Inside this Issue: Special Features on the Engineering Global Leadership Program and the Curriculum Reengineering Project!

Graduate students Yu-li Chou (left) and Albert Sang work the grill at the IOE summer barbecue at Gallup Park.

Alumni Society Merit Award Recipient C. Robert Kidder (left) shares career advice with IOE students Nate Redmond (center) and Dave Benson at this year’s Annual Alumni Weekend Breakfast.
Greetings from the construction zone! If you have visited our World Wide Web page (http://www.engin.umich.edu/dept/ioe/) recently, you know what I mean. The entire campus is undergoing the biggest transformation in its 180 year history. We are right in the middle of it. You can follow our progress through the updated photos of the Lurie Engineering Center and the new IOE space on our Web page.

You can keep up-to-date with many other IOE activities through our home page as well. We currently have links to courses, faculty, students, and other activities on campus. We plan to provide links to alumni home pages and job postings in the near future. Let me know (jibirge@umich.edu) of any other information that you would like us to provide and please visit us often!

The construction photos will also tell you that we are not yet moved into the new space and have yet to begin our retrofitting project in the existing JOE building. The LEC project is now due to complete in Spring 1996 with our renovations commencing at the same time. We are hopeful that if you visit us in Fall 1996, you will see a sparkling new space that will be the envy of the entire nation.

As I did last year, I want to thank you again for making our retrofitting possible. Without alumni support, this project would not be possible. I also thank you for your successes that keep IOE among the top ranked departments in the country. This year, U.S. News and World Report again ranked us third among graduate programs and first in their undergraduate program ratings. The National Research Council survey of graduate programs also placed us third for our effectiveness and fourth for scholarly quality. The Gourman survey continues to rate us first among I.E. graduate programs.

Interest among students continues to grow. Our total student credit hour enrollment increased again by 10% in the last academic year. Placements have also appeared quite strong with the potential for even greater gains in the future. The latest Bureau of Labor Statistics report, for example, placed two traditional IOE careers, operations research and systems analysis, as the only engineering disciplines among the most rapidly growing job areas.

The Department continues to recruit new faculty to help meet our increasing demand. Last year, Stephen Chick (see p. 17) joined us from the University of California at Berkeley while Jan Shi (p. 17) moved across North Campus from his research scientist position in the MEAM Department to an assistant professorship within IOE. We again plan to recruit new faculty this year.

The faculty have been involved in many activities as you will see in this issue. Among the many activities, we are conducting a thorough review of our curriculum as part of a larger College of Engineering effort to ensure that our curriculum is providing our students with the skills and experiences that they need to succeed in their careers and their lives generally in society.

While we set out on this ambitious endeavor, as many of you may know, we are somewhat uncertain about our College and University leadership. President Duderstadt announced his plans to resign as our dean search was entering its final phase. We are now awaiting a clearer picture of the University’s situation before completing the search. I am hopeful and optimistic that this process will bring us inspired leadership continuing into the next century.

-- John R. Birge, IOE Department Chair
The University of Michigan College of Engineering Alumni Society awarded C. Robert Kidder the Industrial and Operations Engineering Alumni Society Merit Award at the College's annual Alumni Society Awards Dinner on October 27, 1995. More than 200 people attended the recognition dinner held in the Michigan League at the University of Michigan.

The Alumni Society Merit Awards were established to honor alumni who personify the College's tradition of excellence and who have achieved significant accomplishments in their professional life. The Award is given to one alumnus from each of the ten academic departments within the College. Recipients are selected by departmental committees whose members are chosen and headed by the department chair.

C. Robert Kidder earned his BSE in industrial engineering from the University of Michigan in 1967 and holds a graduate degree in industrial economics from Iowa State University. He served as an officer in the U. S. Navy Civil Engineer Corps.

Mr. Kidder joined Borden, Inc., as chairman and CEO in January 1995. Prior to his appointment with Borden, he was chairman and CEO of Duracell International, Inc., from 1991 through 1994, heading the firm since being named president in 1984. During Mr. Kidder's tenure, Duracell not only solidified its number one position in the U.S. market for alkaline batteries, but also expanded the brand globally to become the world's leading producer and distributor of alkaline batteries.


Prior to joining Duracell, he was vice president of Planning and Development for Dart Industries in Los Angeles; worked with McKinsey and Company in Chicago, and Ford Motor Company.

Mr. Kidder continues to serve on the Board of Directors of Duracell, and serves on the Boards of General Signal Corporation, Dean Witter Discover & Co., the National Urban League and the Board of Grocery Manufacturers of America, Inc.
Program Updates

Center for Ergonomics

The 40 students, staff and faculty associated with the Center continue to study how materials handling systems, handtools, vehicles, keyboards and other devices used by people can be improved through application of ergonomics principles and methods. In addition, the Center, in cooperation with the Institute of Gerontology has begun several different studies of human aging on human capabilities required while performing manual tasks in industry. The work in the Center is sponsored by Ford, Chrysler, Association of American Railroads, Johns Hopkins University, Sea River Maritime, AMP, Pepsico Food Services, and the National Center for Manufacturing Studies, as well as grants from the Department of Commerce for the State of Michigan, NIOSH and NIH. During the past year, over 1200 practicing engineers, designers, managers and health and safety professionals have attended short courses (2-5 days) to learn about the research in the Center. Please call 313-763-2243 for a brochure describing the Center.

Ergonomics students test equipment for an upcoming research study.

Program in Occupational Safety Engineering and Ergonomics

The IOE graduate program in Occupational Safety Engineering and Ergonomics has received a grant from the National Institute for Occupational Safety and Health (NIOSH) totalling $150,000 for the 1995-96 academic year. This grant is used to support the training of Masters, Ph.D., and post-Doctoral students who plan professional or research careers in Occupational Safety and Ergonomics. In addition, the grant supports library and laboratory facilities in the IOE Building. For additional information on financial aid opportunities, contact Professor Monroe Keyserling.
**Tauber Manufacturing Institute**

This program brings together the strengths of the College of Engineering, Michigan Business School and industry to educate a new manufacturing professional, competent in both engineering and business, and with substantial real industry experience. It coordinates four interdisciplinary degree programs, including the Engineering Global Leadership Program (EGL) housed within IOE. In EGL, honors students take the core of the IOE undergraduate program and add an engineering minor, a business minor, and a cultural core for a region of competitive importance to the US. This includes a foreign language and related history, political science, and other courses. In five to five and a half years they receive a BSEIOE and MSEIOE. TMI also includes a joint MBA with concentration in manufacturing/MSIOE. EGL has grown to 35 students, the joint program to 10, and all TMI to 108 students.

