

WISCONSIN ECONOMIC SUMMIT 2000
WHITE PAPER

TECHNOLOGY & ECONOMIC DEVELOPMENT:
HIGH-TECH BUSINESS CLUSTERS

By

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SUMMARY STATEMENT

This white paper is based on a recent comprehensive academic study, performed by the author, that provides an historical perspective and an analysis of key factors that contributed to the creation and growth of a regional high-tech business cluster developed in close association with the University of Wisconsin-Madison in Dane County, Wisconsin.

The analysis provides the first quantitative data and insight into the dynamics involved that brought about this high-tech cluster formation in Wisconsin. Development of high-tech clusters is, in many states, a major strategy to make the commercialization of technological innovations a key element of economic growth. In this respect, Wisconsin is at the threshold of building a high-tech cluster base. As a homespun high-tech industrial cluster model, the UW-Madison/Dane County experience should provide a framework for the State's decision makers as they contemplate cluster formation and other strategies needed to enhance Wisconsin's competitive advantage in meeting economic development challenges and opportunities that confront the State in the *New Economy*.

Also offered are specific recommendations and commentary for developing diverse regional cluster formation in Wisconsin as part of a comprehensive strategy that makes full use of one of the State's major resources, *intellectual capital*. Within high-tech clusters, breadth and balance are important. Since no two regions face identical challenges in instituting economic change through cluster creation, each region needs to develop an approach that builds on current and potential strengths and adapts to specific regional economic, social and political circumstances.

Disclaimer

This white paper is based, in part, on an independent study conducted by the author ("Creating High-Tech Business Growth in Wisconsin: UW-Madison Technology Transfer & Entrepreneurship," published in 1999) and sponsored by the office of University-Industry Relations, The Graduate School, University of Wisconsin-Madison. All opinions expressed in this white paper are solely those of the author and do not necessarily represent those of the University or The University of Wisconsin System.

BACKGROUND ON HIGH-TECH CLUSTERS AND ECONOMIC DEVELOPMENT

A state's complement of science and technology institutions is an integral part of economic development plans and strategies in many states—typically technology is leading economic growth through creation of high-tech clusters (1). As noted by DeVol (2), "policy makers from Jerusalem to Kuala Lumpur are trying to clone Silicon Valley." High-tech clusters can be defined briefly as a regional agglomerations of interrelated entrepreneurial firms and other organizations such as research universities, suppliers, and service providers that collaborate and in many instances compete to bring technological innovations to the marketplace. These clusters often focus on commercializing specific technological innovations such as those in biotechnology, computer science, and medical devices and instrumentation. It is not uncommon to find that the focus of the regional cluster mirrors the strengths of a nearby research university.

States that have made major long-term investments in their research universities have the most successful high-tech clusters—such as Silicon Valley, Austin, Phoenix, San Diego, and Research Triangle Park. In addition, according to a recent National Governor's Association report on Using Research and Development to Grow State Economies (3), 29 of the top 30 high-tech regions in the U.S. are closely associated with a "highly rated research university."

This white paper provides an analysis of emergence, growth, characteristics, and key factors contributing to the formation of the UW-Madison associated regional high-tech cluster located primarily in Dane County, Wisconsin. This paper is based on a recent comprehensive academic study, performed by the author (4), that provides an historical perspective and an analysis of key factors that contributed to the creation and growth of high-tech businesses included in this cluster.

The analysis provides the first quantitative data and insight into the dynamics that brought about this high-tech cluster formation in Wisconsin. As mentioned previously, development of high-tech clusters is, in many areas, being evaluated as a strategy to make the commercialization of technological innovations a key element of economic growth. In this respect, Wisconsin is at the threshold of building its cluster base. As a homespun high-tech industrial cluster model, the UW-Madison/Dane County experience should provide a framework for the State's decision makers at this 2000 Economic Summit as they contemplate cluster formation and other strategies needed to enhance Wisconsin's competitive advantage in meeting economic development challenges and opportunities that confront the State in what is commonly referred to today as the *New Economy*.

Also offered are specific recommendations and comments for employing regional cluster formation in Wisconsin as part of a comprehensive strategy that makes full use of one of the State's major resources, its *intellectual capital*.

EMERGENCE OF UW-MADISON ASSOCIATED REGIONAL HIGH-TECH CLUSTER

The University of Wisconsin's potential to boost the state economy was recognized at least as far back as 1866, when the Wisconsin Legislature designated the University as a land-grant institution. The same concept was reformulated memorably in the early years of this century by university president Charles Van Hise as the "Wisconsin Idea"—the idea that "the boundaries of the university are the boundaries of the state."

Technical assistance provided by University experts is one of the most direct expressions of the Wisconsin Idea. Over the years, UW-Madison has established an enviable record of contributions to agriculture and other industries through the introduction of new products and processes including diversified dairy, livestock, and farm produce; management and mechanization techniques; and industrial manufacturing improvements from quality control to new materials applications to automation and robotics for the production of high-quality durable goods. It continues this tradition today in the so-called

New Economy by creating technological advances that translate into high-tech innovations that are commercialized by the private sector into new products, processes, and services for the social good.

Recognizing the rapid pace of technological advancements that began during the latter part of the 20th Century, UW-Madison established a variety of programs that facilitate interaction between industry and the campus, ranging from technology transfer and industrial liaison offices to numerous University-industry research consortia. These programs provide technical knowledge needed to enhance industrial competitiveness and have resulted in increasing university-industry research partnerships and commercialization of new products and processes.

