An Investigation into Technology Transfer Processes for Nanotechnology at the Japan National Institute for Advanced Industrial Science and Technology as Compared to Global Best Practice

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Date: August 10, 2007

Supported By: The National Institute of Advanced Industrial Science and Technology
Technical Information Section

Executive Summary

This report provides a high-level review of processes for technology transfer at the National Institute for Advanced Industrial Science and Technology (AIST) (産業技術総合研究所) with a focus on nanotechnology. As a result of new laws, policies, and institutional restructuring undertaken in Japan from 1998 to 2004, a basic framework is in place for technology transfer and licensing of intellectual property. Nevertheless, AIST lags behind the leaders in the United States and other mature industrial centers. This report reviews the relevant data and compares to best practices, in Japan and internationally, as the basis for these and other observations.

First, despite a large volume of domestic patents, the low patent revenue and low number of international patents indicates that overall patent quality may be quite low. Furthermore there are no "home-run" patents. Since AIST is not active in the lucrative medical/pharmaceutical sector, this distorts comparisons with major institutions that do focus on that. There is demonstrable commercial interest in the work at AIST, so the fundamental issue may be specific to the patenting process and not due to the quality of the underlying research itself.

Second, the separation of patent management within AIST from license marketing at AIST's designated technology transfer organization (the external entity AIST Innovations) may impede effective decision making about what to patent and when to award exclusive licenses. Under the current structure AIST Innovations is not involved in decisions about patent applications.

Third, the technology licensing framework at AIST is still relatively new following restructuring in 2001. More time can be expected for processes to mature. Additionally, During the last several years there were significant macro-economic factors, including a period of sustained economic stagnation, which may have affected innovation and business start-up activity.

Fourth, there does not yet appear to be a strong culture of start-up creation at AIST. Although efforts are in place to support entrepreneurial-minded researchers, the number of licensing agreements to start-ups is significantly less than what is found in the United States and other mature industrial centers.

The authors believe this report provides a basis for further detailed investigation and for continued structural and process improvement.

I. Introduction & Project Background

As the US State Department recently noted, governments around the world spend about US$4 billion a year on nanotechnology related research and development (R&D). In total, global spending on nanotechnology R&D continues to increase, and reached nearly US$12 billion in 2006. Currently, the US, Japan, South Korea, and Germany dominate this R&D landscape, however Taiwan and China are quickly becoming key players.

In Japan, nanotechnology R&D has been considered a core component of science and technology policy for at least a decade. Two ministries, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industry (METI), control and assign a majority of the country's R&D funding towards nanotechnology and nanoscience-related programs. In particular, next-generation electronic devices, advanced materials, and biotechnology-related products are key commercial targets for Japan's nanotechnology R&D. The National Institute of Advanced Industrial Science and Technology (AIST) (産業技術総合研究所) has used its unique position within Japan to find ways to apply nanotechnology to help develop a "safe, secure life in a graying welfare society, an advanced information society, and sustainable society in harmony with the environment."

Since technology transfer is fundamental to the mission of AIST, this research project was established to further investigate the processes in place today. This report presents a high-level investigation of technology transfer processes currently in place at the AIST as compared to best-practice examples from other major markets, specifically the United States of America (US). Our focus is primarily technology licensing, with some additional analysis of start-up incubation. We first review the background legal framework and economic factors that impact technology transfer in the US and Japan. We then present specific data from AIST and external examples in the US, China, and India. The report concludes with a series of observations, which may be used as a basis for further detailed investigation, or as a starting point for process improvement.

Many of the technology transfer processes reviewed in this report are not unique to nanotechnology, but are relevant to any technology or scientific discipline. As such, the results remain applicable to nanotechnology without being specific to it. The authors hope that this work will contribute to the development of world-class processes for the industrial application of nanotechnology research.

II. Important Questions Relating to Technology Transfer

Technology transfer is a process by which inventions are assigned to businesses for the purposes of commercialization. Successful technology transfer allows for the widest possible use of innovative inventions in a manner that contributes to society as a whole. Both parties to a technology transfer agreement should mutually benefit from the sharing of an original invention. The researcher (licensor) should be rewarded for his/her discovery, and the business (licensee) should see their sales and profits increase through the use of the discovery. Consumers should benefit from the availability of new, high-quality products.

Given the mandate of AIST, and the goals of technology transfer as described above, a key question is whether technology transfer processes in place at AIST are effective in supporting the industrialization of discoveries and inventions made by researchers. For example, are the Technology Licensing Organizations (TLOs) in Japan successful in marketing the patents and new technologies that are developed every year in the numerous research laboratories and workbenches in Japan? Are these TLOs adept at understanding the market for such technologies? Has sufficient time elapsed for TLOs to mature and become successful? Are effective support structures in place to encourage researchers to establish new companies based on AIST's technologies?

The total license revenue from all approved University TLOs in Japan in 2003 was JPY 550 million across 531 licenses. AIST received an additional JPY 400 million in technology transfer revenue in that same year [data provided by AIST Innovations]. This is compared to JPY 110 billion across 3,739 licenses in the US during 2002. Thus, at first glance there is reason to be pessimistic. Important questions are: what are the root causes of this relatively low license revenue? Has progress been made since 2003? Are there certain cases where TLO activity is successful, such that practices there may be applied elsewhere? Are there structural factors that inhibit the success of technology transfer? These are the questions we consider throughout this report.

III. Background Legal and Economic Frameworks for Technology Transfer

With nanotechnology's 20 trillion yen global market potential, it is highly likely that nanotechnology R&D will continue to be strongly encouraged by governmental and commercial organizations around the world. Nevertheless, as an emerging technology, a robust framework for technology transfer must be in place at an early stage to ensure that AIST is able to achieve its goal of becoming a leader in the effective application of nanotechnology.

This section and related appendixes benefited heavily from a variety of published reports, with futher information available in the Appendix. [Rissanen 2001], [Blanpied 2003], [Kneller 2003], [Shinohara 2004], [Harayama 2004]. [Myers 2005].

In the United States, a pioneering framework for technology transfer from Universities and National Laboratories was put in place in 1980. The University and Small Business Patent Procedures Act, also known informally as the Bayh-Dole Act, encourages government and university collaboration with industry. The law was ratified in 1980. The law created several significant changes to US patent law. Most importantly, the law reversed the presumption of intellectual property ownership. It permits a university, small business, or non-profit entity to claim an invention before the government, even in the case of government funded research. The government retains certain rights to access patented inventions at no cost. The net result has been a dramatic increase in patenting and licensing by US universities. Further information is available in Appendix A.

In Japan, a number of changes to the background legal framework took place during 1998 to 2004. In 1998 and 1999 Japan implemented laws to revitalize the economy, which include a law creating Technology Licensing Organizations. This law has come to be known in the US and elsewhere as the "Japan version of Bayh-Dole." This law authorized Technology Licensing Organizations (TLOs), which could be founded as internal University departments, or as external for-profit or non-profit entities. Additionally, in 2001 AIST was reorganized as an "Independent Administrative Institution" or IAI (独立行政法人). National universities were further reorganized in 2003 and 2004 as independent entities, separate from the Ministry of Education. These changes are further detailed in Appendix B.

For readers unfamiliar with AIST and its nanotechnology programs, more background information is provided in Appendix C and D.

During the same period from 2000 to present, there have been a number of significant background trends. The primary background issue has been a period of economic malaise often called the "lost decade". It started with a collapse of an economic bubble in the early 1990s resulting in bad loan problems at major banks and a period of sustained deflationary pressure. Only through concerted financial restructuring and continued government support for the economy has growth returned.

Recognizing a need for more efficient listing of new companies, the Tokyo Stock Exchange created its "MOTHERS" section for encouraging initial public offerings, particularly in high-technology. The Osaka Stock Exchange created Hercules, with a similar mandate. JASDAQ is also active as an over-the-counter market supporting emerging companies.

Another important trend has been the emergence of China as a major economic power. Japanese firms have succeeded in developing deep industrial ties there, such that Japan continues to enjoy a trade surplus with China. Simultaneously there has been a hollowing out of low-tech manufacturing from Japan to lower cost factories in China and other emerging markets in Asia.