Core to TMI are the summer projects in which teams of MBA, Master of Engineering in Manufacturing and EGL students go on-site for four months to tackle problems important to an industrial sponsor. They have faculty advisors from each the College of Engineering and Michigan Business School. In summer 1995, there were 19 projects including Leybold in France, General Signal, Ford and SPX. The projects saved millions of dollars for the sponsors and gave great experiences to the students.

On the research front, TMI will fund a number of Faculty Fellows. Awards are for pairs of faculty, one each from engineering and business, to develop close relationships with specific companies while doing coordinated research. Professor Jeff Liker was one of the first awardees.

As a multidisciplinary and university-industry cooperative program TMI early on decided to have co-directors representing various perspectives as leaders. The co-directors are Professor James Bean of IOE, Professor Brian Talbot of Business Administration, and Dr. Craig Marks, formerly Vice President of Technology at Allied Signal.

**Program in Manufacturing**

The Program in Manufacturing (PIM) is a multidisciplinary program established by the College of Engineering. Its director is Prof. Galip Ulsoy from the Mechanical Engineering and Applied Mechanics department. Yavuz Bozer from IOE has been serving as Acting Director in 1995. PIM students take a variety of courses from various engineering departments and the business school to earn the Master of Engineering degree in Manufacturing. The curriculum is designed to expose students to all aspects of manufacturing including design, processes, quality, materials, and management. Industrial experience is a requirement for admission. Starting in Fall 1995, PIM is also offering the Doctor of Engineering in Manufacturing degree. Please contact Ms. Henia Kamil at (313) 764-3312 for further details regarding admission and degree requirements.

Grad students Kathy Pryor (left), Vivian Taube (center) and Alfredo Garcia enjoy food and company at the summer barbeque.
Program Update: Japan Technology Management Program

With Jeffrey Liker of IOE as Director, the University of Michigan has received a third renewal of federal funding providing an additional $1.9 million to continue the work of the Japan Technology Management Program for 3 more years. This program was established in 1991 to help American industrial managers learn how the Japanese manage technology and to educate students in Japanese language and culture so they can ultimately do business with the Japanese. JTMP continues to be a cooperative undertaking between the Center for Japanese Studies and Department of Asian Languages and Cultures in Literature, Sciences and Arts, the College of Engineering and the School of Business Administration.

The program’s long-range goal is helping America compete in a global economy. Among the accomplishments of the program to date are the following:

- Research has been conducted on various aspects of technology management in Japan from the conduct of basic R&D, to product development, to manufacturing practices. This has involved 30 faculty researchers and over 20 graduate students, leading this past summer to publication of a major book (Engineered in Japan: Japanese Technology Management Practices, N.Y.: Oxford University Press, 1995).

- Students, particularly engineering students, have been educated in Japanese language and culture and those mastering Japanese have been sent on summer internships to Japan. About 40 students per year at all levels, undergraduate to Ph.D., receive funding to study Japanese at U.M. These students have been selected because they have technical backgrounds and an interest in learning about and working in Japan. About 10 students per year are sent on internships to Japan.

- Short courses for industry have been held every year, some at U.M., some at hotels, and others on-site within companies. The fees participants pay for these programs go back into the budget for JTMP for future years after the government funding runs out. This past year JTMP hired two practitioners with expertise on Japanese manufacturing methods to participate in these outreach efforts. John Shook, who formerly spent 10 years with Toyota, is teaching a course on Japanese manufacturing methods as well as short courses for industry. Mike Rother, who helped create Continuous Improvement User Groups, which bring together small companies to learn continuous improvement methods together right on the shop floor is working with John on the academic course and running user groups through JTMP. Last summer we launched a 2-day “first annual conference on lean manufacturing” which drew over 100 industry participants. The preparations for the second annual conference this coming Spring are shaping up and the program looks very exciting with speakers from Ford, Chrysler, G.M., Freudenberg-NOK and Toyota. Last summer John Shook led a study mission of senior executives to Japan to visit Toyota and associated companies and see lean manufacturing methods in action.

The U-M Japan Technology Management Program was one of four selected for a third renewal this past year. Co-directors of JTMP, in addition to Liker, are John Campbell, professor of political science, Brian Talbot, professor of operations management, and John Shook of IOE. JTMP has developed important connections to the new Tauber Manufacturing Institute also described in this issue and is contributing to growing national leadership of U.M. in manufacturing education.
The several on-going activities in transportation-related education and research include those involving the ITS (Intelligent Transportation Systems) Research Center, the Sloan Trucking Center, and the ITS Education Certificate Program. Also, a committee of College faculty has recently completed a study to define an academic program and research structure for the College in transportation.

The objective of the U.S. Department of Transportation supported ITS Research Center is to stimulate academically-based ITS research, development, evaluation, and deployment. ITS is the application of information, control, and communications technologies to the surface transportation system. The Center is beginning its third year of up to five years of USDOT funding and requires matching funding from industry and state and local governments. The Center is a University-wide activity that currently funds 18 R&D projects and involves the College (IOE, MEAM, EECS, and CEE), the Business School, the Law School, the School of Urban and Regional Planning, UMTRI (the UM's Transportation Research Institute), and LS&A (Economics). The interrelated Rackham ITS Education Certificate Program currently has in the Program or has graduated 65 students in its five year history.

