Interaction of Research and Engineering Education at the University of Illinois at U/C

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ABSTRACT: *As a State University, the task of educating undergraduate and graduate students, (including those who pursue research on the doctoral and post- doctoral level) is supplemented by the obligation to conduct research in support of Industry and to have also a leading role in pure research at the state, national and international level.*

Research Centers have been established to support these activities at all required levels. After identifying named research centers at the University level, special attention is given to those located within, or supporting research and educational efforts, in the Department of Mechanical and Industrial Engineering. These activities can extend across departmental, college of engineering, institutional and national boundaries.

Since the cost of operating research centers generally exceeds the limitation of state funding, financial support through federal grants, industrial sponsors, consulting agreements – and to a large extent through generous endowments by loyal alumni are essential. Indeed, these types of support are also sought by individual staff members on the basis of their personal reputation, without affiliation with named research centers.

The impact of such research activities on the educational programs of the department, including the levels and sources of funding are illustrated by recent examples of scheduled projects. Detailed references to Internet Sites, Publications and Internal Reports are presented.

1 INTRODUCTION

Teaching, Service to Industry, Applied and Pure Research are in the mainstream of an American University. All these function are, however, subject to evolution as shall here be illustrated by the example of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana/Champaign. This presentation reflects the observations of an engineer- myself- who has received his own formal education in Vienna, Austria, but completely unexpected, was invited to an- unknown to him- University in the U.S.A after finishing his doctoral thesis 1947. Consulting an old Encyclopedia, I found a reference to the “small agricultural college in the center of the fertile plains of the Middle West”- end of quote. Living with my family in the Russian Zone of Vienna on the meager daily rations 0f 650 calories opted for my chance.

Indeed, arriving at Urbana, Illinois, I found the University to be larger than expected, met the Dean of the College of Engineering and eventually my Head of Department. He gave me my assignment: “Develop a doctoral program” While the Department of Mechanical Engineering was well known for its teaching program, the only research activity was in the field of heating and ventilating in association with ASHRAE, the American Society of Heating, Refrigeration and Air Conditioning.

During my professional career at the U. of I. starting fall 1948 until my official retirement in 1984, I had the opportunity to take part in the development of formal graduate programs, and the emergence of research on the national and international level.

The main body of the paper thus covers the time span 1948 to present, 2004. It gives an account of a guided evolution under 5 departmental administrations (Heads of department):

(The late) N. A. Parker 1944 – 1962
H. H. Korst 1962 – 1974
B. T. Chao 1974 – 1987
A. L. Addy 1987 - 1998
R. O. Buckius 1998 -

2 INITIAL ASSETS, 1948/1949

The faculty of the Department consisted of 40 Professors (in different ranks) and of a supporting staff of secretaries and mechanics. Budgeted state funding supported all positions.

Traditional undergraduate courses were taught on the basis of selected textbooks.

Of seminal importance was the fact that the formerly obligatory shop course had just been dropped from the curriculum. This left the machine shop and its 8 tenured mechanics available for new assignments. In addition, the University had one of the largest libraries on campus and the college of engineering had a small but up-to- date collection of research reports. Role models existed in research groups in the department of Physics (which just had an influx of scientists -solid state physics- from Los Alamos), the department of Civil Engineering and Electrical Engineering. These departments were ranked nationally. A new activity had just started in developing the ILLIAC, a groundbreaking step towards digital computing.

While I was able to develop test facilities in the wide expanses of an old laboratory with outdated steam engines with the help of my graduate students and the now available instrument makers, my colleague Dr. B.T. Chao who arrived also in 1948 from Birmingham, UK started research in metal cutting in the now available shops while developing graduate courses and research programs in heat transfer/conduction.

3 INITIAL RESEARCH SUPPORT DEVELOPMENT, 1950 -1984

As programs in Fluid Mechanics and Hydraulics already existed in other departments, we emphasized our aims by offering options in GAS DYNAMICS. Learning about the problems in early space programs, my group's efforts concentrated on basic research in rocket propulsion. In the year 1952, I obtained the first AIR FORCE support for our department (initially just about $30000) for studying the base drag and base-heating phenomenon in rocket launches. While not called a CENTER, the department still conducts research on a continuing basis in high velocity flow as the Gas Dynamics Laboratory. In 1983, one year before my official retirement I was presented with a list of students who received their doctor degrees from me or my own students, or their students numbering (then) 270.

