Academic and Professional Resources for Student-Led Technology Ventures

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Abstract

Student researchers face daunting challenges when attempting to commercialize technology that they have developed. Engineering students typically lack an overall understanding of the commercialization process associated with academic research. Furthermore, the resources required span several disciplines including law, business, and engineering. Only recently have engineering programs included entrepreneurial courses covering the basic concepts that are essential for technology business development. At the University of Michigan, such courses include an MBA business plan development sequence that is elected by an increasing number of engineering graduate students, an undergraduate engineering course in business plan development, and a patent law class specifically for engineering students. Academic resources such as these significantly increase the likelihood of stimulating student entrepreneurial activity and of successful commercialization of university research. However, these resources alone are typically insufficient. Professional resources, such as those offered by the Office of Technology Transfer and the Sam Zell and Robert H. Lurie Institute for Entrepreneurial Studies at Michigan, provide business development support ranging from one-on-one business development counseling to grant programs for emerging businesses. This paper discusses a complete process of commercializing engineering research. Critical academic and professional resources supporting this process are described as well as how these resources have fostered entrepreneurial activity, contributing to successful commercialization of engineering research at the University of Michigan. Several of the challenges faced by the student entrepreneur have been addressed by these resources at Michigan, while others still require development that is underway. Here the authors report on these activities, while aspiring to foster inspiration for the development of entrepreneurial resources at engineering institutions across the country.

I. Commercialization of Engineering Research

A. An Engineering Student Researcher's Perspective

Graduate student researchers are all too often completely isolated from any notion of commercializing their research, so it appears as a daunting challenge to the student. The irony of this circumstance is that a great deal of engineering research has tremendous commercial potential. Moreover, engineering students are quite prone to having interest in emerging businesses given

the success of a myriad of technology start-ups in the past decade. However, once that interest appears, how does the student proceed? Many engineering students and researchers forego their entrepreneurial ambitions simply because of a lack of knowledge, lack of resources, or even lack of knowledge of resources. This comes as little surprise since the questions faced by an aspiring entrepreneur can seem overwhelming. Intellectual property (IP) is a foreign concept to most student researchers. In previous years, the idea that one can utilize university resources to commercialize technology has been received with utter surprise by many student researchers at Michigan. But even with these resources, students begin to ask themselves, how can a business plan be developed? How can one learn about business development while pursuing an engineering degree? How can capital be raised to support an emerging business? Who can help? And quite simply, where should one start? It is our contention that an engineering curriculum in the United States should support students along this career path by providing resources, both academic and professional, that can help answer these questions so students can pursue their career ambitions with the appropriate preparation.

B. The Importance

There are strong advocates both for and against commercializing university research. Arguments on both sides are compelling. Opponents voice concerns regarding conflicts of interest and effort; ethics; and compromising situations surrounding ambiguity in defining one's primary responsibility—is it at the university or within the company? These concerns are clearly legitimate, but they can be addressed with proper conflict management.

Proponents have recognized the current trend that both domestic and foreign corporations are relying more heavily on external technology and intellectual property to feed their commercial pipeline. Specifically, early stage research and development is often no longer supported internally, so companies are integrating new intellectual property supply chains into their business models. Colleges of engineering across the country are well positioned to play an active role in this chain. Figure 1 illustrates the percent of companies relying on external sources for technology in North America, Europe, and Japan. The trend for the past nine years clearly indicates that the