The Alfred P. Sloan Foundation has provided three years of support, beginning this year, to UM in order to establish a center to address important issues associated with the trucking service industry. The transportation service industry represents 17% of the Nation's GDP, 45% of which is generated by the movement of freight and trucking, accounts for approximately 80% of the revenue generated by the movement of freight. The mission of this University-wide, multidisciplinary center is to develop an understanding of the U.S. trucking service industry among faculty and students; to develop and execute an interdisciplinary research agenda and education program; and to collect, assimilate, and disseminate the results of the research. The major goal of the newly created center is to examine the impact of the trucking service industry on the nation's economic competitiveness while also considering safety, congestion, mobility, environmental impact, energy efficiency, regulation, and job creation.

IOE faculty who have participated, or are currently participating, in the ITS Center, Sloan Center, or the ITS Certificate Program include Jim Bean, Izak Duenyas, Jeff Liker, Yili Liu, Katta Murty, Bob Smith, and Chip White.

In light of the importance of transportation to the state and nation and to the growing activities in transportation, the dean of the College late last year appointed a committee of College faculty to define an academic program and research structure in transportation in order to enable the College to attain and maintain a position of strong leadership in transportation. This Committee completed its study this Spring. Distinguishing features of the resulting proposed Program in Transportation Engineering are that the Program is interdisciplinary within the College and not formally associated with any one discipline and that information technology is highlighted. The Committee proposed a Masters of Engineering in Transportation Engineering, which has as its objective to prepare engineers to improve the safety, reduce the environmental impact, and enhance the economic productivity of the transportation system by providing students with advanced skills in their engineering discipline, breadth across engineering and non-engineering disciplines, and applications-based learning experiences. The development of this newly proposed masters was motivated by the need for technical leaders who understand the physical and information infrastructures and the vehicles that comprise the transportation system and their impact on safety, the environment, and the economy. The College is currently in the process of considering the Committee's proposals.

Members of the Committee from IOE were Bob Smith and Chip White.
Engineering Global Leadership Program

One of the most exciting programs new to the College of Engineering is the Engineering Global Leadership (EGL) Honors Program. This five year program, leading to a BSE and MSE in Industrial and Operations Engineering, is the only honors program found within the entire College. Its focus is to attract and train outstanding people, talented both in the classroom and out, to meet industry’s need for an individual capable of leading industrial enterprises to competitive global success.

The unique and exceptional academic program is comprised of extensive engineering, business, and cultural cores. The engineering core consists of basic engineering requirements as well as a technology concentration, comprising a secondary strength in engineering such as manufacturing or economics. Essential management skills of finance, accounting, and marketing are integrated into the business core. The cultural core offers the student an opportunity to gain a deeper understanding of one region of the world considered crucial to the emerging global economy. Some regions currently being studied include the European Economic Community, China, Japan, and Latin America.

The EGL Honors Program is one of four degree programs associated with the Joel D. Tauber Manufacturing Institute (TMI). In addition to the EGL honors degree, TMI also supports a Master of Engineering in Manufacturing, an MBA with Manufacturing Concentration, and a joint MBA/MSEIOE. The Institute is the result of a unique and progressive partnership between the College of Engineering, School of Business Administration, and an Industrial Advisory Board comprised of over thirty corporations. Its mission is to produce leaders with the necessary skills to successfully integrate business and engineering perspectives and lead America’s manufacturing industry into the future. Co-directors James Bean, Professor of Industrial and Operations Engineering, Brian Talbot, Professor of Operations Management at the Business School, and Craig Marks, a Visiting Professor of both schools with significant experience in industry, signify the three way partnership that forms the basis for the Tauber Manufacturing Institute.

TMI has been able to leverage the capabilities of both an engineering college and business school consistently ranked in the top ten in the country along with an integral partnership with American industry to firmly establish itself as a cutting-edge program. In doing so, it is producing the hybrid managers companies need today: individuals well-versed in multidisciplinary skills and world-class manufacturing principles and practices.

One of the unique experiences available to EGL students is the interaction across other disciplines and programs not only in primary classes but through the TMI. This cross-functional focus offers several venues for interaction through specialized TMI courses. All TMI students participate in a weekly seminar jointly taught by faculty and industry experts. The seminar exposes students to current trends through speakers, tours, and case studies via live video conferences. In addition, EGL students may elect courses designed especially for TMI students. One such course, New Product Development, pairs teams of students who compete in the actual designing, costing, prototyping, and marketing (in a trade show) of a specific product. Students also have the option of attending common knowledge workshops focused on fundamental concepts such as ABC (activity based cost) accounting and lean manufacturing.
The cornerstone of the program, and a unique experience open only to TMI students, is the summer team project. Designed to complement classroom learning, the project brings together a team of usually two or three students from different disciplines as well as a faculty advisor from both the College of Engineering and School of Business, to solve a substantive manufacturing challenge. Projects range from high-level strategic analyses and positioning, to detailed plant layout and work flow issues for a specific product line. A few of the projects current EGL students participated in this past summer are detailed below.

LEYBOLD AG
Valence, France

TMI student team:
Frank Fontana – EGL, BSE & MSE 1995

Signifying the opportunity available for some EGL students, Frank lived and worked overseas at a plant that produces industrial vacuum pumps. While there, he was responsible for doubling production capacity for the largest of three production lines. Subobjectives of the project included developing a visual Kanban system, reducing material flow and handling, and making the processes ergonomically correct for the workers.

To double production capacity, line balancing concepts were employed. Significant efficiencies resulted from recognizing and eliminating the four stations that provided some sort of bottleneck. A visual Kanban system was installed that ensured all employees knew how to make it work. The simple approach, using no cards, was much easier for everyone to understand, whether they spoke French or English. This visual Kanban redirected material flow directly from the machine shop to assembly, avoiding long rides to and from an inventory storage area. Annual material flow was reduced from 183 km/year to 50 km/year. Ergonomically correct lifting quantities were also computed for the heavy vacuum pumps upon which a new staging system was based.

