The Development of a Technology Entrepreneurship Culture And Lessons Learned

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1. Introduction

This paper discusses activities of the Maryland Technology Enterprise Institute (MTECH) of the Clark School of Engineering at the University of Maryland to foster mutually beneficial interactions with technology companies and an entrepreneurship culture. MTECH started operations in 1984 as an initiative by the college's board of visitors with the purpose of increasing mutually productive interactions between faculty and students of the Clark School and companies in Maryland. The first programs that began operations were: a consulting service to strengthen Maryland manufacturers, an on-campus incubator for technically-oriented start-up companies, and a biotechnology program to help biotech companies through training and productivity enhancement and to scale up processes from research lab levels to commercial scales. In 1987 a technology transfer program was started which facilitates faculty and graduate students performing commercially-oriented R&D for Maryland companies. While these programs are not purely entrepreneurship, the experience gained from interacting with small and startup companies laid the foundation for a new three-phase entrepreneurship initiative which was begun in 2000 to create a robust technology entrepreneurship culture for students and faculty. The purpose of this paper is to describe the development and operation of the entrepreneurship initiatives and to discuss the lessons that were learned.

1.1. Holistic View of Programs

As we have gained experience over the years, we have identified barriers that students and faculty must overcome to build successful technology ventures, and we have realized that to have a truly effective impact, it is necessary to have a continuum of programs and activities that provide education and assistance to help faculty and students transform ideas, concepts and technology into sustainable ventures through education, acceleration, and incubation as well as to have programs that assist companies after they mature.

Each program and activity will be discussed in detail later in this paper; however; we first provide an overall view. Table 1 provides a listing of whom each program is designed to serve. Figure 1 illustrates the way these programs fit together to form a holistic culture to assist faculty/students, young and mature firms. It is expected that the reader will refer to the table and figure as details are provided.

Table 1. Participation in MTECH Programs

Program Activity	Undergrad Students	Graduate Students	Faculty	Companies
Hinman CEOs Program	X			
Business Plan Competition	X	X	X	
Technology Startup Boot Camp	X	X	X	
Technology Startups Ventures Course	x	X		
Technology Ventures Club		X		
Venture Accelerator Tier I	X	X	x	
Venture Accelerator Tier II		X	X	
Technology Incubator		X	X	X
Technology Transfer Program		X	X	X
Technology Extension Service		X	X	X
Biotechnology Program	X		X	X
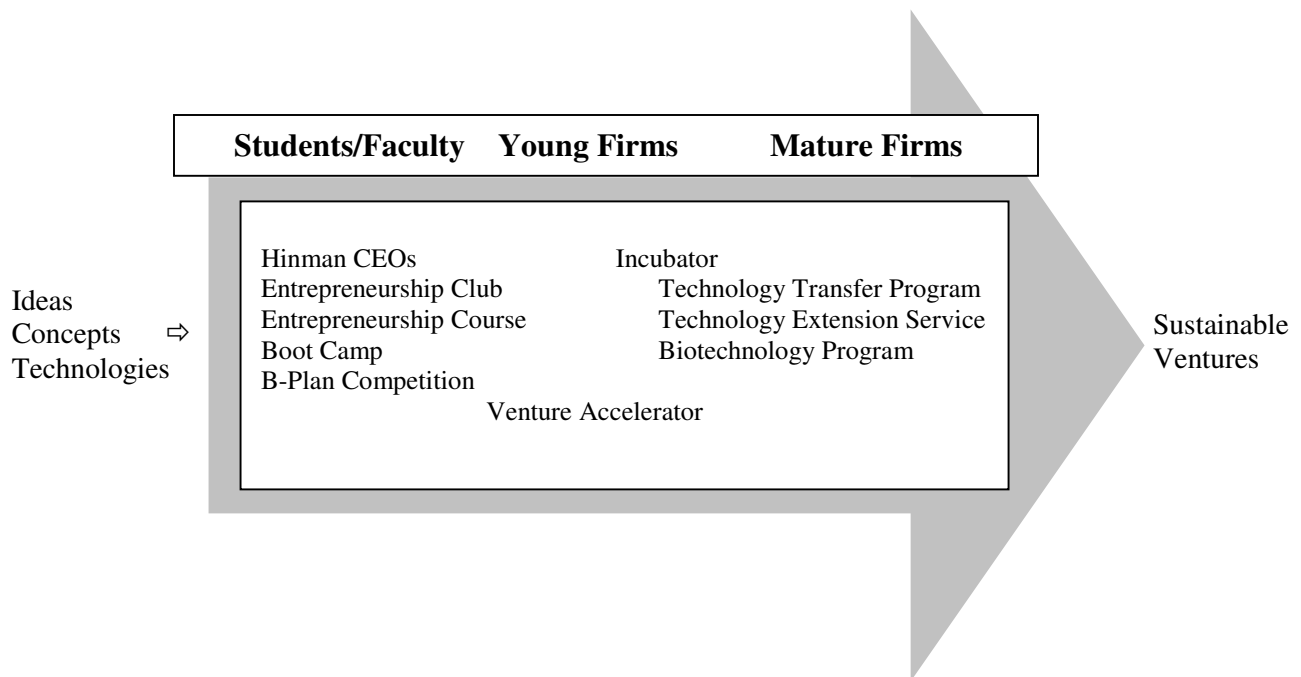
Figure 1. Holistic View of MTECH Programs

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2. MTECH Base Programs

The base upon which entrepreneurship activities were built was almost twenty years of experience with startup companies gained through operation of the incubator, technology transfer, technology extension and biotech programs. All MTECH programs were proposed and developed by MTECH personnel, and it was important to the success of the program that the leaders of MTECH were given a relatively free hand to design the activities without political considerations.