This white paper, will highlight UW-Madison's key role in establishing what appears to be the first major high-tech cluster in Wisconsin and subsequent economic impact, *i.e.*, that attributable to its campus scientific and engineering research, technology transfer, university-industry cooperative research, and the promoting of entrepreneurship in the creation and growth of high-tech business ventures in Wisconsin especially over the past two decades. I believe the activities described here represent some of the University's most powerful contributions to Wisconsin's current and future economic vitality. UW-Madison, as one of the nation's leading public research universities, is a vital resource to produce the scientific and engineering knowledge base for emerging technologies to fuel a growing high-tech business sector.

UW-Madison's annual research expenditures, currently exceeding \$475 million, support thousands of research projects across campus. It is a major *engine of inventive research*. Many of the research projects produce the knowledge and discoveries that lead to technological advances in the physical and life sciences, medicine, and engineering. And many of these advances are going directly into Wisconsin's businesses and industries.

Today, technology transfer — the process of moving technological advances into the private sector, where they can be commercialized to produce new products and processes or used to improve existing ones — increasingly is being recognized as a legitimate role, indeed an obligation, of large research universities. Unless new technologies are brought to market, they typically can not benefit the economy or society in general. Rapid commercialization of innovative technologies and early market entry are critical to economic competitiveness and industrial growth. Small high-tech firms excel producing, as well as, rapidly commercializing university and their own technological innovations.

The cumulative economic benefits of university technology transfer are enormous — and growing rapidly. Based on an examination of licensing revenues, a recent survey by The Association of University Technology Managers (AUTM) (5) estimated that in FY1997 alone, transfer of university technologies nationwide through licensing activity accounted for nearly \$28.7 billion of U.S. economic activity supporting nearly 246,000 jobs. Approximately 60% of university inventions are licensed to small businesses.

UW-Madison consistently ranks among the top tier of U.S. universities in terms of both number of patents awarded and amount of royalty payments and licensing fees received. In fiscal year 1997, UW-Madison received 69 U.S. patents and more than \$17 million in gross licensing income (5).

The AUTM survey also reported that whereas total gross income from licenses and options increased by 18 percent over FY 1996; the formation of new start-up companies based on licenses from academic institutions increased by 34 percent. *The latter finding suggests that new company formation is the fastest growing sector within academic technology transfer activities.*

The importance of university-developed technologies and university-based technology transfer programs has, within the last decade, become an acknowledged major contributor to a state's economic development. Traditional economic impact statements, in the past, often overlooked the stimulus that outcomes from basic research and technology development provide for entrepreneurship in high-tech enterprises and for industrial and economic development in general.

Other potent contributions — similarly often overlooked and difficult to quantify — include the university's role in attracting business and industry to Wisconsin, the so-called "magnet effect;" the "knowledge spillover" through technical and business assistance provided by faculty and staff on a daily basis to Wisconsin's business and industrial sectors; the new commercial products and processes created as a result of technology and knowledge transfer, together with tax revenues generated and jobs created or sustained; and the training of our graduates, who bring new technical knowledge to many tech-based firms in Wisconsin each year.

For more than three decades, the University-Industry Relations office (UIR) of UW-Madison's Graduate School has served the University as the primary point of contact for industrial liaison. UIR provides access to the vast technical resources available across campus and directly assists in technology development, the transfer of technologies to Wisconsin's private sector, and the start-up of high-tech enterprises. It is from this base of knowledge and experience, supplemented by additional research and surveys, that UIR staff first undertook a project to shed some light on the interactions of research outcomes on the industrial and economic development of Wisconsin. Study findings were published in "The Campus, Technology, & Wisconsin: A Look at UW-Madison as a Catalyst of Industrial and Economic Development," (P.Z. Sobocinski, 1993).

The findings of a follow-up study was the subject of a second publication "Creating High-Tech Business Growth in Wisconsin: UW-Madison Technology Transfer & Entrepreneurship," (P.Z. Sobocinski, 1999) and forms the core of this white paper. Research and data collection for the latter study was performed from May 1996 through January 1999 and covered a forty year period, 1959-98. Since the subjects and assessments covered in the study are in a dynamic state, the data and findings presented represent only a snapshot of the situation during this period and are indicative of trends present during the performance of the study.

This paper focuses on several key parameters that include circumstances and conditions that contributed to the:

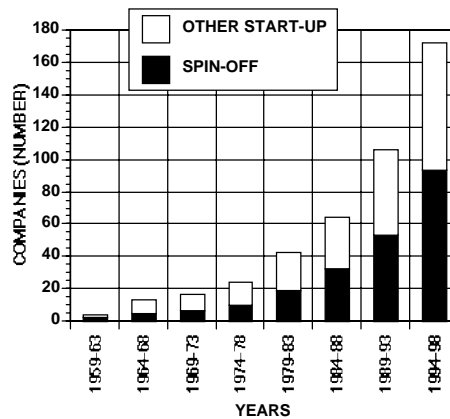
- **Creation and growth of spin-off companies, conservatively defined as start-up companies in Wisconsin whose basis is technology that arose directly from UW-Madison research.**
- **Formation and growth of other technology-based start-up companies in Wisconsin created by campus faculty, staff, students, or alumni to commercialize technological innovations. In this instance, many of the innovations being commercialized arose not as a direct result of campus research, but rather from the company founder(s): 1) trying an ancillary scientific approach to their primary campus research effort; 2) conceiving novel commercial application(s) of specialized academic training; and 3) identifying commercially viable technical solutions to federal, industrial, and business needs.**

• **Contribution of technological innovation to industrial and economic development through the support of basic and applied research, technology transfer, and the commercialization of new products and processes for the social good, stimulated by the joint efforts of UW-Madison's office of University-Industry Relations (UIR), the Wisconsin Alumni Research Foundation (WARF), and the University Research Park (URP).**

GROWTH OF HIGH-TECH COMPANIES

A total of 178 Wisconsin technology-based spin-off and other start-up companies whose origins are tied intimately to UW-Madison were identified in the study. Several of these firms were established in the early 1900s. Most of the firms (171) were created over the last four decades. The phenomenon of new business creation in high-tech areas through spin-off or other start-up activities has increased significantly in recent years. Figure 1 shows the cumulative number of firms.