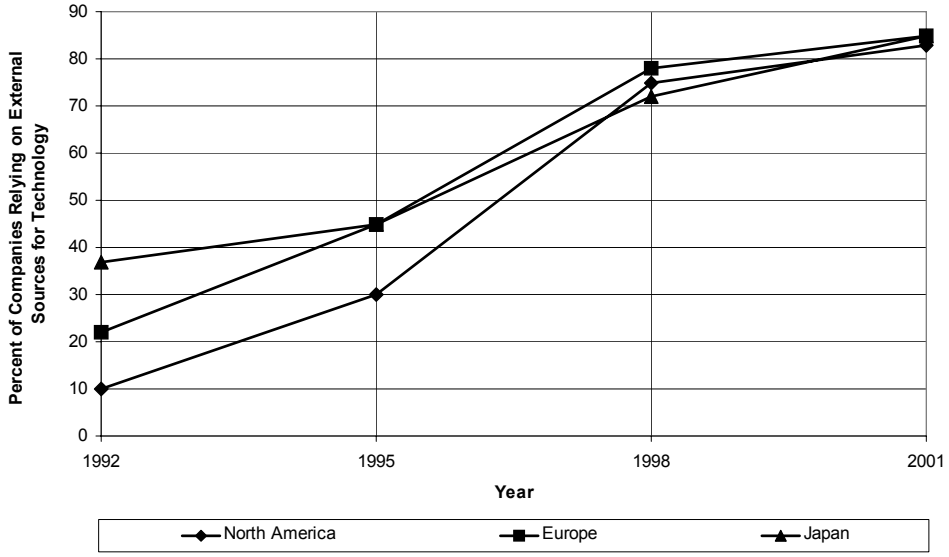

Figure 1. Percent of companies relying on external sources for technology from 1992 to 2001[1]

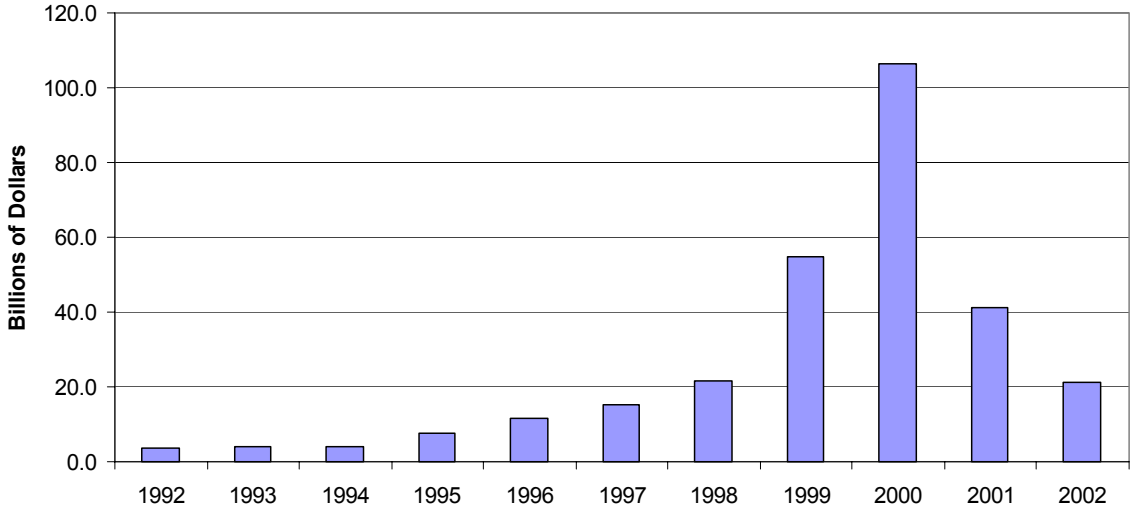

Figure 2. U.S. venture capital investment from 1992 to 2002[2]

livelihood of the global technology economy is dependent on these external resources. Therefore, it is important that colleges of engineering provide companies with access to research for commercial consideration. For state-funded universities, legislators like to see jobs created from university research.

Of equal significance are the opportunities that exist in emerging businesses. In recent years, the infusion of capital from venture funds into start-up companies has been increasing steadily, as shown in Figure 2. Although most investment professionals consider 1999 and 2000 to be anomalies attributed to the "internet bubble," in 2001 the market returned to a figure predicted by the growth rate from the years 1995 through 1998. 2002, is also anomalous and the reduction in investment dollars can be attributed to the state of the national economy. Nevertheless, the substantial amount of capital infusion to start-up companies reflects the fact that much early stage research and commercialization is occurring through emerging business and not within large corporate entities. These trends have created career opportunities for U.S. engineers that are substantially different from those of previous years. However, education will be the key that distinguishes these engineers in the competitive marketplace. Specifically, engineers who have been introduced to business issues will have a significant advantage in building emerging businesses.

C. Commercialization at the University of Michigan

The creation and launching of a new technology-based business can take one of many paths. As a result, it is difficult to describe "the" process for commercializing University-developed technology. In the text that follows, a typical commercialization process that has been implemented by the University of Michigan is examined to illuminate the implications for faculty, students, and technology managers. Figure 3 captures the milestones that are described.