2.1. Technology Incubator

The incubator is known as the Technology Advancement Program or TAP for short. The first company was admitted into the incubator in May, 1985. Candidate companies are admitted into the incubator only after passing rigorous technical and business reviews. About one in six applicant companies are admitted. Once admitted, companies that are making reasonable progress can remain in the incubator for up to four years. All types of technology companies are acceptable unless there is some reason, such as environmental issues, that prohibits them from being on campus. Biotech companies tend to stay the full four years, and IT companies tend to stay for a much shorter time. Once admitted, companies enjoy increased credibility due to the rigorous admittance process. TAP services and dynamic atmosphere create an environment where entrepreneurs flourish, with flexible, furnished office and laboratory space, modern IT and biotechnology infrastructures, in-house business support, and convenient office facilities. As the first technology business incubator facility in Maryland, TAP has refined its services so entrepreneurs can focus less on administrative details and more on growing their companies.

Companies pay a license fee that is based on the space occupied plus they grant the University 1% equity per year of incubator occupancy. Forty seven companies have graduated from the incubator, and 70% are operating five years after graduation. Six of the graduate companies were faculty founded, and two faculty-founded companies are currently in the incubator. While most of the companies have not approached growth necessary to consider IPO's, three companies are publicly traded, two through IPO's and one through an acquisition. Over 1,000 jobs have been created by graduate companies.

2.2. Technology Transfer Program

Begun in 1987 as an MTECH initiative, the Maryland Industrial Partnerships (MIPS) Program is a technology transfer and economic development program which promotes the development and commercialization of products and processes through industry/university research partnerships. Through MIPS, University faculty and graduate students conduct research projects for Maryland companies. The feature that distinguishes this program from other research programs is that MIPS proposals are evaluated not only on technical merit, but most importantly on potential for economic benefit. Maryland companies with MIPS projects gain access to the creative talents and

extensive research base in engineering, computer science, physical sciences and life sciences.

Two major issues that were resolved early in the design of the program were intellectual property and publications. IP is owned by the University but the company is given the right of an exclusive license in its market area. Publications can be delayed up to 12 months giving the company an implementation lead before competitors learn of the results. This is accommodated within the publication policy of the University and has not posed a problem to date. One reason for this not being a barrier is that the normal process of getting a paper published in a referred journal is fairly lengthy, and the actual additional delay is relatively short, if it is necessary at all. MIPS project funding is almost always used to support student PhD and masters research, and students and faculty publish papers as is customary with research grants. Before a project is begun, a standard contract is signed that includes items discussed above as well as many other items.

MIPS projects are carried out by faculty and gradate students of any of the 13 institutions of the University System of Maryland. Proposals, accepted twice a year in May and October, must be co-authored by a faculty member and a company representative. The timing of the proposal evaluation and contracting processes are timed to be in synch with faculty selection of masters and PhD students to work on the projects.

Sometimes a faculty member will have a pre-existing relationship with each other, or at least know of each other. In this case, no effort to match faculty member and company is necessary. When a faculty member or company is interested in pursuing a MIPS project, but need to be matched, MIPS staff will find a match for a company or faculty member seeking a partner for a proposal.

Benefits of MIPS projects accrue to three constituencies - companies, faculty and students, and the State of Maryland. A primary benefit for faculty and students is that MIPS projects facilitate the transfer and application of their technology, expertise, and use of their facilities to create new and improved products for companies. New and improved products for Maryland companies translate into creation and retention of jobs, diversification and strengthening the State economy and increasing the attractiveness of Maryland to firms seeking to relocate.

MIPS projects allow Maryland companies to tap into unique expertise and facilities of the University to conduct R&D projects in a cost-effective manner. In addition to providing access, MIPS also shares in funding the on-campus projects carried out for companies. MIPS matching limit is $100K per year for all companies except startups for which the limit is $70K. Table 2 shows details of the cost sharing as a function of the size (number of employees) of the company involved.

Table 2: Annual Budgets for MIPS Projects

Number of Company Employees	Minimum Company Part of Budget	Maximum MIPS Part of Budget	Total Budget/ MIPS Part
> 1000	75%	25%	$400K/$100K
> 100 <1000	50%	50%	$200K/$100K
< 100	35%	65%	$154K/$100K
< 12	10%	90%	$78K/70K

Notes: (1) Assumes that company contributes the minimum amount of cash and MIPS contributes maximum amount
(2) The duration for MIPS projects can be a maximum of two years

MIPS will contribute a maximum of $70K per year for up to two years for a project with a startup company; thus, the $140K in MIPS funding is equivalent to seed funding. While the figures in the table are for cash that goes into a University account to conduct each project, companies generally make non-cash contributions to the projects and also conduct complementary work in their own locations. The ratio of company effort divided by MIPS cash for all projects carried out to date is 5:1.

As of October 2003, 256 faculty members of 11 of the 13 University System of Maryland institutions have conducted 445 projects for 300 companies. Over half of the projects have been for small and startup companies.

2.3. Maryland Technology Extension Service (MTES)

Started almost 20 years ago, MTES is a program that provides practical, hands-on business and technical assistance to Maryland companies, especially those in manufacturing, typically of small and medium size. The MTES mission is twofold: to apply Clark School of Engineering resources to the benefit Maryland manufacturers and to strengthen the competitiveness of Maryland manufacturers by providing information, decision support, and implementation assistance.

As an affiliate of the National Institute of Standards and Technology Manufacturing Extension Partnership (NIST MEP) network, MTES supports manufacturers in becoming more globally competitive and assisting them in overcoming a range of challenges facing small manufacturers. MTES facilitates a wide variety of national and regional resources to client companies including: University System of Maryland resources, the national

NIST/MEP network of manufacturing assistance centers, federal labs and Maryland state resources.