Figure 1. Cumulative growth of UW-Madison spin-off and other start-up companies for the past 40 years (n=172).



Of the 178 total firms, spin-off firms (97) slightly outnumber the amount of other start-ups (81). The greatest rate of growth of these firms has occurred over the past approximately 15 years (Fig. 2). For the last five years, an average of approximately 13 new firms were created per year (range, 10-17 companies per year).

Figure 2. Comparison of the average rate of growth of UW-Madison spin-off and other start-up companies during five-year intervals for the past 20 years (n=148).

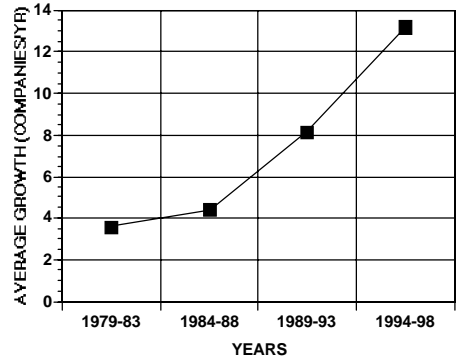
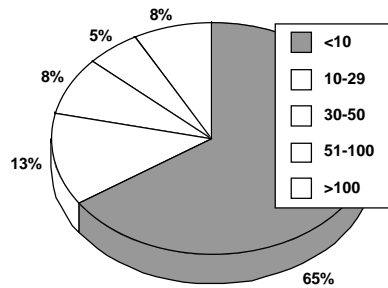
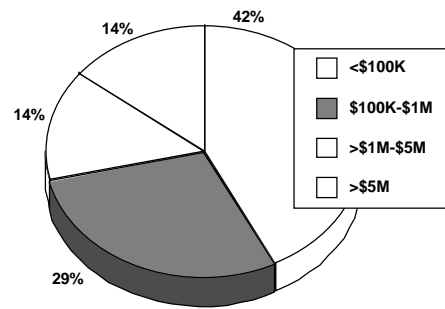


Figure 3. Distribution of the estimated number of employees of UW-Madison spin-off and other start-up companies in Wisconsin (n=137).



Currently, these firms employ over 6,700 people (estimated) in Wisconsin, mostly professionals and skilled support staff – many of whom are UW-Madison graduates. The majority of firms are small with less than 10 employees (Fig. 3).

Figure 4. Distribution of gross revenues of UW-Madison spin-off and other start-up companies in Wisconsin (n=139).



Of the 147 companies that reported revenues in our survey, 71 percent have annual gross revenues less than \$1 million, reflecting the relatively young age of the majority of firms (Fig. 4). However, according to the most recent data available, firms identified in the study had aggregate gross revenues of \$1.01 billion.

Table 1. Comparison of the number and percentage of new firms formed during the 10 year period, 1989-98, according to company category (biological or physical sciences) and type (UW-Madison spin-off or other start-up).

	NEW FIRMS	SPIN-OFF	OTHER START-UP
BIOLOGICAL	61 (57%)	42 (68%)	19 (42%)
PHYSICAL	46 (43%)	20 (32%)	26 (58%)
TOTAL	107 (100%)	62 (58%)	45 (42%)

Overall, more than half (93), or 52 percent, of the 178 companies created over the past several decades and identified in this study had their technologies and product applications oriented primarily to the biological sciences. However, based on the data obtained for the last 10 years (shown in Table 1), 57 percent of firms created have their origins in the biological sciences. This finding is considered more indicative of the current trend. In addition, firms with their origins in the biological sciences constituted the greatest proportion (68 percent) of the total UW-Madison spin-off companies formed in the last 10 years.

This growth in spin-off companies in the biological sciences (biotechnology) is outpacing that of spin-offs in the physical sciences by more than two-fold; firms with origins in the physical sciences, however, created slightly more start-up firms during this period. These findings may forecast a continued higher spin-off growth in the biotechnology sector. *However, during the same ten year period, the overall average annual growth rate of firms based primarily in the physical sciences is occurring at an essentially similar yearly growth rate of bioscience firms.*

It should be pointed out that the primary designation of a firm as having its origin in either the biological or physical sciences is becoming more arbitrary than in the past. Many of the firms being created today are multidisciplinary rather than strictly biological or physical sciences related. This is especially true in firms engaged in biotechnology and software development which mix disciplines frequently. Thus, the distinction between these categories is becoming

blurred.

The vast majority of UW-Madison spin-off and other start-up companies in Wisconsin have been quite successful. Study findings shown in Table 2 indicate that less than 9 percent (n=16) of the 178 identified firms created over the past several decades are no longer operational. About 11 percent (n=20) have been partially or totally acquired. The vast majority of acquired firms remained in Wisconsin. Approximately 1 percent (n=2) of non-acquired firms moved out of Wisconsin. *Once created, most of the high-tech firms stay in Wisconsin.* Further, more than 98 percent of spin-off and other start-ups cluster in Dane County, most within an hour travel time of UW-Madison.