The transitions have not been without pain. The so-called "Livedoor Shock" resulted from allegations of accounting fraud within subsidiaries of the formerly successful Internet conglomerate Livedoor. The sudden increase in TSE trading volume highlighted a lack of investment in the TSE's trading systems. The TSE was unable to process the sudden increase in sell orders and temporarily had to shut down its operations. An additional series of allegations against the Murakami fund occurred against the backdrop of attempts by the fund to champion shareholder rights and aggressively pursue changes to corporate governance within Japan. Both of these issues are still being dealt with by the courts in Japan. For this report it is sufficient to say that political interest and public opinion have been affected by these events. In the US, the collapse of Enron, the accounting scandal at Worldcom, and related issues at a few other public companies have lead to new reporting requirements known as the Sarbanes-Oxley law. There are similar laws now coming into effect in Japan.

IV. Japan Technology Transfer

This section provides a high-level review of recent information relating to the performance of selected technology transfer organizations in Japan, specifically AIST Innovations, which is an independent TLO affiliated with AIST. In addition, we discuss comments made by a number of leading dignitaries that were present at the first Asia Innovation Initiative meeting, which took place June 6 and 7, 2007 in Fukuoka, Japan.

IV.a. Japan TLOs

The majority of TLOs in Japan are affiliated with specific universities or groups of universities, with over 40 in operation today [Shinohara 2004]. Most have been established outside of their affiliated university, either as a for-profit or non-profit organization. Only about seven were established within their affiliated university, and these tend to be private universities (e.g. Keio, Meiji, Waseda). As mentioned earlier in this report, total revenue across all university TLOs in 2003 was JPY 550 million from 531 licenses. Detailed data on the financial health and licensing successes of these TLOs is beyond the scope of this high-level study, but it is apparent that results vary widely. The leader is CASTI, affiliated with the University of Tokyo, with revenue data presented in Figure 1. CASTI has typically JPY 100 million to JPY 200 million in technology transfer revenue each year. In 2004, CASTI reported an exceptional income of JPY 2,493 million [Riihela 2005], due largely to proceeds from an initial public offering of a start-up company based on CASTI technology in cancer therapy. CASTI has more than 15 full time staff and a portfolio of 237 licenses and 882 patents as of 2004. Interestingly CASTI also provides 40% of license revenue to the inventor, which provides strong incentives to University of Tokyo researchers.

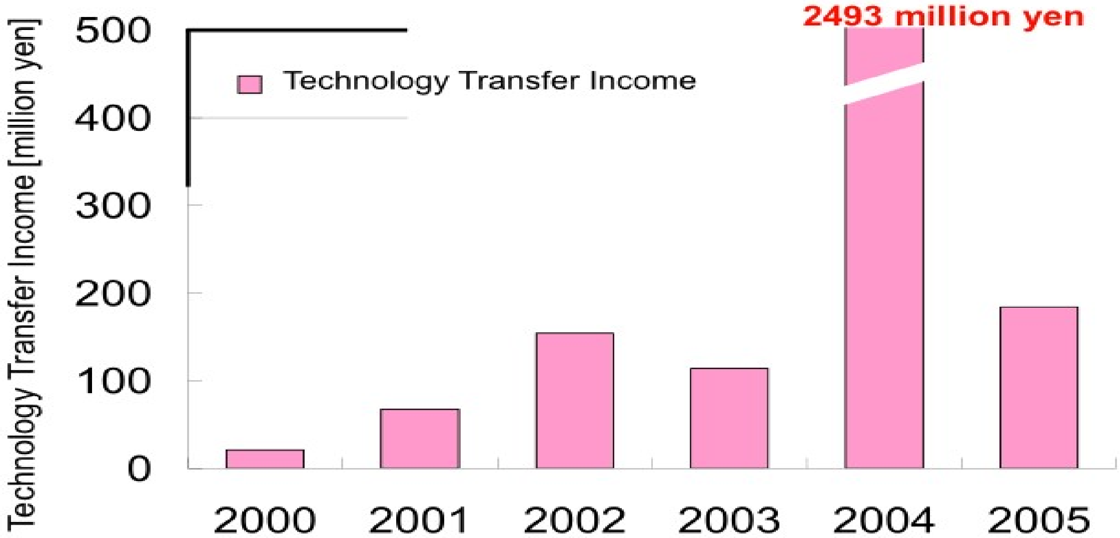

Figure 1. Technology Transfer Revenue at Tokyo University (CASTI)
(Source: http://www.casti.co.jp/about/performance.html).

For this report, we have not gathered comprehensive data for all TLOs, which would require considerable effort, including interaction with each TLO individually. Nevertheless, conversations with a few TLOs and information gathered from public sources, indicates a few key themes. TLOs that see themselves as successful are unanimous in the view that three elements are critical: (1) the quality of the patent portfolio, (2) the expertise of the TLO staff in marketing intellectual property to companies, and (3) the ability of TLO staff to actively participate in decisions about what technology is licensed and by what means (e.g. exclusive license to a start-up, broad licensing to multiple companies, etc.) Staff with specific business experience and strong contacts in industry, are well placed to be successful in determining what intellectual property is likely to have commercial value. Additionally, TLOs that are co-located with both strong research institutions and willing industrial customers have strong prospects. It has also been suggested that some of the best licensing deals are with non-Japanese companies [Blanpied 2003], thus international skills are also of value. For example, the Max-Plank institute in Germany earns 41% of license revenue from the USA and 12% from Japan, further highlighting the international appeal of strong technologies (as of 2003).

IV.b. Technology Transfer at AIST

For this section, the authors are grateful to helpful comments and information provided by Dr. Masanori KUROMOTO, Director of Marketing for AIST Innovations, whom we interviewed on June 29, 2007 at AIST's offices in Kasumigaseki, Tokyo. We further

reference information publicly available on the AIST Internet website and gratefully acknowledge the assistance of AIST staff to locate certain specific information.

On June 27, 2001, AIST established formal policies for Patents and Technology Transfer, with specific and well defined goals: (1) Making use of AIST research achievements, which will lead to an improvement in living standards; (2) Making people aware of AIST research achievements, which will help AIST develop its recognition in society, leading to an increased awareness of the significance of the institute; (3) Using AIST research achievements to increase future research funding and pass the rewards to the research staff. The policy makes clear that it is the duty of all staff to properly manage and secure AIST's intellectual property in support of the core goals of the organization, and that staff evaluations will take this into account. Each research unit is also required to appoint one person to be in charge of technology transfer and intellectual property rights management, to facilitate interaction with staff within and outside the unit. Specific to patents, AIST policy ensures that the original inventors are rewarded. Currently, 25% of license revenue goes to the inventor, and another 25% to the inventor's research division.

The policy also assigns AIST Innovations as the exclusive agent for licensing AIST's technologies. AIST Innovations is an independent, non-profit, accredited TLO organization that is part of the Japan Industrial Technology Association. AIST Innovations has its historical roots going back to 1969, from within the technology transfer division of the former MITI/AIST organization, but was re-established in 2001 as part of the same restructuring of AIST overall. AIST Innovations has 4 offices (Tsukuba, Tokyo, Kansai, Tohoku) and 22 staff, with specialist intellectual property and industrial expertise.

The exclusive relationship with AIST is a strong advantage for AIST Innovations as compared to independent TLOs affiliated with many Japan universities. However, unlike most TLOs, AIST Innovations is not involved in patent evaluation, patent application, nor patent maintenance and management. These functions remain within the Intellectual Property Department of AIST. Additionally, AIST Innovations is not involved in start-up company creation, which is supported by the AIST internal department called the Innovation Center for Start-ups (ICNS). Furthermore, as a non-profit entity, AIST Innovations can only accept cash, and cannot be paid in potentially lucrative shares or options from start-up companies.