1. *Define IP Terms of Research Grant or Award*
   It is imperative that the intellectual property assignment be clean for any contracts, grant, or gift monies received. This enables the university to later license the developed technology into

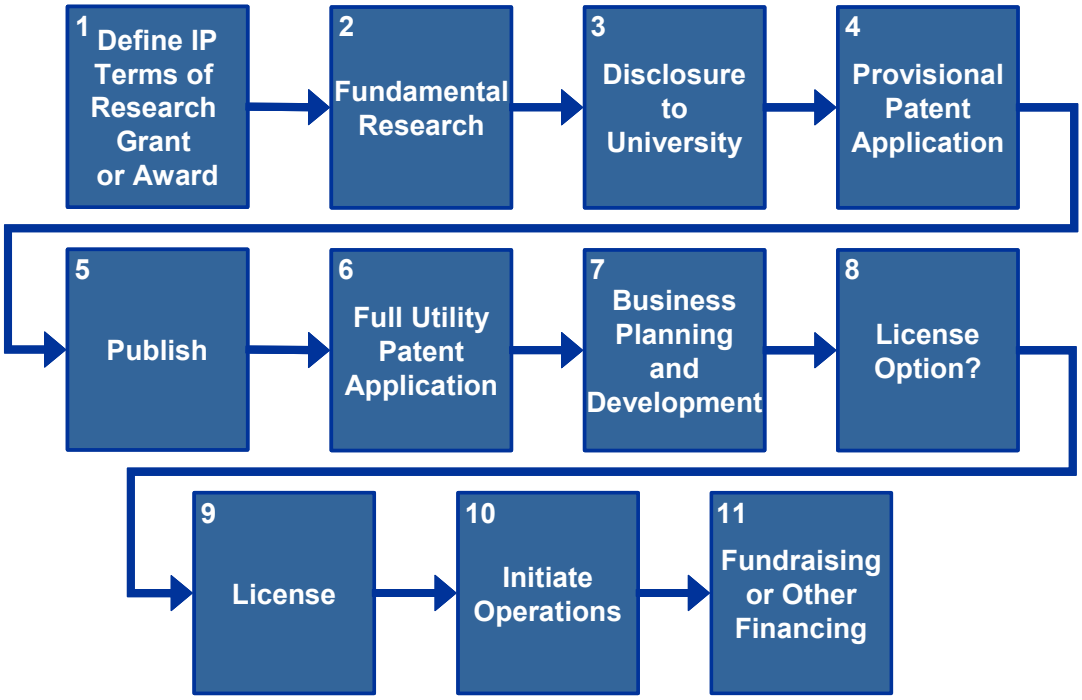

Figure 3. Commercialization Milestones: Summary of the process of technology transfer to emerging businesses at the University of Michigan. Milestone numbers will be referenced throughout the text.

an emerging enterprise. The Bayh-Dole Act of 1980 was substantial legislation that essentially transferred ownership of IP from granting federal agencies to the awarded institutions[3]. Thus, federal grants are typically clear from any commercial obligations and the developed intellectual property can be licensed from the university at which the research was conducted. Complications typically occur when collaboration exists with commercial entities. Often these companies wish to retain some or all rights to the intellectual property developed with their funding, which is reflected in the research contract, thus limiting the choice of commercialization paths. Negotiations with external entities prior to acceptance of any research award is mandatory to eliminate this pitfall. It should be noted that inventorship is separate from partnership and licensing, thus inventors will still be listed on all patents regardless of how they are utilized for commercialization.

2. *Fundamental Research*
   In this phase, the researchers develop the initial technology and any IP surrounding it. It is imperative that researchers understand that developed concepts cannot be disclosed to outside parties at this time. This includes disclosures through web pages, conferences, journal publications, company presentations, and a variety of other forms of communication. If the technology is disclosed, a one year time limit is imposed from the date of disclosure to the application deadline for a U.S. patent, and all foreign filing opportunities are lost.

3. *Disclosure to University*
   The University of Michigan utilizes an internal disclosure process. Typically researchers will file a pending publication as full disclosure of the technology. However, a variety of formats are acceptable.

4. *Provisional Patent Application*
   The Office of Technology Transfer will review the submitted disclosure through an advisory committee to determine whether the technology has commercial potential and what type of protection might be appropriate. If it is a patenable technology, a patent application is filed. Often a provisional application is filed that is inexpensive, simple, and timely. It offers the inventors the ability to publish research while the technology is protected for one year. The provisional application sets a priority date at the United States Patent and Trademark Office. The Office of Technology Transfer at the University of Michigan assigns the case to a patent attorney who files the application.