4 MILESTONES IN INSTITUTIONAL RESEARCH AND SUPPORT.

The success of our new graduate education activity led to fundamental revisions in the undergraduate curriculum as the newly developed research facilities could now be utilized in hands-on laboratory experimentation.

When I was assigned administrative duties as head of department in 1962, creation of the position of an associative head of department allowed me to continue research with my students. Establishment of the departmental Alumni Association (1967) initiated organized interest of our ALUMNI in the activities and needs- financial as well as guidance. It turned out to be a true gold mine! The first 1 Million-Dollar Endowment arrived in 1972. When word came that a wealthy industrialist in our alumni group intended to give financial support, I hoped to get a new laboratory building. Yet the answer I got was not quite as I had expected: " I want to give my fellow engineers at the University what they need most: CULTURE!" The Center for the Performing Arts on our Campus (the KRANNERT CENTER FOR THE PERFORMING ARTS) (*)[1] Is a beacon of light on the national and international level.

Major developments of research facilities at the University (National Center for Supercomputing, Beckman Institute)(*) level, the college level (Grainger Engineering Library) (*) and the presence of role models (departments of Civil Engineering, Electrical Engineering, Physics) provided stimulating environments for our own department.

Many donors have meanwhile contributed to the growth of our department enabling it to expand our support for faculty, students, research projects and building projects.

Driving to my office, (some day in 1968) the car radio announced that the department of mechanical and industrial engineering at the University of Illinois was now ranked among 10 best in the country. This was just the beginning.

[1] The Mark (*) indicates that detailed information can be obtained from the Internet under www.uiuc.edu and links

5 DEPARTMENTAL RESEARCH DEVELOPMENT BY UTILIZATION OF EXTERNAL FACILITIES, 1953-1987

Prior to the formal establishment of departmental Research Centers, research activities depended mainly on the initiative of individual faculty members. Since theoretical solutions generally have to be backed up by experimental evidence, limited laboratory facilities available in the department may not be adequate. When a major breakthrough has to be verified, cooperation has to be secured from external, better equipped and funded partners. An illustration of how pooling local capabilities with other Universities, and government agencies in the US and abroad succeeded in demonstrating the possibility of predicting interference effects between the aerodynamics of high- speed vehicles (missiles, airplanes) with their propulsive systems (rockets, hot jet exhausts) by modeling with air jets. In this case, a hot Freon 12 facility had to be built to simulate rocket plumes in the transonic and supersonic wind tunnels at the FFA[2] in Bromma, Sweden.

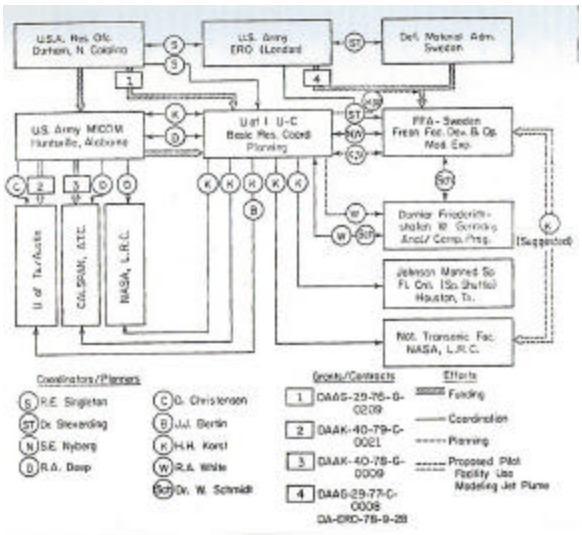


FIG. 1 Organizational Chart, Research Coordination under U.S. Army Grant DAAG-29-76-G-0209

An organizational chart, FIG.1, illustrates the management (planning), funding and support by furnishing applicable test data to achieve verification of the theoretical scheme. While this project was carried out during 1971-1980 it is of interest to note, that presently planned experimentation with the European ESA VEGA vehicle is based on these results (transonic wind tunnel tests in Bromma, Sweden, supersonic wind tunnel experiments at ALR, Netherlands, CFD calculations for Fiat, Italy and general computational support at the University of Illinois.