AIST has seen a significant growth in new patent applications since its restructuring in 2001, shown in Figure 2. For example, in 1998, Japanese patent applications by AIST researchers numbered less about 700. This grew substantially to over 1000 in 2001 and more than 1500 by 2003. Recently, however, there has been a drop off in patent filings, to about 1200 in 2004 and 2005, and just over 1000 in 2006, and about 430 in the first 5 months of 2007. It is not clear if this is a temporary trend following from the normal research funding cycles, nor does a simple count of patent applications say anything about the quality of the individual inventions. Nevertheless, there has definitely been a retrenchment in the total volume of patent applications. The number of US patents is much lower, numbering less than 200 per year. Also, as noted above, since AIST Innovations is not involved in decisions about what technologies should be patented, there is potentially a gap in the linkage between commercial interest (given that AIST Innovations is very close to potential licensing customers) and the patents themselves.

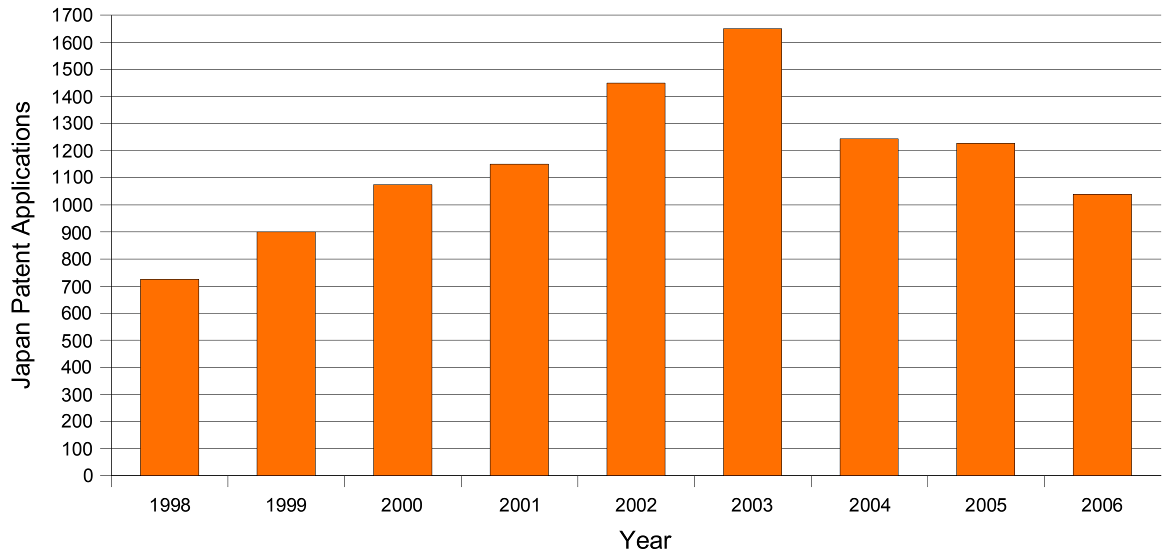

Figure 2. Japanese Patent Applications by AIST and its predecessors (Source: AIST).

AIST Innovations has published information on technology transfer income, shown in Figure 3, which has grown from much less than JPY 100 million in the late 1990s, to over JPY 400 million per year in 2004. Subsequently there was a slight drop in 2005, and no significant change for 2006. About 60% of this revenue is from small and medium size companies, but less than 5% comes from start-up ventures.

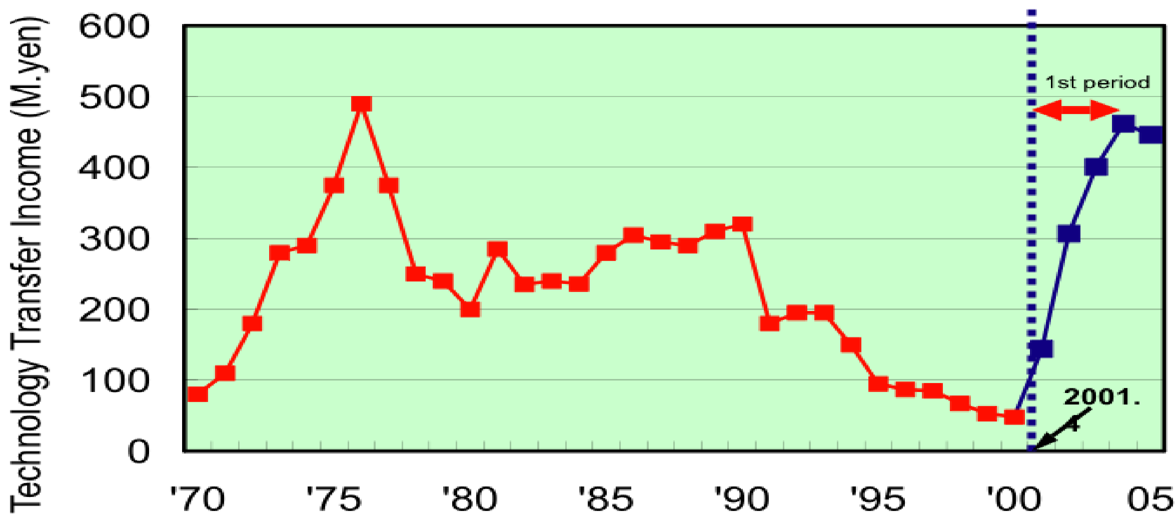

Figure 3. Historical Revenue from Technology Transfer at AIST and its predecessors (Source: AIST Innovations).

Despite this growth, a further breakdown of the revenue sources (Figure 4) shows that only about 25% is from license royalty income, which grew from just under JPY 50 million in 2000 to just over 100 million in 2005. All of the rest of the revenue growth is from one-time information disclosure agreements, one-time license options, and patent infringement settlements in excess of JPY 120 million in both 2003 and 2004. The recurring income due purely to patent licensing is quite small, and is not currently growing. It should be noted that this is against a backdrop of an AIST budget of JPY 98,574 million for fiscal 2006. In other words, total technology transfer revenue is no more than 0.4% of the total expenditure across all of AIST.

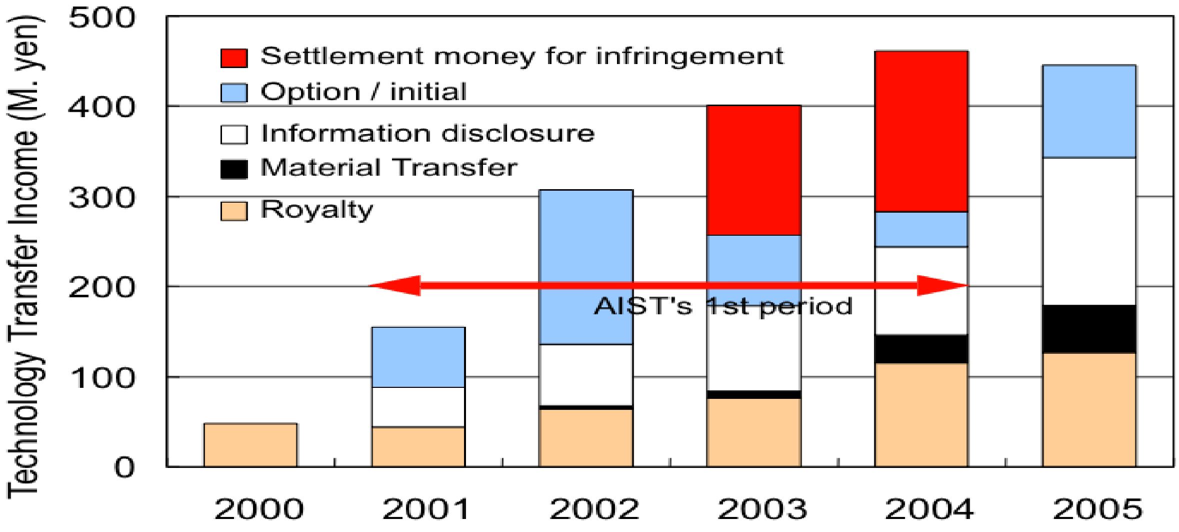

Figure 4. Breakdown of AIST Technology Transfer Revenue by type (Source: AIST Innovations).

One unique aspect of AIST technology transfer is a service where companies can request access to review certain unpublished research for a fee. This service has proved quite popular, generating nearly as much revenue as patent licensing itself. This provides a strong indication that AIST research is of interest to companies, but somehow there is a gap in commercial interest between the initial inventions and the resulting patents.