5. *Publish*
   Once the provisional patent application is filed, the researchers may choose to publish their work in the typical forums.

6. *Full Utility Patent Application*
   Within a year of the provisional patent filing, a full utility patent application must be filed. The grace period afforded by the provisional patent application is often an advantage allowing inventors time to further refine the intellectual property. A full utility application is extensive and time consuming. The inventors are much more involved in this process and typically work directly with the patent attorney throughout the development of the application. The Office of Technology Transfer facilitates this interaction. Once the application is filed, revisions with the United States Patent and Trademark Office may be necessary. Applications may also be considered in additional nations. The IP is ultimately considered established once the patent is granted.

7. *Business Planning and Development*
   Once the IP is established, university researchers can develop a business plan. Here it is critical to leverage resources from various departments and offices from within the university. Typically a core founding team is established at this point, which is often comprised of a mix of technologists and business personnel. Legal counsel is retained and a corporate entity is established. In subsequent sections of this paper, Michigan's resources for fostering emerging business development will be discussed.

8. *License Option?*
   The researchers a may engage in an option for the IP. At Michigan, this typically involves some set of negotiable terms under which the technology is removed from the open market for a specified time while the researchers examine its commercial potential and plan for commercialization. The university usually requires some type of plan or development timeline in order to grant a license option. The option agreement often involves a fee paid by the optionee. In return, the licensee can examine the technology exclusively and later exercise the option to license the IP outright. The fee is often less than that required for a full license. Expectations regarding what would be needed to exercise the option are often reflected in the time period of the option. Of course, such an option is also available to established companies.

9. *License*
   Once the researchers have the business plan, people, and funding arranged that is needed to

initiate operations, they are ready to exercise the option. A license is negotiated and a variety of terms are established including equity, royalty, milestones, and fees. Once the license is executed, the company has access to the technology in order to sell products based on it.

10. *Initiate Operations*
    In this phase the researchers typically continue some development of the technology in order to refine it for commercial applications. Once the development is complete, they are ready to begin selling the product.

11. *Fundraising or Other Financing*
    Possessing IP is critical for any technology-oriented emerging business. Fundraising and financing are substantially easier when the IP position of a company is secure. From this point, the researchers retain the rights to commercialize the developed IP and have advanced the technology to some nearly commercial status. Funding is typically sought throughout the development process and often in collaboration with the Office of Technology Transfer and other professional resources. Some sources of funding include venture capital, angels, and grants. Each source carries with it different expectations and requirements.

This discussion shows the breadth of activities required for commercialization of engineering technology—the most notable being resources for intellectual property development, business plan development, and fundraising support. In the sections that follow, the resources that have been developed recently at the University of Michigan are described in order to address many of these challenges while also facilitating the critical component of interaction with fellow entrepreneurs.

II. Academic Resources

In recent years, Michigan has established a variety of entrepreneurial courses for both its undergraduate and graduate engineering students. Some are offered in the college of engineering while others are electives that an increasing number of engineering students select as part of their curriculum. These courses are described in the sections that follow. These courses are instrumental in completing milestones 3, 4, 6, and 7 presented previously.

A. Courses for Engineers[4]

Electrical Engineering and Computer Science 498: Patent Fundamentals for Engineers
This course covers the fundamentals of patents and intellectual property for undergraduate and graduate students in engineering. The first part of the course focuses on the rules and codes that govern patent prosecution in the U.S. The course covers most parts of the Manual of Patent Examining Procedure (MPEP), with a special emphasis on patents and patentability. The second part of the course focuses on strategies and methodologies for claim drafting and patent prosecution. Since it is important to write a patent with the opponent in mind, some lectures also examine litigation issues and common techniques used to overturn patents. Finally, the ethics, codes, and licensing agreements are covered briefly. As a final project, the students have an opportunity to write their own patent application on an invention of their choosing, which includes the specification, drawings, and claims. The best projects may even be filed in the U.S. Patent and Trademark Office.

Industrial and Operations Engineering 422: Entrepreneurship
Engineering students learn the dynamics of turning an innovative idea into a successful commercial venture, including the role of e-commerce. By creating an actual business plan they learn about innovation and creativity, risk management, stress and failure, ethics and other aspects of starting a business. Specific skills developed include accounting and financial evaluation, market and competitive analysis, supply chain development, and others.

