UNITED STATES – CHINA

SCIENCE AND TECHNOLOGY COOPERATION

DECEMBER 2006

Biennial Report to the U.S. – China Economic & Security Review Commission

Office of Science & Technology Cooperation
Bureau of Oceans & International Environmental & Scientific Affairs

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I. Statement of Tasking

This report has been drafted to satisfy the requirements of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (Public Law 107-314) (see Tab 1), which states, in part, that the Secretary of State shall submit to Congress a biennial report which provides a comprehensive review of activities under the 1979 U.S. - China Science and Technology Cooperation Agreement and its protocols, including an assessment of the benefits of the Agreement to the economy, to the military, and to the industrial base of the People's Republic of China (PRC). More specifically, the report aims to achieve:

1. An assessment of how the Agreement has influenced the policies of the PRC toward S&T cooperation with the U.S.

2. An analysis of the involvement of Chinese specialists in nuclear weapons, intelligence, and military affairs in the activities of the Joint Commission.

3. A determination of the extent to which the activities conducted under the Agreement have enhanced the military and defense industrial base of the PRC, and an assessment of the effect that projected activities under the Agreement for the next two years, including the transfer of technology and know-how, could have on the economic and military capabilities of the PRC.

4. Recommendations for improving monitoring of the activities of the Commission by the Secretary of Defense, the Secretary of State, or the Director of Central Intelligence.

5. An accounting of all activities conducted under the Agreement since the previous report (2002-2003), and a projection of activities to be undertaken during the next two years.

6. An estimate of the annual cost to the United States to administer the Agreement. (These are found in the compendium of unclassified attachments.)

II. Executive Summary

The Agreement on Cooperation in Science and Technology is the oldest Agreement between the United States and the People's Republic of China. Scientific and technological (S&T) exchanges began in the early 1970s with informal academic exchanges among American and Chinese scientists. This informal relationship provided the impetus for what would become an expansion of S&T- related academic exchanges, government-to-government collaboration, and an acceleration of growth in China's economy.

President Nixon's visit to China in 1972 marked a turning point in U.S. - Sino relations. Both countries pledged to work toward the full normalization of diplomatic relations with the signing of the Shanghai Communiqué at the conclusion of his visit. By the end of 1972, 100 American scientists and scholars traveled to China and the first group of Chinese scientist arrived in the United States. This exchange led to an expansion of cooperative agreements. On January 1, 1979, the United States and China established normalized diplomatic relations. On January 31, 1979, Presidents Deng Xiaoping and Jimmy Carter signed the first formal cooperative Agreement between the Government's of the People's Republic of China and the United States of America on Cooperation in Science and Technology (S&T). This Agreement is among the longest standing U.S. – China accords and provides a framework for promoting bilateral S&T exchanges. These exchanges have fostered cooperative research in a diverse range of fields such as the environment, fisheries, earth and atmospheric sciences, basic research in physics and chemistry, agriculture, civil industrial technology, geology, health, disaster research, and energy-related areas. The S&T Agreement has withstood the test of political turmoil and has provided a stabilizing influence on U.S. – Sino relations.

The establishment of diplomatic relations and signing of the S&T Agreement coincided with China's economic development strategy. As China began to move away from industrial development, economic reforms began to occur across a wide spectrum of areas such as science and technology. China began to implement dozens of policies to stimulate the development of S&T. These policies include increased manufacturing and home grown innovation, exports, foreign investment, and S&T reform of high-tech enterprises. The most prominent programs include the 863 Program, the Spark Program, the Torch Program, the 973 Program, and most recent, the implementation of the *11th Five-Year Plan* and China's most recent *Guidelines on National Medium to Long Term Program for S&T Development*, which envisages China to become a major player in innovation by 2020. According to China's State Council, research and development spending is expected to rise above 2.5% of its GDP. Science and technology advances accounts for more than 60% of China's economic growth, and its dependence on foreign technologies will fall to under 30% of its economic growth by 2020.[1]

Consistent with findings in 2004, the Department of State finds no direct evidence that the S&T Agreement has contributed to the development of China's military capabilities. While a recent Pentagon report indicates that "Chinese military acquisitions by the People's Liberation Army (PLA) is generating military capabilities beyond a Taiwan scenario,"[2] State has found no direct evidence that cooperative exchanges and activities under the S&T Agreement has contributed to the transfer of technology and development of China's military. State's analysis has also found

[1] China State Council. *Guidelines on National Medium to Long Term Program for S&T Development.*
[2] Office of the Secretary of Defense. Annual Report to Congress, "*The Military Power of the People's Republic of China 2005.*"

no area in which China's acquisition of militarily-useful technologies or information can be attributed with any degree of certainty to cooperative S&T activities under the Agreement.

There is however no denying that China seeks to improve its military capabilities through civilian channels. However, with stringent controls on U.S. exports, the vast majority of military technologies acquired by China are acquired from other sources. For example, 90% of China's semiconductor market is reliant on foreign imports. China maintains agreements for military, commercial, industrial, and S&T cooperation with many countries. Comparatively, transfers of technology to China are highest among European countries, Japan, and Russia than from transfers from the United States. With Europe's lack of security concerns over China as a potential threat, Europe has now become an attractive market for China to acquire new advanced technologies such as the sale of semiconductor manufacturing equipment. Likewise, Japan's need to develop close economic ties to China for the sake of its own economic and regional security also creates an attractive acquisition market. Russia has also become an attractive market for the Chinese to procure aircrafts and defense related technologies.[3]

When China became a member of the WTO in 2001, China committed to eliminating technology transfer requirements and offsets as a condition for investment approval or importation. The terms and conditions of any transfer of technology must be agreed upon between the parties to a contract and not imposed by the government. Companies are permitted to negotiate these terms without interference from the Government of China. China also committed to providing better intellectual property protection for technology that is transferred and eliminate requirements mandating that the Chinese partner in a joint venture gains ownership of trade secrets. Prior to China's WTO accession, technology transfer requirements were as high as 100%. While many firms remained hesitant to comply with this requirement, others found the financial profits more attractive and were often willing to comply with the technology transfer requirement. However, in spite of China's WTO commitments, it is common among state-owned enterprises and local governments to use industrial policies to encourage tax incentives and technology transfers in exchange for investment. Another example of an industrial policy imposed to encourage domestic goods over foreign goods is China's adoption of its Government Procurement Law which became effective on January 1, 2003. At present, China is not a member of the WTO Agreement on Government Procurement (GPA); however, this law attempts to follow the spirit of the GPA and incorporates provisions from the United Nations Model Law on Government Procurement of Goods. China's Government Procurement Law also directs central and sub central governments to give priority to local goods and services. Many companies complain that, these policies discourage imports on government purchases of foreign goods and promote domestically manufactured products to strengthen China's innovation and broaden its role in the global economy.

China has used foreign direct investment (FDI) to spur economic and technological development. The largest volume of technology transfers to China comes from the FDI of international firms seeking to gain market access as compared to S&T exchanges operating under the U.S. – China umbrella S&T Agreement. China's open door policy has caused foreign firms to race to gain a presence in China. According to a report by the U.S. Department of Commerce, the majority of transfers on technology occur through private sector foreign direct

[3] Adam Segal. The Washington Quarterly*. Practical Engagement: Drawing a Fine Line for U.S.-China Trade*, Summer 2004.

investments.[4] The Organization of Economic Cooperation and Development reports, China is one of the world's most favored destinations for FDI and receives more foreign direct investment than any other developing nation. China was the largest recipient of FDI inflows in 2004, not only among all countries in the regions but among developing countries. Worldwide, China was the second largest destination for FDI after the U.S.[5] In 2004, China had a cumulative total of $563.8 billion in FDI. The U.S. remains the second largest foreign investor in China after Hong Kong. By year end 2004, the stock of total U.S. investment in China totaled US$15.4 billion on a historical cost basis, much of which was invested in manufacturing enterprises.[6] Foreign investors in high-tech industries face Chinese government pressure to transfer technology, both through incentives, such as rebates and lower tariff rates, and explicit requirements not imposed on domestic competitors, including local content provisions, production export quotas, and/or collaboration in production, research, or training. Multinational companies are encouraged to invest in research and development activities in China and often agree to signing investment agreements that systematically include some form of technology transfer. A common practice in China is the use of "offset deals" in which firms provide industrial and commercial benefits to foreign governments as inducements or conditions in order to do business. These may involve the establishment of a laboratory, center or institute intended for joint research and development in key industries such as ICT, telecommunications, electronics, chemicals, and other areas. "Offset deals" can be described as de facto coercion by Chinese officials to transfer technology as a price of admission to the Chinese market.

While U.S. export control laws are designed to ensure that direct exports from the United States and re-exports of U.S. origin items from third countries are consistent with U.S. national security and foreign policy interests, and U.S. persons are not involved in any activity related to the proliferation of chemical, biological, or nuclear weapons, State has not pinpointed any specific instances of transfers of dual-use technologies to China under the S&T Agreement. Additionally, no direct link has been found between U.S. Government agencies engaged in S&T activities and the PLA. However, given the complex nature of China's close cooperation with commercial enterprises, military, research and development institutes, civil-military linkages cannot be entirely ruled out.

In light of other sources and avenues open to China to acquire dual-use technologies and scientific information, it is State's belief that, if indeed any technologies of military utility were transferred to China in the context of S&T cooperation under the Agreement –the impact on the enhancement of China's military capabilities would have been minimal and of little significance in the larger context of PRC efforts to strengthen its military.

Both the U.S. and China have immensely benefited from the bilateral S&T relationship. The Agreement has promoted scientific, economic, and social progress which has produced mutually beneficial outcomes. Because of the shortfall of American students enrolled in graduate and higher education programs, the U.S. research establishment – academia, industry, and public research institutions relies on educated and scientific engineering students from overseas. China,

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[4] U.S. Department of Commerce, Bureau of Industry and Security. *U.S. Commercial Technology Transfers to the People's Republic of China.* 1999

[5] The Organization of Economic Cooperation and Development. International Investment Perspectives 2005 Edition: Trends and Recent Developments in Foreign Direct Investment.

[6] U.S. Department of Commerce, Bureau of Economic Analysis

among other countries is a leading source for providing students, scholars, researchers, and skilled technicians with strong science and engineering backgrounds. These students work in U.S. laboratories in both the academic and private sectors and help to make vital contributions to U.S. research efforts in the scientific community. While these students and researchers represent a powerful tool that the PRC can exploit to gather information on virtually every sector of the U.S. science and technology development, they also form an important avenue for the U.S. to exert influence on the PRC and advance social change in China.

Benefits to the U.S. also include: sharing of satellite, meteorological, climate, and seismic data; enhanced nuclear power plant safety in China; access to fusion experiments and data; new fossil fuel technologies; precise subatomic particle measurements in energy regimes unavailable in the U.S.; advances in regional water management; aquaculture, the successful conversion of Chinese industry away from ozone-layer destroying Chlorofluorocarbons (CFCs) which are nontoxic, nonflammable chemicals containing atoms of carbon, chlorine, and fluorine used in aerosol sprays, and other agents to more environmentally-friendly substitutes; computer software development; promotion of the U.S. system of measurements and standards; improved climate data forecasts testing and development of U.S. environmental monitoring technologies and agricultural market analysis.

Certainly, cooperative activities under the agreement have also provided some economic benefit to China, in ways such as helping to develop China's minerals, mining and petroleum industries, increasing agricultural production, enhancing energy efficiency, reducing pollution and improving public health (which equates to increased economic performance).