Consulting contracts with all major aerospace companies in the US provided funding for additional explorations related to missile and airplane aerodynamics and allowed supporting a whole generation of PDH students in the Department of Mechanical Engineering.

Starting 1987 a major remodeling and extension project for the old MELab was initiated and with the help of state funds (7.4 million $) and private donors contributions (3.3 million $) resulting in a total of 12000 M^2 space for laboratories, offices and support space. The dedication of this new and improved MELab was held in April of 2002.

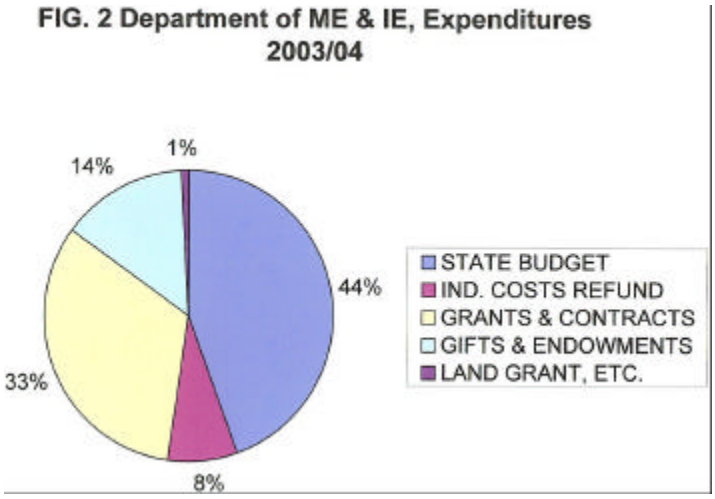
6 PRESENT (2003/04) POSITION OF THE DEPARTMENT OF ME & IE IN ENGINEERING RESEARCH AND EDUCATION.

According to the "poll of peers"[3] the department is now consistently rated among the leading 5 institutions for graduate engineering education in the US. The faculty consists of 46 academic positions (20 professors, 13 associate professors and 13 assistant professors), a supporting staff of 33 academic and non- academic professionals.

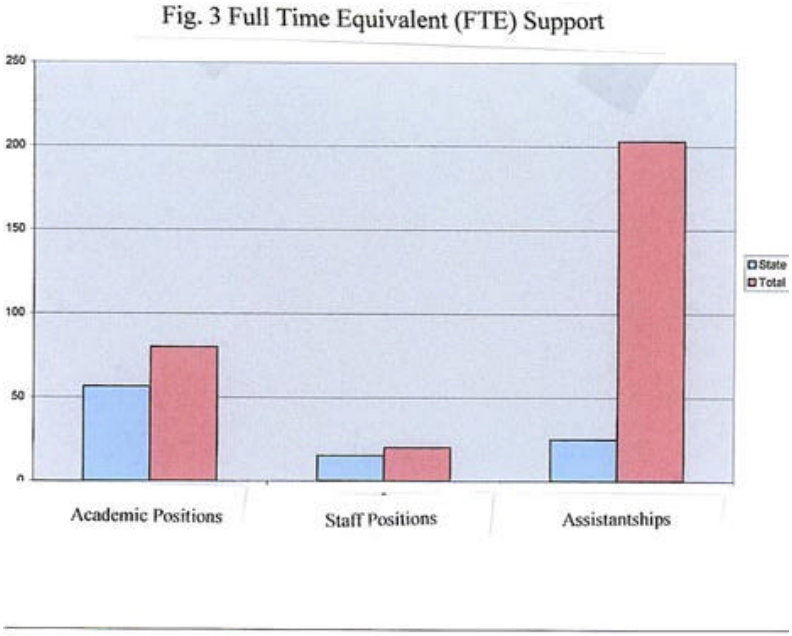
[2] Now part of the Swedish Defense Organization (FOI), FFA Aerodynamics Section, Bromma, Sweden
[3] US News and World report.