Adding to the international flair of the project, all work was conducted in French. Frank developed a technical dictionary to deal with these difficult words. He felt that speaking French fluently undoubtedly helped the people to respect him. The French were patient and eager to teach Frank about the language and culture as well as the business. A plus for this project was the opportunity to travel around France and even into Italy and Switzerland. Such international experience shows the ability of the EGL students to adapt and perform.
EATON CORPORATION
Milwaukee, Wisconsin

TMI student team:
Brad Briggs – EGL, BSE & MSE 1995
Cameron Hykes – EGL, BSE & MSE 1996
Sang Kim – MBA with Manufacturing Concentration 1996

The Eaton team also demonstrated the ability to adapt. When selected, the team anticipated spending the summer working on the manufacturing development of an electric vehicle contactor. Preparation during the spring consisted of getting familiar with the electric vehicle market, legislative atmosphere, and advanced component technologies. Unfortunately, the team learned on the first day of work that the electric vehicle contactor project had been delayed due to volatility in the market. Management’s decision to postpone the project forced the TMI team to be adaptable amid changing expectations.

The revised project maintained similar deliverables and consisted of two focuses:

   a) Introduce Continuous Flow Manufacturing Principles to improve operations within an assembly cell of the Land Transportation Products Division of Eaton. This primarily involved managing the industrialization associated with a crash program. Activities included setting up the manufacturing cell, creating a quality plan, resolving sourcing issues, and finalizing the design of a key new product.

   b) Identify potential markets in which to leverage the newly developed electric vehicle contactor technology.

The TMI team accomplished both objectives by meeting production deadlines, improving productivity, cutting costs, and presenting recommendations from an in-depth marketing study. The summer as a whole gave the students valuable experience in a fast-paced manufacturing environment and provided Eaton with a unique set of resources that were able to quickly come up to speed and add significant value in a limited time frame.

GENERAL ELECTRIC LIGHTING
Cleveland, Ohio

TMI student team:
Nathan Redmond – EGL, BSE & MSE 1997
Peter Hyman – MBA with Manufacturing Concentration 1996

This two student team was brought in to analyze and evaluate the financial, technical, human resources, environmental, and market impact of a proposed international relocation of manufacturing capacity. Handed significant responsibility from the beginning, the team was responsible for the actual project management, not just reporting data, and for driving the project to completion. Initial research was conducted in Cleveland, as the team quickly moved up the learning curve and gained
an understanding of the associated product line. They conducted market research and evaluated labor costs, manufacturing and technical capabilities, sourcing, and transfer pricing for the United States, United Kingdom, and Hungary.

Once the proposed direction of relocation had been decided upon, the team developed comprehensive production and relocation cost models based upon on-site interviews with plant and corporate personnel located in the US and UK. Over half of the time was spent away from Cleveland, at one of the two plants, building actual and proposed production costs. The project culminated in presenting the analysis, recommendations, and an implementation timeline to the division vice presidents. With a project NPV in excess of $4,000,000, the recommendations are now being implemented by GE.

Rarely is a summer team handed a project with such a full business perspective. While the project was partly comprised of gathering information, it also presented the problem for analysis from an upper management perspective. In addition, participating in the globalization of GE Lighting gave the team valuable experience with such international business issues as transfer pricing and sourcing. GE was impressed with the quality of the work, and undoubtedly gleaned value from the partnership.

These examples show why the team project is considered so crucial. The EGL Honors students have the opportunity to develop and utilize an integrated multidisciplinary skill set: engineering and business with an international flair. Upon returning to campus in the fall, the teams relate their findings in formal presentations to corporate representatives, faculty members, and the press at the Team Project Spotlight. Student teams gain tremendous exposure and networking opportunities, and compete for awards based on quality of project approach and execution, use of both business and engineering analysis tools, teamwork, and leadership. As an example of both the skills and ability of the EGL honors students, they received four of this year’s six awards, selected by members of the Industrial Advisory Board.

The Engineering Global Leadership Honors Program is turning out a new breed of business leaders — talented, skilled in the verse of both engineering and business, and comfortable interacting in an international arena. The program draws its merit not only from design, but from an unequalled base of resources offered by both a top notch Industrial and Operations Engineering Department and Business School brought together under the umbrella of the Tauber Manufacturing Institute. There is no doubt that once again this cutting edge program has other schools scrambling to compete with “the Leaders and Best”.

If you would like additional information about either the EGL Honors Program or the Tauber Manufacturing Institute, please contact the following:

Pam Linderman, EGL Program Administrator                   Tel: 313/ 764-3297
Marika Jones, TMI Managing Director                           313/ 998-8163
Tami Harnish, TMI Team Project & Recruitment Manager        313/ 998-8162

-- Nathan Redmond, EGL (BSE & MSE 1997)
an understanding of the associated product line. They conducted market research and evaluated labor costs, manufacturing and technical capabilities, sourcing, and transfer pricing for the United States, United Kingdom, and Hungary.

Once the proposed direction of relocation had been decided upon, the team developed comprehensive production and relocation cost models based upon on-site interviews with plant and corporate personnel located in the US and UK. Over half of the time was spent away from Cleveland, at one of the two plants, building actual and proposed production costs. The project culminated in presenting the analysis, recommendations, and an implementation timeline to the division vice presidents. With a project NPV in excess of $4,000,000, the recommendations are now being implemented by GE.

Rarely is a summer team handed a project with such a full business perspective. While the project was partly comprised of gathering information, it also presented the problem for analysis from an upper management perspective. In addition, participating in the globalization of GE Lighting gave the team valuable experience with such international business issues as transfer pricing and sourcing. GE was impressed with the quality of the work, and undoubtedly gleaned value from the partnership.

These examples show why the team project is considered so crucial. The EGL Honors students have the opportunity to develop and utilize an integrated multidisciplinary skill set: engineering and business with an international flair. Upon returning to campus in the fall, the teams relate their findings in formal presentations to corporate representatives, faculty members, and the press at the Team Project Spotlight. Student teams gain tremendous exposure and networking opportunities, and compete for awards based on quality of project approach and execution, use of both business and engineering analysis tools, teamwork, and leadership. As an example of both the skills and ability of the EGL honors students, they received four of this year’s six awards, selected by members of the Industrial Advisory Board.