These courses are easily accessible to engineering students as they are offered within the College of Engineering. They offer the student knowledge in two critical areas of emerging business: intellectual property (milestones 3, 4, and 6) and business plan development (milestone 7). IOE422 is a team-based course; the learnings from team collaboration are essential to effectively running a business. These courses are taught at an undergraduate level, although many graduate students elect the intellectual property course as it is most pertinent to their research and the development of IP surrounding it.

B. Business Electives[5]

Entrepreneurial Studies 515: New Venture Creation I
The ES515 course first looks at the factors that lead to entrepreneurial success—the characteristics of the entrepreneur, the trends in the environment, and the availability of support—and then focuses on the means of developing innovative products, markets, or methods that can serve as viable venture concepts. Lastly, the course considers the means of defining those concepts so that they are clearly understandable, and of confirming the competitive advantage or advantages so that they are clearly recognizable by potential investors. Defining the concepts and confirming the advantages are essential before large amounts of time are invested in the preparation of a complete business plan.

Entrepreneurial Studies 517: Researching & Writing the Business Plan
Once new and better products, markets, or processes have been defined and confirmed for a new entrepreneurial venture, whether a startup or turn-around, it is necessary to prepare a full business plan. A full business plan is more than just a document that is to be handed to potential investors; it is a detailed roadmap of the actions that will have to be taken to either start or turnaround the proposed venture. It should contain sections on marketing policies, market research, production policies, cost analysis, organizational policies, financial projections, financial sources, and long-term growth plans. The ES517 course looks at each of these sections in detail, and helps students in the preparation of realistic business plans based upon their startup or turnaround venture concepts. Teams of four or more students complete business plans for venture concepts defined and researched in ES515.

These courses are part of the MBA curriculum and are taken as a sequence. Nevertheless, several engineering graduate students elect these courses as part of their curriculum. Students may present business concepts to the class and those that generate the most interest are assigned a team. Enrollment is not necessary to present a concept, so some engineering students simply present technology business concepts to the class and recruit a team to develop a plan. These courses offer student researchers essentially pro bono business plan development by bright and enthusiastic MBA students. At a minimum, the result is a baseline business plan (milestone 7) that the student researcher can refine at a later date.

C. Resources Offered by Student Organizations

Several student organizations have become instrumental in not only pooling resources across the university, but also breaking down the barriers that exist between departments and colleges. A grass roots organization appropriately named "Michigan Entrepreneurs" was founded by electrical engineering students in 1999 and has established itself as the furthest reaching organization addressing student-led emerging business. The organization describes itself and its mission as follows:

> Michigan Entrepreneurs (UME) is an association of students devoted to exploring the many opportunities that surround us all in today's exciting business world. Our mission is to create a community of students interested in exploring these opportunities through education, meetings, influential speakers, and workshops. UME is a unique campus group as it is open to the entire community. You'll find engineering, music, literature science and arts, and business students in this diverse and exciting organization[6].

UME has sponsored events including a showcase of entrepreneurial start-ups by Michigan students. Here students of all disciplines are able to learn of the experiences of colleagues in the development of their businesses. UME has also developed focus groups on particular aspects of technology and business from semiconductor technologies to patent law. However, the organization's greatest contribution is fostering interaction between students, faculty, and the local business community. The organization has created a truly transparent network where individuals of all disciplines can interact. This interdisciplinary interaction has been instrumental for many in recruiting a team to develop a business concept.

Business students have also formed organizations at Michigan such as the Entrepreneur and Venture Capital Club and the High-Tech Club, which involve engineering students. Both of these clubs are willing to circulate solicitations to their members from engineering teams looking for business talent. All of these organization facilitate team formation and ultimately business development, as described in milestone 7 previously.

III. Professional Resources

Student organizations and course work can take an engineering student a long way, but the professional resources available to Michigan entrepreneurs are what truly allow engineers to develop the skill set required to become successful entrepreneurs. Here the role of two organizations which are central to commercializing engineering research are discussed: The College of Engineering Office of Technology Transfer and The Zell Lurie Institute.