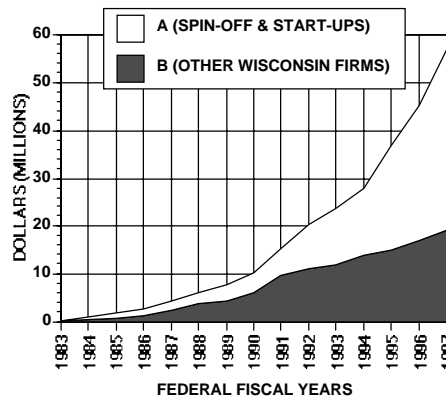
Table 2. Outcomes of the 178 UW-Madison spin-off and other start-up companies identified in the study.

	NUMBER OF FIRMS	PERCENT
RELOCATION: OUT OF STATE	2	1.1
ACQUISITION: NO RELOCATION	17	9.5
ACQUISITION: WITH RELOCATION	3	1.6
DISSOLUTION	16	8.9

The technology base of the new firms reflect the strengths of UW-Madison’s research program and, in many cases, the entrepreneurship of the university’s faculty, staff, students, and graduates. In fact, 97 of total 178 companies identified in this study are true spin-offs — that is, they were created specifically to commercialize technologies arising from UW-Madison research, whereas 81 other start-up firms were created to commercialize technologies not directly related to any specific campus research projects. Many of the 81 start-ups are developing innovative ideas that their entrepreneurial founders conceived independent of their research program and undertook the formation of a start-up company to demonstrate technical and commercial feasibility efforts that cannot be readily addressed in the university laboratory setting – either because the work is considered too applied to obtain federal funding support or is beyond the scope or capacity of their current academic research program.

There is little doubt that these entrepreneurial founders of spin-off and other start-up companies begin to develop new knowledge and commercialization strategies stimulated, in large part, by the opportunity to fund the effort to demonstrate technical feasibility and develop commercial prototypes with federal small business set-aside programs such as the Small Business Innovation Research Program (SBIR). In fact, the SBIR and the federal companion set-aside program, the Small Business Technology Transfer Program (STTR), were, and continue to be, critical sources of high risk "seed" capital to UW-Madison's spin-off and other start-up firms within the UW-Madison high-tech cluster . No other source of seed venture capital has invested as much in these Wisconsin companies. In federal fiscal year 1997, Wisconsin ranked 25th nationally in capturing SBIR awards. About 67 percent of the cumulative total SBIR and STTR funds awarded to Wisconsin small businesses, since 1983, went to UW-Madison related spin-off and start-up companies (Fig.5).

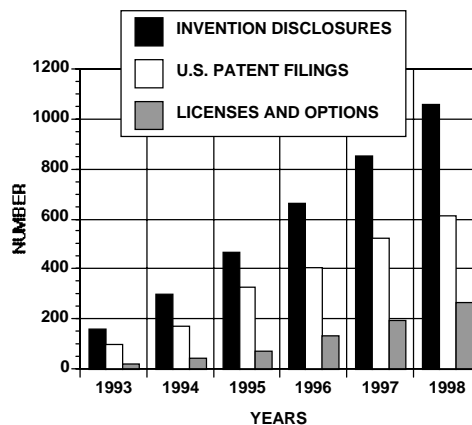
Figure 5. Cumulative total annual federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program research funding awards to UW-Madison spin-off and other start-up companies (A) compared to other State firms (B) for the past 15 years



Growth of these new high-tech ventures over the past two decades is due, in part, to the:

- **Rapid pace and scope of scientific discoveries (disclosures) and patenting and licensing activities in the biological and physical sciences occurring at UW-Madison. Figure 6 shows the cumulative number of disclosures, patent filings, and licenses and options.**

Figure 6. Cumulative number of UW-Madison invention disclosures, U.S. patent filings, and licenses and options processed by the Wisconsin Alumni Research Foundation (WARF) for the six year period shown.



- **Support by UW-Madison leadership for campus entrepreneurial programs and activities that encourage entrepreneurship.**

- **Availability of scarce seed capital to small high-tech firms to commercialize technological innovations (especially through the federal SBIR, STTR, and the federal Advanced Technology Program (ATP) funding opportunities).**

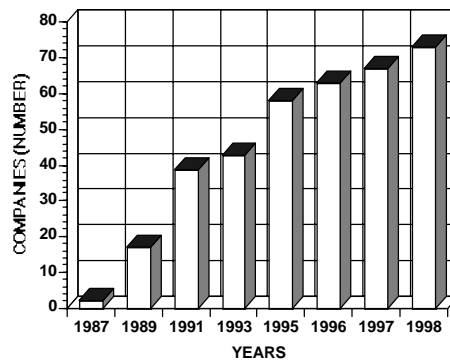
- **Creation of the Bayh-Dole Act (P.L. 96-517, December 12, 1980) which allowed universities and small businesses to patent and license their discoveries that were funded by federal sources.**

- **Expanding awareness by faculty, staff, students and alumni to high-tech market opportunities.**

- **Establishment of an initial critical mass of high-tech enterprises within an entrepreneur friendly environment (culture not adverse to risk-taking) and supportive infrastructure (including a major research university, accounting and legal firms specializing in small business high-tech issues, high quality of life, an available angel capital network, skilled labor pools, and regulatory and tax policies that promote high-tech ventures and investments).**