The Engineering Global Leadership Honors Program is turning out a new breed of business leaders – talented, skilled in the verse of both engineering and business, and comfortable interacting in an international arena. The program draws its merit not only from design, but from an unequaled base of resources offered by both a top notch Industrial and Operations Engineering Department and Business School brought together under the umbrella of the Tauber Manufacturing Institute. There is no doubt that once again this cutting edge program has other schools scrambling to compete with “the Leaders and Best”.

If you would like additional information about either the EGL Honors Program or the Tauber Manufacturing Institute, please contact the following:

Pam Linderman, EGL Program Administrator  Tel: 313/764-3297
Marika Jones, TMI Managing Director  313/998-8163
Tami Harnish, TMI Team Project & Recruitment Manager  313/998-8162

-- Nathan Redmond, EGL (BSE & MSE 1997)
Curriculum Reengineering Project

From our last alumni survey and other observations throughout industry, we have found that IOE careers are changing rapidly with increased emphasis on information systems, new opportunities in logistical support, wide dissemination of change methods through corporate reorganizations, and team programs incorporating multiple cultures, countries, functions, and disciplines. The IOE Department and College of Engineering have begun the process of reengineering our curriculum to meet those needs.

At the college level, this effort has focused on the first two years of study and the common core. Among the changes under consideration are reductions in the number of courses with increased credit for each individual course, integration of engineering topics into the basic science and mathematics courses, and earlier departmental introductions.

At the Department level, we have begun with a group from the IOE Alumni Academy to identify career paths and core abilities that IOE graduates should have. The Alumni Academy has developed teams to analyze skills in five different areas:

i) manufacturing and operation skills;
ii) public skills;
iii) individual skills;
iv) basic skills;
v) group dynamics.

These teams are starting to identify specific capabilities in each area and how those skills might fit into a curriculum.

From the faculty side, the department first performed an exercise to determine relative values of various skills. The results of this exercise appear in the figure to the right.

To form this figure, the entire faculty moved skills up to indicate higher priority and down for lower priority. The result is a rough approximation of the faculty’s perception of core skills and their relative values from highest priority at the top to lowest at the bottom. The IOE Curriculum Committee has at the same time identified the skill goals for each class in our current curriculum. Our task now is to integrate these efforts.

We would like your input as well. Please feel free to send us comments (via email to jrbirge@umich.edu) on your thoughts on an ideal IOE curriculum and the capabilities that it should give students. You can help us construct a curriculum to give students the best opportunities for their life after graduation.
### Higher Priority

<table>
<thead>
<tr>
<th>Skill Area</th>
<th>Priority 1</th>
<th>Priority 2</th>
<th>Priority 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental mathematical modeling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State ideas in writing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer literacy (comfortable/able to learn)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design and build something</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand manufacturing systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyze data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able to simulate real systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General problem solving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement methods in IE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand ergonomics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time management skill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering graphics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able to collect data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign language</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial engineering - quantifying risk/time value of $</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able to sell ideas and solutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics / circuits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounting - tax</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work in teams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense of playfulness / enjoyment of work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Political skill in a workplace</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor relations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesthetics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tolerance - cultural awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job hunting skill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Priority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IOE Student Organizations

Note: The student groups are always interested in having alums return to campus and present a short luncheon topic about their company or current topic in the area. Any alumni wishing to contact the student organizations may do so through Jolene Glaspie at (313) 763-1332.

Alpha Pi Mu

The University of Michigan chapter of Alpha Pi Mu, the National Industrial Engineering Honor Society, is looking forward to another exciting year for its members and initiates. We welcome IOE faculty member Tava Olsen as our new faculty advisor, and look forward to working with her to promote further student, faculty, and staff interaction within the department. One of the primary goals of Alpha Pi Mu’s executive committee this year is to increase the Industrial and Operations Engineering program’s presence within the College of Engineering. Just recently, our society participated in Tech Day, a program sponsored by the College of Engineering to allow high school and first and second year college students’ to learn more about the various engineering disciplines and the College of Engineering in general. We were fortunate to have the opportunity to speak with many prospective IOE students and tell them more about the exciting opportunities our program has to offer. Students were invited to participate in an assembly process re-engineering activity, in which they were asked to improve the efficiency of a process for assembling a Halloween “goodie” package of candy.

We are also committed to helping IOE students in their search for job opportunities. Many members of Alpha Pi Mu recently helped at the annual Engineering Career Fair, where over 80 companies spent a day on North Campus presenting information to engineering students. Alpha Pi Mu and the student chapter of the Institute of Industrial Engineers recently sponsored a luncheon with Intel Corporation, in which representatives of Intel were on hand to describe the many opportunities available to IOE students and graduates at Intel. Alpha Pi Mu’s Career Development committee is hard at work inviting other companies to come to U of M to speak personally with IOE students. We are also assembling a resume book of Alpha Pi Mu members to distribute to companies interested in hiring IOE’s.

The Tutoring and Mentorship committee is busy working on providing IOE students with help in 300-level courses. The committee is also helping first and second year university students and those new to the IOE program feel comfortable with their new experiences. The Blueprint committee has many new and exciting ideas planned for the IOE monthly newsletter, “The Industrial Blueprint,” and the Fundraising committee is developing new ideas to raise funds to help support many of the activities in which Alpha Pi Mu is involved.

We are also committed to serving our community. The Special Events committee has already planned for Alpha Pi Mu to once again participate in a special day of community service known as “Into the Streets.” Our society will spend a day in the Ann Arbor community working on volunteer projects and activities to help the environment, help the community’s youth, and combat hunger and homelessness.

Of course, Alpha Pi Mu is also concerned with providing members and IOE students with opportunities for further social interaction outside the classroom, and the Social committee has some great activities planned for this year, including a road rally, football game tailgate parties, and ski trips.