A. The College of Engineering Office of Technology Transfer

The vision of the College of Engineering (CoE) Office of Technology Transfer is as follows:

> The goal of the College's Technology Transfer & Commercialization function is to expand the impact of CoE research through commercialization and to effectively transfer University technologies to the market so as to generate benefits for the University, the community, and the general public. The office provides assistance with Michigan's technology

transfer process, disclosures, patents, copyrights, licensing, and proposals[7].

The Office does just this and does it well. With a clear technology transfer process and support for any student researcher wishing to commercialize developed technology, this Office is indispensable. The Office also provides valuable support, including access to a Business Development Specialist for each individual or group aspiring to commercialize engineering research. The Specialist, who is part of a UM Business Development Group, will introduce the researchers to the technology transfer process at the University, arrange appointments with potential investors, clarify the group's IP position to investors, and support the group in its business development efforts. These professional resources provide engineering student researchers with additional information that is unlikely to be found in the classroom. All of these activities contribute to achieving milestones 1, 3, 4, 6, 7, 8, 9, 10, and 11.

The Office also provides significant monetary support for researchers aspiring to develop a new business. The Engineering Technology Development GAP Fund is a fund targeted at providing monetary support in order to bridge the gap between research results or findings and commercially viable products that incorporate those innovative research results. The Office also uses discretionary money to support consultants in business development with the coordination of the Business Development Specialist. The idea is to foster interaction between researchers and seasoned entrepreneurs from the community. These opportunities facilitate the development of a core business team (milestone 7).

B. The Samuel Zell and Robert H. Lurie Institute for Entrepreneurial Studies

The Zell Lurie Institute is affiliated with the University's Business School. Founded in 1999 with a ten million dollar gift from Samuel Zell and Ann Lurie, the Institute has moved forward with the following mission:

> The Institute is an umbrella organization for existing and expanding efforts in entrepreneurship. Approximately sixteen faculty members, both academics and practitioners in the field of entrepreneurship, prepare students for turning knowledge into new venture success. In addition, the Institute offers symposia, internships, scholarships, alumni networks, curriculum development and other activities to advance the interests of the entrepreneurial community[5].

The Institute has been instrumental in linking engineering student researchers with MBA students. Its members participate actively in the MBA business planning courses and collaborate with engineers aspiring to develop business plans in these courses (milestone 7).

The Institute also administers its own grant program, the Dare to Dream Program, where teams submit business proposals in collaboration with Michigan MBA students and receive funding for commercialization efforts. In addition, the Institute manages a program that subsidizes internship salaries for Michigan MBA students at start-up companies in the area. The companies that utilize this resource receive world-class talent at reduced rates and several companies have found this to be a cost effective manner in which to retain desired talent, with salary, despite low cash flow.

Lastly, the Institute provides teams with access and sponsorship to business plan competitions around the country. Faculty and staff at the Institute will coach teams prior and during their attendance at these events. It has been an invigorating experience for many students to present their business concepts in a competitive format while interacting with fellow student researchers and entrepreneurs across the country. The Business School also manages business plan competitions of its own, and participation has been increasing steadily over the years.

The availability of these resources to engineering students, despite the fact that the Institute is housed by the Business School, is an outstanding facet of the entrepreneurial culture at Michigan. The boundaries that exist across academic disciplines, such as business and engineering, must be broken down in order to foster a healthy entrepreneurial community and develop the resources required for students. All of these resources provided by the Institute clearly help student entrepreneurs achieve milestones 7, 10, and 11.

C. Connections to External Resources

Both of the offices described play an important role in connecting entrepreneurs with external resources, and in particular to venture capital, grant programs, legal support, and professionals within the community; this final item is the most significant. Entrepreneurs require some form of communication with those outside of the University environment. They must get some feel for what it is like to raise money through grants or venture capital. Interaction with entrepreneurs in the community is a critical component to developing the entrepreneurs of tomorrow. Both the Zell Lurie Institute and the Office of Technology Transfer sponsor events and make individual introductions that connect student and faculty researchers with business students and faculty, as well as with members of the outside community.

IV. Statistics Measuring Entrepreneurial Activity at Michigan

The College of Engineering Office of Technology Transfer provides statistics that indicate the level of activity of technology transfer at the University and within the College[8]. These statistics are presented as a measure of success of the various resources described above.