- **Access to "incubator" and other specialized facilities and resources such as that provided by the University and the University Research Park (URP). (See URP growth, Fig. 7)**

Figure 7. Cumulative growth of companies residing in UW-Madison's University Research Park during the period shown



These contributing factors may drive the growth of technology-based spin-off and other start-ups to new highs. However, it is unlikely that the trend to an increasing rate of growth combined with a relatively low failure rate can be sustained without some major changes in the local and regional entrepreneurial environment. Such changes include:

- **Improved access to early start-up (seed) and other levels of venture and private ("angel") investment capital necessary to proceed beyond seed stage to actual commercialization.**

- **Continued availability of low-cost incubator and other facilities.**

- **Greater supply of skilled technical and management personnel.**

- **Increased educational opportunities in high-tech venture entrepreneurship.**

- **Continued improvements in State, regional, local government, and university infrastructure and policies that promote entrepreneurial activity and research partnerships between academia and the technology-based small business sector.**

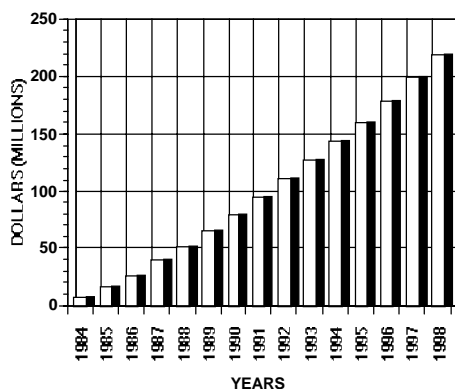
The potential for growth in new venture creation in the Madison area was noted in the results of a study performed more than seven years ago, “Entrepreneurial Hot Spots: The Best Places in America to Start and Grow a Company,” (September 1993, Cognetics, Inc., an economic research firm in Cambridge, Massachusetts), which ranked the Madison area fourth among small metropolitan areas in the United States. The report lists the presence of universities as the first of several factors that will be key to the “entrepreneurial hot spots” of the future (other factors included quality of life and a positive entrepreneurial culture). I would add the other factors discussed above to that list.

OUTCOMES FROM BASIC AND APPLIED RESEARCH

Novel technologies developed in the laboratory often lead to new products and processes in the marketplace. A variety of research grant and contract programs are available to help turn promising research ideas into valuable applications, ranging from new disease-fighting agents to enhanced manufacturing processes. UW-Madison has ranked consistently in the top tier of U.S. universities, based on total research expenditures from federal and other sources. As such it constitutes a powerful research engine producing the innovations that fuel the process of translating discoveries into economic outcomes (technology transfer) in the commercial sector for the social good.

One critical form of this technology transfer occurs through the patenting and licensing activities of the Wisconsin Alumni Research Foundation (WARF). These activities produce the critical revenue stream which further fuels UW-Madison's ability to broaden its basic research activities and to explore new frontiers. Over the past 15 years, WARF has provided a total of nearly \$220 million in unrestricted research funds to the campus (Fig. 8).

Figure 8. Cumulative dollar amount of Wisconsin Alumni Research Foundation (WARF) annual general research grants to UW-Madison for the 15 year period shown.



In addition to federal, UW Foundation, WARF, industrial and other sources of basic research funding, the UW-Madison is involved in several programs dedicated to promoting economic development through the support of applied research.

These programs include a UW-Madison grant program sponsored by State funds, specifically to support campus research having potential benefit to industrial and economic development in Wisconsin. Other program funding opportunities include cooperative research efforts between a Wisconsin technology-based small business and the University, such as the federal SBIR, STTR, and the Cooperative Research and Development (CRADA) program

(involving various federal laboratories, industry, and university partners) to commercialize technological innovations. In many instances, State funds are highly leveraged with funding provided by these and other extramural sources.

For more than 35 years, the office of University-Industry Relations (UIR) in the UW-Madison's Graduate School, has awarded State-funded grants to campus researchers to support research that is technically innovative, of interest to a broad economic sector, and has a high potential to benefit Wisconsin's industrial and economic development in the near term. UIR receives approximately \$925,000 each fiscal year from the UW-Madison Graduate School in State support for research projects. These funds are made available to UW-Madison faculty and academic staff in a variety of fields through the UIR's competitive Industrial and Economic Development Research Program (I&EDR). Researchers from all disciplines are eligible for UIR funding, although the majority of grants go to those in agricultural, physical, and biomedical sciences.

Most I&EDR grants are awarded as seed money to support early stages of applied research. Typically, these one-year grants are modest and can range from about \$5,000 to a maximum of \$50,000. UIR currently awards close to 40 grants each year. These grants often allow campus researchers to generate additional public and private-sector support for their research programs, engage in innovative research, and promote technology transfer between the University and Wisconsin industry. Several UIR-funded projects have led to the formation of university-industry research consortia or new Wisconsin companies.

The results of a most recent (1996) survey of UIR grant recipients are summarized below. This survey provides a snapshot of a continuum that spans more than three decades.

*Key Outcomes of UIR Grants Sponsored by State Funds and Awarded during Fiscal Years 1985-86—1994-95**

- **31 patents awarded, 31 pending**
- **1 patent awarded per \$81,379 invested by UIR**
- **9 spin-off companies formed**
- **Every \$1 invested by UIR returned, on average, over \$10 in subsequent funding**
- **Over 231 scientific and engineering articles published**
- **Approximately 1,097 students benefited through educational training**

*231 grants totaling \$2,522,742 supported 174 projects. Data were obtained for 81.2% of 174 projects.