Other events we have planned for this year include “IOE Options Night,” in which seniors and IOE graduate students give advice to younger students on the many 400-level IOE classes that are offered. We will also be working with other student societies within the College of Engineering on various community service projects. Alpha Pi Mu will provide IOE students with the opportunity to make suggestions for improving IOE courses through a faculty feedback program, and we’ll be asking students for their help in selecting a professor and teaching assistant of the year. Initiate induction will be held in April, and the officers are already working on making the ceremony and banquet an exciting conclusion to the year.

We welcome with open arms the opportunity to work with IOE alumni in achieving the goals we have set for our society, and we are always looking for alumni to come back to campus to speak with current students and share their experiences as a Michigan IOE graduate. If you are interested in doing this, or have any suggestions for other activities, please do not hesitate to contact us. We look forward to hearing from you.

-- Sean Burke, APM President
Institute of Industrial Engineers

The student chapter of the Institute of Industrial Engineers is in the middle of a busy school year. The primary goals of this year's officers have been to increase IOE student participation in IIE, and to facilitate student, faculty and staff interaction outside of the classroom.

This year's activities began with a mass meeting, to let students know about the many opportunities available through IIE. The annual IOE Student-Faculty-Staff Barbeque was also held in September. The attendance at the barbeque was so phenomenal that additional food had to be purchased on a "Just-In-Time" basis! Another popular activity this year has been the Alpha Pi Mu/IIE Happy Hours held one Friday each month at local establishments. In November, IIE jointly worked with Alpha Pi MU to present the IOE Options Night, in which faculty and seniors of IOE gave invaluable information about the different courses in IOE. Another ongoing activity has been the monthly publication of the Industrial Blueprint, the IOE student Newsletter. Additionally, the preparation for the annual IOE Yearbook, which will be published in the spring, is well underway.

On the "professional" side of IIE activities, we were pleased to have Boyd Baughman and the Detroit Senior Chapter members join us for a meeting in November. During the meeting, Mr. Baughman presented The Job Market Today. In addition, we had luncheons with Intel semiconductor, Andersen Consulting Group and EDS. These luncheons and meetings were very popular and educational, and we hope to have many more this year. If you are interested in coming to speak about your experiences, or in giving a tour of your workplace, please contact us by mailing to the IOE main office or send us an e-mail at IIE.officers@umich.edu. There is a great deal of student interest in the variety of careers available with an industrial engineering degree, and we would love to hear what you have done with yours. If you have World Wide Web access, please do not hesitate to check out our web site at http://www.engin.umich.edu/soc/iie/.

-- Kwok Poon, IIE Publicity Chair

Undergraduate students participate in Alpha Pi Mu sponsored tutoring.

Alpha Pi Mu officer Kellie Ralph recruits a prospective IOE student at Tech Day.
Introducing... New Faculty

Tava Lennon Olsen

Tava Olsen joined the University of Michigan as Assistant Professor in Industrial and Operations Engineering in September 1994. Professor Olsen received her B.Sc. (honours) in Mathematics in 1989 from the University of Auckland, New Zealand. She then received both her M.S. in Statistics in 1992 and her Ph.D. in Operations Research in September 1994 from Stanford University.

Professor Olsen teaches courses in simulation and stochastic processes. Her research interests include the stochastic modeling of manufacturing systems, queueing systems and applied probability. Her current research activities focus on the scheduling and analysis of multi-class queueing models with significant set-up times. She is particularly interested in studying systems that arise from within actual manufacturing companies.

Professor Olsen was married on December 30, 1995. With her recent change from her maiden name of Lennon, she hopes she hasn’t caused too much confusion among her friends and colleagues. The IOE department wishes Professor Olsen and her husband, Tim, well in their marriage.

Rachel Zhang

Rachel Zhang joined the University of Michigan as Assistant Professor in Industrial and Operations Engineering last fall. Dr. Zhang received her B.S. in Applied Mathematics from Zhengzhou Institute of Technology, People's Republic of China and her Ph.D. in Industrial Engineering from Northwestern University. She had taught mathematics for five years before starting graduate school.

Professor Zhang teaches courses in Operations Management and Production and Inventory Control. Her research interests lie in the application of optimization methods and stochastic analysis to manufacturing and inventory control systems. Her recent research activities include developing easily implementable policies for multi-echelon spare parts inventory systems, which is funded by NSF CAREER Program, and scheduling in manufacturing systems. She supervises student projects with Chrysler and Ford, and serves as a consultant for Bell & Howell Company and Cummins Engine Company.
Introducing ... New Faculty

Stephen Chick

Stephen Chick has joined the University of Michigan as Assistant Professor in Industrial and Operations Engineering. Prof. Chick received his B.S. in Mathematics from Stanford University. He received his M.S. and Ph.D. from U.C. Berkeley's department of Industrial Engineering and Operations Research. He has five years of experience in the manufacturing and software development industries, including work based in Detroit analyzing materials handling systems for the automotive industry using simulation.

Professor Chick teaches courses in simulation, information systems, and reliability. His research interests lie in engineering statistics, particularly in probabilistic design, decision support systems, stochastic optimization and reliability. His work has been applied to many areas, including manufacturing process design, intelligent manufacturing, digital communication, flood-defense design, and biostatistics.

Jianjun (Jan) Shi

Jianjun (Jan) Shi is an assistant professor in the Department of industrial and Operations Engineering at the University of Michigan. He received his B.S. and M.S. in Electrical Engineering at Beijing Institute of Technology in 1984 and 1987 respectively, and received his Ph.D. in Mechanical Engineering at the University of Michigan in 1992. Before he joined the IOE Department, he was an Assistant Research Scientist in the MEAM Department at U of M for three years.