Since MTES, like the other MTECH programs, is an integral part of the University, access to faculty is uncomplicated, and since 1996, 276 MTES projects have involved faculty from institutions of the University System of Maryland. Over the past two and one half years, MTES has had a $45 Million impact on Maryland manufacturers by helping them to increase and retain sales, save costs and avoid unnecessary investments.

2.4. Biotechnology Program

MTECH's Biotechnology Program is designed to bolster Maryland's burgeoning biotechnology industry and to train students who work part-time in the facility. To that end, MTECH offers bioprocessing facilities and services, training, and consulting for companies. The Bioprocess Scale-Up Facility (BSF) offers a broad range of bioprocess scale-up and production services, including fermentation (up to 250 liters), cell culture, separation, purification, and product analysis. The BSF and associated services are especially important to startup companies which usually lack the equipment necessary to scale up bioprocesses from research-lab quantities to commercial volumes. Since 1998, the BSF has conducted nearly 700 fermentations for 50 companies. Students who have worked part-time in the facility are in great demand by biotech companies.

Workforce training is provided by an expert staff featuring customized training in many aspects of bioprocessing. Also offered are consulting services in productivity enhancement for bio-manufacturing to help companies improve their processes to yield benefits such as reduced costs, decreased production delays and less re-work. MTECH personnel work closely with the Clark School's Biotech Program featuring Master of Science and Doctor of Philosophy degree programs in Bioengineering, as well as the nation's first Biomolecular Engineering Graduate Certificate program.

2.5. MTECH Base Programs Summary

With nearly 20 years of experience in working with technology companies of all types and sizes, especially startups, MTECH personnel have gained extensive knowledge of the processes and steps needed to start and develop successful companies. In the late 1990's, MTECH leadership saw an opportunity to have an even greater impact through new activities aimed at helping faculty and students better understand the technology startup process. Since then, we have embarked on a three-phase process to create a robust entrepreneurship culture for technology-oriented students and faculty. The remainder of this paper discusses this endeavor. Table 3 provides the list of activities and dates when they were initiated.

3. Entrepreneurship Culture - Phase I

The first phase of building the entrepreneurship culture established three activities: A program for undergraduates, a business plan competition and a boot camp.

Table 3. Chronology of Entrepreneurship Activities

Activity/Program	Year Started
Phase I:	
Hinman CEOs Program	2000
Business Plan Competition	2001
Technology Startup Boot Camp	2001
Phase II:	
Entrepreneurship Graduate Course	2001
Technology Ventures Club	2002
Phase III:	
VentureAccelerator	
Tier II	2002
Tier I	In development
Entrepreneurship Portal	planned

3.1. The Hinman Campus Entrepreneurship Opportunities (CEOs) Program

The Hinman CEOs program was initiated by the Clark School of Engineering and the Smith School of Business in the fall semester of 2000 for undergraduate students having a strong entrepreneurial drive. The program attracts these entrepreneurial students and creates a strong sense of community and cooperation among them. The University and its academic and corporate partners provide many resources, activities, courses, technologies and services to help students learn how to start, grow, and manage successful companies. The most important feature of the program is that students admitted to the program live together in a modern incubator-like residence hall where they can freely exchange ideas and network with their fellow CEOs. Living, studying, working and playing together, these students are provided with unique opportunities to form teams that often evolve into commercial ventures.

The environment is rich in diversity and the students' influences on each other are evident as they learn from each other in informal ways. At Sunday evening social events, apartment groups plan special cultural events where students from a particular culture offer ethnic food, demonstrate native dances or talk about their culture. When teams are pursuing a business idea, they call upon each other for assistance. With a population that is typically one-third engineering, one-third business and one-third from a broad set of academic disciplines, brainstorming ideas occurs in a rich environment. When not calling upon each other for ideas or help, these entrepreneurs have the benefit of an on-site, full-time staff member who advises and mentors them. They also have the benefit of mentoring from faculty and outside experts when they have business ideas that require additional assistance. The practical knowledge and experience these students gain from

the program impacts the way the CEOs think about their careers, their destinies, and their ability to start businesses.

The target audience is primarily juniors and seniors, along with some exceptional sophomores, and the program size is limited to about 100 students to help build a tight-knit community. The program elements are structured around a comprehensive group of activities and state-of-the-art facilities designed to provide a rich and supportive environment for learning about entrepreneurship, forming teams, starting companies and sharing lessons learned. These include:

- A dynamic community environment that is centered around a residence hall where all Hinman CEOs live and interact closely
- An incubator-like technology environment with features such as wireless Internet access, videoconferencing, modern computing facilities and state-of-the-art business and technology software tools
- Weekly seminars and workshops with speakers such as investors, accountants, legal experts and successful entrepreneurs
- Participation in a Boot Camp (discussed later) at the beginning of the academic year which brings together regional experts to introduce fundamental entrepreneurial concepts to both students and faculty
- A mentoring program that matches student teams with experts from the technical, business and academic communities
- Support for product development projects to assist student teams in fabricating pre-prototypes and obtaining intellectual property protection
- Opportunities for CEOs to form companies with faculty and graduate students who have created technology-oriented intellectual property through their research
- Entrepreneurship education which consists of courses available in the business and engineering schools
- An annual business plan competition (discussed later) which gives students the opportunity to compete for prize money which can then be used to further their companies and ideas
- Possibility of obtaining space in the on-campus technology incubator that the engineering school has operated for 17 years.

Each semester students receive one-credit in engineering. Their grade is determined by the level and quality of their participation in program activities and contributions to improving the program.

Thirty companies have been formed by undergraduate students in the Hinman CEOs Program. These range from small ventures to more substantive ones that have received investment funding. A Hinman CEOs company was awarded honorable mention in the 2001 University of Maryland Business Plan Competition, and another was awarded second place in the 2003 competition.