Fig. 4 shows a breakdown of the disclosures made to the Office in fiscal year 2002 and divided by engineering discipline. Not surprisingly, the two largest departments, Electrical Engineering and Computer Science and Mechanical Engineering, comprise a significant majority of the activity.

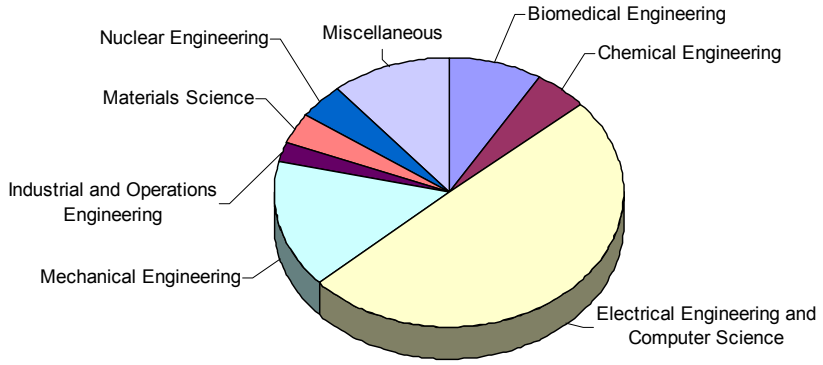

Figure 4. Breakdown of disclosures in FY2002 at the University of Michigan by engineering discipline

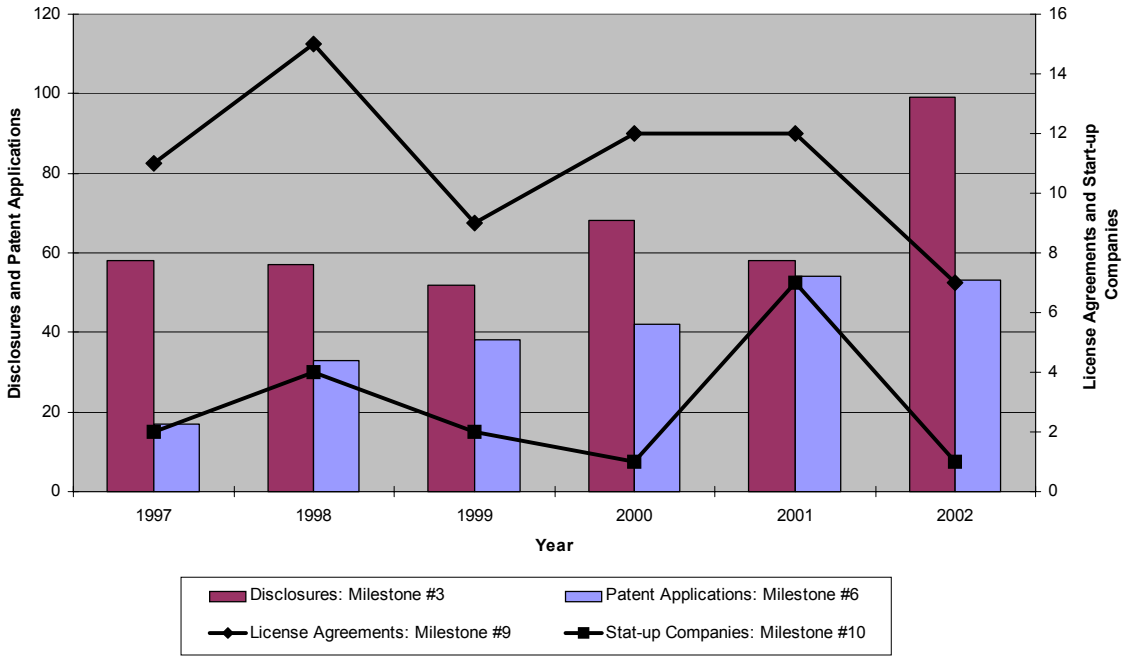

Figure 5. University of Michigan College of Engineering disclosures, patent applications, license agreements, and start-up companies from 1997 to 2002.

The best indication of increased commercialization activity is given by the dramatic increase in disclosures (milestone 3) and patented technology (milestone 6) in the College of Engineering. Figure 5 illustrates the trends for the past six years. In 2002, the College generated almost twice as many disclosures as it did in 1997 and the number of patented technologies tripled from 1997 to 2002. Licensed technologies (milestone 9) have ebbed and flowed for the past five years and the general trends follow the health of the national economy. It is important to note that nearly every technology that is disclosed and patented within the College of Engineering at Michigan contains at least one student inventor. Typically this student inventor is a graduate student, but the authors have also disclosed their own technology including undergraduate students, who support graduate research projects, as co-inventors.