Professor Shi currently teaches courses in statistical quality control (IOE 466) and time series analysis, forecasting, and control (IOE 565). His research interests are the fusion of advanced statistics and engineering knowledge to develop in-process quality improvement (IPQI) methodologies achieving automatic process monitoring, diagnosis, and compensation, and their implementation in various automotive manufacturing processes. He is one of the first researchers to contribute to the field and has produced two Ph.D. graduates. Currently, he is supervising five Ph.D. students and three M.S. students working on the IPQI research. His current research is being sponsored by General Motors Corp., Chrysler Corp., Auto Body Consortium, National Institute Standard and Technology - Advanced Technology Program, and the National Science Foundation. He also serves as the associate director of the S. M. Wu Manufacturing Research Center, Assistant Director of National Science Foundation Industrial/University Cooperative Research Center at the University of Michigan, and Program Technical Director at Auto Body Consortium. He is a member of ASME, ASQC, IIE, and SME.
Faculty Focus

James Bean continues to work with joint engineering-business education and research in the area of manufacturing. He was recently named Ford Motor Co. Co-Director of the Joel D. Tauber Manufacturing Institute (formerly Michigan Joint Manufacturing Initiative). He is also advisor to the Engineering Global Leadership Honors Program. His research focuses on application of artificial intelligence approaches to large-scale Markov decision processes with applications in manufacturing and transportation. He has funding from NSF, the Sloan Foundation and the Great Lakes Center for Truck and Transit Research. Professor Bean is Vice-President for Information Technology of the Institute for Operations Research and the Management Sciences (formerly ORSA and TIMS).

John Birge continues his work on global emissions, power systems, capacity evaluation, scheduling, and general methodology with support from the National Science Foundation, Electric Power Research Institute and Ford Motor Company. (Working papers on all topics are available on his web page: http://www-personal.engin.umich.edu/~jrbirge.) During the past year, his computational group has found optimal solutions to problems with literally billions of variables for dispatching trucks for a less-than-truckload carrier. He has also begun to develop an interdisciplinary financial engineering program at the University with faculty from Business, Economics, Mathematics, Physics and the College of Engineering.

Don B. Chaffin, the Johnson Professor, was honored by two awards during the year. He was elected a Lifetime Fellow of the Ergonomics Society (Great Britain) and received an Outstanding Alumni Award from GMI. His research continues to focus on modeling human motions and exertions for use in Computer Aided Design of manual workplaces and vehicle interiors.

Jeffrey Liker continues as Director of the Japan Technology Management (JTM) program which has been renewed for another 3 years (see article in this issue). His articles on Japanese product development and supplier relations have appeared in the past year in the Harvard Business Review and Sloan Management Review and others were accepted for publication in IEEE Transactions on Engineering Management and Research Policy. The book he and others edited based on JTM research came out last summer and is entitled: Engineered in Japan: Japanese Technology Management Practices, N.Y.: Oxford University Press, 1995. He has also been working with Chelsea White on the Sloan trucking grant studying the impact of Just-in-Time manufacturing systems on trucking in the U.S. and Japan.

Gary Herrin returned from his third sabbatical with material for a new graduate level course in “Advances in Quality Control”. He also has resumed his third tour of duty as the IOE Department’s Undergraduate Program Advisor. He recently completed the first offering of a new multi-media course entitled “Statistical Methods in Manufacturing” developed with NSF support for Focus Hope and the Greenfield Coalition for a New Manufacturing Education. This multi-university, multi-corporation coalition offers inner city youth opportunities to learn advanced manufacturing engineering skills via a six-year “whole cloth” curriculum integrating hands-on manufacturing with interdisciplinary engineering education within the Center for Advanced Technologies in Detroit, Michigan. In addition, he will be delivering his popular course IOE 466: “Statistical Quality Control” via the Engineering TV Network next fall as part of the department’s new “Quality Engineering” masters degree program beginning September 1996. The curriculum is offered in the late afternoons to permit practicing engineers in the area to pursue advanced degrees at Michigan while working full-time.

Yili Liu continues research in the area of cognitive ergonomics. In addition to publishing several research articles in the best journals in his field, he has also completed the development of a software program that integrates a computer-aided design software with an ergonomics analysis software. He is also working with his Ph.D. students in the area of intelligent transportation systems (ITS), with a focus on modeling and aiding highway traffic operators. He received the Outstanding Teaching Award this year awarded by Alpha Pi Mu.

Monroe Keyserling assumed the Directorship of the University of Michigan Center for Occupational Health and Safety Engineering in July. This interdisciplinary center includes programs in Occupational Medicine, Industrial Hygiene, and Occupational Health Nursing in addition to the Safety Engineering and Ergonomics program within the IOE Department. In April, Keyserling was a keynote speaker at the International Conference on Ergonomics in Occupational Safety and Health in Taipei, Taiwan. While in Taiwan, he also presented seminars at National Tsing Hua University
Special Honors

The IOE Department is proud to announce the following awardees for 1995.

Outstanding Teaching Award
Yili Liu

Teaching Assistant of the Year
Scott Grasman

Wyeth Allen Award
Tammy M. Rice

Outstanding Undergraduate Student
Brian C. Contat

Outstanding Graduate Student
Bryan A. Norman

In addition, we would like to honor the 1994 awardees (whose names were mistakenly omitted from last year’s newsletter).

Outstanding Teaching Award
Gary D. Herrin

Teaching Assistant of the Year
Anjali Kapur

Wyeth Allen Award
Thomas J. Hemr

Outstanding Undergraduate Student
Calisa L. Tucker

Outstanding Graduate Student
Raj K. Kawira

Congratulations to them all!

Charitable Contributions

We thank you for your pledge of support in making our retrofitting project possible. If you have already met you pledge commitment, we thank you again. If you have not already done so, then please remember to fulfill your commitment this year so our plans can proceed.

We have other needs such as student fellowship and scholarship support and equipment to allow students and faculty to make the most from their studies. Remember that you may take full-market value deductibility for appreciated assets, designate “I.O.E.” or “Industrial and Operations Engineering” on the donation form under “Other” designation, and that many corporations offer matching funds.

... daily challenges on North Campus.
and the National Institute for Occupational Safety and Health.

Keyserling has recently initiated a study of ergonomic and safety issues in distribution centers and trucking operations. Sponsored by PepsiCo Food Services, the goal of this project is to reduce musculoskeletal injuries and disorders while enhancing productivity in warehousing and delivery operations. Co-investigators include Profs. Yavuz Bozer and Don Chaffin, and Ph.D. student Kimberly Monroe.