An example of a company started within the Hinman CEOs is Squarespace. With the new, sophisticated web publishing system created by Hinman CEOs student Anthony

Casalena, nearly anyone can create a web site within minutes. Pages, files, journals, pictures and many other types of content are easy to publish on the Internet using Squarespace, which is simple enough for the novice, yet powerful enough for even the most advanced web developer. No HTML knowledge is required. File transfer protocol (FTP) software programs are also not needed. For advanced users, nearly every aspect of a site is customizable, giving developers full control over their content. Site updates take seconds rather than minutes or hours. Squarespace also offers integrated web site statistics and user tracking features. Instead of seeing what URL's viewers are accessing, Squarespace enables developers to see exactly what content visitors are looking at. Search engine hits leading to subscribers' sites are also recorded and grouped automatically. Squarespace currently hosts web sites for 326 subscribers

While the Hinman CEOs Program provides the extensive array of activities exclusively for undergraduates, a concerted effort has also been made to develop technology entrepreneurship initiatives to reach graduate students and faculty. Two initiatives in Phase I that were established to increase the reach were the Business Plan Competition for all students and alumni within five years after graduation and the Technology Startup Boot Camp designed for technical graduate students and faculty as well as the Hinman CEOs.

3.2. Business Plan Competition

Each academic year concludes with a business plan competition, typically with $50,000 that is raised from regional sponsors representing the investment and professional services communities. Goals of the competition are to provide education and networking opportunities for students, to foster new venture ideas and to provide new opportunities for students and recent alumni to compete for funding that will enable them to start or further existing businesses.

The competition is campus-wide and is open to graduate and undergraduate students. Eligible teams may include non-students; however, each team must have at least one member who is a current University of Maryland student or recent graduate (within five years) who plays a material role in the team. "Material role" is generally interpreted as being an officer of the corporation or having an equivalent position.   A team is ineligible if it has received prior institutional funding.

The competition commences with the submission of executive summaries in the late fall. Maryland personnel and judges, representing the investment and professional services communities, narrow down all submissions in two steps to six finalists who prepare full business-plans. Finalists present their plans to the judges and a large audience at which time winners are selected by the judges. Most submissions tend to be technically oriented. Funds awarded must be used to start a business or further an existing venture. Winners are monitored for several years following the competition to ensure funds are used properly as well as to assess the success rate of competition awardees.

For the three years of the competition, nine companies have received awards ranging from $25,000 to $5,000. Of the nine, one has graduated from the UMD incubator, another is expected to graduate within a year, and the company that won last the competition last year is progressing through the admission process. A third-place company in the first competition was recently admitted to another incubator in the region. Of these companies, one has received over $1M in investment and has been awarded a major NIST Advanced Technology Program award, and a second is progressing in a bootstrapping mode and is developing its products through contracts with the federal government and large companies. Overall, six of the nine companies are progressing along successful paths.

3.3. Technology Startup Boot Camp

Each academic year is "kicked off" with a one-day program designed to introduce technical students and faculty to fundamental concepts associated with starting and managing technology enterprises. It also serves to establish their network within the University and with regional professionals. Typical topics include:

- Evaluating Tech Business Ideas
- Intellectual Property Basics
- Licensing from the University and the Federal Government
- Federal and State Programs to Assist Startups
- Legal Fundamentals
- Building a Team
- Obtaining Financing
- Lessons from successful entrepreneurs

Bootstrapping, angel funding and seed funding are emphasized in the financing session, and the importance of customer-driven product development is stressed throughout. Presentations are given by experts from law firms, accounting firms, investment banks, investment partnerships and entrepreneurs from regional technology companies. The event is concluded with a panel of successful regional entrepreneurs. Included in the panel are several University of Maryland students and faculty entrepreneurs who discuss their experiences in starting technology ventures on campus.

Boot Camp attendance has grown from 180 the first year to about 250 in 2003. The event is strictly for students and faculty and not for the broader regional community. Attendees are given notebooks containing the presentation materials and contact information of each speaker. The program is conducted in a manner that encourages and facilitates networking among the attendees and the speakers. Attendees, who generally are newcomers to entrepreneurship, come away from the Boot Camp with a basic knowledge of the fundamental concepts, a list of available resources and contact information for the speakers and other attendees.

 The third annual boot camp was somewhat different than the previous two in that it was conducted in cooperation with the National Collegiate Innovation and Inventors Alliance

(NCIIA) and students and faculty from regional universities were invited. The attendance rose to 250 faculty and students. The NCIIA is conducting similar boot camps across the nation modeled after the University of Maryland Technology Startup Boot Camp.

4. Entrepreneurship Culture - Phase II

The Hinman CEOs Program provides an extensive array of activities in which undergraduate students are immersed in entrepreneurship. The launch of the business plan competition and the boot camp started the process of extending services to a larger campus population. However, it was not until the launch of Phase II that more rigorous educational and networking opportunities were extended to graduate students on a systemic basis.   The first of these initiatives was the "Fundamentals of Technology Startup Ventures" course which was intended to provide students with the concepts of technology startups. The second initiative was a club, the Technology Ventures Club, to provide students a forum for learning from regional experts and to exchange ideas.

4.1. Fundamentals of Technology Startup Ventures

This multi-disciplinary, three-credit course helps students learn how to assess the feasibility of a technology startup venture as well as how to apply best practices for planning and launching tech companies. The course structure involves lectures on fundamental topics as well as insights by outside experts who speak about the practical application of these concepts. Course content is organized into four parts: background information on tech startups; assessing the commercial feasibility of a technical innovation; planning and launching technology ventures; and writing and presenting business plans and presentations for investors.