S&T cooperation with China has also provided enormous economic benefits and paved the way for unprecedented commercial opportunities across a wide spectrum of industries. Exports are a direct result of "commercialization," which is the process of turning basic research into technologies that are then brought to market. Scientific research and information technology has made the world smaller through connecting people, nations, ideas, and innovation. Private firms have globalized research and development and technological innovation. During the 1990's, multinational corporations dispersed manufacturing, research, and development around the world. Information technology has made it possible to locate all aspects of the R&D process throughout the world, and U.S. companies' use of licensing agreements, R&D alliances, and foreign subsidies has expanded. The Internet has made scientific information and technical data available around the world at little or no cost. China now leads the way in Asian and ranks seventh in the world for high-tech exports, which make up 21% of manufactured exports. According to Chinese export statistics these exports fall in to the following categories: computers and telecommunications, life sciences, electronics, weaponry, computer-integrated manufacturing, aeronautics and space, opto-electronic technology, nuclear technology, biotechnology, and material design.[7] In 2005, China became the U.S. third largest trading partner behind Canada and Mexico and fastest growing export market in the world for U.S. exports. U.S. export goods totaled $US 41.8 billion, up 20 percent from 2004.[8] China is now importing more high-tech goods such as chips from other Asian countries rather than from the

[7] UNESCO Science Report 2005. East and South-East Asia.
[8] U.S. Census Bureau data

EU and the U.S. OECD figures show that trade between China and other Asian countries grew last year, while ICT exports to China and Asia from the European Union and the U.S. declined.[9]

In response to the Congressional request, this submission thus has three components: State's unclassified report; a compendium of unclassified attachments as submitted by the agencies; and a summary of the classified assessment by the Intelligence Community. This unclassified report is based on State's consultation with and information submitted by all relevant technical agencies identified as having conducted bilateral S&T cooperation with China during 2004-2005. The report will also provide an assessment of how the Agreement has influenced China's policies toward cooperation with the U.S.; the involvement of Chinese specialist in nuclear weapons, intelligence, and military affairs in the activities under the Joint Commission; an examination of the extent to which activities conducted under the Agreement has enhanced China's military and defense industrial base; recommendations for improving monitoring activities of the Commission; and an accounting and estimated cost to the U.S. to administer the Agreement.

The legislative mandate for this report recommends the scope to include those activities conducted under the auspices of the 1979 S&T Agreement; however, State determined that it would be reasonable and useful to report on all cooperative activities with China which were 1) conducted or funded by a U.S. government agency other than the Department of Defense; 2) scientific or technological in nature; and 3) done bilaterally-cooperation through multilateral institutions is not included. These materials were submitted to the Intelligence Community for independent analysis, and their findings will be submitted as a classified annex to this report.

[9] Nancy Gohring, IDG News. *China surpassed the U.S. to become world's No. 1 exporter of IT goods in 2004, according to a report released by the OECD*. December 12, 2005.

III. Introduction

The State Department believes that advancing common interests in peace and prosperity with China is key to achieving our long-term national security goals. As noted in the President's 2002 National Security Strategy, "[t]he United States relationship with China is an important part of our strategy to promote a stable, peaceful, and prosperous Asia-Pacific region. We welcome the emergence of a strong, peaceful, and prosperous China." One of the requirements of this report is to provide an "assessment of how the Agreement has influenced the foreign and domestic policies of the People's Republic of China and the policy of the People's Republic of China toward scientific and technological cooperation with the United States." Through government, scientific, and academic contacts with a large number of Chinese officials and citizens, we are exerting a critical influence over their views, their path of development to a market-based system, and policies towards the United States.

A key component of any nation's economic and social development is the effort to advance scientifically and technically. The personal interaction and sharing of knowledge between scientists in different parts of the world is a critical driver of technological innovation. China has long endorsed the view that there can be no true economic or social growth without such advancement. Since 1979, China and the U.S., under the S&T Agreement, have carried out a diverse and mutually beneficial exchange of ideas through scientific cooperation, education, and dialogue across the entire spectrum of human knowledge. Although there are areas where we likely will compete, as well as areas where we must protect both information vital to our national security and the intellectual property of our citizens, the benefits of our scientific and technological cooperation with China far outweigh the costs of this relationship. Achieving a candid, constructive and cooperative relationship with China is the task set before our diplomatic and scientific communities by the President. In response, the goal of the federal agencies now engaged in the efforts highlighted in this report is not only to tap into and help shape China's growing scientific and technological resources, or to help China handle pressing problems like environmental damage or HIV/AIDS, but to influence China's development into a country with whom we can share common interests that align our nations together against poverty, international crime and terrorism, and other global threats to human welfare, health and dignity.

IV. History of the Agreement

The U.S.-China S&T relationship has been a constant source of success in U.S. –China relations. Activities under the Agreement have remained resilient to political tensions and trade disputes since its beginning. Informal academic exchanges occurred among American and Chinese scientist prior to signing the formal Agreement in 1979. In May 1971, shortly after the American Ping Pong team's visit to China, Arthur Galston, a plant physiologist from Yale and Ethan Signer, a microbiologist from MIT were the first two American scientists to visit China since 1949. After a visit in North Vietnam, both scientists requested a stopover in China after hearing of the Ping Pong team's story and were granted an invitation. They were received in Beijing by Premier Zhou Enlai and had exploratory discussions with their Chinese counterparts. In the summer of 1971, U.S. physicist and Nobel Laureate Chen-ning Yang of SUNY Stony Brook was granted an invitation to China. Chen was received by both Zhou Enlai and Mao Zedong and discussions with Chinese scientist in Beijing and Shanghai.

In 1972, President Nixon's visit to China was a turning point in U.S.-Sino relations as the U.S. and PRC Governments issued the Shanghai Communiqué. The Shanghai Communiqué solidified both governments' commitment to normalizing relations. Both governments' agreed on the facilitation of non-governmental contacts and exchanges in science and technology as well as culture, sports, and journalism. In the absence of formal diplomatic relations, academics and scientist served as "diplomats" and shapers of public opinion about China. By the end of 1972, some 100 American scientist and scholars traveled to China and the first group of Chinese scientist arrived in the U.S.

In 1978, President Carter's Science Advisor Frank Press led a high-level mission of representatives from several U.S. Government agencies to China to determine what was of interest to China for cooperation with the U.S. This visit laid the foundation for subsequent cooperative agreements such as the Understanding on Agricultural Exchange, the Understanding on Cooperation in Space Technology, and the Agreement on the Exchange of Students and Scholars which were all signed in 1978. In the fall of 1978, U.S. Secretary of Energy, James R. Schlesinger traveled to China with representatives from the Department of Energy (DOE), Department of Interior (DOI), the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers, the Bonneville Power Authority, and the Tennessee Valley Authority. Secretary Schlesinger met with Chinese counterparts to discuss cooperation on a broad agenda of energy related items including, the upgrading and expansion of China's coal production, assistance in the planning, design, and construction of hydroelectric power in China; technical and information exchanges on renewable energy sources; and joint programs in high energy physics, nuclear physics, and contained magnetic fusion.

The year 1979 marked the following three significant events that would open China's doors to the outside world and pave the way for major policy reforms: 1) President Deng Xiao Ping implemented China's economic reform plan. 2) On January 1, 1979, the U.S. and China established normalized diplomatic relations, and 3) On January 31, 1979, President's Deng Xiaoping and Jimmy Carter signed the first formal cooperative agreement between the two governments known as the *Agreement between the Government's of the People's Republic of China and the United States of America on Cooperation in Science and Technology*. The three aforementioned existing agreements were incorporated into the umbrella agreement through an exchange of letters. [10]

The 1979 Agreement text remained in force until 1991, when it was revised to include an annex on the protection and allocation of rights to any intellectual property (IPR) created in the course of joint S&T cooperation. This IPR annex was the product of a lengthy negotiation that reflected the arduous process – still continuing today – of bringing China's standards and practices of IPR protection up to acceptable world standards. The annex is a standard annex customarily identified by USTR as the "original 1990 annex." The original 1979 Agreement and the 1991 revised Agreement are provided at Tab 3. The State Science and Technology Commission was replaced in 1998 by the Ministry of Science and Technology (MOST). The Agreement provides for renewal every five years, and was last renewed in April 2001 by exchange of diplomatic notes. The Agreement will be renewed again in April of this year for an additional five years.

[10] Jin Xiaoming. The China-US Relationship in Science and Technology.

V. The Objectives of U.S.-China Science and Technology Cooperation

The principal objective of the Agreement is to provide broad opportunities for cooperation in scientific and technological fields of mutual interest, thereby promoting the progress of science and technology for the benefit of both countries and of mankind. Cooperation under the Agreement includes activities in the fields of agriculture, energy, space, health, environment, earth sciences, and engineering, inter alia. The Agreement provides for exchanges of scientists, scholars, specialists and students, and of scientific, scholarly and technological information and documentation. It also provides for joint planning and implementation of programs, courses, conferences, seminars and projects, joint research, development and testing, and the exchange of research results and experience between cooperating U.S. and Chinese entities. Facilitation of scientist-to-scientist collaboration under this agreement has been a key to the success of the bilateral S&T relationship.

The bilateral S&T relationship is coordinated through two mechanisms: the Joint Commission on S&T Cooperation and the S&T Executive Secretaries. The high-level Joint Commission Meetings (JCM) focuses on key themes in U.S. - China S&T cooperation and charts the course for the future. The U.S. co-chair for the JCM has customarily been the White House Office of Science and Technology Policy (OSTP) Director. The Chinese co-chair was the State Science and Technology Commission Chairman before that Commission was abolished in 1998. Since then, the Chinese co-chair has been the Minister of Science and Technology. While the text of the Agreement calls for annual JCM meetings, it has become customary for the Joint Commission to meet every two years, with each partner hosting the event alternately. In actuality, the Joint Commission has no permanent existence, but meets only when a JCM is convened. The composition of the JCM on both sides varies greatly from meeting to meeting, depending on those holding office at the time and the agency/ministry participating.

The Executive Secretaries for the Agreement are the Director of the State Department's Office of Science and Technology Cooperation (OES/STC) and the Director of International Scientific Cooperation in China's Ministry of Science and Technology (MOST). There has been considerable variation in the timing of Executive Secretariat Meetings (ESM) over the years, but in recent practice the two sides have agreed to hold an ESM regularly during the year between JCMs, in order to avoid a two-year interval between consultations. At an ESM, working level delegations from both sides conduct a systematic review of accomplishments under each protocol, examine any problems and propose solutions, discuss logistical aspects of the cooperation (meeting sites, delegation composition, travel, etc.) and discuss future plans for S&T cooperation. If the sides perceive a need to modify the text of the Agreement with addenda, annexes or additional protocols, these changes are worked out at the ESM, as mutually agreed. The main product of the ESM is a series of reports on the progress of the bilateral S&T cooperation to be presented at the JCM.

The last JCM was held in April 2004 in Washington, DC, while the last ESM was held in October 2005 in Baltimore, MD. Planning is currently underway for a JCM to be held in Beijing, China in October of this year. Minutes and other documentation from the last JCM and ESM are included at Tab 2.

VI. Protocols under the S&T umbrella agreement

The S&T Agreement itself is a broad "umbrella" agreement which provides for some of the more universal conditions for cooperation, but which cannot anticipate all of the subjects for cooperation which might arise over the years. The U.S. technical agencies and their Chinese ministry counterparts therefore develop subsidiary, subject-specific agreements for their cooperation that are "Protocols" or "Memoranda of Understanding." Some of these protocols refer to single specific joint S&T activities, while other protocols cover a broader subject area and may contain a set of related sub-agreements (project annexes) to further define cooperation in specific areas. Many protocols provide for annual meetings between technical experts of the cooperating agencies/ministries to discuss joint activities, resolve problems and outline the future course of the cooperation. The number of protocols, etc. has grown over the years, and there are now more than 26 active protocols and over 60 annexes. Protocols typically are signed to cover a five-year period of cooperative activity. In some cases the planned cooperative projects have been completed within that span and the protocols have been allowed to lapse without renewal.

VII. Assessment of how the Agreement has influenced China's foreign and domestic policies

According to China's State Council Information Office, in 1900, China had no modern S&T at all – Fewer than 10 people in the country understood calculus.[11] Prior to the reform period of 1978, the main goals of S&T policy were simply to satisfy the needs of production. After holding a state S&T Conference in 1978, the Chinese government acknowledged that S&T was instrumental to increased productivity and many reforms began to take place. China implemented the science and research responsibility system and contract on charge system. Under the science and research responsibility system, institutes could receive projects from enterprises and other organizations and create revenues for themselves when they finished the tasks granted by the higher administration. With the contract on charge system, institutes signed contracts with users, including central and local governments, enterprises and other unit organizations.