The final metric indicating increased entrepreneurial activity is the number of start-ups (milestone 10) that have originated from the College, also shown in Figure 5. An unprecedented number of engineering start-ups was recorded in 2001. The state of the national economy is largely at blame for the sharp downturn in 2002.

V. Conclusion

This paper has presented the importance of educating engineering students in the area of commercializing engineering research and technology in today's economy. The process for commercializing research at the University of Michigan was described in order to create an appreciation for the breadth of activities involved. Both academic and professional resources available at the University of Michigan were described. Clearly, course work is an important starting point in fostering the interest of engineering students and providing the support required for business plan development and IP protection. However, the significance of professional resources cannot be over-

looked. As described, many of the resources required by an entrepreneur are not academic in nature. If a student researcher aspires to commercialize his or her inventions, a team must be built, relationships must be established, and financing must be secured. These are the less tangible resources that will make or break the entrepreneurial environment at an engineering research institution. The culture, community, and resources at Michigan have come a long way in a short period of time and the authors have reported statistics that indicate a substantial increase in entrepreneurial activity. Nevertheless, courses continue to be added to the curriculum and programs continue to develop to fulfill the needs of aspiring engineering entrepreneurs. In closing, the authors hope to have contributed to the spirit of enterprise and the development of engineering technology through research, while inspiring others in the development of their own entrepreneurial resources for students.

VI. Acknowledgement

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VII. References

1. E. B. Roberts, "The Strategic Management of Technology: Emerging Global Trends in Industrial Innovation," MIT Sloan School of Management.
2. National Venture Capital Association. Internet. January 2003. <http://www.nvca.org>.
3. The Bayh-Dole Act of 1980, PL 96-517.
4. Michigan Engineering - Course Catalog. Internet. January 2003. <http://www.engin.umich.edu>
5. Zell Lurie Institute. Internet. January 2003. <http://www.zli.bus.umich.edu>.
6. Michigan Entrepreneurs. Internet. January 2003. <http://www.engin.umich.edu/soc/ume>.
7. Tech Transfer at the University of Michigan. Internet. January 2003. <http://www.techtransfer.umich.edu>.
8. *TECHtransfer University of Michigan Annual Report Year Ending June 30, 2002*, University of Michigan, 2002.

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Michael received the B.S.E. with honors in Electrical Engineering from The University of Illinois at Urbana-Champaign in 1997 and the M.S.E in Electrical Engineering in 2000 from The University of Michigan where he is now a Doctoral Fellow. While at Michigan, he has served in business development with the Office of Technology Transfer where he was involved in the identification of the resources required for successful commercialization of microsystems research. Michael is the co-founder and Chief Executive Officer of *Mobius Microsystems Inc.*, a start-up enterprise formed around his graduate research that has been conducted under the direction of Richard B. Brown. *Mobius* has received a wide variety of recognition in Michigan having been awarded several grants and prizes associated with local and regional business planning competitions. In 2002, *Mobius* was one of the recipients of the University of Michigan's Dare to Dream Grants, and it was awarded first prize in Indiana University's Spirit of Enterprise Regional Business Planning Competition.

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Rich received B.S. (with Highest Honors) and M.S. degrees in Electrical Engineering from Brigham Young University in 1976, and a Ph.D. degree in Electrical Engineering from The University of Utah in 1985. He has worked in computer design as Vice-President of Engineering at Holman Industries, Oakdale, CA, and as Manager of Computer Development at Cardinal Industries, Webb City, MO. In September 1985, he joined the faculty of The University of Michigan Department of Electrical Engineering and Computer Science, where he is an Arthur F. Thurnau Professor, and currently serves as Interim Chair. Rich has conducted major research projects in the areas of solid-state sensors, high temperature CMOS, SOI, mixed-signal circuits, and high performance and radiation-tolerant computing systems. In addition to his academic responsibilities, he is a co-founder of *Sensicore* and *i-sens*, companies that produce solid-state chemical sensors for water and blood. Rich also co-founded *Mobius Microsystems Inc.* in 2002, with his graduate student research assistant, Michael S. McCorquodale**.**