Students organize themselves into groups by week two, and each group selects an innovative technology to build a business around. Technologies come from the student's own academic research (PhD or Masters) or IP available from the licensing office. During the course, each team plans a business around the chosen technology by completing a variety of assignments including development of a full business plan and an investor-oriented PowerPoint presentation. Attendance of this course is mandatory, as topics increase in complexity and build upon each other week-by-week.

Goals of the course include teaching students: to assess the commercial viability of an innovation, to plan and begin launching a technology startup and to prepare market-accepted business plans and fundraising documents. Grading is based on participation, quality of their business plans and their investor presentations and homework assignments.

The course is team-taught by instructors with substantial technology and business experience, and lectures are also given by highly qualified professionals and successful entrepreneurs from the region. Topics included in the four parts of the course include:

- o Background on technology startups
  - ▪ Group formation/selection of business ideas
  - ▪ Overview of the startup process
  - ▪ Commercialization options
  - ▪ Terminology and definitions
  - ▪ Preparing and analyzing financial statements
  - ▪ Introduction to business models
- o Commercial feasibility analysis
  - ▪ Technical feasibility for commercialization
  - ▪ Intellectual property protection, availability and options
  - ▪ Introduction to market research
  - ▪ Assessing demand and market needs
  - ▪ Supply-side and cyclical market factors
  - ▪ Competitive threats
- o Planning and launching tech ventures
  - ▪ Establishing realistic goals and milestones/phases
  - ▪ Launch options
  - ▪ Planning and execution alignment theory
  - ▪ Introduction to business plans/examples
  - ▪ Entrepreneur to speak about planning businesses
  - ▪ Product development/R&D plans
  - ▪ Incorporating market analysis into product development planning
  - ▪ Introduction to sales and business development plans
  - ▪ Sales and business development plans and tactics
  - ▪ Securing alpha and beta customers
  - ▪ Operating plans
  - ▪ Team building and executive recruiting
  - ▪ Advisory boards
  - ▪ Introduction to finance plans/financial modeling
  - ▪ Determining funding needs/financial modeling
  - ▪ Valuations
  - ▪ Funding options
  - ▪ Partnerships and joint ventures
  - ▪ Legal fundamentals
  - ▪ Value creation
  - ▪ Exit options/exit planning
  .
- o Writing and presenting business plans and presentations for investors
  - ▪ Preparing business plans
  - ▪ Preparing presentations
  - ▪ Lessons from entrepreneurs

In the final six hours of the course, teams present their plans in class to a panel of judges who ask questions and provide critiques in a manner that is similar to that which takes place when entrepreneurs present to potential investors.

4.2. Technology Ventures Club

The Technology Ventures Club (TVC) is a dynamic forum for technical graduate students to learn about technology entrepreneurship, network with fellow students, as well as with investors and service providers, and obtain assistance forming a new venture. The TVC meets monthly and is open to all graduate students who are majoring in technical disciplines. Monthly meetings include seminars, workshops, and social networking events.

Seminar speakers represent the investment and professional services communities as well as the local technology community. Workshops focus on specific startup topics, including business planning, forecasting, conducting marketing research, making sales presentations, and fundraising. They are led by a mix of university staff and outside experts. Social mixers give students opportunities to network with each other with the goal of forming teams, and to meet members of the technical and business communities.

Members of the MBA Entrepreneurship Club are invited to Technology Ventures Club meetings to build relationships among technical graduate students and MBA students.

Several companies in various stages of development have been started by graduate students participating in the Technology Ventures Club and the Fundamentals of Technology Startup Ventures course. One such company formed by two students who had conducted their research under the supervision of a leading mechanical engineering professor was awarded first place in the 2003 business plan competition. The lead student is Vice President of the club and was a student in the Spring 2003 course. Of the nine teams formed in the course during the Spring 2003 semester, four have reasonable prospects of becoming viable companies, and these teams are seeking involvement with the incubator, technology transfer program and the VentureAccelerator.

5. Entrepreneurship Culture - Phase III

To complete the third phase of building a robust technology entrepreneurship culture, three new activities are being developed: A two-tiered VentureAccelerator including a new experiential undergraduate course and an Entrepreneurship Portal.

5.1. VentureAccelerator
With the long history of the campus incubator, the technology transfer program and other programs that have encouraged entrepreneurship since the 1980's, and the launch of the Hinman CEOs Program four years ago, the University of Maryland had developed a strong track record of using processes to incubate small numbers of regional early-stage companies, as well as assisting ambitious undergraduate students with interests in entrepreneurship. By capitalizing upon this experience, a new program, VentureAccelerator, is being developed to substantially extend entrepreneurship assistance to many more faculty and graduate students while providing an organized environment for talented undergrads to hone their entrepreneurial skills.

This initiative began approximately a year ago to provide a high degree of attention and support to qualified students and faculty seeking to form new ventures based on research or some other type of technical innovation. Services included executive recruitment, board development, business planning, strategic consulting, fundraising assistance, marketing analysis, and licensing negotiations. This part of the VentureAccelerator is now referred to as Tier II. It became apparent that an even earlier stage of accelerator was needed to guide a large number of fledgling entrepreneurs through market and competitive research and the development of business plans. This part of the VentureAccelerator is referred to as Tier I.

The two-tiered VentureAccelerator is designed to efficiently manage demand for mentoring and other services that will guide our faculty, student entrepreneurs, and small number of regional technology entrepreneurs through progressive steps to a successful technology venture. Tier-I, which will be the entry point for entrepreneurial teams at the concept stage, is in the planning stage and will become operational in Fall 2004. Tier-II, which provides extensive hands-on assistance, has been beta tested, and three case studies will be discussed later in this paper.