With Deng Xiaoping's economic reform plan of 1979 and the signing of the U.S. - China S&T Agreement, domestic focus shifted towards S&T policy reforms. China tried to combine its central planning with market-oriented reforms to ignite economic and industrial development, increase productivity, living standards, and technological quality without exacerbating inflation, unemployment, and budget deficits. These reforms led to average annual growth rates of 10% in agricultural and industrial output and China became the world's fastest-growing economy. By the late 1980's the economy became overheated and experienced a period of disinflation; however, it later rebounded in 1992.[12] In the 1980's China began to implement a series of programs for S&T R&D. These programs aimed to improve China's competitiveness by the 21st century.

Key Technologies Program

In 1982, China launched the Key Technologies Research and Development Program and became the first and largest S&T program during the 20th century. This program was oriented toward

[11] China State Council Information Office. February 2006.
[12] The Rise of China. William Overholt. 1993

national economic development and aimed to stimulate industrial productivity and sustainable development. The program outlined priority areas in agriculture, information technology, transportation, mineral resource exploration, environmental protection, modernizing China's traditional medicine, and other fields. This program also contained the largest budget for S&T programs, employed the most people, and engaged more than 1,000 research institutes.

Decision on S&T System

In March of 1985, China issued the *Decision on S&T System*. This program became the foundation for reform of the S&T system. The *Decision on S&T System* contained the following three components: 1) the commercialization of technology, in which the government stipulated the marketing and selling of new technologies; 2) the merging of S&T institutes with enterprises and development of new enterprises; and 3) the importation and development of new technologies and renovation of existing equipment. As a result of this policy, many Chinese S&T institutes found it difficult to rely on government funding. Many began to merge with existing enterprises and others formed independent businesses to market their own research. This era gave birth to a rise in new entrepreneurs, and technology conglomerates such as Lenovo, Founder, and Qinghua Ziguang were founded.

The 863 Project & Spark Program

In March of 1986, China launched the 863 Program, otherwise known as the National Hi-tech Research and Development Program. This program included 20 themes in biology, spaceflight, information, laser, robotics, automation, energy, new materials, and oceanography. Still in existence today, the goal of the program is to bring a cross-disciplinary range of specialist together in many fields for collaboration. The 863 Project introduced the concept of peer review mechanisms to technology plans. Under this project, researchers focused mainly on civilian technologies.[13] In 1986, the Chinese government also launched the Spark Program. This program aimed to revitalize rural areas through development and S&T education. Currently, there are more than 140,000 S&T demonstration projects being carried out in 90 percent of the rural areas in China.[14]

The Torch Program

In 1988, China launched the Torch Program. This program is known to many as the most significant high-tech industry and national guideline program. The Torch program emphasized commercializing new technologies, supporting the growth of high-tech industries, and developing high-tech products in domestic and foreign markets. The program established high-tech industrial development zones throughout the country, and included projects in areas such as new materials, biotechnology, information technology, integrated mechanical and electrical technologies, and advanced energy saving technologies.[15]

S&T Progress Law of the PRC and the Climbing Program

In 1992, the socialist market economy was initiated and China's S&T policy reforms moved toward structural adjustments. A series of laws and regulations were instituted such as the *S&T Progress Law of the PRC* and the *Climbing Program*. These regulations were designed to

[13] "High-Tech R&D Program (Project 863) Surges Ahead" Zhongguo Keji Luntan, no 5, 18 September 1989. pp 8-10, the Joint Publication Research Service-Shina Science and Technology, January 4, 1990.
[14] China's Major S&T Programs 2001-2005. Ministry of Science and Technology. Published Beijing,China.
[15] Export IT China. U.S. Department of Commerce, April 2003.

encourage institutes to implement organizational innovations. Many institutes began to operate as enterprises and many changed their legal status during the reform of 1999. Out of this policy grew 100 institutes that were granted foreign trade operating and S&T import and export rights. In 1994, engineering design units formally transformed into enterprises. China began to encourage the development of high-tech industry zones and private new technology enterprises. Many state-owned enterprises, universities, and medium-to-large size enterprises began to create state-owned but privately operated new technology enterprises. This encouraged more S&T employees to become principle partners of these enterprises. In 1995, China issued the *Decision on Accelerating S&T Progress* and the *Decision on Profound S&T System Reform*. These reforms established a science and research system composed of independent institutes and universities.[16]

The 973 Program

In 1998, the Chinese government launched the 973 Program. According to Chinese data, the 973 Program focused on the development of basic scientific research and involved research on important scientific issues in agriculture, energy, information, resources, population, health, and materials. The program encouraged scientists to carry out basic research on S&T issues related to socio-economic development.[17] In 1999, the State Council and Central Committee held the National Technology Innovation Convention. After the Convention a document was issued entitled *The Decision on Strengthening Technology Innovation, Developing High-Technology and Realizing Industrialization*, which emphasized that the central government should strengthen China's position in technology innovation.[18]

The 11th Five - Year Plan for Economic and Social Development

In March of 2006, the China's National People's Congress endorsed the 11th Five-Year Plan for Economic and Social Development, which is China's newest five-year development blueprint. The plan aims to invigorate China through science and education and enshrines a "Scientific Concept of Development," meaning China will shift its focus from an over-reliance on a cheap labor force, funds, and natural resources to educating workers and the improvement of S&T. The plan outlines China's new economic policies relying on rural development and science and technology progress. This concept was raised after President Hu's visit to Guangdong Province during the SARS crisis of 2003. The five-year plan sets an 8 percent growth rate for 2006 and 7.5 percent annually for the next five years, by reducing energy consumption and pollutant discharge.

The Plan will focus on the following six areas to promote development:

1. China plans to rely on expanding domestic demand through consumption and investment. China will also widen income distribution, raise the income levels of urban and rural residents, and increase the capacity for consumption.
2. China plans to rely on developing the industrial structure which will be driven by primary, secondary, and tertiary industries. Top priorities will be given to agricultural, rural areas, and farmers.

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[16] High-Tech R&D Program (Project 863) Surges Ahead" Zhongguo Keji Luntan, no 5, 18 September 1989. pp 8-10, the Joint Publication Research Service-Shina Science and Technology, January 4, 1990

[17] China's Major S&T Programs 2001-2005. Ministry of Science and Technology. Published Beijing, China.

[18] Review of the Reform of Research Institutes. Yuli Tang. Conference on China's New Knowledge Systems and Their Global Interactions. September 2003.

3. Chins plans to rely on resource conservation and environmental protection. Environmental protection will be strengthened by protecting and restoring ecosystems, improving resource management, and balancing population growth to achieve sustainable development.
4. In an effort to ignite economic growth, China plans to promote a national strategy of enhancing innovation through the advancement of science and technology. Priority will be given to science education which includes a free 9-year compulsory education program for rural communities.
5. China plans to rely on systematic reforms such as restructuring government functions, reforming enterprises, and its financial system.
6. China plans to rely on human resource development to reduce regional economic gaps.

This plan signifies a major shift from urban development and industrial investment policies to increasing rural S&T investment for sustainable development. The plan includes a project to divert water from the country's south to north, and a gas pipeline that runs from western China to its east coast. A government fund will be used to raise the living standards of 900 million people living in rural areas, and boost S&T research for manufacturing low cost domestic products. Infrastructure investment will focus on farmland, roads, safe drinking water, methane facilities, power grids, and telecommunications. The plan also proposes to increase the development and design of key technologies and equipment to localize core components, and integrate manufacturing and systems. It will also focus on information technology, biotechnology, environment, and reducing energy consumption.

Guidelines on National Medium and Long Term Program for S&T Development
As a subset of 11th Five-Year Plan for Economic and Social Development, China's State Council most recently unveiled the *Guidelines on National Medium and Long Term Program for Science and Technology Development*. These guidelines outline China's strategic high-tech development for the next 15 years (2006-2020), and set the proportion of research and development expenditure in GDP at 2.5 percent. The State Council expects that by 2020 science and technology will contribute to at least 60 percent to the country's development, and reliance on foreign technology is expected to decline below 30 percent. The number of patents granted to Chinese nationals is expected to increase and scientific and academic essays are expected to rank among the top five nations in the world. The guidelines focus on the following 11 areas:

More support to the innovation of enterprises. China will urge large enterprises to set up R&D institutes and encourage innovation of small and medium sized enterprises. State owned enterprises will be evaluated by their ability to show innovation. The central government will encourage enterprises to spend more on R&D. R&D partnerships between state-level engineering labs, industrial engineering centers, and state owned enterprises, universities, and scientific institutes will also be encouraged.

The Chinese government also plans to issue a broad range of incentive policies such as, favorable taxation policies for innovation-oriented enterprises. Enterprises will be allowed to offset 150% of the income tax they should pay for the relevant year according to the actual expenses on technological development of the same year and establish venture capital firms to finance innovation-oriented start-ups. Specific policies will also be included on government procurement of foreign technologies, intellectual property protection, human resources, and improving science awareness. China also plans to set up a national committee to oversee mergers of high-tech firms to protect domestic intellectual property.

Strengthen basic research. China plans to strengthen basic research to meet its strategic demands and achieve national goals for the next 15 years. The government will encourage research programs that promote economic and social development, national security, and innovation.

Issue guidelines to boost innovation. China plans to encourage innovation to ensure its competitiveness in equipment manufacturing, information technology, agricultural sciences, energy exploration, energy saving technologies, and environmental technologies. The guidelines urge all government officials to support efforts to make China an innovation-oriented country.

Create a better environment for listing of high-tech firms. The government will adopt preferential banking policies that will allow more start ups and high-tech companies to go public. China pledges to build and improve risk investment for start-ups by drafting and stipulating laws, regulations, and relevant policies. The government also plans to set up a secondary stock market and multi-level capital market system for science and technology based enterprises. High-tech companies with favorable conditions will be encouraged to go public on domestic primary and secondary stock markets. The plan will also encourage small high-tech companies to go public overseas and create a stable banking and foreign exchange environment for these ventures to raise funds abroad. The government plans to conduct experimental stock trades of unlisted high-tech firms located in development zones, set up markets for property rights exchange, and increase capital for start ups in the venture capital market. Financial institutions will be encouraged to grant preferential credit loans to support state projects that industrialize technology, and improve the creditability assurance system to help small businesses to raise funds.

Set goals for developing S&T in 15 years. In addition to developing areas in equipment manufacturing, information technology, agricultural sciences, energy exploration, energy saving technologies, and environmental technologies, the government also plans to improve research for the prevention of infectious diseases; develop and manufacture pharmaceuticals and medical equipment; safeguard national security; develop a cadre of world-class scientist and research teams in the areas of information technology, biology, materials, and space; and develop world class research institutions, universities, and company owned R&D centers.

Increase investment in S&T. Investment in R&D is expected to account for 2 percent of GDP by 2010 and 2.5 percent of GDP in 2020. Government investments will be used to support basic research, frontier research, and key technologies. The central and local governments will monitor to ensure that S&T expenses are much higher than its financial revenues. China will publicize the expenditures of research organizations and scientific projects, increase investment in S&T, increase transparency in state scientific research projects, and establish a system to monitor scientific expenditures.

Create a blueprint for the development of frontier technologies. By 2020, China expects to have developed a number of frontier technologies in the biological sector. China plans to design animal and plant species, pharmaceutical elements, genetic operation and protein engineering, and dry cell-based human tissue engineering. For the information industry, China will aim for high efficiency and low cost computer applications. For materials technologies, China will work on high-temperature superconductor technology, and efficient energy and material technology. For advanced manufacturing technology, China plans to make breakthroughs in extreme manufacturing and robotics. China will also focus on efficient and clean use of energy research, the exploration of new energy resources, and develop technologies for ocean and sea exploration. China also plans to make breakthroughs in maritime monitoring, sea bed measurements, exploration of mixing gas-water, and deep-sea operations. Finally, China plans to develop laser and space technologies.

Accelerate the implementation of a national IPR strategy. China plans to expedite the implementation of a national strategy on intellectual property rights, which would enhance the existing legal environment for IPR. China will develop programs to increase people's awareness of IPR protection, and crack down on infringements. China also plans to set up a system to monitor IPR issues involving mergers and acquisitions and technology transfers. Enterprises, research organizations, universities, and industry associations are also routinely urged to publicly support IPR protection. China also plans to support the filing of patent applications, and increased cooperation in international trade.

Accelerate technological development in 11 key industries. China will give priority to the development of the following major sectors: mining resources, the environment, agriculture, manufacturing, communications and transportation, information technology, and service industries, population and health, urban development, public security, and national defense.