As this 1996 survey data indicates, UIR grants have led to an extraordinarily high level of patent activity, with one patent being generated for every \$81,379 invested by UIR. Such results far exceed the commonly accepted guideline: "A technology transfer program should expect five disclosures [the initial step which might lead to a patent application] per \$10 million in research support" ("A Study of Selected University Technology and Technology Transfer Programs," Research and Sponsored Programs of Indiana University-Purdue University at Indianapolis, July 1990). In addition, the grant program has a return on investment of 10 to 1. The fact that these State dollars are well spent is obvious – programs such as this are rare within academia. UW-Madison is fortunate to have these dollars available to award on a competitive basis so that the most innovative ideas can be translated into positive economic outcomes. Accountability is critical to success.

UW-Madison, through UIR, also actively assists Wisconsin firms in competing for federal and state grants and contracts for technology development and commercialization. In the first 15 years of the highly competitive federal SBIR and STTR Programs, from 1983 to 1997, Wisconsin companies won more than \$57 million. Their success is due in part to the assistance of university partners, and UW-Madison continues to be active in providing such assistance. These data are

indicative of the competitiveness of these firms for federal R&D dollars and the outstanding quality and commercial potential of their technological innovations.

A STRONG TECHNOLOGY TRANSFER SYSTEM

UW-Madison's technology transfer strength is built on three diverse and highly specialized and experienced organizations working in concert to move University developed technological advances from the laboratory to the marketplace – The Graduate School office of University-Industry Relations (UIR), University Research Park (URP) and, the Wisconsin Alumni Research Foundation (WARF).

THE OFFICE OF UNIVERSITY-INDUSTRY RELATIONS

UIR has, for the past 38 years, been the primary campus liaison to small as well as large businesses and the UW-Madison office designated to receive campus invention disclosures. Its mission is to establish the most productive relationship possible between the private sector and the UW-Madison by:

- building productive research partnerships in basic and applied research**
- promoting technological innovation and assisting in technology transfer for the social good, and**
- fostering local, regional and national industrial and economic development**

UIR offers detailed knowledge of resources and expertise across the UW-Madison campus. It also offers experience in promoting many kinds of university-industry relationships — from simple one-time referrals to technical research briefings for individual companies, to industry-sponsored research arrangements with University researchers. To facilitate sponsored research, UIR maintains the campus gateway to Community of Science (COS) databases, which match campus research expertise to funding opportunities available from federal, industrial, and foundation sponsors.

It also plays a major role in promoting and facilitating joint university-industry-government research partnerships through federal and state programs, such as the federal Small Business Innovation Research Program (SBIR), Small Business Technology Transfer Program (STTR), Cooperative Research and Development Agreements (CRADAs), and the State-sponsored Technology Development Fund (TDF).

The Robert F. Draper Technology Innovation Fund (TIF) is managed by UIR and administered by UW-Madison's Graduate School. Funding is provided by revenues generated from the licensing of University discoveries by the Wisconsin Alumni Research Foundation (WARF). Funds are available to UW-Madison faculty and staff with permanent principal investigator status, to support the additional research often necessary to bring new UW-developed concepts and inventions to the patent and licensing stage. Activities eligible for TIF support include prototype development, preparation of samples for test and evaluation, and other research projects that enhance the scope of patent protection for inventions or their potential licensing to the commercial sector.

UIR seeks inventions from University faculty, staff, and students and advises inventors on the disclosure process. It is the University office that is charged with receiving all invention disclosures and performing equity reviews to determine ownership interests. Upon completion of its disclosure responsibilities, UIR works closely with inventors and WARF, the University's patent and licensing organization, to further the process of bringing inventions to the marketplace for the social good.

UIR administers an annual competitive grants program (mentioned above) to support research conducted by campus principal investigators that is technically innovative, of interest to a broad economic sector, and has high potential to benefit Wisconsin's industrial and economic development in the near term. Funding for the Industrial and Economic Development Research Program (I&EDR) is provided by the State of Wisconsin.

In economic development, UIR works closely with the University Research Park, WARF, the Wisconsin Department of Commerce, and other public and private organizations to promote the commercialization of technological innovations and the start-up of entrepreneurial ventures. UIR advises and assists campus entrepreneurs, as well as, new and established Wisconsin technology-based companies in partnering with UW-Madison researchers. These partnerships can be funded by SBIR/STTR and other federal and state programs. Assistance is available in agricultural, biomedical, physical sciences, and engineering topics.

THE WISCONSIN ALUMNI RESEARCH FOUNDATION

The Wisconsin Alumni Research Foundation (WARF) is a separate non-profit entity serving, since 1925, the patenting and licensing needs of UW-Madison. It is the first of its kind amongst U.S. academic research institutions. Recently, a subsidiary organization was established to serve The System needs in intellectual property matters.

WARF is a non-profit organization designated to receive and license to industry new discoveries made by University of Wisconsin-Madison researchers. WARF matches University discoveries and knowledge with commercial industry needs, resulting in new products marketed to benefit mankind. Proceeds generated from licensing to industry are used to provide appropriate financial rewards for inventors and fund further research at UW-Madison.

Since WARF's inception, 75 years ago, its revenues from licenses and investments have enabled it to contribute over \$415 million in grant support to UW-Madison. WARF grants principally provide direct research support but also new research facilities and research equipment. In the last 15 years alone, WARF provided nearly \$220 million in unrestricted research grants (See Fig. 8).