VentureAccelerator exhibits several unique characteristics. First, the processes supporting VentureAccelerator are rooted in commercial venture capital theories for cultivating new companies. These processes include levels of detail, flexibility, validation, and rigor uncommon in other university acceleration programs. Likewise, VentureAccelerator's comprehensive level of services is unique for a college-campus consulting organization. Finally and most importantly, VentureAccelerator provides undergraduate students not only an opportunity to be exposed to entrepreneurship but also gives them true hands-on training with fledgling companies in a supervised, highly-structured environment in exchange for valuable upper-level credits.

5.1.1 VentureAccelerator Process

The VentureAccelerator provides a milestone-driven path to venture formation. The tripping mechanism to entering the program is based on a detailed application. A standard review process is required for each potential company candidate, and once admitted; the companies are expected to remain in the program until demonstrating self-sustainability (usually evidenced by a significant institutional investment, customer engagement, and/or licensing arrangement) or failure to move forward. The VentureAccelerator uses a case-by-case method of selection based on evaluation criteria that include but are not limited to the following:

- Background and experience of the principals
- Competitive uniqueness and viability of the technology-based idea
- Applicants' commitment to the venture

Each candidate submits a formal application along with an executive summary. After review of the application which includes a pre-admission due diligence executed by the student E-Team, a VentureAccelerator admission committee will interview candidates.

5.1.2 Tier-I

A team-based pre-admission due diligence process will be performed by multi-disciplinary student-teams. To support the needs for due diligence and market assessment, a new experiential course for Hinman CEOs is being designed. This course serves two primary purposes: 1) to provide proposed startups with technical, market and business analyses and 2) to provide students with practical experience in analyzing startups.

The Tier-I is the entry point for companies at the concept stage. During this phase, the primary goal is validating the venture idea.   The idea is validated on three feasibility levels: technical, market and business. Repeatable processes are put in place so that student teams have clear guidelines to perform the due diligence. Students collect data which is then analyzed to determine the feasibility of the venture.

The VentureAccelerator Leadership Team is presently comprised four faculty and staff who spend part of their time on the VentureAccelerator. The leader is the Director of the technology incubator, and others on the leadership team are Associate Director of the technology incubator and the authors of this paper. Relationships have been established with many experienced professionals in the regional community who augment the leadership team by providing substantial mentoring services to the startup companies. These mentors come from legal, accounting, human resource, advertising and VC firms as well as faculty and staff of the business school and government and quasi-government entities.

 The process begins with mentoring and guiding process and services include:

- Providing business and strategic planning
- Providing assistance for market research
- Planning for launch
- Performing forecasting and financial analysis
- Recruiting boards of directors and other advisors
- Developing a marketing strategy and marketing materials
- Negotiating with licensees
- Advising the initial "technical" CEO
- Funding strategies.

Once the commercial potential is validated by conducting rigorous market and business research and analysis and technical feasibility of the product is established, the technologist can begin the processes of product design, bread boarding, testing, and pre-prototyping. If these steps are successful, then substantial customer feedback can lead to the final development of the product taking the technology through a final prototyping stage to alpha and beta testing.

5.1.3 New Experiential Course

To support the needs for due diligence, market, competitive assessments and business plan development, a special course is being designed. In this new course, students will provide assistance to the VentureAccelerator in gathering and analyzing data needed to assess applicant startups and to provide on-going information as the startups are admitted into VentureAccelerator and gain maturity. Students will follow faculty-developed templates that will lead them through standard processes for technical, market and business analyses.

Early in the semester, students will form into cross-disciplinary teams and will be assigned to specific projects, and the teams will be closely supervised by the VentureAccelerator management team and outside mentors.

5.1.4. Tier II

Entry into Tier II of the VentureAccelerator occurs at such time that the company has reached commercialization stage of product development. A typical Tier II company may have joined the campus incubator (TAP). With assistance from the VentureAccelerator Leadership Team, some of the significant events may have occurred such as recruitment of some of the executive team and an initial funding event. The success of thorough research and advising will have placed the company in a position to be developing a commercialization and growth strategy. VentureAccelerator companies are expected to "graduate" after achieving "self-sustainability," which is defined as acquiring their first major customer; acquiring first significant financing (equity, grants, etc.); and/or hiring key business executives.

5.1.4.1. Tier II Case Studies

Between October 2002 and October 2003, the VentureAccelerator program was tested with ten startups including student-founded and faculty-started companies, as well as firms initiated by regional entrepreneurs external to the university. Provided below is a synopsis of results for three such entrepreneurs and/or firms that have participated in the VentureAccelerator.

5.1.4.1.1. Student-Startup

Two graduate students from the university's mechanical engineering department presented proprietary geometric algorithms, that enable automated design of injection molds, to VentureAccelerator in November, 2002. Initially, VentureAccelerator, using full-time staff and student interns, conducted market analysis to confirm demand for automation within the mold manufacturing supply chain. VentureAccelerator recommended the students pursue the formation of a company and focus on developing easy-to-use software for mold design and manufacturing. The company, incorporated in early 2003, was subsequently guided by VentureAccelerator staff and students to develop a phased business plan contemplating prototypes, credible alpha customers, grant

funding, and supplemented advisors, including professional service providers and domain experts. At present, this company is executing the plan conceived by VentureAccelerator, and recently rolled out its alpha prototype. Reference customers include Black & Decker and other large mold producers. Likewise, the company is forecasting commercial sales in 2004, and has created a three-person advisory board which includes a potential full-time CEO. The company won the university's business plan competition as well as a $50,000 State of Maryland grant. Finally, the company is a candidate for the university's incubator program.