China will publish major research programs for the next 15 years. China recently made public four major research programs covering the study of protein, the control of quanta, nanotechnology, and growth and reproduction.

Combining military and civilian research organizations. China plans to reform its science and technology management system and coordinate military and civilian research organizations to promote scientific development.

These policies are all designed to spur economic growth and innovation. However, the guidelines also acknowledge that compared to developed and emerging industrialized nations, China's investment in S&T is still insufficient, and the basic conditions for S&T are still weak.

The 11th Five - Year Plan on Revitalizing Trade through Science and Technology

China's Ministry of Commerce (MOFCOM) is becoming a new player in the role of S&T. MOFCOM recently unveiled the 11th Five-Year Plan on Revitalizing Trade through Science and Technology, which is a subsection of the national 11th Five-Year Plan. This plan aims to build 100 "export innovation" bases which will serve as a platform to produce domestic high technologies and "re-innovate" imported technologies. MOFCOM expects that by 2010 there will be 100 innovation bases that will contribute to 70 percent of China's total export of high-tech products. The bases will cover fields the following areas: information technology, pharmaceuticals, software, new materials, fine chemicals, marine biology, and production of automobiles and component parts. MOFCOM also expects to develop 160 domestic high-tech brand name exports, upgrade existing technologies and R&D programs, support 100 large scale enterprises and 1,000 export oriented companies. The plan also expects domestically manufactured high-tech products with proprietary IPR to make up 15% of all high-tech exports.

On the import side, the plan aims to increase patented technologies and contracts to 50% of all technology imports by 2010.[19]

Technology Challenges and Intellectual Property

According to the American Chamber of Commerce in China, "China continues to encourage technology transfer and establishment of research facilities, but it is clear that weak IPR enforcement is a material deterrent to both."[20] China has undertaken substantial efforts to implement its commitment to overhaul its legal regime to ensure the protection of IPR, but overall enforcement still remains a problem. Counterfeiting and piracy levels remain high, and have a serious impact on many U.S. businesses. However, S&T reforms and the development of homegrown IP in China will likely have an impact on China's IPR enforcement measures. As the Chinese government continues to implement reforms that encourage the development of S&T innovation, IPR enforcement will become even more important to national, local and provincial officials. China's senior leaders readily acknowledge in meetings with USG officials and in the press that innovation will be crippled without adequate IPR protection. They also acknowledge that improved IPR protection and enforcement is just as much in China's interest as in the interests of trading partners whose companies and inventors have suffered IPR related losses in or from China.

Current S&T policy reforms are aimed to encourage domestic high-tech entrepreneurs and new innovation in S&T. Under the banner of these reforms, China has taken steps to address the role of IP in fostering innovation. These efforts may lead to effective enforcement of IP, as intellectual property infringements will equally affect both domestic and foreign innovation. Under the banner of scientific development, China is ramping up attention to intellectual property protection and enforcement. One such example, is the March 2006 *China's Plan on IPR Protection Action 2006*, formulated by the National IPR Working Group. This plan outlines and prioritizes legislation and enforcement campaigns for 2006 designed to better protect IP in China. To date, increased enforcement efforts by the Chinese government, actions and legal remedies have not been strong enough to deter intellectual property pirates and counterfeiters, although the medium and long-term effects of the S&T policies on IPR protection have yet to be determined.

In 2005, China was among the top ten countries filing international patents with the World Intellectual Property Organization (WIPO). China filed 2,452 patents under its Patent Cooperation Treaty. This is a 44 percent increase since 2004.

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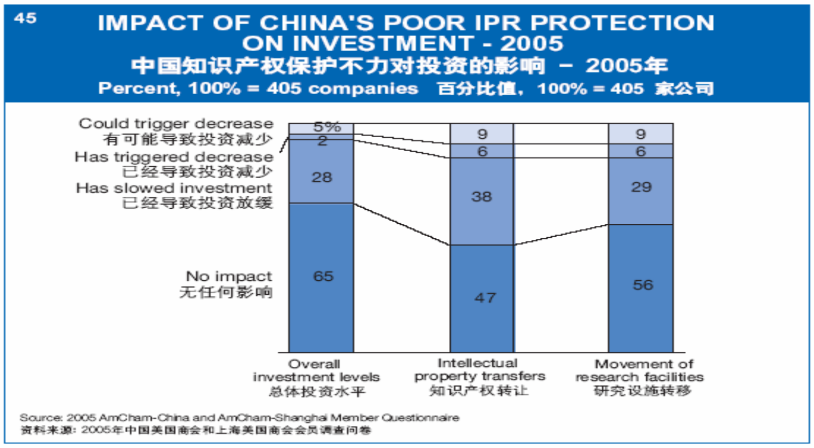
[19] International Business Daily. March 16, 2006.

[20] American Chamber of Commerce, *American Corporate Experience in a Changing China*, 2006.



Global Standards Setting

Shortly after China joined the WTO, it began bringing its standards setting process more in line with international practice. However, concern continues to grow over China's active pursuit of developing unique requirements despite the existence of well established international standards, particularly in sensitive, high technology areas. Many leaders believe that developing homegrown technology standards is a way to protect and foster the development of the local industry, and view standards setting as an industrial policy tool. Preference for homegrown standards developed and incubated in China will place the U.S. and other foreign countries at a disadvantage particularly in export markets.[21]

U.S. companies often experience hidden barriers in the form of technical regulations and mandatory technical standards requirements. Foreign companies across a number of sectors have found that many of China's standards, licenses, and inspection procedures interfere with their ability to market their goods and pose non-tariff trade and investment barriers. Many companies complain that China's certification requirements for high-tech and other products are particularly restrictive. In applying for certification, some foreign firms reportedly have been required to submit detailed and even proprietary or confidential information, including technical specifications, manufacturing processes, designs, blueprints, formulas, patents, etc.[22] Hence, private sector transfers of technological innovation and know how far exceeds transfers of technology under the activities of the S&T Agreement. USG trade agencies and our diplomatic missions in China and Geneva frequently advocate for a transparent, market driven standards development system, urge Chinese participation in international standards setting activities and remind China of its WTO obligation to timely notify technical requirements that could have an impact on trade.

VIII. The Benefits of the S&T Agreement

The S&T Agreement has facilitated a deep and ongoing dialogue between the U.S. and Chinese science communities. This dialogue occurs between U.S. technical agencies and their Chinese ministry counterparts at a policy level, but is probably most intensive at the level of individual scientist-to-scientist communication, either face-to-face at conferences, meetings, in the

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[21] National Trade Estimate 2005.

[22] U.S. Department of Commerce, Bureau of Industry & Security. U.S. Commercial Technology Transfers to the PRC. 1999, Part 3.

laboratory, or through the internet. Such communication would undoubtedly occur regardless of the presence of a diplomatic agreement, but the cooperative activities undertaken as a result of agency memoranda of understanding's (MOU's), signed under the Agreement and its protocols, provide a structural basis for individual scientists to develop partnerships with colleagues living in other countries who have common research interests. This individual scientist-to-scientist collaboration is largely unhampered (outside of security background checks and clearance of information for release to China by agency nonproliferation offices) by either government and is a natural outgrowth of the expanding network of individual collaborations among scientists in countries around the globe using the internet.

While the overall U.S. - China relationship may swing up or down as a result of political and economic developments, changes in leadership and other factors, the Agreement has helped moderate the bilateral relationship. The U.S. - China S&T relationship has remained a largely stable pillar of U.S. – China relations. It allows a continuance of cooperative activities in science and technology at levels determined by scientific accomplishment, mutual interest, and available budget than by geopolitical interest. The common bond of knowledge among American and Chinese scientists keeps channels of communication open in times of tension and gives an influential segment of Chinese society a stake in maintaining peaceful relations with the U.S.

The Benefits of the S&T Agreement to the United States

The scientific relationship is perceived by both countries as beneficial. China has supplied the U.S. with significant amounts of high tech research talent and labor. As a result, both countries have benefited from the Agreement, though in different ways. The following are examples of benefits the U.S. gleans from maintaining a positive S&T relationship with China:

- In the case of China, data is especially important. Some of our most important collaboration involves the sharing of data, such as, satellite, meteorological, climate, seismic, etc.

- Science and technology cooperation helps offset tensions in other parts of the U.S.-China relationship.

- China has an increasingly large cadre of well-trained and well-equipped researchers which U.S. scientists can leverage for cooperative research to meet U.S. scientific goals. Cooperation in scientific research is a win-win situation as both sides benefit from the research.

- U.S. scientists from NRC and DOE who visit Chinese nuclear power plants under the auspices of nuclear safety cooperation are learning about and keeping current on the evolution of the Chinese nuclear power industry and the state of its technology. This transparency/confidence building element is also important in efforts to promote nuclear safety in China.

- The U.S.-China cooperation in the nuclear industry helps open potential markets for advanced U.S. nuclear power technology, such as Westinghouse's 4th generation reactors.

- U.S. nuclear engineers and regulators are extremely interested in new reactor designs that are being built in China. China has built an experimental pebble bed reactor which at the moment is one of only three in the world, and the most advanced. The Chinese nuclear industry is advancing quickly and the U.S. will likely look towards China or other countries in the Far East to draw upon state-of-the-art nuclear technology designs. U.S. nuclear engineers and regulators are also interested in new fossil fuel technologies, such as coal liquefaction and integrated gasification combined cycle (IGCC) plants.

- High-energy physics research is becoming an increasingly globalized effort and cooperation allows U.S. scientists to use scientific facilities in China that the U.S. does not support domestically. Substantial numbers of DOE physicists from national laboratories visit China annually in connection with high-energy physics cooperation. Cooperation with the Chinese on the Beijing Electron-Positron Collider (BEPC) gives U.S. researchers the rare opportunity to make precise subatomic particle measurements in a high luminosity energy regime. Only one US facility conducts experiments in this energy regime and future upgrades of the BEPC will likely increase the BEPC's utility to US researchers. In addition to advancing particle physics research of value to both countries, U.S. scientists learn what China's capabilities are in basic physical science.

- U.S. science benefits significantly through joint and collaborative fusion physics experiments at Chinese test facilities. Coordinated experiments and comparative data among many fusion facilities are required to make progress with the U.S. Fusion Energy Sciences Program. Despite budget cuts in the U.S. Fusion program, bilateral cooperation with China has led to advances and innovation in fusion science, technology and plasma confinement across the entire spectrum of fusion science and technology. In the area of nuclear data for fusion design and analysis, China has unique facilities that can provide nuclear reaction cross-section measurements and conduct integral experiments to validate and guide the development of computational and predictive methods. Like high-energy physics research, DOE foresees that the U.S. will gain important scientific information from collaborations with the Chinese as they build facilities that the U.S. does not plan to support domestically.

- U.S. conventional energy cooperation is aimed at accelerating the adoption and dissemination within China of cleaner energy technologies, so that China's future greenhouse gas emissions (China is the world's second-largest greenhouse gas emitter, after the U.S.) from energy generation will be less.

- Adoption of clean coal and clean burning fossil fuel technologies in China also opens a huge potential market for clean energy technologies and equipment, in which U.S. industry is the world leader. Collaborative projects have set the stage for Chinese support of U.S. energy businesses. U.S. energy companies interested in the China market have received one-on-one specialized business support assistance from Chinese organizations such as customized market research, excellent contacts, introductions to key industry and government representatives, and facilitation of business deals. The Energy and Environmental Technology Center also enhances the competitiveness and adoption of U.S. energy and environmental technologies in China.

- The delegations of Chinese scientists that visit NIST each year help promote the use of U.S. measurements and standards in China. Not only do these exchanges expose other countries to the U.S. system of measurements and standards and increase the potential for others to adopt similar practices, they also contribute to the development of the measurement infrastructure necessary to support international trade and ultimately, increase U.S. exports. In addition, NIST visits to China provide the opportunity to visit Chinese laboratories and learn more about China's measurement capabilities and ongoing research efforts.