Approximately 25% of this income is from nanotechnology, which employs about 17% of AIST's research staff, which does indicate at least that nanotechnology researchers are quite productive in terms of revenue-generating IP, at least as compared to the rest of AIST.

AIST Innovations and AIST are pursuing many programs to improve the marketing of AIST inventions, including an innovative program to accelerate commercialization of IP through targeted research grants, participation in on-line patent market places (yet2.com), and participation in international technology showcases (e.g. Hannover Messe, Germany 2006).

IV.c Asia Innovation Initiative

Two of the authors of this report had an opportunity to attend the Asia Innovation Initiative conference in Fukuoka, Japan during June 6 and 7, 2007. This conference was organized by N. Idei, former CEO of Sony Corporation, with an express goal of investigating ways to improve innovation and collaboration in high-tech industries across Asia. This meeting brought together experts in business, investment banking, venture capital, and government, who participated in a number of panel discussions covering a wide range of topics. Of interest to this paper were the discussions on obstacles to venture investment in Japan. Similar themes have been presented by other authors [Feigenbaum 2002]. Specifically, the following challenges facing start-up companies are common: (1) Venture investing is still not yet well developed in Japan, hampering ability of new companies to raise capital. (2) Large companies and government entities are often reluctant to purchase products or services from new companies. (3) It is difficult for start-up companies to recruit and retain quality employees. These issues are not unique to Japan, but appear to be particularly acute there.

Some commentators provided an alternative view. For example, in Kyushu, there has been much more ability to get past these issues, in part due to strong local support for venture investing (e.g. Kyushu Venture Partners), government incentives for locating buildings and offices in industrial parks in Fukuoka and Kita-Kyushu areas, and a strong focus on technology transfer at Kyushu University. The focus of the meeting this year was semiconductors, but several commentators pointed out that the semiconductors industry is mature, and that emerging industries are more dynamic. Thus, there are positive examples in Japan where entrepreneurial activity is delivering economic growth and social value. Nevertheless, it was widely recognized that Japan does not have an ecosystem for new venture incubation that is anywhere near the scope and size of Silicon Valley in the US. (More of this is covered in section V.b. of this report).

V. International Technology Transfer

This section presents examples of best practice technology transfer and start-up company incubation processes, primarily in the USA. This is not an exhaustive listing of all such systems, but rather presents a high-level overview of some widely recognized successes. By 2003, US universities were generating more than $1.3 billion of patent license income from 4,516 licensing deals, and additionally some 374 new companies had sprouted from university research [Leaf 2005]. Processes are now so well established, that an Association of University Technology Managers exists for university technology licensing officers to compare results and best practices across the field. More than two dozen universities now report more than $10 million a year in license revenue, across a wide variety of disciplines. We also comment on nanotechnology specific initiatives in the US, China, and India.

V.a. The University of California Office of Technology Transfer

The University of California system has a well established technology transfer process, built around an Office of Technology Transfer (OTT), supporting licensing of research from 10 university campuses, and 3 Department of Energy national laboratories that are managed by the University of California. The UC OTT is the leader in the US both in terms of number of patents and in the number of successful commercializations of new technologies. The OTT's own website best describes their mission (available at http://www.ucop.edu/ott/about.html):

> The Office of Technology Transfer (OTT) provides leadership and strategic direction for the system wide University of California technology transfer program and is responsible for administration of intellectual property on behalf of the University. OTT functions include the development and administration of intellectual property policy, including the University of California Patent Policy, the evaluation of inventions, prosecution of patents, licensing of intellectual property, monitoring of licenses and other intellectual property agreements, distribution of resulting income, and provision of support to other University units in copyright, trademark, and research funding agreements.
>
> In addition, OTT provides outreach services for the community on behalf of the system wide technology transfer program. These services include giving forums about how to work with UC, and providing ways to access the UC tech transfer system though publications, Web sites, and visibility at relevant meetings.

The UC OTT website provides an excellent guide to how the University of California system approaches technology licensing. The website is organized into four key sections: (1) Resources for Faculty, (2) Resources for Industry, (3) Resources for Staff, and (4) General Resources. In the Resources for Industry section, listings of available technologies are readily accessible, including links to patent abstracts and contact information within the OTT offices for any specific licensable technology. These databases are very easy to navigate by keyword, research area, or other commonly used search criteria, making it very easy for interested customers to locate licensable technologies.

The UC research websites also contain the annual reports published by the OTT and related information (available at http://www.universityofcalifornia.edu/research/techtransfer.html). The data below are drawn from these reports.

In fiscal year (FY) 1992, license revenues were are relative modest $32 million. This grew gradually to about $70 million by FY1996 and to $80 million by FY1999. By FY2000, UC System license revenue (for 9 campuses) dropped slightly to about $67 million per year for a portfolio of 1,976 US and 1,634 non-US patents, with an additional one-time special payment of $200 million relating to legal settlement of a dispute relating to human growth hormone invented by UC San Francisco. Also in that year, over 900 individual inventors received payments of up to 1/3 of license revenue. By FY2006, revenue had grown to $93 million for a portfolio of 3,316 US and 3,692 non-US patents, with an additional one-time $100 million payment relating to a legal settlement for bovine growth hormone. A total of 1,479 inventors received over $60 million in payments. The OTT office itself has consistently run a surplus of several million dollars after paying all distributions, operating costs, and legal and filing fees. These surpluses are redistributed into the university research funding pools, which support new research. The recent trends are shown in Figure 5.

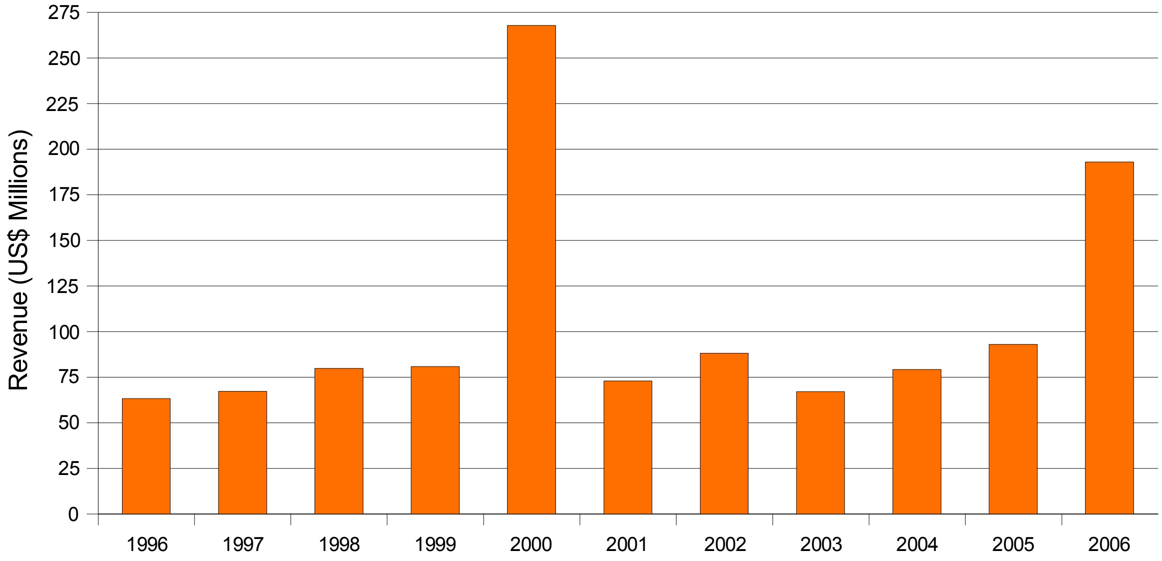

Figure 5. University of California System Technology Transfer Revenue 1996 to 2006 (Source: UC Technology Transfer annual reports).

The 3 Department of Energy national laboratories run by the UC (Lawrence Berkeley, Lawrence Livermore, and Los Alamos) generated an additional $8.4 million in license revenue in FY2006, for both patents and licensed software.

While there is an overall growth trend from FY1992 to FY2006, some individual years showed a downtrend, for example only $61 million revenue in FY2003. Also, one-time special payments distort the overall trends, but it is worth noting again that just two such payments during 2000 to 2006, added $300 million in revenue, which is significant compared to the $486 million from all other licenses over the same period.