Faculty, staff, and students have strong incentives for entrusting their discoveries to WARF for licensing. WARF has a long record of patenting and licensing success. Its staff is skilled in protecting intellectual property, identifying appropriate markets for the technology and negotiating appropriate licenses. WARF also has a commitment to enforce its patents against infringement. In addition, WARF offers educational and consulting programs to encourage researcher's participation in this program, which is the oldest and most successful university-industry partnership in the United States.

UW-Madison and WARF consistently rank within the top five university sources of technologies and licenses for industry. Since fiscal year 1993, WARF has received more than 1000 invention disclosures, filed 617 U.S. patent applications, and executed 266 licenses and options (See Fig. 6). Many of the spin-off firms highlighted in this publication include those created to commercialize some of these innovations. *Revenues from gross worldwide sales of products produced under WARF licenses are more than \$1 billion.*

THE UNIVERSITY RESEARCH PARK

The University Research Park (URP), also a non-profit separate entity, provides state-of-the-art facilities available to both spin-off and other start-up firms as well as more established scientific and engineering firms and various service providers. Three miles from the UW-Madison campus lies URP, which is now home to 88 Wisconsin companies employing approximately 2,500 people.

The URP's primary mission is to serve as a conduit for transferring technologies from the campus to the private sector for the mutual benefit of all. It provides an atmosphere custom designed to nurture a productive combination of economic and technological development. In 1996, the Association of University Related Research Parks awarded UW-Madison's University Research Park the coveted "*Outstanding Research Park Achievement Award*."

University Research Park was organized in 1984 by then UW-Madison chancellor Irving Shain and the UW Board of Regents. University land that is no longer conducive to agricultural research because of urbanization is sold to University Research Park, Inc., a separate, nonprofit entity that develops the land and leases it to companies interested in maintaining close contact with the university community. Profits from University Research Park, Inc., are donated to UW-Madison to support education and research. It is now one of 140 such parks that are affiliated with a university.

In addition to providing land and infrastructure, University Research Park offers unique opportunities and incentives for newer companies through specialized growth environments such as the Madison Gas & Electric (MGE) Innovation Center and the University Science Center.

Unlike most research parks, URP receives no city or state funds to support its infrastructure. University Research Park, Inc., is not only self-sustaining, but donates all profits to UW-Madison research programs, which in turn fuel the kind of technology transfer and economic growth that the park encourages. The hallmark of URP's operation and growth is a strong commitment to carefully planned, responsible development in the context of a long-term outlook. University Research Park has been steadily attracting new tenants since its inception, despite a nationwide slowdown in economic growth, and is showing no signs of changing its course.

Most University Research Park tenants have developed close relationships with UW-Madison scientists, who, through collaborative research and information sharing, help them stay on the cutting edge of technology. Other companies provide services that help the park function as a viable business complex. Park tenants range from pure R&D organizations to service companies providing various types of assistance. Many of the companies profiled in this publication are park residents.

Ideally, an invention disclosure made to the University (UIR) will result in one or more U.S. and foreign patents and one or more royalty-generating licenses through WARF patenting and licensing activities. Many of the firms locating in the URP have WARF licensing agreements covering University-developed technologies.

CONCLUSION

I hope that this white paper gives readers new knowledge and a deeper appreciation of the catalytic role that UW-Madison's basic and applied research and technological innovations play in Wisconsin's industrial and economic development. And, in particular to high-tech cluster formation. No single metric presented here stands above the rest. Rather, the impact of the UW-Madison on Wisconsin's *New Economy* must be viewed as the sum of a host of individual efforts, contributions, and State-University-Private Sector partnerships. In this paper, I have attempted to demonstrate some

of the ways in which basic and applied research outcomes, technology innovation and transfer, and entrepreneurship have contributed to the creation of high-tech firms, jobs, and new products and processes that have enhanced Wisconsin's industrial and economic development. In many instances, UW-Madison has provided not only the discoveries leading to innovations but also the entrepreneurs to commercialize the innovations and create careers and high-tech jobs for many of its graduates in Wisconsin.

RECOMMENDATIONS AND COMMENTARY

•***The UW-Madison/Dane County high-tech cluster described in this white paper represents a model for cluster formation in Wisconsin.*** Also, consistent with published studies on cluster formation elsewhere, a major research university is central to cluster formation and cluster formation takes time to develop – as shown in the current paper. Silicon Valley was born in 1938, North Carolina's Research Triangle Park, 1959, UW-Madison/Dane County, circa 1978-81. Long term investment by the State in basic and applied research is critical. The author knows of no University or State strategic plan that was developed to induce this cluster formation. The cluster resulted primarily from: strong multidisciplinary academic research centers; entrepreneurial tenure track faculty "stars", staff, students, and alumni providing leadership in recognizing the potential applications of their discoveries for the social good; a high rate of technological discoveries/innovations from the University as well as from the high-tech firms; an experienced University-associated team promoting technology transfer (UIR, WARF, URP); support of entrepreneurial activities by University senior leadership and policies and procedures which provide safeguards to protect the integrity and reputation of the University; increased interest in entrepreneurship amongst faculty, staff, students, and alumni; and, availability to compete for federal seed funding provided through SBIR/STTR and ATP (Advanced Technology Program) grants and contracts to the UW-Madison high-tech spin-offs and other start-ups.