- Joint research with the U.S. Geological Survey, NASA, ONR, and the National Science Foundation into mineral resources, including oil and gas, has given the U.S. a leg up in a number of areas. Increases in China's oil and gas potential provide both nations with a potential alternative to Middle East sources of supply. U.S. cooperation in discovering and developing China's fossil-energy reserves also creates large potential markets for U.S. oil industry equipment suppliers, as well as joint venture opportunities for U.S. oil companies. USGS assessments of identified and undiscovered mineral resources in China such as copper, platinum-group metals, zinc, lead, chromium, manganese, and potash will provide information to U.S. industries that will facilitate access to these mineral resources. China is also a very significant source of rare earth and other exotic minerals of critical use in today's high-tech industries, such as fiber optic communications, microelectronics, and computers. Exchanges not only provide the U.S. with potential access to sources of supply, but also to understanding the geological habitat of these ores so they also can be located elsewhere.

- Successful work by EPA in helping China to phase out old production and use of CFCs and other substances that deplete the ozone layer, substituting more environmentally friendly refrigerants. China is currently the largest producer and consumer of ozone depleting substances, so this type of tech transfer is vital to protecting the global ozone layer, a benefit for the entire world.

- U.S.-China cooperation in the environment helps reduce the potential for ecological damage to the U.S. West Coast, Alaska and Hawaii from Chinese pollution and dust storms. If China's pollution continues unabated, its impact will counterbalance progress made in the United States. These and other environmental efforts demonstrate the U.S. commitment to international environmental issues and improve political stability in the East Asia region by decreasing tension over energy supply, natural resource management and environmental degradation.

- China has some extreme environmental conditions that provide scientific test cases that are unavailable in the United States. For example, the Yellow River collects huge sediment loads that the USGS uses to calibrate models to include sediment levels that would be off the scale in U.S. rivers. Cooperation with Chinese scientists helps the USGS devise new sediment transport monitoring technologies by testing their accuracy under extreme sediment-laden conditions. The U.S.-China Joint Center for Soil and Water Conservation, based in Yangling, is used for joint research on China's uniquely challenging erosion topography. U.S. and Chinese scientists use this outdoor laboratory to examine ways to prevent wind and water-driven soil erosion in both China and the

United States. Cooperation often sets the stage for the sale of advanced US environmental monitoring technologies to Chinese collaborators.

- On water resource management, the benefits to the U.S. from helping China are twofold: 1) Maintaining regional stability and ecological integrity (including for downstream South and Southeast Asia) and 2) obtaining information and experience that will enable the U.S. to deal with our own water management problems in fast-growing arid regions, which, while not currently as critical as those facing China, could become so in the foreseeable future.

- China has invested heavy resources in remote sensing and mapping research and a large number of Chinese scientists are international leaders in the field. Almost every Chinese research university has a department or program in remote sensing and they collectively graduate thousands of Chinese students each year. USGS-China cooperation leverages Chinese expertise to provide global data valuable in monitoring trans-boundary environmental phenomena and to solve other mutually beneficial, non-sensitive, remote sensing and mapping research problems.

- Joint research with China on climate change helps NOAA achieve its scientific goals through access to environmental data and partnering in international climate observation programs. China's increasing investments in climate change and similar climate patterns to the U.S. help ensure that cooperation aids both countries to better understand the impact of climate on society. NOAA's efforts to establish international climate observation programs and gain access to environmental data in China are critical to improving climate data coverage and, subsequently, climate forecasts.

- The similar climate and ecosystems of the two countries mean that the analysis of environmental data in China can be profitably used to develop and calibrate U.S. software models, contributing to their robustness and applicability. USDA scientists intend to use Chinese data sets to help improve their models of wind and soil erosion and watershed management in the U.S. The U.S. Forest Service calibrates some of its geographic information systems with hydrological data garnered from collaboration with Chinese partners. Remote sensing data used in monitoring wildfires is also being validated in a joint project between the U.S. Forest Service and the Chinese Academy of Forestry.

- U.S. commodity analysts have learned about China's agriculture sector and the cross commodity relationship among major agricultural commodities in China through publications produced by Chinese government agricultural analysts and economists trained by USDA's Emerging Market Project. The project trains Chinese analysts in market analysis on grain crops, corn, oilseed crops, and livestock products.

- China also bears watching on genetic engineering (especially rice) and other agro-biotechnology. For example, China is already the world's leading producer of GM (genetically modified) cotton. In projects of mutual interest, like DNA sequencing of the cotton and rice genomes, cooperation provides access to the DNA sequencing data in a shorter timeframe at much less expense than if the US were to work on it alone. A landmark paper, "A Draft Sequence of the Rice Genome (Oryza sativa L. ssp. Indica)" was published in the journal, Science. All 100 authors are Chinese geneticists, agronomists, or computer specialists. Two were also associated with Washington University in St. Louis, an example of growing U.S.-China S&T Cooperation between academic/research institutions.

- China is also a valuable source of germplasm that can be used by the U.S. to improve domestic varieties of important crops. There is ongoing work to incorporate Chinese flood tolerant soybean genes into U.S. domestic soybean crop base. This has the potential to increase US soybean yields significantly in areas that have problems with water drainage. Through access and exchange of Chinese germplasm, the US is able to strengthen crop varieties and potentially increase production.

- Wide-ranging joint research and exchanges on disease prevention, pathogen resistance, animal disease management, and disease diagnostic technology and food safety techniques protect many U.S. agricultural products.

- Since China and the U.S. have many species and ecosystems in common, research results in numerous scientific fields can be applied in both countries. The U.S. and China currently conduct joint research on the biological control of a variety of pests in the U.S. including termites, Japanese beetle, wheat stem sawfly, saltcedar, alligatorweed, water hyacinth, kudzu and leafy spurge. In addition, a Grazingland Ecosystem Restoration Center has been established in Gansu Province that will promote joint research in grassland and rangeland management. China has large areas of grassland in the western region of China that experience similar problems to grasslands in the western United States, where little grassland data is available. Global trade has meant that the US hosts invasive species previously unknown to this part of the world. Conducting research on invasive species in their native environments provides ARS scientist’s access to enemies of the invasive species and can study crops resistant to the pests. This research directly contributes to the security of U.S. crops and the U.S. landscape.

- Chinese scientists have also succeeded in increasing the temperature tolerance and hence growing range of edible seaweeds. Using genetic techniques, they have increased the production of such seaweeds several fold. The growing Chinese capabilities in genetic engineering offer opportunities for productive collaboration in this area that can benefit both countries. Access to Chinese expertise in developing alternative food sources could prove important to the U.S. food industry and to future U.S. food exports as world population continues to increase.

- Cooperation in marine resources benefits the U.S. scientific and commercial sectors by providing them access to large scale fisheries and aquaculture production technologies practiced in China.

- Additionally, China, where earthquakes occur quite frequently and all too often with devastating effect, has a centuries-old tradition of earthquake predicting studies, a field that is also of enormous interest to the U.S. Joint U.S.-Chinese earthquake prediction research is doubtless of mutual benefit from the humanitarian perspective, but strongly favors the U.S. in terms of potentially mitigating the economic costs of earthquake disasters. Cooperative research on earthquake engineering and hazards mitigation continues to yield information of mutual use in the reform and enhancement of design and construction standards for buildings, roads, bridges and other structures in earthquake prone areas. In addition, research in health monitoring and damage detection of civil infrastructure systems increases U.S. capacities to respond to potential earthquakes, accidents or terrorist attacks.

- Meteorologically, China also offers major test sites for devastating coastal phenomena, e.g. tidal bores, tsunamis, typhoons, etc. Opportunities for joint research on these destructive weather phenomena also holds promise for the development of disaster forecasting and disaster mitigating technologies of great potential benefit to the U.S.

- On the medical front, a major benefit to China is access to cutting-edge U.S. epidemiological expertise, but reciprocal benefits to the U.S. encompass the presence of isolated populations for genetic pharmacological and immunological testing and diagnosis. A major benefit to the U.S. has been the introduction and subsequent acceptance of traditional Chinese alternative medicines into U.S. society. Recent advances in genomics have provided new tools that make it possible to conduct systematic research on Chinese traditional medicines and there is mutual interest in expanding research in that field.

- NSF educational and research opportunities in China for U.S. students and researchers help them become globally knowledgeable and competent researchers. Examples include the Research Experience for Undergraduates in Ocean Engineering and the Summer Institute in China for U.S. Graduate Students in Science and Engineering.

- In certain areas, China has developed a very significant S&T base that warrants U.S. attention. Though still behind the United States, China is quickly advancing in the information technology, software development, biotechnology, and nanotechnology research sectors. These fields all represent cross-cutting priorities highlighted by the Office of Science and Technology Policy's science agenda for FY 2004. Cooperative research in these areas would provide the U.S. with global access to cutting edge research and development trends and would improve U.S. efficiency in achieving its scientific objectives.

The Benefits of the S&T Agreement to China

In addition to promoting good will, trust and openness, U.S. - China science and technology cooperation has fomented PRC domestic policy reforms by providing the PRC government with information that helps guide the ongoing reform process. The Agreement has provided China with some benefits that have helped close some of its scientific and technological development gaps. The following are examples of the benefits to China:

- In the area of remote sensing, cooperation between USGS and the Chinese Academy of Sciences has involved joint research and exchanges in the rectification, enhancement, classification and interpretation of remote sensing images. In 1997, after viewing images of 17 Chinese cities and regions from NASA's LANDSAT-5 for 1987, 1991 and 1995, the Chinese leadership concluded that China was losing cultivated land to development at a rate two and one-half times greater than previously thought. Jian Ailin and Chen Haiqiu of the Hunan Province Land Management Bureau wrote in an April, 1997 issue of Chongqing Environmental Science that local governments and central government ministries often approve improper farm land conversions in order to enrich local government treasuries or to fund swollen government bureaucracies. In response, the Chinese leadership promptly ordered a one-year freeze on all agricultural land conversions not specifically authorized by the State Council and imposed strict new measures to intensify land management initiatives to protect China's cultivated land. China continues to use remote sensing to check local compliance with central government land use regulations, as well as to monitor flooding, to fight forest fires and to measure the total amount of arable land.

- Remote sensing information revealed that local governments in China, intending to maximize their disaster relief assistance, exaggerated the amount of land affected by the 1998 Yangtze flood by ten times. Both of these examples illustrate how U.S.-China cooperation in remote sensing can provide information that helps redress local government misreporting and corruption.

- Cooperation between the USGS and China's Hai He River Water Conservancy Commission has produced a comparative water-quality assessment and a joint study on reservoir eutrophication of the Hai He River Basin. The joint study will determine the sources of nutrients, and what reduction in nutrient load, primarily phosphorus, is required to bring the reservoir water to the desired level of quality as a source for drinking water. This data will then be used by the Hai He River Commission to develop a plan that reduces the nutrient loads in the reservoir through land use changes or regulatory actions. The study bridges the gap between examining watershed loadings of nutrients or other contaminants and using this scientific data to develop strategies to reduce those loads.

- The application of remote sensing data to initiate land management reform and USGS water quality monitoring of the Hai He River Water illustrate how U.S.-China cooperation can provide Chinese government bureaus with the ammunition they need in bureaucratic battles aimed at pushing China towards more sustainable agricultural and resource management practices. Other U.S.-China cooperative activities that have improved China's ability to monitor its environment include the establishment of an air quality monitoring network, on-line water quality and quantity monitoring systems, hydrologic monitoring and measurement procedures and sediment transport measurements.

- The development of China's mining and petroleum industries has been facilitated by joint S&T projects in mineral research, geology and deep-ocean drilling.

- The overall level of Chinese scientific expertise and research capabilities has been strengthened by collaboration and contact with U.S. scientists working jointly on activities under the Agreement. Scientific advances from joint projects have pushed back the frontiers of knowledge in numerous areas.

- The overall public health of China's population has been improved through collaboration in the fields of medicine and health with U.S. partners such as the National Institutes of Health. For example, the Global AIDS Program, collaboration between the U.S. CDC and China CDC, has assisted the Chinese government on HIV prevention, HIV/AIDS care and treatment, and capacity building in the public health response to the AIDS epidemic in China. In addition, an NIH grant to the China CDC has strengthened China's existing HIV/AIDS research infrastructure by supporting Chinese research projects on the epidemiology of HIV transmission, behavior interventions for preventing HIV transmission, safety and efficacy of HIV treatment drugs and the development of vaccines that prevent HIV infection.