Keyserling continues to serve as the IOE Graduate Program Advisor. He also serves as a member of the American Trucking Foundation's Medical Advisory Board.

Katta Murty is on sabbatical leave during the 1995-96 academic year. One of several places he is visiting is Hong Kong University of Science and Technology. Before going to Hong Kong, he served as an advisor to the US Army on an optimal plan for stationing mobile combat simulators called M-CCTT, and developing routes for them to provide training to the National Guard and Army Reserves scattered all over the country.

Romesh Saigal has authored a new book, Linear Programming: A modern integrated analysis, published by Kluwer Academic Publishers of Norwell, Massachusetts. This book presents the new methodology developed since the publication of Karmarkar's pathbreaking paper in 1984, and the earlier methodology in a unified and integrated manner. In addition, he has developed (with N. Choi) a game theoretic model to understand the behavior of the players in an internal audit situation. This is then used to develop a risk assessment and planning strategy. Professor Saigal continues research on developing new methods for linear programming and its extensions under a grant from NSF.

Bob Smith is serving this year on SACUA (Senate Assembly Committee on University Affairs) which is the Executive Committee of the faculty Senate Assembly. He continues as Director of the Dynamic Systems Optimization Laboratory, exploring the problems of optimal decision making over time. He is project director of an NSF grant in infinite horizon optimization and a contract from UM's Intelligent Transportation Systems Center in the area of Traffic Modeling for Dynamic Route Guidance. Three of his recent Ph.D. students have taken positions as OR analyst at American Airlines, a senior underwriter at Plymouth Rock Assurance Corporation, and an Assistant Professor at the University of San Andreas in Columbia.

Chelsea C. White, III’s current professional involvement is primarily focused on transportation and includes Director of the ITS Research Center, Co-Director of the Sloan Trucking Center, Chair of the Rackham Transportation Studies Program Committee, member of the Board of Directors of the ITS World Congress, member of the Board of Directors of ITS Michigan, Chair of the IEEE Institute-wide ITS Committee, Convener of the ISO TC 204 working group on common carriers, Chair of the College Committee on Transportation Engineering, and Editor-in-Chief of the ITS Journal. His current research includes applications of Markov decision processes and heuristic search to various types of vehicle routing.

Graduate student April Luehmann (left) chats with faculty members Don Chaffin (center) and Izak Duenyas at a recent student-faculty mixer.
Alumni Updates

This news is from alumni responses to the Fall 1994 newsletter.

Amir Walidraif Abillania joined Project Advisors Consortium, Ltd of Ann Arbor. At PAC, Amir is doing management consulting work for Ford Motor Company, Powertrain Division.

Michael C. Gladden (BSE '79, MS '91 -Industrial Hygiene) is working for Toyota Motor Manufacturing in Georgetown, KY. As a Safety Specialist, he is responsible for managing an ergonomics program for a 6000+ member manufacturing workforce.

Stephanie Brett Hanks-Tingley (BSE '87, MSE '91, MBA '91) is working at Drever Partners, Inc., as a Acquisitions Associate. She performs financial analysis on potential acquisitions, manages due diligence process, and conducts market research on cities in which Drever owns properties.

Robert E. Heiberger (BSE '59) is working as a treasurer at Evanson Bond and Mortgage Co. in Illinois. He is responsible for real estate property management and development.

Michael Hoekstra (BSE '88, MSE '89) is working at GKN Automotive, Inc., in Roxboro, NC, as an Area Supervisor. He is responsible for managing 3 assembly lines which produce driveshafts for automobiles.

Dawn M. Hogh (BA '84, MS '85) is serving as Director of Offer Management for AT&T in California. Dawn has profit and loss responsibilities for sales of equipment to Pacific Bell, US West and SBC, Inc. She manages a R&D portfolio for transmission and ATM, Frame Relay, SMDS equipment.

Yung-Kuei Kan (MSE '85) is manager of the Automation Management Department for Philips Taiwan.

Rick Karlowski (BSE '82) is working at Saturn Corp. as a Senior Reliability Engineer. He is responsible for reliability estimation/prediction, development of validation test plans, and review of designs for reliability considerations.

Glenn LeMieux (BSE '93) is a Sales Engineer at Benteler Industries, Inc. There, Glenn’s responsibilities include quoting new products and changes to existing products, customer interfacing, and coordinating activities between engineering and sales.

Rob Lepler (MSE '95) is currently working at Ford Motor Company’s Wixom Assembly Plant.

Andrew Masterman (BA '89 - Colorado College, MBA, MA, MSE '93) joined Walbro Corporation as President of Walbro Japan Inc., a subsidiary responsible for the manufacture, distribution and sales of Walbro small engine products in Japan. Andrew looks forward to hearing from alumni as they travel through Tokyo.

Teddy M. Mertyris (BS '94 - Cornell, MSE '95) is currently working for Andersen Consulting in New Jersey as an Analyst.

Mark Murphy (BSE '87, MSE '88) is employed at Ford Motor Company, Powertrain Division as a Product Engineer.

Professor Richard L. Patterson (BS '54 - Forestry, MS '59 -Math, Ph.D. '63) is beginning retirement furlough in January 1996 after 34 years of college teaching at the University of Florida and the UM. As professor at the UM’s School of Natural Resources, Richard taught ecosystem modelling.

Richard Slayton (BSE '60, MBA '65) is President of Slayton International, Inc. Richard oversees Chicago’s 12th largest executive search consulting firm. He was selected for the third time as one of the countries top executive search consultants in the book The Career Makers.

Kevin R. Stout (BSE '80, MBA '83 - U of Houston) is a partner at Ernst and Young in Pennsylvania.

Recent Ph.D. graduates David Nembhard, Harriet Black-Nembhard, and Russell Meller are faculty members at Auburn University in Industrial Engineering and the School of Business.
North Campus Construction

The Integrated Technology Instruction Center (ITIC) is approaching completion, while the Lurie Bell Tower (right) just begins construction, as seen in this photo taken from the north.

As seen from the west, the new Lurie Engineering Center will house the College of Engineering administrative offices and provide additional space for the IOE Department.