•***Technological advances arise from a strong scientific and engineering basic research and development (R&D) base.*** We need to create innovative programs to expand State financial and other resources in support of Wisconsin's university and high-tech businesses R&D efforts – to create partnerships that will enhance their abilities to compete for and leverage federal funding opportunities targeted to the commercialization of technological innovations. The development of a strong technology transfer network and viable high-tech businesses in the State is crucial in translating academic technological discoveries into new products and jobs in Wisconsin. *The most promising, commercially viable, academic innovations that cannot be commercialized by Wisconsin firms will most likely be developed and brought to market elsewhere.*

•***Entrepreneurs are at the forefront of the State's technology-driven New Economy.*** There is a need to establish a State network with programs and policies to promote entrepreneurship involving the academic, government, and private sectors. To date, the high-tech cluster formation discussed in this white paper was driven by entrepreneurial University faculty, staff, students and alumni. We need to make entrepreneurship and the acceptance of taking risk a credible endeavor that is rewarded. Further we need to insure that the tax and regulatory environment is conducive to investment in new business development in Wisconsin.

•***Technology Diversity in the makeup of the State's high-tech sector needs to be promoted to achieve breadth and balance.*** Innovations that have strong commercial potential arise from both biological and physical sciences. The strengths of the State's collective academic and industrial intellectual capital needs to be involved in building Wisconsin's high-tech regional business sectors.

•***Success of high-tech start-up ventures is dependent primarily on (not necessarily in priority order or all inclusive): continuous stream of commercially viable technological innovations, available supply of high-tech***

management expertise and pool of skilled labor, availability of all stages of capital investments, and access to and penetration of markets on a worldwide scale. Wisconsin needs to address and reassess strategies to meet these and other specific needs of the developing high-tech sector and help many of the State's established firms to have access to and utilize technological advances to enhance productivity and develop new product lines and processes.

- For example, high-tech clusters initially are very dependent on early stage seed capital to demonstrate technical and commercial feasibility, the kind of money that the federal SBIR/STTR dollars (noted in this paper) fund. We need to become more competitive in these types of programs. One way is to create and leverage committed State R&D funds to assist Phase I award winners in competing for Phase II awards. A State Program modeled on SBIR/STTR should also be considered as an option.

- Creative initiatives should also be considered on increasing the supply of managers having expertise to operate small high-tech multidisciplinary ventures.

- The recent initiatives of CAPCO (Certified Capital Companies) by the State and SWIB (State Investment Board) capital infusions that total approximately \$115 million has strong potential to alleviate some of the shortage of venture capital in the State. However, calculated projections need to be made on the current and future investment needs and a strategy developed to address future financial need projections. For example, it is most likely that not all of the high-tech start-ups in the Dane County cluster will progress to IPO stage. To date, only about 5 of the cluster companies included in this paper underwent or are planning an IPO. The current need for major infusions of investment capital lies in financing the early stage high-tech companies showing the greatest potential to develop products, processes, and services from commercializable platform technologies and to stimulate further diverse regional cluster development in Wisconsin, *e.g.*, information technology, nanotechnology, optoelectronics, and genomics. Sustainability of this growth and evolution of firms to the mature state will require appropriate levels of financial resources to take the firms to the next stage of development, and a continued supply of management and skilled labor personnel specific to the needs and characteristics of individual regional clusters.

We must also realize that the induced investment needed to commercialize technological innovations vary greatly amongst various disciplines. A recent study (6) performed by the Center for Technology Transfer at the University of Pennsylvania has confirmed that the average pre-commercialization *induced investment (pre-commercialization economic impact vs post-commercialization impact generated by product sales) required for a university biotech start-up is \$102 million compared to \$14 million for a start-up in the physical sciences* or slightly more than 7 times as much induced investment is needed by biotech firms. When financial figures such as these are considered together with other requirements for continued growth outlined in this paper, our challenges to build sustainable high-tech clusters become very apparent.

Philip Z. Sobocinski, Ph.D.

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About the Author

Throughout his career, Dr. Philip Z. Sobocinski has been involved intimately in all aspects of research and development (R&D) and the commercialization of technological innovations. His experiences include serving as researcher, principal investigator, and senior administrator in R&D positions in industry, federal laboratories, and academia. As an entrepreneur, he was a founder of two biotech start-ups. In addition, he is a former senior technical advisor to the U.S. Department of Defense, State, and Commerce on national and international technology transfer issues involving biotechnology.

At UW-Madison, he is associate director of technology development & commercialization in the office of University-Industry Relations. He is involved primarily in intellectual property management and technology transfer; promoting university-industry-government collaborative research efforts; and, the creation of UW-Madison high-tech spin-off and other start-up companies in Wisconsin to promote the State's industrial and economic development. His studies and experiences with the spin-off/start-up phenomenon and campus entrepreneurs at UW-Madison led to his first publication on the subject "The Campus, Technology, & Wisconsin: A Look at UW-Madison as a Catalyst for Industrial and Economic Development" (1993) and a 1999 publication entitled "Creating High-Tech Business Growth in Wisconsin: UW-Madison Technology Transfer & Entrepreneurship" that quantifies the high-tech business growth phenomenon over the past 40 years. Dr. Sobocinski has assisted directly in the formation of many of the companies established in the past 14 years that compose the UW-Madison/Dane County high-tech business cluster.

Dr. Sobocinski received the national Tibbetts Award from the U.S. Small Business Administration in 2000 in recognition of his State leadership in the federal Small Business Innovation Research (SBIR) Program.

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