- The safety of China's growing nuclear power industry has been enhanced by cooperation with the U.S. Nuclear Regulatory Commission and the Department of Energy.
- Chinese agricultural production has increased as a result of collaborative programs with the U.S. Department of Agriculture. New crops, new varieties, improved irrigation and farming techniques introduced through S&T collaboration have made a positive impact on Chinese agriculture. Exchanges have led to increased knowledge in a wide variety of areas including animal disease management, disease and pest control, food inspection, quality control, agricultural biotechnology and food production regulation and management. Improved Chinese agricultural production helps stabilize the global food supply and is critical to improved nutrition and health, and environmental sustainability and security.

- China' s efforts to clean up industrial pollution and to prevent further degradation of its environment have been aided by cooperation with U.S. agencies such as EPA and NOAA. This has improved Chinese capacities in air quality monitoring and management, emissions trading, emission inventories, and local and regional pollution modeling. For example, EPA's efforts to introduce sulfur dioxide emissions trading to China in hopes of reducing acid rain have not only received high-level Chinese political support, but emissions trading pilot projects have expanded to include Jiangsu, Shanxi, Shandong and Henan Provinces, Tianjin, Shangai and Liuzhou Municipalities and the Huaneng Company, Nanjing Jiaguan Power Plant and Taicang Port Huambao Power Company. Chinese and foreign experts believe that success in emissions trading in China could lead to its expansion on a national scale.

- In marine resources, access to U.S. research labs has helped Chinese scientists address disease, genetic and biotechnology issues and environmentally-friendly fish farming techniques.

- China has become more efficient in the use of energy as a result of cooperative programs with the Department of Energy. Alternative energy technologies introduced through cooperative programs with the National Renewable Energy Laboratory (NREL), such as biomass, photovoltaic, wind power and microscale hydroelectric power, have brought electrification to isolated areas of China's interior.

- China's efforts to monitor and mitigate water resource problems have been enhanced by cooperation with U.S. agencies such as USGS and USDA. Findings from a joint USGS-Hai He River Water Conservancy Commission study will be implemented in a Chinese plan to reduce the loadings of nutrients to the reservoir through a series of land use changes or regulatory actions. USDA watershed monitoring sites provide innovative

U.S. water and wastewater treatment technologies and real-time water quality monitoring, data collection, and treatment system management.

- DOE assistance to the Beijing Municipal People's Government to develop clean energy technologies and environmental policies will help the City of Beijing improve its environmental quality to an acceptable level by the 2008 Olympics and help present the event as a magnificent "high-tech" sports meet.

- U.S. National Park Service exchanges and training have highly influenced Chinese park management policies. After studying U.S. park management policies and practices at the U.S. National Park Service (NPS), a senior member of China's National Parks Agency drafted NPS concessions and planning policies into park management laws that are now applicable to all Chinese provinces.

U.S. and China Economies Benefit from Students, Scholars and Researchers

Over the past several years, more than 100,000 Chinese students have studied abroad annually, up from 4,900 students in the mid-1980s. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), China sends more students abroad than any other nation, worldwide. Approximately 82% of Chinese students studying in the Unites States are post-graduate students. Science related fields are commonly the most chosen fields of study. In 2003, the Ministry of Education statistics indicate that 93% of students studying abroad were self-financed with the remaining 7% financed by employers. A survey by the National Bureau of Statistics found that families spend 10 percent of their savings on education, which has grown approximately 29 percent annually since 1990. In addition to savings, a growing number of middle-class families borrow money to finance an overseas education.[23]

Table 2. Number of Chinese Students Studying Abroad

	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
Chinese Students Studying in the United States	54,466	59,939	63,211	64,757	61,765
Total Number of Chinese Students Studying Abroad	.	.	83,973	125,179	120,000

Table 2-3: PRC students awarded doctorates in the United States are among the highest of all foreign recipients of U.S. S&E doctorates, by country from 1983-2003 (Total of 35,321).[24]

Table 2-3
Foreign recipients of U.S. S&E doctorates, by country/economy of origin: 1983–2003

[23] U.S. Foreign Commercial Service, Beijing, China. *China Overseas Study Market*.
[24] National Science Foundation, Science and Engineering Indicators 2006.

Country/economy	Number	Percent
[redacted]		
All foreign recipients	176,019	100.0
Top 10 total	111,959	63.6
China	35,321	20.1
Taiwan	19,711	11.2
India	17,515	10.0
South Korea	17,112	9.7
Canada	5,832	3.3
Iran	3,807	2.2
Turkey	3,413	1.9
Thailand	3,102	1.8
Japan	3,100	1.8
Mexico	3,046	1.7
All others	64,060	36.4
[redacted]		

NOTE: Foreign doctorate recipients include permanent and temporary residents.
SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations (2003).
Science and Engineering Indicators 2006

Many scientists in this group continue to maintain personal and professional links to U.S. institutions and individual U.S. scientists. China's senior leadership cadre is dominated by scientific specialists and engineers. Although China's most senior leaders were trained at home or in the former Communist bloc, a growing number of high-level officials in the PRC science and technology policy community were educated as graduate students in the U.S. and returned to China to take up key positions in China's government. The remarks of Chen Zhili, the State Councilor responsible for overseeing all of China's science ministries, foundations and academies, illustrates the positive impressions that are left with U.S.-educated Chinese officials and how this can influence the perspectives of PRC policy-makers. In a speech to an NSF delegation in February 2004, Ms. Chen noted her personal experience in a U.S. university research environment at Pennsylvania State University and the important role universities play in both countries. She described herself as deeply impressed by her lab's dynamism, the relationship between professors and their students, and the fact that students then carry what they learn from their labs out into the larger society. She said that she felt the United States success in such areas as the Space Race of the 1960s had been due to the investment put into laboratories at that time, and she felt China needed to learn from this lesson.

Table 3 lists a few other prominent Chinese science and technology officials who have studied in the U.S.

Table 3: Prominent U.S.-Educated Science and Technology Officials in the PRC

Name	**DOB**	**Job Position**	**U.S. S&T Affiliation**
Chen Zhili	1942	State Counselor	1980-1982, Visiting Scholar, Materials Science Laboratory, Pennsylvania State University
Cheng Jinpei	1948	Vice-Minister of Science and Technology	1987, PhD, Organic Chemistry, Northwestern University
Wang Longde	1947	Vice-Minister of Health, Director of the Office of the State Council HIV/AIDS Working Group	1980-1982, Residency, Mount Sinai School of Medicine of the City University of New York
Huang Jiefu	1946	Vice Minister of Science and Technology	Guest Lecturer at Harvard University, Massachusetts Institute of Technology, Stanford University
Jiang Zuojun	1955	Vice Minister of Science and Technology	Oct. 1993-Nov. 1994, Visiting Scholar, University of Buffalo

Bai Chunli	1953	Vice President of the Chinese Academy of Sciences	1985-1987, Visiting Scholar, California Institute of Technology
Jiang Mianheng		Vice President of the Chinese Academy of Sciences	1991, PhD, Electrical Engineering, Drexel University, Philadelphia
Li Jiayang		Vice President of the Chinese Academy of Sciences	1991, PhD, Biology, Brandeis University
Guo Huadong	1950	Vice President of the Chinese Academy of Sciences	1984-1985, Visiting Scholar, Oregon State University
Zhu Zuoyan	1941	Vice President of the National Natural Science Foundation of China	1988-1991, Faculty Member, University of Maryland
Sun Jiaguang	1946	Vice President of the National Natural Science Foundation of China	1985-1986, Visiting Scholar, University of California, Los Angeles 1991-1992, Worked at Hewlett-Packard in the United States
Qin Dahe		Director-General of the China Meteorological Administration	Visiting Scholar, at the Space Technology Center of University of Kansas and at the University of New Hampshire
Li Huang		Deputy Director-General of the China Meteorological Administration	1987-1988, Visiting Scholar, National Meteorological Center, NOAA

Since Chinese students did not begin obtaining U.S. graduate degrees in large numbers until the late 1980s and ‘90s, the number of high-level Chinese officials with U.S. graduate degrees will likely increase as these former students gradually achieve seniority within the PRC. Chinese scientists are collectively able to wield an unquantifiable, but certainly significant, degree of influence over PRC policies. For example, U.S.-educated Chinese officials in the Ministry of Health have contributed significantly to bilateral cooperation and information flows on important health issues such as HIV/AIDS and SARS and are generally more open to new ideas.

In our estimation, China’s large reservoir of U.S.-educated scientists is a positive factor in promoting greater openness. This has led to greater engagement across the full spectrum of scientific disciplines, particularly in activities initiated under the 1979 S&T Agreement.

Thus, under the influence of a domestic science community clearly interested in expanding connections to both the U.S. scientific community and the American public, the PRC has moved to forge broad-ranging links to the U.S. science agencies under the S&T Agreement. Over the years, a rich network of U.S.-China S&T cooperation has developed, spanning many scientific and technical disciplines. The breadth of PRC engagement extends well beyond those subjects relevant largely to military or industrial utility.

Within U.S. science policy circles, it has long been a source of concern that the number of graduates with diplomas in science and engineering from U.S. universities is insufficient to sustain the needs of the U.S. research and development enterprise within both academia and industry. America’s technology-based society demands great numbers of highly-trained scientists, engineers and technicians to staff the academic, public and private sector R&D institutions which are at the center of U.S. economic prosperity. Attracting enough young Americans into careers in the sciences and engineering to satisfy the demand for skilled S&T manpower has proven increasingly difficult over the past two decades.

The U.S. manpower for science, technology and engineering has been made up through the integration of overseas students, scholars, researchers and high-tech workers in all sectors of the U.S R&D establishment. Of these, Chinese students compose the second largest group of foreign students in the U.S., followed by Indians and account for 11% of the 572,509 enrolled international students.[25] The degree to which U.S. academia and industry are becoming dependent on skilled brainpower from abroad is indeed worrisome.

The size and configuration of the U.S. college and university system is predicated upon the annual admission of a large number of foreign students. Academic research laboratories rely heavily on this highly productive source of talent, along with substantial numbers of post-doctorate or more established scholars and researchers. A large percentage of these students and scholars remain in the U.S. following their studies, amounting to a tremendous "brain-gain" in favor of the United States. U.S.-educated students and researchers from abroad, of which the largest number are Chinese, find ready markets for their talents in U.S academic and private sector laboratories. Similarly, the U.S. high-tech industry, relies heavily on overseas S&T talent to staff R&D crucial to U.S. competitiveness.

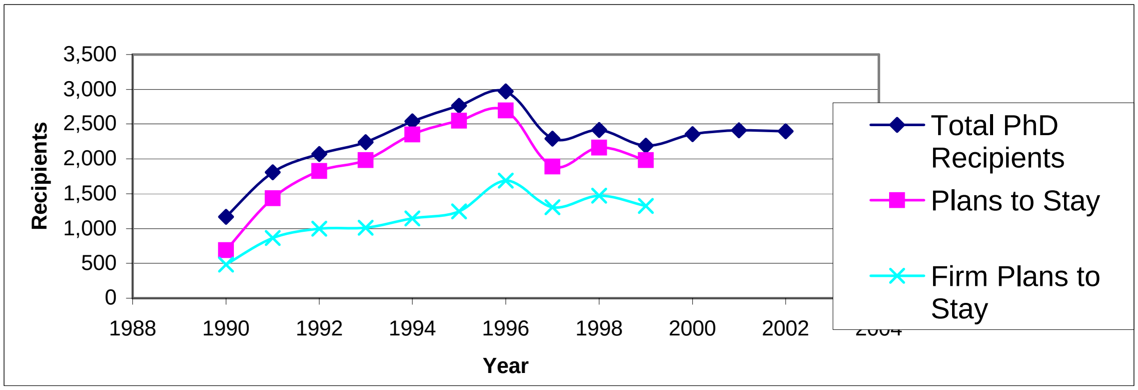
A major benefit of this infusion of overseas talent – a small percentage of which takes place through exchange programs conducted under the 1979 Agreement -- is that China's best and brightest young S&T talent flows to the U.S. during the most creative years of their careers. Their contributions to U.S. academic research and industrial development are incalculable.

At the same time, it is clear that a major facilitating channel for the flow of scientific/technological information and know-how from the U. S. to China is through the vast number of Chinese students within the U.S. higher-education system.