Another key point is that a small number of "home-run" patents generate most of the revenue. In 2000, 59% of the revenue was earned from just 5 inventions, and 82% from the top 25. By 2005 this was somewhat more balanced, with 46% from the top 5 and 72% from the top 25. Most of the top earning inventions were in the biomedical and pharmaceutical fields. Nevertheless several interesting inventions are highlighted in the various reports, such as advances in solid state lighting (UC Santa Barbara group lead by Shuji Nakamura) and nanotechnology (NanoFoil developed by Lawrence Livermore National Laboratory and collaborators).

More than 200 start-up companies have licensed technologies from the UC OTT. Over 25% of these companies were started by faculty and students of the University of California at Berkeley, which is located near the Silicon Valley. The individual university campuses are active in coordinating and encouraging venture capital investors to participate in start-ups, particularly in the information technology and biotechnology sectors.

<u>V.b. Start-up Incubation in Silicon Valley and Boston 128 Corridor</u>

Silicon Valley, centered around San Jose, California and Stanford University, and the highway Route 128 Corridor near Boston, Massachusetts and major universities such as Harvard and MIT, are well known as successful environments for start-up company incubation. Recently as much as half of all US venture capital investment has gone into to firms in those two locations. Much has been written about the reasons for this success, and it is beyond the scope of this report to review all of that work. Nevertheless, it is worth repeating these common themes.

First and foremost is the recognition that failure is integral to the process. Some 70% to 80% of new start-ups fail within 3 years. In the Silicon Valley, this is well known by all participants in the process, including venture capitalists, potential employees, and service providers such as law firms and accountants. Nevertheless, some 1 in 20 achieve incredible financial and market success, thus creating wealth for reinvestment and attracting top talent. The failed companies also provide a steady stream of skilled employees for the next start-up.

Another critical factor is that the components necessary to start a company are all readily accessible at reasonable cost. This includes office space, legal advice, accounting services, and start-up entity registration services. Venture capital is also near, with dozens of firms willing and able to review start-up business plans. One venture investment professional from Silver Lake Partners, a noted technology incubator, recently told the authors that proximity is critical to their ability to oversee their investments and provide coaching and guidance to the start-up companies. A commonly given rule of thumb is that the venture capital firm should be only a 20 minute commute from their target companies.

Silicon Valley and Boston 128 Corridor are also adjacent to world-class research institutions with a strong history of commercialization of technology. Stanford, UC-Berkeley, UC-San Francisco, Harvard, and MIT are world famous for their academic and research excellence and strong contributions to technology and medicine.

Finally, both regions offer a dynamic lifestyle that is attractive to both young entrepreneurs and more established highly-skilled and educated employees.

V.c. US National Nanotechnology Initiative

Since 2001, government-funded nanotechnology research and development in the US has increased 127% percent to over US$1 billion, with the cumulative 5-year nanotechnology investment (FY2001 - FY2006) standing at US$4.7 billion. This investment has been made under the watchful eye of the multi-agency National Nanotechnology Initiative (NNI).

The mission of the NNI is to use its massive budgetary resources to support fundamental and applied research on nanotechnology by funding cutting-edge research, creating multidisciplinary centers of excellence, and developing key research infrastructure. It also supports activities aimed at addressing the societal implications of nanotechnology, including ethical, legal, human and environmental health, and workforce related issues.

As of last summer, 11 federal agencies were funding nanotechnology research and development under the NNI, and another 11 participated in coordination. Agencies that have recently joined the NNI as participants include the U.S. Patent and Trademark Office and the Consumer Product Safety Commission, indicating the increasing importance of commercialization activities in the NNI's mission.

The NNI is not the only means by which the US generates nanotechnology research and development. In general, large industry supports about half of the current work on nanotechnology in the US - about US$2 billion per year. The other half comes from small business and investors, as well as from Federal, state and local governments. It is this latter half of the pie that the NNI dominates with its over US$1 billion per year bankroll.

In detail, the NNI invests money in various agencies that are then free to offer up Federal research grants, which are defined and awarded by the individual government departments and agencies, in accordance with their respective missions. In addition to these grants are the special programs designed to seed commercialization activity for economic growth. These programs support small business collaboration with universities and other research institutions conducting nanotechnology research. Since 2001, the NNI has had a hand in facilitating business partnerships, state and regional funding as well as helping to create positive business environment specifically for nanotechnology. In fact, as Stephen Fluckiger has noted [Fluckiger 2006]:

> Policies suggested by the [NNI] offer a number of ideas for overcoming barriers to multidisciplinary and inter-institutional research and illustrate some of the ways in which academia can structure partnerships with industry that will not only provide needed funding for multidisciplinary and inter-institutional biomedical research in an era of diminishing federal resources, but may permit academia, on the one hand, and industry, on the other, to benefit from the strengths provided by the other without compromising either academia 's or industry's basic missions.

This highlights coordinated government support for nanotechnology in the US.

V.d. China 's Z-Park

The Chinese government has been actively promoting the creation of business ecologies that can support a myriad of start-up and small business models that are looking to have a global reach and a global market presence. The most obvious example of such an entrepreneurial zone is the Zhongguancun Science Park (Z-Park) located in the northwest corner of Beijing. The biggest and oldest of the 53 national high-tech zones in China, Z-Park has become an important gateway for global corporations looking both to develop R&D for all sectors and to get a foothold in the Chinese market.

Z-Park is made up of a group of seven parks, covering an area of about 100 square kilometers, close to the city's major educational institutions and the Chinese Academy of Science (CAS). As recent media reports have noted, the park was founded in 1980 when Chen Chuxian, a researcher at CAS, returned from a trip to Silicon Valley. He opened the Advanced Technology Service Association, the first privately funded, civilian-run, scientific and technological consulting firm in China. Soon after, other scientists came to the district, attracted by the support afforded by both CAS and the central government. A virtuous circle began, with new ventures spinning off from Chinese universities. Foreign companies also began establishing divisions there.

Today, some 18,000 companies operate in Z-Park, including more than 1,500 foreign firms. In 2006, Z-Park generated US$85.75 billion in revenues and US$12.6 billion in exports. From January to November of last year, the IT industry within Z-Park generated US$45 billion in revenues, including US$5.8 billion in technology income, US$16.8 billion from new products sales, and US$7.29 billion in exports [5 June 2007 Business Week].

Because of its success, Z-Park has become the role model for a new economic growth program that has its roots in a recent policy manifesto by Chinese President Hu Jintao. His decree, announced in 2006, was to have China become an "innovation-oriented" country by the beginning of the third decade of this century.

V.e. India and Nanotechnology Innovation

The current president of India, the honorable A P J Abdul Kalam is a believer in the transformational power that science and technology can have on a country, its economy, and its society. In this regard he has been actively promoting the development of indigenous nanotechnology, IT, and genomic research and development, not only at the country 's leading institutions of higher learning, but also at small companies and small colleges.

As a scientist, President Kalam sees his role as being more than just about finding ways to increase funding for basic research, but to advance the economy as well. Recently he urged the Indian Institute of Science (IISc) to follow the example of Stanford University and become a nurturer of small start-ups: "[The] IISc could become a major catalyst for entrepreneurial boom in the country that would transform Indian graduates from employment seekers to employment generators." [25 June 2007 edition of The Hindu]

This spirit is already apparent in the government. The Indian government announced late last year that it is embarking on plans for launching a nanotechnology and Nanoscience-related "Science and Technology Mission" (Nano Mission) with an estimated public investment of INR 10 billion (approx. US$224 million) over the next five years to further intensify its promotional efforts in this area. As part of the Nano Mission the government plans to launch a variety of educational and human-resource development (HRD) programs, R&D programs, establish centers of excellence, promote institution-industry linked projects through increased public private partnerships, promote entrepreneurship through establishment of business incubators, and so on. The Nano Mission also plans to make special efforts for the development and commercialization of nanotechnology, not only through public-private partnerships but also by encouraging and enabling the private sector to invest in, and leverage, this sunrise technology. As President Kalam has stated: "Even while we are concentrating on basic research with eminent scientists working in it, simultaneously Indian industrial group small, big and medium should concurrently work on commercialization of nanotechnologies. It may well be that the technologies are developed in India or in USA or in other countries. The main focus should be speedy commercialization to fit into the global market." [22 February 2006 Government of India Press Information Bureau].