5.1.4.1.2. Faculty-Startup

A senior engineering faculty member presented unique thermal management (removing and transferring heat) technology, applicable to numerous industries, to VentureAccelerator in October, 2002. The faculty member had conducted some preliminary market analysis and obtained initial SBIR grant funding for prototype development. VentureAccelerator assembled a team of staff, undergraduates, and graduate students to advise this company. Initially, the team analyzed potential markets for and competitors of this technology and concluded high potential opportunities exist in semiconductor cooling and frost removal in transport freezers. Next, the multidisciplinary team developed a three-phased business plan for the professor. Phase one included using grant funding and R&D services revenues to support technology development, while Phase Two contemplated pursuing a license for the frost-removal application. Phase Three included rolling out chip-cooling modules for commercial sale. With a plan developed by the first quarter of 2003, the VentureAccelerator team proceeded to assist with execution. The team recruited a CEO from a similar, venture-capital-backed startup, who joined the firm in August, 2003. Likewise, the plan enabled the professor to focus his fundraising efforts on relevant grants, resulting in over $2 million in new grants in 2003 alone. At present, the company is four-to-six months away from negotiating its first license and is continuing technology development incident to commercial products using grant funds and service revenues.

5.1.4.1.3. Incubator Startup

The founder of a six-person, $1M revenue-per-year XML software company sought VentureAccelerator help in identifying and capitalizing upon growth opportunities beginning October, 2002. VentureAccelerator aggregated a team including an MBA student, multiple undergraduates, and one full-time staff person. First, this team analyzed the XML data market and concluded (a) significant opportunities exist to convert disparate data to XML if tools and services are easy-to-use and affordable; and (b) the market is a fragmented, "cottage-industry." Second, the team conducted business model financial analysis to determine whether the firm should sell software or services (fulfilled with software). The team generated a business plan with a five-year goal of $20M in annual revenue. The plan contemplated targeting systems integrators, government agencies, and commercial companies, namely in the insurance and publishing industries, where large volumes of unusually-formatted data exist. The plan further proposed the company adopt a services model and use software to continuously reduce costs-of-goods-

sold. With a plan complete, the team began execution. The MBA student implemented computerized accounting software and constructed sensitivity models and pricing templates. Other team members helped recruit a VP of Sales, who joined in the summer of 2003. With VentureAccelerator help and plan, the company will record over $3M in revenue in 2003 with over 20 employees on board. The firm is projecting $6M in revenue in 2004.

5.2. Entrepreneurship Portal

An entrepreneurship web portal is being planned which will contain information and tools linked into one site. The purpose is to provide faculty and students with information that will help them to access "best practices" associated with starting technology ventures. Types of links include:

- Template for forecasting revenues and income statements
- Business plan preparation guidance
- Intellectual property rules
- Information on funding sources
- Testimonials and case studies
- Fundamental legal resources

Over time, the web portal will evolve so that it includes information on most topics associated with starting a technology company and commercializing technology.

6. Lessons Learned

In developing and operating the programs discussed above, we have continuously looked for ways to improve them. Many detailed changes and improvements that may only apply to our university and region are not included in this paper; however, those of general importance that may be of help to other universities interested in initiating similar activities are discussed below. The reader may want to refer to Table 1 and Figure 1 for context.

6.1. MTECH Base Programs related to Entrepreneurship

Over the years some important revisions have been made in incubator and technology transfer programs. At first, contracts with incubator companies were negotiated on an individual basis. The main item for negotiation was the equity that the University would receive. As more companies were accepted into the incubator, it became apparent that too much time was taken up with this, and a standard contract was developed. This license agreement has been used successfully, and only a few qualified applicants have rejected the contract. Another important issue was formula for University equity and its relationship to the time at which companies moved out of the incubator into commercial space. The amount of equity that was settled on was 1% per year of occupancy. As companies grow and become successful, they become increasingly reluctant to give up

equity, and this becomes a forcing function to encourage them to make the move to commercial space.

Until recently, the incubator contract did not have a "put" clause. This became a problem because the majority of the graduate companies remained private firms; therefore, there was no mechanism, other than good will on the part of the companies, for the University to liquidate its equity. Now, the standard contract contains the "put right" that is exercisable at the earlier of: (1) a range or transactions including mergers and acquisitions or (2) two years after graduation. Typically in (1), the value of the company will have already been established, while in (2) an appraisal would have to be conducted. The contract contains a process for valuation.

Since the incubator is operated with a small staff (two professionals and an administrative assistant), another important lesson was to standardize as many processes as possible, including move-in, move-out, business and technical reviews, mentoring schedule, conference room signups, etc.

The University of Maryland incubator was the first one in Maryland, and now there are a dozen, and as a result competition for the best companies has increased and a good marketing plan is imperative. We have formed strong relationships with regional venture capital, legal and accounting firms that deal with startups, and these relationships provide good sources for incubator applicants.

Finally, it was found that even the best companies encounter barriers for which they don't have the experience to overcome. It was learned that relationships with regional professionals who were willing to provide substantial mentoring was important.

Several important lessons were also learned from operating the technology transfer program. Developing ways to satisfy University of Maryland policies for intellectual property, proprietary research and publications while also working with companies that are accustomed to exclusive licenses and publishing in a limited way, if at all, were major hurdles. As mentioned earlier, giving the companies the option for exclusive licenses in their markets and delaying publications for up to 12 months has proven to be satisfactory.

A second lesson was the need to actively manage the projects. Faculty members are accustomed to best effort research grants, while companies are used to closely following work statements. At the beginning, a few projects did not turn out to be satisfactory to the companies, primarily because of lack of communication between the faculty and graduate student researchers and the sponsors; i.e., the companies. To correct this problem, a process of holding a "kickoff" meeting at the beginning of each project and periodic progress meeting was instituted, and this has been effective. As with the incubator, it is necessary to use a standard contract, and companies know the rules and requirements before deciding to submit a proposal.