A student body of 730 undergraduates and 279 graduate students is resident on the campus. 67 laboratories support teaching and research and 6 chartered Research Centers.

Strict hiring and promotion policies also account for the large number of individual laboratories: Newly hired assistant professors receive a starting package enabling him or her to establish a research program with providing discretionary funds (~$ 150.000) for laboratory equipment, space, summer appointments and graduate assistants. This shall establish a recognized researcher, able to attract outside funding and eventual leading to the qualification for promotion to a tenured (associate professor) position.



The importance of external funding for the present departmental operation is illustrated by FIG.2. Only 45% of its expenditures are covered by the State Budget (total expenditures for the year were 15.5 million $). In particular, FIG.3, below, shows the large number of our graduate students depending on salaried (part-time) assistantships as made available through external support.



7 DEPARTMENTAL RESEARCH CENTERS (**)[4] HAVE BEEN ESTABLISHED IN THE FOLLOWING AREAS:

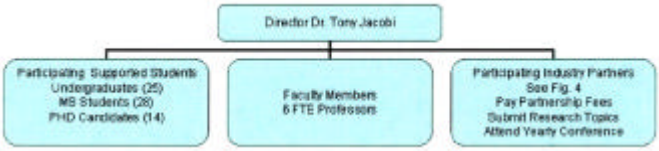
1.) the Center for AIR CONDITIONING and REFRIGERATION (ACRC), formally chartered in 1985[5]
2.) BUILDING SYSTEMS LABORATOY (BLAST),established 1988
3.) Center for Machine Tool Systems Research (CMTSR) including the Ford Laboratory[6],established 1993
4.) Continuous Casting Consortium (CCC), established 1991
5.) Fracture Control Program (FCP), established 1971
6.) Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS) chartered 2002, funded by an NSF GRANT

APPENDIX A

An example for a successful cooperative University/Industry/Educational Research Center is the AIR CONDITIONING AND REFRIGERATION CENTER at the University of Illinois at Urbana/Champaign. The Center came into being more than 18 years ago in response to a government mandate to phase out CFC refrigerants in favor of less polluting materials. The new refrigerants required new designs for refrigeration systems, for air conditioning systems, refrigerators and automotive A/C devices.

FIG. 4 ACRC

est. 1985, Dept. of ME & IE



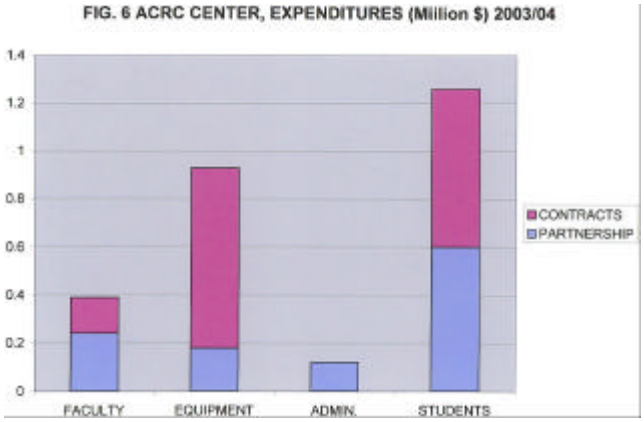
The CENTER, -see organizational chart, FIG.4 - a part of the Department of Mechanical and Industrial Engineering has presently 25 partners, including virtually all the major firms in the industry. The challenge was to get these competitors talk openly with us and with one another about their common problems. From the department's side, we were able to offer the cooperation of a trusted elder statesman, Dr. Will Stoecker, an internationally renowned author [1,2][7] in the field, existing excellence in the pertinent research area (ASHRAE, sponsorship) and an effective legal and persuasive administrative support through the University. Focus had to be on the pre-competitive research areas to alley reluctance within the industry about sharing information. Thus, the industry partners view the University faculty and students as non-threatening because they have no association with the competitive industrial climate in which the companies must operate. From the viewpoint of the University, the Center offers faculty and students insight into real world problems and financial support for their research projects (mainly on the Masters Thesis level). Direct interaction between academia and industry is exemplified by ANNUAL MEETINGS at the CENTER when UIUC faculty members, their students and their industrial partners share past research results, new progress and agree upon the allocation of funds for the coming year. See FIG. 5.