Various Ministries/Departments of the Indian government such as the Department of Science and Technology (DST), Defense Research and Development Organization (DRDO), Council of Scientific and industrial Research (CSIR) and Department of Biotechnology (DBT) have been supporting R&D in nanoscience and nanotechnology. For example, DST launched a special nanoscience and nanotechnology initiative (NSTI) in October 2001. The NSTI has been focusing on research and development in nanoscience and nanotechnology in a comprehensive manner so that India can become a significant player in the area and contribute to the development of new technologies besides carrying out basic research at the frontier of knowledge. The program supports R&D projects strengthening categorization and infrastructural facilities, creation of center of excellence, generation of trained manpower, joint projects between educational institutions and industry for application development and so on [20 December 2006 Government of India Press Information Bureau].

V.f. European Examples.

Without going into significant detail, European research institutions that are similar in many ways to AIST also show significantly more technology transfer revenue per research expenditure than AIST. Figure 6 presents some examples from 2003, based on data collected by AIST Innovations.

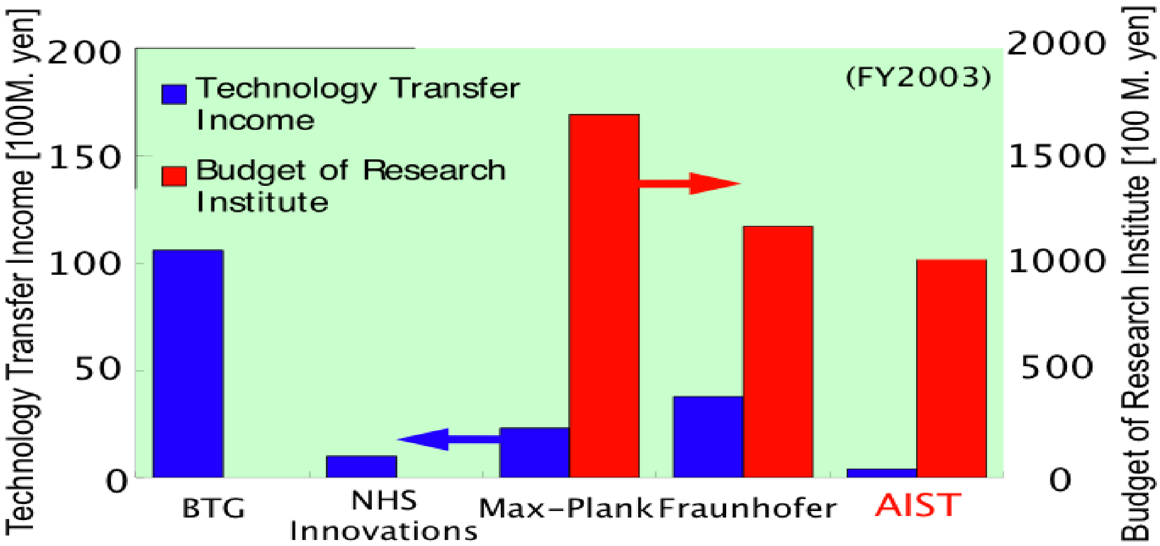

Figure 6. European Technology Transfer Revenue vs. Research Budget compared to AIST (Source: AIST Innovations).

VI. Observations and Analysis

From the proceeding sections and our own reading of the various materials referenced in this report, we are able to offer several observations. We propose that our observations provide valuable insight into the technology transfer process between AIST research organizations and industry. We further identify those success factors that are already in place or that may be easily implemented to provide a foundation for more effective technology transfer.

AIST TLO Revenue is Low: Despite a large patent portfolio, low revenue indicates many low-value patents. Furthermore AIST patent decisions are separate from the TLO (AIST Innovations), possibly leading to insufficient commercial input.
The actual volume of Japan TLO license revenue remains quite low at something less than 0.5% of total research investment in the case of AIST. There has been significant growth in licensing from near zero to current levels, but only a small fraction of this increase is from new patent royalties. There has also been stagnation in new revenue in the last two years. It would appear that despite a large portfolio of inventions, the overall patent quality is quite low. This may be a result of insufficient interaction between the AIST Intellectual Property Management and the designated TLO, AIST Innovations. In leading institutions, all stages of IP management are within one technology transfer organization (e.g. UC OTT). The fact that core processes are separately assigned to internal and external organizations is not operationally effective. There is commercial interest in AIST research, as evidenced by the increases in agreements to review confidential information. This is an indication that the research itself is not the problem, but rather the process of generating patents from such research may be weak.

No “home-run” patents: The most lucractive patents tend to be a small number of compelling inventions in medical fields. This is an opportunity for nanotechnology.
At many leading institutions, a small number of patents in biomedical or pharmaceutical fields generate a substantial share of licensing income. AIST is not a medical institution, but many nanotechnology inventions have potential medical application. Examples include drug delivery and encapsulation of nanometer scale proteins and nucleic acids. There exists an opportunity to focus research effort further into areas with direct medical application. The AIST TLO (AIST Innovations) should be engaged to assist in identifying the most promising medical applications on which to prioritize research. AIST Innovations should also be engaged to assist in the creation of robust domestic and international patent applications.

Difficult to access information about AIST's technologies: Websites are poor and information in English is limited.
It has been observed by some analysts that many of the most successful licenses have been to non-Japanese firms. While reviewing AIST's website the authors noted that it is very difficult to identify what technologies are available and whom to contact to license a particular technology. This is in contrast to the University of California technology transfer website, which has clear sections for searching and locating all patents or patent applications, including direct links to the US Patent Office's own abstracts. Each licensable item lists a contact officer within the University of California TLO, who is expertly trained to engage with industry. The original inventor is listed as the creator of the IP, but may only be contacted via the TLO office.

AIST is not yet well known: Poor branding may impede marketability of technology. There should be more focus on the technology, and less focus on the inventor.
AIST does not appear to have a well recognized "brand". This is in contrast to RIKEN, which has retained a level of visibility for its name and brand in Japan and abroad. Strong branding is a core element of successful marketing. Improved brand development will enhance AIST's ability to license its intellectual property. For example, in AIST publications about research programs, the contact person listed is typically a researcher. Corporations who wish to license technology should be directed to a TLO officer, not to a researcher. Maintaining the focus on the technology via the TLO office will reinforce the AIST brand.

TLO Exclusivity: Japan universities do not usually require IP to go through an affiliated TLO. AIST is an exception, which is a positive factor.
Another key difference between the US and Japan is that US TLOs normally have exclusive access to all intellectual property generated by their affiliated institution. In Japan, this is typically not the case. Japanese TLOs must solicit the right to represent specific licensable technologies from their affiliated institutions. Historically, the most established professors in Japan often have deep ties with specific companies, and have no compelling need to work through a TLO. Additionally, US TLOs are not measured solely on the license income that they generate, but rather on their contribution to the overall goals of the institutions that they support. This is a result of US TLOs typically being a division within their university, often supported directly by the office of the university president or vice president. AIST is more like the US model in that all AIST research must be licensed through the AIST Innovations. However, as mentioned earlier, the separation of AIST patent decision processes from AIST Innovations is a structural inefficiency.

TLO Time to Maturity: US Experience is 10 years, and Japan TLOs are not that mature, thus more time is expected.
An observation made by many US investigators is that it often takes 10 years or more for US University TLOs to become fully established and successful. In Japan, it can be said that TLOs are relatively new, most having been formally designated as TLOs between 2000 and 2002, thus just over half the time normally required for TLOs to mature has elapsed.

Unsettled Environment 2001-2004: Period of change may have created uncertainty and distraction, which should now be settled.
The authors also believe that the significant restructuring of AIST in 2001 and within Japan national universities in 2003 and 2004 likely distracted researchers over the last several years. Research output may have declined somewhat during this period. Now that the operational environment has stabilized, it can be expected that focus can return to the fundamentals of quality research production and technology transfer. In the case of the University of California, once revenues grew from about $30 million in 1992 to about $80 million in 1999, license income became stable. Growth continued to $93 million by 2006, excluding the impact of one-time settlements. The one-time impact of specific inventions with global applicability and robust patent rights that stand up to litigation can add significantly to revenue. Just two such cases added $300 million to the UC OTT revenue between 2000 and 2006. These are the so called "Home Run" patents.