U.S. academic research laboratories throughout the country are host to thousands of Chinese students and researchers who have first-hand knowledge and participation in some of the most advanced S&T research projects across a spectrum of scientific disciplines. Many of these students return to China, taking their knowledge and expertise obtained in U.S. labs with them. Many others remain in the U.S., and may find work in the high-tech industry, or remain in academia. Table 2 shows the total number of U.S.-educated Chinese Ph.D. recipients in science and engineering from 1999 to 2004. A large majority of these students intend to stay in the United States after graduation. Greater political and academic freedom, better career opportunities, and a higher standard of living are the most common reasons for staying in the U.S. according to a 1997 survey of Chinese students.[26]

Figure 3: Chinese Science & Engineering doctoral recipients from U.S. universities who plan to stay in United States (excluding Taiwan)

[25] U.S. Foreign Commercial Service, Beijing, China. *China Overseas Study Market*.
[26] U.S. Embassy Beijing. Bringing the PRC Students Home: Why They Stay, Why They Return, February 1997.



Links between U.S. and Chinese academic research institutions typically develop from connections between Chinese students who remain in the U.S. and those who return to China. An example of S&T collaboration arising from such connections is the recent sequencing of the rice genome by a U.S. - Chinese joint research project involving the Washington University in St. Louis and the Beijing Genomics Institute.

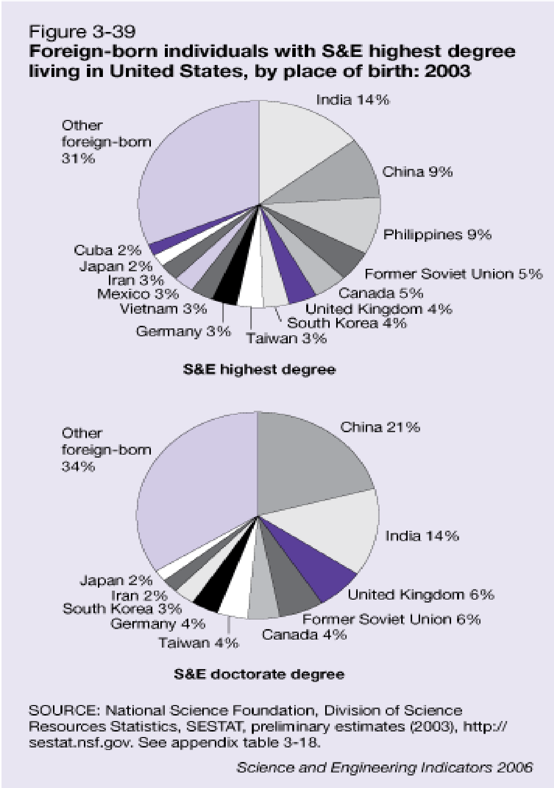
Similarly, U.S. high-tech firms employ thousands of Chinese who have completed their studies in the U.S. Thus, thousands of Chinese are currently working on H-1B visas in high-tech laboratories of U.S. firms, where the latest U.S. technologies are being developed for market. (The U.S. Embassy in Beijing reports that the volume of student applications and visas issued in 2005 has so far shown a marked increase compared to 2004. In May 2005, the U.S. Embassy and four consulates in China issued 2,314 F-1 (student) visas and 617 J-1 (exchange visitor) visas, in comparison to 1,518 F-1 and 209 J-1 visas in May 2004.[27] China was among the top six countries of origin of foreign-born scientists and engineers employed in the U.S., as of 2001[28].

Many of these Chinese immigrants in the science and technology sectors maintain connections to China and some advise or invest in technology ventures there. In a 2002 survey of Asian-born professionals in Silicon Valley, the Public Policy Institute of California found that 34% of Chinese immigrants surveyed reported that they had helped to arrange business contracts in China and 20% of Chinese respondents reported having regular exchanges on information about technology with colleagues in China.[29]

Figure 3-39: Foreign-born individuals with Science and Engineering highest degree living in the U.S. by place of birth: 2003[30]

[27] U.S. Foreign Commercial Service, Beijing. *China's Overseas Study Market*.

[29] Annalee Sanexian. Silicon Valley Immigrants Forging Local and Transnational Networks. Public Policy Institute of California. April 2002.
[30] National Science Foundation, Science and Engineering Indicators, 2006.



It is therefore not surprising in light of the pervasive presence of Chinese nationals in U.S. laboratories – both in academic fundamental research and industrial technology development – that valuable information on U.S. S&T developments filters back to China through this mass of individuals. The large numbers of Chinese students, scholars, researchers and high-tech workers, ubiquitously present throughout the U.S. academic and industrial research establishment, collectively represent one of China's important means of gathering information on U.S. scientific and technological development. Viewed against the context of what China can glean from the proliferation of its nationals working in U.S. laboratories and corporations, whatever knowledge China might possibly have gained from cooperative S&T activities conducted under the 1979 S&T Agreement would be negligible by comparison.

IX. *China's FDI Strategy and Private Sector Technology Transfer*

Foreign direct investment (FDI) is regarded as the most significant source of technology inflow into China. This high rate of investment and often coerced transfers far exceed transfers of technology under USG activities under the S&T Agreement. At the same time, foreign multinational corporations, as the purveyors of FDI, play an important role in promoting the transfer of advanced technology through three channels, namely technology diffusion, intensified competition, and personnel intercommunication. Because of the positive effects of FDI on China's economy, particularly the inflow of technology, China has adjusted its policy to attract more FDI.

Forecasted to eventually become the world's largest consumer market, China is now moving from a manufacturing center to an advanced R&D center. The growing U.S. business investment in China is vital to the development of bilateral commercial ties, and reflects the eagerness of U.S. firms to position their business early in the market. Since 1997, MOST has doubled its expenditure to 104 billion RMB (approximately $13 billion) to promote S&T research and development, compared to the previous five year period. Corporate R&D accounted for 65 percent of total spending. 1997 was also a year of large-scale investments by foreign R&D institutes and the beginning of a new phenomenon in attracting FDI to China. Many multinational companies (MNCs) choose to establish their own independent R&D institutes in China.[31]

In his recent annual report at the National People's Congress in Beijing, Chinese Premier Wen Jiabao said "China has entered a stage in history where it must increase its reliance on scientific and technological advances and innovation to drive social and economic development." Beijing's campaign to strengthen domestic innovation to help push the country into more advanced niche markets is demonstrated though the implementation of China's *Guidelines on National Medium and Long Term Program for S&T Development* and the recent implementation of the *11th Five – Year Plan*. This represents MOST's commitment to increase spending for the high-tech sector. The combination of China's increased spending to encourage investment, its large and inexpensive talent pool, and increased investment in R&D by multinationals will broaden China's role in the global economy to become the world's largest consumer market. The cost of hiring engineers and researchers is relatively low and China draws its talent from a pool of nearly five million graduates annually, where nearly one-fifth of these graduates major in science or engineering.

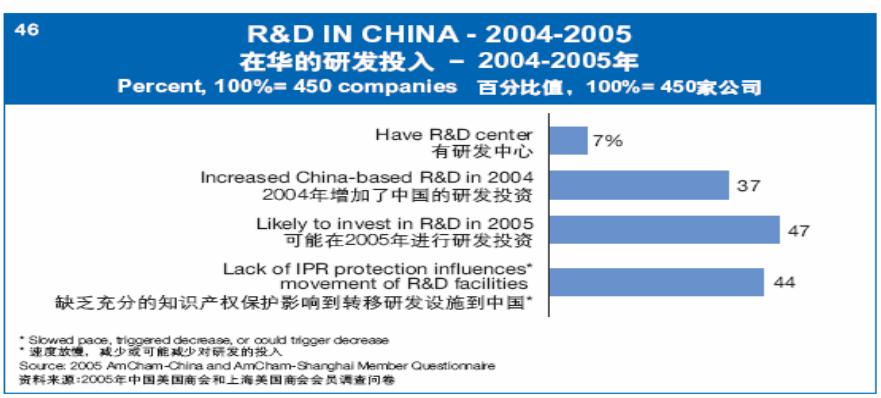
A Department of Commerce study highlights China's policies concerning investment by overseas firms, American companies in particular. According to this report, China has used the attraction of its enormous emerging consumer market to induce firms wanting to get into the Chinese market to sign investment agreements that systematically include some form of technology transfer. Chinese investment policies encourage foreign investment in high technology industries in particular, with a system of preferential tariff and tax rebates designed to create incentives for high-tech industries as contrasted with lower-tech industries. Among the industrial sectors in which China is seeking investment are information technology, aerospace, electronics, and telecommunications. Some IT multinational companies have even agreed to transfer core technologies, such as source code, in order to gain market position. Ericsson transferred its source code for its CDMA cellular technology to a Chinese partner while Microsoft transferred its source code for Windows to the Chinese government[32]. Although Chinese private companies are no longer allowed to require technology transfer as a condition of doing business under World Trade Organization obligations, state-owned enterprises and local government bodies are still widely believed to continue in this practice. Until China joins the WTO Government Procurement Agreement, technology transfer may still be a condition for government procurement. As part of its 2001 WTO Protocol of Accession, China pledged to join the WTO Government Procurement Agreement "as soon as possible." Disappointedly, China began technical consultations with trading partners about future formal accession negotiations to this agreement in April of this year.

The infusion of private sector capital from abroad has paralleled a concurrent burgeoning of China's own private sector, capital markets and investment from within the Chinese economy, creating an economic juggernaut and growth rates unknown in other areas of the industrial

[31] FDI and Technology Transfer in China. Jiang Jiang. Conference of China's New Knowledge Systems and Their Global Interaction. September 2003.
[32] *The Digital Triangle: A New Defense-Industrial Paradigm*?

world. With the help of Western commercial investment and contracts, China's industrial base has rapidly moved into progressively higher levels of technology, with semiconductors, automobiles, aircraft, computers, telecommunications, chemicals and electronics now firmly established as manufacturing staples. According to China's Ministry of Commerce, the total number of foreign-invested R&D centers in the country has surged from 200 to 750 since 2002.[33]

In a recent survey published by the United Nations Conference on Trade and Development (UNCTAD), China is the most popular destination for R&D expansion, with the U.S. trailing behind as second and India third. Many companies have rushed to take advantage of China's low labor costs to expand their business there. Companies such as Motorola, IBM, and Proctor & Gamble Co. (P&G) have been investing to expand their Chinese R&D operation to develop products for the global market. In 1988, P&G opened a research arm in China, consisting of 24 employees hired to study Chinese consumer laundry and oral hygiene habits. Today, P&G runs five R&D facilities in China with about 300 researchers. Motorola began investing in low level R&D in China in 1993. The company now has 16 R&D offices in five cities, with an accumulated investment of about $500 million. The company also has more than 1800 Chinese engineers, and expects this number to surpass 2000 by the end of this year. Motorola has also begun to manufacture products for the domestic market and exports from China to overseas markets. Microsoft established its first basic research lab in Beijing in 1998. Currently, this lab employs about 200 full time scientists and the company expects total R&D employees in China to double this year to about 800 researchers. IBM's research lab in Beijing is developing new technologies now being used abroad such as the "voice morphing" software that concerts typescript or a recorded voice into another voice. Engineers at China's state run Institute of Computing Technology are designing a computer microprocessor. In 2005, the Institute unveiled its second-generation microprocessor. This year it plans to complete work on a third-generation chip that could narrow the gap between second and third generation technologies. Other MNCs that have established R&D institutes in China are Ericsson, Dupont, Unilever, Bayer, and many others.[34]



Another significant source of technology transfer from U.S. private sector companies to China is the increasing use of offset deals which include the creation of a laboratory, center or institute intended for joint research and development in key industries such as information technology, telecommunications, electronics, chemicals and auto manufacturing. Majority-owned affiliates

[33] *Low Costs, Plentiful Talent Make China a Global Magnet for R&D*. Kathy Chen and Jason Dean. The Wall Street Journal. March 13, 2006
[34] Ibid.

of U.S. parent companies in China performed $506 million in R&D spending in 2000, compared to $7 million in 1994. Furthermore, U.S. affiliates in China spend a higher ratio of R&D spending to gross product (9.2%) compared to the aggregate of U.S. affiliates in all host countries (3.3%).[35]

U.S. companies attempting to gain a presence in the Chinese market are often reluctant to complain about the difficulties in doing business in China, the DOC study reports. However, widespread complaints have been received from U.S. firms investing in China about de-facto coercion by Chinese officials to transfer technology as the price of admission to the Chinese market. The DOC study quoted U.S. businessmen as observing that "…technology transfers are required to do business in China." Using the leverage of its colossal potential market, China pitted would-be foreign investors against one another, promoting them to up the technology transfer ante in order to win coveted contracts. The result, said DOC, "is usually more technology being transferred as competitors bid up the level or type of technology that they are willing to offer." The Cox Report underscored this phenomenon as well, noting, "Although many countries require technology transfer when they do business with U.S. firms, no country makes demands across as wide a spectrum of industries as the PRC does." This Chinese investment strategy, designed to extract technology transfer from American firms as a condition for entering the Chinese market, in State's estimation has been the principal source of technology transfer from the U.S. to China.