6.2 . Technology Entrepreneurship Programs

One of the lessons learned that applies to all of our technology entrepreneurship activities is that there is a substantial gap between the place where these tech startups begin and the point where they can begin to be of interest to venture capitalists. We learned very early that presentations by VC's tended to be very much over the heads of students and faculty who were in the beginning states of getting tech ventures going. Information about how to get started with small amounts of funding from business plan competitions, friends, family, credit cards and other forms of bootstrapping was much more relevant.

Since one of the most important aspects of the Hinman CEOs Program is the community in which strong bonds are formed among diverse students, it was necessary to introduce team forming, creativity and social aspects to the program. Among these were: a team building workshop conducted by a group of engineering faculty; a creativity workshop conducted by a faculty member from another university and a ropes course exercise to promote students learning to trust one another, and various informal social activities such as ice cream and informal gatherings on Sunday evenings. These activities have helped to build a stronger community which has become a true benefit over time. We also keep the size of the program small to keep the community tight-knit. When students know everyone in the program, this helps their sense of community.

The original target audience in the Hinman CEOs was primarily juniors and seniors; however, soon after beginning the program, we discovered that we should accept exceptional sophomores. The advantage of admitting students as sophomores is the increased amount of time they have to learn skills and then pursue ventures. Typically, the first year of the program, students are learning and exploring. The additional year in the program that students admitted in their sophomore year have provides these students with time to explore, plan and conduct research, and then execute their ideas. This is especially important with technology ideas that take time to research and develop.

Another lesson learned with the Hinman CEOs Program has been to offer a credit course associated with the weekly activities. In the first year of the program, the weekly seminars were voluntary. These entrepreneurial students are especially busy and having a credit course on their academic schedule has helped them to budget their time to include attending the important educational activities within the program.

Finally, we have had to address issues related to the students' pursuit of a wide set of majors. The Smith School of Business has been offering an Entrepreneurship Citation Program consisting of four courses. Most of the business majors who are CEOs and some students in other majors can fit those courses into their schedule, and these academic courses have been beneficial to those students; however, engineering students typically can't fit four additional courses into their already demanding schedule. As a result, one of the problems faced in the Hinman CEOs Program is dealing with this disparity. The solution will be the introduction of one, three-credit, course for CEOs. This course will have similar content to the Fundamentals of Technology Startup Ventures which is currently offered to graduate students.

The Technology Startup Boot Camp has been particularly successful, and has been refined over the three year period. Even though some of the modules are suitable for panel discussions, our experience is that, except for the entrepreneurs' session, lecture style presentations work best. Each attendee getting a book with all of the material presented during the boot camp reinforces assimilation of the presentation content. Networking and helping fledgling entrepreneurs to begin developing a "rolodex" are also important aspects of the boot camp and are facilitated during breakfast, lunch and at the end of the program. Most of the regional professionals are willing to answer questions and provide advice subsequent to the event.

An additional aspect of the Technology Startup Boot Camps has been the understanding gained over time that many of the potential ventures are more suitable for grant, debt and other non-VC financing strategies. The last session of the event is a panel discussion by successful entrepreneurs at various stages of company development. For example, three of the panelists this year were the winner of the previous year's business plan competition, a faculty entrepreneur and the CEO of a highly successful incubator company that had followed a bootstrapping strategy. Demonstrating various ways of moving a venture forward helps fledgling entrepreneurs to realize that progress can be made without VC funding, at least up to a point.

A final benefit of the Technology Startup Boot Camp is the involvement of venture, legal, accounting and entrepreneurial communities in our activities. This interaction has been quite effective. Representatives from those communities have tremendous knowledge to impart, and they enjoy interactions with faculty and students. Needless to say, they also see them as future clients.

The Technology Ventures club (TVC), the graduate entrepreneurship club, has generally worked well; however as we further develop the initiative, we believe that involving more faculty could be beneficial.

As we have developed a robust entrepreneurship program, and as new elements of the program were developed, the need for an integrated continuum of activities, such as that shown in Figure 1, became evident. It is not enough to provide entrepreneurship education for students and faculty and encourage them to start ventures without providing the infrastructure and support to help them overcome barriers. Filling this gap with the VentureAccelerator was vital to leading entrepreneurial students and faculty smoothly from idea to sustainable venture.

Since both human and financial resources are limited, it has become imperative to install as many "standard" processes as practical to guide entrepreneurs to the level where they warrant personal assistance. VentureAccelerator Tier I and the Entrepreneurship Portal both follow this approach.

Although some engineering and other technical graduate students were generating technology with commercial potential through the conduct of their masters and PhD research, and they were interested in starting ventures, almost none of them had been

exposed to even the most basic concepts needed to make progress. We found that a rigorous, experiential one-semester course, now regularly offered through engineering and supplemented with activities such as the Technology Ventures Club, has been enough to get them to a point where they can take advantage of the many services within the University and in the region to grow into becoming an entrepreneur. With the addition of the VentureAccelerator Tier I, the gap is being filled between getting that initial education and actual launch. Tier II adds a new level of support that increases the probability of success with a fledging venture.

7. Summary

This paper has discussed a comprehensive set of programs and activities in operation or being planned at the University of Maryland. All of these initiatives, except the multi-disciplinary Hinman CEOs Program, are designed specifically for students and faculty in engineering and other technical disciplines. Four of the programs have been in operation for nearly 20 years, while the purely entrepreneurship initiatives are relatively new. The overall MTECH program provides a continuum of programs and activities to build a robust tech entrepreneurship culture, to support new technology ventures and to strengthen existing companies. These activities are having a large impact on the technology entrepreneurship culture of the campus as well as the economy of the State of Maryland. While some of the programs require substantial funding, many do not, and we believe that our approach and many of these activities are transferable to other universities and that the lessons that we have learned may be useful to others.

The impact of the programs discussed, especially the ones that have many years of operation, is clear and strong. For details, see the web sites provided in the last item of the bibliography.

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