Lack of Start-up Support: There does not appear to be a strong culture of start-up creation at AIST, especially with respect to venture investor introduction.
The authors have less specific observations relating to start-up companies, but a few common themes are apparent. There has been progress in the availability of funding and venture capital to support start-ups, but the level of activity is still significantly less than in the

established incubator ecosystems of the Silicon Valley or Corridor 128 in the US. Fundamental to the US system is the realization that 60% to 70% of start-ups fail, and that this is to be expected. The failed companies provide feeders of talented employees and managers to new start-ups, thus continuing to feed a virtuous cycle of renewal even amidst repeated failure. We have seen the beginnings of this, for example in Kyushu where industry, university, and government appear to be successfully collaborating to create an infrastructure somewhat similar to the Silicon Valley in the US. At AIST, we did not encounter a strong culture of start-up creation, particularly with respect to critical factors such as investment funding. This is in contrast to the University of California at Berkeley, which proudly lists on their website both start-up companies and venture investors related to the University. Additionally, AIST Innovations, due to its legal structure, is restricted from accepting options or shares in start-up companies, thus limiting a potentially lucrative opportunity for itself. Hurdles for start-ups remain significant even with direct access to license AIST technology.

AIST Incubation Support (INCS) is located far from researchers and likely start-up locations.
We noted that the incubation division of AIST is geographically located in central Tokyo. While this is close to government sponsors and the headquarters of AIST, it is not close to the majority of AIST researchers who desire access to these services. Furthermore, it is not close to the likely locations for start-ups. Start-ups prefer to be located near to their customers and suppliers, and in lower-cost districts.

Long-term opportunities for non-Japanese researchers are limited.
Another observation tangential to this report but commonly seen is that non-Japanese researchers rarely have long-term research opportunities in Japan. While there are several opportunities for short-stay assignments, it is generally not possible to build a long-term career in Japan [Osborne 2007]. This is fundamentally different from the US case, where for example Nobel laureates such as Albert Einstein and Leo Esaki had long and productive careers. More recently Shuji Nakamura has established himself as a leading expert in semiconductor lighting at UC Santa Barbara.

Competition: China and India on the rise, with US continuing to lead.
It should be noted that strong competition comes not just from the US, but also from China and India. Significant efforts are underway in those countries to develop strong technology transfer processes and to encourage entrepreneurial start-ups. These initiatives cover a variety of fields including nanotechnology. Japan must compete aggressively or risk falling behind.

VII. Summary

This investigation performed a high-level review of the most accessible relevant literature and related data, with a particular focus on technology transfer processes at AIST of interest to the field of nanotechnology. This report is not meant to be exhaustive, nor is it the final word on the factors necessary for technology transfer to succeed. Nevertheless, from the information gathered during the course of this investigation, it is possible to draw a number of high-level conclusions.

It almost goes without saying that TLOs can only be successful if the fundamental intellectual property available for license is itself compelling to a wide range of potential customers. The large number of Japanese patents, but relatively low patent license revenue and low number of international patents indicate that the patent quality is poor. This may be due to the structural split between the AIST IP Office and AIST Innovations when it comes to decision making regarding what to patent. Commercial interest in AIST research itself remains strong as evidenced by the rapid increase in agreements to access confidential information.

Assuming such quality IP is available, a key observation is that the technology transfer process improvements established during 2000 to 2005 in Japan are very much still an experiment in progress. As with any scientific experiment, the first attempt is generally not successful, and additional tuning and corrective actions must be taken until success is achieved. It is realistic to expect another 4 to 5 years to be required before the current TLOs in Japan achieve their full potential.

That being said, it is also clear that success will not occur without continued focus and implementation of the best practices that are succeeding both in Japan and elsewhere.
Like any business, success must be clearly defined as measurable outputs, which are then regularly tracked. Only then can the inputs be reviewed to determine which contribute the most to a successful outcome. All parties to this process must be aligned to these goals of continuous improvement. Specifically, marketing must emphasize the technology and the organization, and information about licensable technologies must be easy to access.

Given that Japan's most successful industries have pioneered the application of "kaizen" and are strong competitors in the global marketplace, we can expect that with continued support from all stakeholders, success is possible.

Appendix A – Further Comment on the 1980 Bayh-Dole Act of the United States

In the United States, The University and Small Business Patent Procedures Act is a pioneering legal framework to encourage government and university collaboration with industry. The law was ratified in 1980. This law, also known as Bayh-Dole after the legislators who sponsored the law in the US Congress, provided for several significant changes to US patent law. Most importantly, the law reversed the presumption of intellectual property ownership. It permits a university, small business, or non-profit entity to claim an invention before the government, even in the case of government funded research. The government retains certain rights to access patented inventions at no cost. There are certain restrictions on the ability to grant exclusive licenses, but the net result has been a dramatic increase in patenting and licensing by US universities. [Kneller 2003].

Two additional aspects of the Bayh-Dole law have reinforced aspects of the US university technology transfer system. First, the law requires comprehensive reporting. Second, the law has certain cumbersome procedures for inventors to retain ownership. This has reinforced the tendency of universities to require faculty and researchers to report all inventions to the university. The university then has exclusive rights to license inventions to 3rd parties, while providing compensation to the original inventor(s). These policies typically apply even to inventions that are made without government funding. The intent of the policy is to ensure all inventions at a particular university are processed and licensed consistently, and are compliant with all legal requirements.

The Bayh-Dole law does not specifically discuss incubation of start-ups, but the law does encourage small businesses generally. It is a fact that some 2/3 of new jobs in the US is are created by small companies. Specifically, the law and related regulations require preference to be given to small companies for any exclusive licenses. Therefore, it is relatively common for an inventor to later establish a company based on exclusive licenses for his or her inventions. Particularly in the Silicon Valley, and in the so-called Route 128 corridor near Boston, start-up companies have indirectly benefited from the desire of key research institutions to develop and license patentable technologies. Universities such as Stanford, MIT, and the University of California at Berkeley, provide start-ups with ready access to intellectual property generated by the universities.

The effect of the law is not without controversy. For example, some have suggested that the law encourages universities and other non-profit research institutions to become too "entrepreneurial". Unbalanced focus on applied engineering, at the expense of the core missions of education, basic research, and social benefit. The most significant criticisms have been in the biomedical and pharmaceutical areas [Leaf 2005], which have also generated the most license revenue. Nevertheless according to Kneller and others, there is no specific evidence that research focus has shifted significantly away from fundamental research or that the overall mission of educational institutions has been compromised. By contrast, it can be observed that institutions with the most successful licensing programs gain additional prestige. Prestige for the university has the positive effect to attract new research funding, high-quality faculty and students, and further enhances the quality of research output.

Appendix B - Changes to the Japan Legal Framework during 1998 - 2004

Japan has had national research institutions for over 100 years, and many universities both public and private have had organizations for managing intellectual property and technology licensing since the 1940s, for example, The Tokyo Institute of Technology (1946), Chubu area universities (1943), and IIS University of Tokyo (1953). In 1998 and 1999 Japan implemented laws to revitalize the economy, which include a law creating Technology Licensing Organizations. This law has come to be known in the US and elsewhere as the "Japan version of Bayh-Dole." This law authorized Technology Licensing Organizations (TLOs), which could be founded as internal University departments, or as external for-profit or non-profit entities. Most universities chose to establish TLOs as external entities, as this allowed the TLO to be free of civil service requirements that were in place for national university faculty and staff at the time. Additionally, government funding became available to support the operating costs of TLOs for up to 5 years at a maximum of JPY 30 million per year. The result was a proliferation of new TLOs. The law also attracted considerable international interest.

The law and related regulations also clarified a number of elements of intellectual property ownership. Kneller discusses the implications in detail, but is nevertheless drawn to a conclusion that there remain gray areas particularly in the case of government funded research and commissioned research. The gray areas create an atmosphere where many TLOs believe that government and commissioned research would be difficult to license.