[4] The Mark (**) indicates that detailed information can be obtained from the Internet under www.mie.uiuc.edu and links.
[5] details of its origin, purpose, organization and role in research, service to industry and education are given in Appendix A.
[6] example of utilizing this center, the departmental construction shop and laboratory facilities in its role in the design project for graduating seniors ME 280 is given in [3]and Appendix B.
[7] Numbers in brackets refer to REFERENCES at the end of the paper

FIG. 5 ACRC Industry Partners

- Contributing Partner's Fees
- Submitting Pre-Propriatory Research Topics
- Participate in Annual Planning Conference at Dept. Of ME&IE at Urbana

Funding is shared by the Department (facilities and contributed partial faculty salaries and. assistantships) and the membership fees of the industrial partners. The benefits of the Center income for education are documented in FIG. 6.



Yearly contributions (2003/04) from Industry Partners (1.2 million $) and income from contracts (1.5 million $), totaling 2.7 million $, are shown as they are individually appropriated.

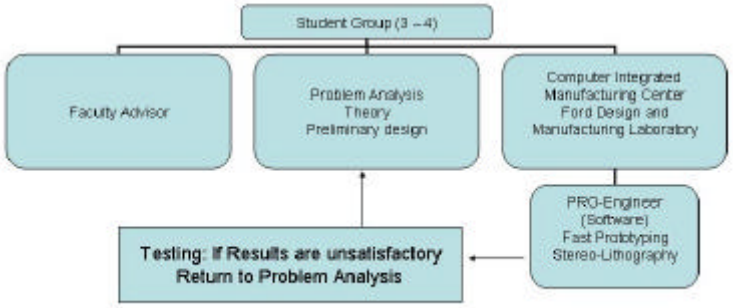
Presently, the Center involves 5 full-time equivalent faculty members (FTE) and about 67 students. Students are participating (and supported) as

i) undergraduate researchers
ii) Masters Degree students (finding their essential financial support and intellectual challenge for thesis research)
iii) PHD candidates finding basic and fundamental problems suited for their research.

APPENDIX B

Presence of Research Centers supports both undergraduate and graduate educational programs. In addition to Departmental Centers, the Grainger Library (*) and the Center for Advanced Computation (*) are available. The example of RESEARCH CENTER/ Educational Program is here illustrated for a case of the design project for undergraduate senior students, ME 280. FIG. 7.

Fig. 7 ME 280 Senior Design Project
Interaction between Research Centers and
Educational Programs (Ref 3)



Groups of students (3 -4) select a meaningful project in cooperation with a selected faculty advisor. An initial examination of available information (Library) and available facilities allows a Theoretical Analysis and leads to a preliminary design. The CENTER for Machine Tool Systems Research (CMTSR) gives the student groups access to its Software and Rapid Prototyping facilities (**). Prototype performance can then be evaluated in an appropriate LABORATORY. In the case of unsatisfactory results, a revised approach of analysis and preliminary design will be taken. The efficiency of the rapid prototyping procedure allows a fast iterative design revision and testing. A detailed presentation of a typical design project carried out by succeeding student groups is given in REF [3]

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[1] W. F. STOECKER, MCGRAW HILL, *Refrigeration and Air-Conditioning.* New York,1958 (English, Spanish and Russian Editions).

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[3] JOHN W. NOWAK, HELMUT H. KORST, TODD M. LEICHT, *Feasibility Study for a Two-Stage Axial Flow Automotive Cooling Pump*. The International Journal of Engineering Education, Vol. 18, Number 1, 2002, Dublin, Ireland

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