacturing, the Center for Machine Intelligence, the Industrial Technology Institute, and the Computer Aided Engineering Network.

The UM Engineering Television Network's impact will extend beyond that of individual companies, however. It will provide the midwest with a unique environment for technological evolution, and it will provide a unique resource in stimulating and attracting new industry.

Staffing Strategy - AY1985-86

Some General Comments:

We will have to be a bit more cautious this year, in view of the uncertainty surrounding the Research Excellence Fund as base support. However, this is appropriate anyway, since we will have a major challenge just assimilating the faculty hired during the past four years.

Fortunately, the rebuilding job for Electrical Engineering is almost complete (with 35 faculty hired into EECS over the past four years). All hires in EE this year should be based on one-for-one replacements. Primary attention should be directed within the Department to recruiting for the CSE division.

However, it is important that we maintain an active recruiting posture by ALL departments by encouraging them to continue to hunt for "superstars" and targets of opportunities. For this reason, all departments should be allowed to advertise formally for positions.

Since we are reaching equilibrium (i.e., addition = attrition) in most departments, we now have the luxury of spending more time on recruiting faculty who can stimulate and "glue" our departments together better (including establishing closer bonds with other units of the University). In particular, we should keep a close eye out at the Deans level for opportunities to recruit candidates of exceptional creativity (i.e., working on the "exponential" part of the knowledge vs. time curve) or cross-disciplinary nature (e.g., applied physics, computational science and engineering).

A&OS: 2

Steady-state target (addition = attrition)
Specific Needs
- Physical oceanographer
- Meteorologist

Aero: 2

Rebuilding mode (addition > attrition)
Specific needs
- CFD type
- Design

Chem: 4

Major rebuilding model (addition > attrition)
Specific authorization
- Two senior faculty (electronics, biotech)
- Two junior faculty

Endowed chairs
- Benton Chair
- GG Brown Junior Chair

Civil: 1 (superstar candidates)

Steady Rebuilding Mode (addition = attrition)
Specific needs: none
Endowed Chairs
- Emmons Chair

EECS - Electrical Engineering: 2

Steady-state mode (to allow assimilation of new faculty)
Specific needs
- Optoelectronics
- Director of SSEL

EECS - Computer Science and Engineering: 4

Aggressive recruiting activity
Specific targets
- All areas and levels

NOTE: Most EECS effort should be directed at CSE this year

IOE: 1 (superstar candidate)

Steady-state mode (addition = attrition)
Specific needs:
- Manufacturing

MME: 2

Major Rebuilding (addition > attrition)
Specific needs
- Director of EMAL

More junior faculty

MEAM: 4

Continued steady rebuilding (addition > attrition)
Specific needs
    Manufacturing (senior faculty)
Endowed Chairs
Modine Chair

NAME: 1 (superstar candidate)

Steady-state mode (addition = attrition)
Specific needs: none
    Nuclear: 1
Steady rebuilding mode (addition = attrition)
Specific needs
    General theorist (fusion)
    Computational scientist

DEAN'S DEPARTMENT (Recruiting from Dean's Office): 6

Computational science and engineering
Applied Optics
Applied Physics
Manufacturing Sciences

TARGETS OF OPPORTUNITY: Usual open "superstar" licenses

TOTALS

Departments: 21
Deans: 6