Another key impact of the trend of TLOs being separate is that, in general, TLOs do not have exclusive access to intellectual property produced by specific universities. AIST is an exception to this trend, where all AIST patents must be coordinated through the AIST Patent Office and licensed via the independent TLO called AIST Innovations. In this sense the AIST system is similar to that of major US Universities. Nevertheless, there are some structural differences between the AIST technology transfer organizations and US universities that we present in more detail in section IV.b.

In addition to the TLO law, as mentioned earlier, both universities and research institutes underwent a major legal restructuring during 2000 to 2004. AIST was reorganized in 2001 as an independent research institute and is now no longer part of the government civil service employment structure. Additionally, Japan's national universities became independent administrative entities in 2003 and 2004, and were thus freed from some of the restrictions that were in place when such universities were directly a part of MEXT.

Appendix C - Overview of AIST (産業技術総合研究所)

In April 2001, the current version of AIST began operations. This latest incarnation represents the amalgamation of 15 research institutes that were previously under the former Agency of Industrial Science and Technology (the former AIST) that was part of the former Ministry of International Trade and Industry (MITI) and the Weights and Measures Training Institute. AIST, while new in its present form, has predecessors that have been contributing to the modernization of Japanese industry and society since 1876.

AIST is headquartered in Tsukuba and Tokyo and is currently led by Dr. Hiroyuki YOSHIKAWA. AIST is not a government agency in the traditional Japanese sense. AIST is now an "Independent Administrative Institution" or IAI (独立行政法人). AIST staff are no longer government officials, although their salaries are still largely subsidized by funding from the government.

Currently, AIST oversees 15 laboratories, eight of which are in Tsukuba, with the rest located across seven major cities in Japan. These research institutes are known for their original R&D that has served as the basis for numerous, industry-leading, technological innovations that have acted as engines of growth for specific sectors in the Japanese economy. AIST also has over 50 autonomous units in various innovative research fields, located at 9 research bases and several smaller sites. About 2500 research scientists (about 2000 with tenure) and well over 3000 visiting scientists, post doctoral fellows and students are working in AIST. About 700 permanent administrative personnel and many temporary staff provide support.

Today, the mission entrusted to AIST and its staff, as members of the scientific community, is to develop science and technology that complements society and the environment. AIST's charter, "Full Research in Society, for Society," mandates the following of its staff:
1. Accurate assessment of social trends.
2. Creation of knowledge and technology.
3. Application of research findings.
4. Responsible conduct.

Lastly, AIST is active in six major research fields:
1. Life Science and Technology.
2. Information Technology.
3. Nanotechnology, Materials and Manufacturing.
4. Environment and Energy.
5. Geological Survey and Applied Geoscience.
6. Metrology and Measurement Technology.

AIST researchers are focused on dramatically improving materials and manufacturing technologies, as well as developing, advancing and integrating individual nanotechnology and nanoscience-related technologies that can be used for industrial applications.

At this time, AIST has established multiple research strategies revolving around the concept of "minimal manufacturing." AIST has created this term in order to label those technological systems that it sees as being "capable of creating products with maximum functions from minimal resource inputs using minimal energy (production cost, environmental loads) in the manufacturing process, and with minimal end-of-life environmental loads." In order to facilitate these efforts, AIST reorganized some of its research units in April 2004: the Advanced Manufacturing Research Institute (AMRI) was established to carry out R&D on materials and manufacturing technologies in a single research unit. The Materials Research Institute for Sustainable Development (MRISD) was created to address global warming countermeasures and the Nanotechnology Research Institute (NRI) was strengthened.

Appendix D - Overview of Nanotechnology and Nanoscience-related R&D at AIST

Leading AIST's approach to nanotechnology is the Nanotechnology Research Institute (NRI), a research unit headed by Dr. Hiroshi YOKOYAMA and tasked with supporting a diverse number of nanotechnology and nanoscience-related R&D activities. NRI's goal is to become the world's premiere research center in the field. In this regard, NRI's researchers are on record as being "strongly committed to long-sighted and strategic advancement of methodology and concepts in nanomaterials and device technology, elucidation and utilization of novel physical, chemical and biological phenomena on the nanometer regime, and their extension to industrially relevant technologies."

AIST takes special pride in its capacity as a collaborative research environment. For example, the NRI has strong links with researchers in both the computational sciences and the standards/measurement technology fields. These fields are natural enablers of new nanotechnology R&D. By combining actual experimental research on nanomaterials with the computer simulations of their structure and physical properties, the researchers can achieve more efficient R&D. AIST is also involved in developing sophisticated measurement technologies that are essential for the widespread acceptance and usage of new nanotechnology R&D to industry.

In terms of actual research achievements, AIST has recently showcased work on silicon carbide (SiC) metal oxide semiconductor (MOS) based power devices; ultrafast optical telecom devices based on CNTs; quantum-dot based mass spectrometry; heavy-metal detection strips based on nanoparticles and nanofibers; Cadmium-Selenium (CdSe) quantum dots for industrial and life science applications; and new manufacturing methods for micro electromechanical systems (MEMs). For more information concerning specific nanotechnology R&D efforts being undertaken at AIST, please see the Winter 2007 (No. 23) edition of "AIST Today."

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National Institute of Advanced Science and Technology website
http://www.aist.go.jp/index_ja.html

AIST Innovations website http://unit.aist.go.jp/intelprop/tlo/index.htm

AIST Today, International Edition, Winter 2007. No. 23. ISSN 1345-602X.

Appendix G – Author Profiles

Edward W. Scheckler, PhD, （工学博士 エドワード W シェクラー）is currently a Senior Associate with Monolith Corporation based in Tokyo. In 1991, Dr. Scheckler earned a Ph.D. in Electrical Engineering from the University of California at Berkeley, with a research focus on 3D simulation of etching and deposition processes for semiconductor manufacturing. Dr. Scheckler then came to Japan as a visiting researcher at Hitachi, Ltd. Central Research Laboratory, where he developed techniques for simulation of advanced lithography at the nanometer scale. Dr. Scheckler also holds bachelor's degress in Electrical Engineering and in Modern Languages, earned in 1987 from the University of Notre Dame, in Indiana.

In 1994, Dr. Scheckler moved into information technology management in the financial services sector. He was at Credit Suisse First Boston from 1994 to 2004 where he had both Japan and Asia Pacific wide responsibilities. From 2004 to 2006, Dr. Scheckler was head of Technology Infrastructure for the Japan region at Citigroup. Dr. Scheckler is now active as a consultant to businesses and the investment community, with a particular interest in new business incubation and venture investment.

Todd Tilma, PhD, （理学博士 トッド ティルマ） in addition to working with Monolith Corporation as a part-time Associate, is a technology analyst at the Asian Technology Information Program (ATIP) Tokyo office, and an affiliated researcher in the Center for Complex Quantum Systems at The University of Texas at Austin. Previously, Dr. Tilma was a visiting scientist at the Institute of Physical and Chemical Research (RIKEN), as well as a post-doctoral researcher at the University of Texas in Austin, working on developing mathematical models for nano- and quantum-scale systems.

Dr. Tilma graduated from The University of Texas at Austin with a Ph.D. in mathematical physics and a minor in modern Japanese studies. He currently focuses his time on analyzing nanotechnology, high-performance computing (HPC) and quantum information technology in the Asia/Pacific region.

Thomas Giuffre （トーマス ジュフレ）is CEO and Founder of Monolith Corporation, an IT management and technology business advisory firm. Established in 1992 in the US and Tokyo, Monolith Corporation has a history of developing large-scale IT infrastructures for multinational firms, particularly in the financial services industry. The firm also provides advisory and due diligence on technology M&A, restructuring, and venture investing. Mr. Giuffre has actively participated in numerous technology venture projects, having established and sold several technology based companies since the establishment of Monolith.

Prior to Monolith, Mr. Giuffre began his career in the defense communications sector for major US defense contractors Harris Corporation and Litton Industries. Mr. Giuffre also worked in the semiconductor industry for Emerson Electric and in radio communications R&D in Japan with several of the major Japanese corporate and government research and development centers. Mr. Giuffre holds a BS in Electrical Engineering and Physics from Clarkson University of New York.

---End Report--