In 2004, China maintained its position as the world's top destination for foreign investment. It held the third highest FDI inflows in the world and the largest among developing countries.[36] On a cumulative basis the U.S. invested $15.4 billion through the end of 2004,[37] and according to Chinese government data remains the second-largest foreign investor after Hong Kong. FDI growth rates in previous years were 1.4% in 2003, 12.5% in 2002, and 14.9% in 2001. From 1994 to 2001 cumulative U.S. investments of in China more than quadrupled, from $2.6 billion to $10.5 billion, growing at an average annual rate of 20.1%, adjusting for inflation.[38]

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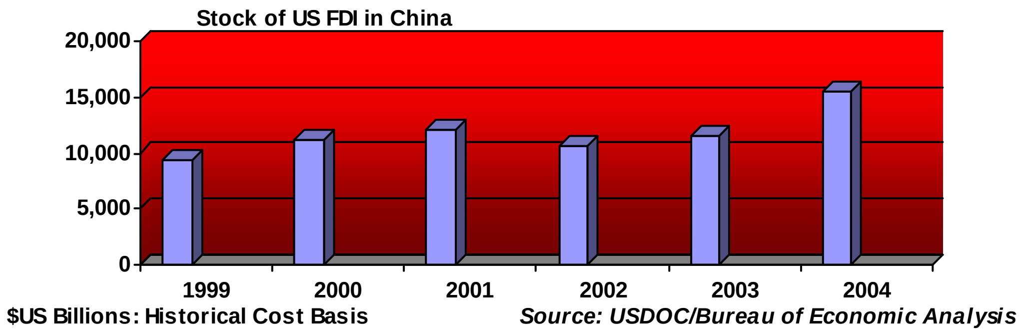
[35] Francisco Moris. U.S.-China R&D Linkages: Direct Investment and Industrial Alliances in the 1990s. February 2004. http://www.nsf.gov/sbe/srs/infbrief/nsf04306/start.htm

[36] The Organization of Economic Cooperation and Development. International Investment Perspectives 2005 Edition: Trends and Recent Developments in Foreign Direct Investment.

[37] 2006 U.S. Department of Commerce, Bureau of Economic Analysis.

[38] 2005 U.S. Department of Commerce, Bureau of Economic Analysis. Note: The U.S. Bureau of Economic Analysis (BEA) defines direct investment as ownership or control of 10 percent or more of the voting securities of a business in another country. Direct investment capital outflows consist of net equity capital outflows, reinvested earnings, and inter-company debt outflows from U.S. parent companies to their foreign affiliates. Direct investment position is a cumulative measure of the financing provided by U.S. parents to their foreign affiliates in the form of equity and debt, recorded at historical cost (net book value). Data for gross product, R&D expenditures, and number of affiliates are for majority-owned affiliates of U.S. parent companies are those affiliates in which the combined ownership of all U.S. parents is more than 50 percent.



Multinational companies are encouraged to make investments in China, including in R&D activities, by attractive tax-based incentives, with foreigners currently paying only 15% tax on investments while domestic firms pay 33%. One possible damper on FDI may be the implementation of the long-awaited plan to unify the tax rate paid by domestic and foreign-invested companies. The change is expected to raise the tax rate paid by foreign firms. However, the high-tech sector located in the coastal areas may continue produce opportunities for tax relief through tax incentives offered by special economic zones and coastal open economic zones.[39] Many Chinese research institutes and companies now form joint ventures with multinational companies to achieve specific research or technology development objectives, as described later. Furthermore, foreign capital, along with funding from the Torch Program, has helped establish 17 science and technology research parks in China. These research parks huddle around China's main research universities in order to concentrate S&T resources in one area and provide the infrastructure and preferential tax policies necessary to attract innovative S&T enterprises.

It is estimated that China has more than 50,000 talented research scientists in the biotech industry alone, and this number is expected to grow by 4,500 scientists each year. Both Beijing University and Tsinghua University are world-renowned for the quality of the science and engineering students that they graduate. The Chinese government offers foreign educated Chinese student's incentives such as generous research grants and opportunities to run their own R&D projects when they graduate from universities abroad and also offers them higher salaries, generous housing packages, and even putting entire research teams at their disposal[40]

In 2002, there were over 100,000 S&T nongovernmental enterprises in China employing over 6,444,300 people. In the same year, these enterprises had a total income of approximately $220 billion, profits over $12 billion and research and development expenditures totaling over $5 billion[41]. While S&T Agreement-related joint activities may have provided some ancillary economic benefits to China, the trend lines of its economic transformation would have been largely fixed in place regardless of whether an S&T Agreement with the U.S. had been in place during this period.

X. The Impact of S&T on China's Commercial Landscape

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[39] China Daily. FDI continues to rise, up 11% in Jan. February 2006.
[40] U.S. Embassy Beijing. Evaluation of China's Science and Technology System and its Impact on the Research Community. Summer 2002.
[41] Adam Segal. Prospects for "Spin-On" from the Commercial Side of Chinese R&D. Council on Foreign Relations. March 19, 2004.

Commercialization of S&T has led China to become the most rapidly developing scientific and technological center in Asia. Although it remains far behind the U.S. in overall S&T resources, China ranked 8th worldwide in major international scientific publications in 1999 and 8th for the number of papers cited[42]. Several areas in China's S&T base warrant close U.S. attention, including information technology, software development as well as the budding biotechnology and nanotechnology sectors.

As China progresses toward catching up with Western industrialized nations, continued U.S.-China research cooperation allows the U.S. to monitor China's technological advancements. But U.S. - China cooperation can also help leverage U.S. research investments in key high-tech areas by using the contributions of each country to advance the research. China's developing science and technology capabilities suggest that future U.S.-China cooperative activities could yield more benefits to the U.S. than ever before.

This win-win scenario of science and technology cooperation is not specific to the U.S.-China relationship, but is part of a much wider trend in the way science is advancing in all corners of the world. Multinational corporations, seeking to tap into emerging markets and low-cost, highly skilled labor in developing countries, have led the internationalization of research and development worldwide. In China and other countries, the rise of the internet and the increasing mobility of humans and financial capital have led to the global dispersion of well-educated engineers, scientists and researchers into the far corners of the world, laying the foundation for international research cooperation opportunities in both the private and public sectors.

Now, more than ever, government-funded science has become a unified global effort. For the past two decades, the most challenging science and engineering problems, whether it be the International Space Station, the Human Genome Project, Antarctic field research or the quest for a cure for AIDS, SARS and other infectious diseases, have been tackled by international teams of researchers with common interests and complementary expertise. Scientists cooperate with each other around the world because each considers that the other has something to offer in terms of scientific resources, such as knowledge, experience, perspective, funding, or data. This is just as true of China as it is of other major partners around the globe. In an increasingly globalized world of open information and collaboration, scientific cooperation is not a zero-sum enterprise. Generally, scientists only cooperate if they share complementary resources that can be leveraged to achieve mutually beneficial goals. Today's team-centered, global approach to science and technology provides tremendous potential for advances and discoveries in international "big science" cooperative projects. Bearing these trends in mind, tomorrow's technological leaders won't be the countries that restrict the sharing of knowledge and technology, but those which can effectively use international scientific resources to create innovative new solutions through cooperation.

Supported by the government's emphasis on technology commercialization, market-based reforms, strategic research programs and a highly-skilled S&T labor force, high-tech nongovernmental enterprises in the Chinese economy have flourished. China began to recognize

[42] U.S. Embassy Beijing. An Evaluation of China's Science and Technology System and its Impact on the Research Community. Summer 2002.

the ICT industry as a pillar industry for the first time in the Tenth - Five Year Plan (2001-2005). This national priority has been characterized as "Industrialization Driven by Informatization," and includes creating a skilled IT workforce, providing incentives for R&D in the technology sector. China has become the fastest growing IT market in the world for IT products and services and has averaged 25% growth over the last five years.[43] Output value, sales and profits of electronic and telecom manufacturing all outstripped those of traditional industries, making the information industry the largest contribution to national economic growth.[44] China is expected to see at least 10 major S&T breakthroughs over the next 10 years. These breakthroughs include the following areas[45]:

Next Generation mobile communications technologies

In 1987, China's mobile telecommunications industry began to emerge. Now the mobile network covers all medium-to-large sized cities, and more than 2,800 small cities and county seats. Currently, China Mobile as a registered subscriber base of 334 million, which is the highest in the world. China has already begun to develop domestic home-grown wireless standards such as Time Division-Synchronous Code Division Multiple Access (TD-SCDMA). China believes its domestic technology standards to be comparable to global competitors and is expected to be commercialized after 2010. International roaming service exists with over 150 countries and regions all over the world. The Chinese mobile industry attributes this development to Huawei and Zhongxing, two leading domestic high-tech communication equipment manufacturing companies.

Next generation Internet technology

The Chinese government maintains that the next-generation Internet technology is essential to enhancing the country's information security. However, it acknowledges that R&D in this area lags behind other countries because of the absence of a systematic research method. The government aims to increase the scale of Internet users, application, technology, and Internet products.

Integrated chip technology

China's integrated circuit (IC) manufacturing sector, however, it still lags two to three stages behind. Chinese IC companies are capable of designing over 500 varieties of chips. The sector comprises 10 key enterprises, 10 key packing facilities, and over 20 design companies.

Chinese information processing technology

In 1994, Microsoft entered China's software market, and its MSWord software overtook China's word processing technology. Before long, the domestic Chinese information processing software sector found itself in a predicament. After China's entry into the WTO, China has place more attention on developing homegrown information processing technology. China intends to implement more preferential policies and investment to facilitate research on Chinese character and language technologies.

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[43] Export IT China. U.S. Department of Commerce. April 2003.
[44] Ibid.
[45] A Forecast Report on China's Technology. Outlook Weekly Magazine, Beijing, China. December 19, 2005.

Research on human functional genome
China boasts that with one fifth of the world's population, it has an abundance of hereditary disease resources, which are conducive to developing research of the functional genome. However, with few independently innovative results in research and application, it is still not capable of providing enough knowledge on the development of biological pharmacy.

Protein group research
The Chinese government maintains that its R&D foundation in protein group research is only five years behind developing countries. Chinese scientists note their achievements in results in researching the treatment of liver cancer.

Biological pharmacy technology
According to statistics from the 2004 China Biological Technology Development Report, China has 25 gene-based medicines and vaccines. Nine medicines, with intellectual property rights belonging to China, have been introduced to the market. However, there is still some way to go before these Chinese products achieve world-class market share. The sales of bio-tech medicines only account for 7.5 percent of the entire medicine industry.

Biological information research
China had an early start in this area. Many universities and research organizations have set up biological information centers or research institutes as well as relevant workstations, which are connected to the major international genome database and research centers. Chinese scientists have also established a series of new calculation and genome sequence analysis methods. China's biotech market is currently about $3 billion, and is forecasted to grow at 13.5% annually to reach $9 billion in 2010[46]. The Chinese government spends between $500-600 million per year on biotechnology through research institutes and academic centers[47]. But while China is globally competitive in genome sequencing, agricultural biotechnology and gene therapy, its biotech industry as a whole struggles to commercialize new products and produces relatively few exports. Experts predict it will take at least a decade for China to develop a world-class biotech industry. Major barriers to commercialization include a weak venture capital industry, poor patent protections and difficulties in adopting Chinese products to fit stringent regulations in major world markets.

Crop cultivation technology
China has cultivated a "super hybrid rice" with an output of 807.4 kilograms per mu (15 mu=1 hectare). In 2004, cropland for genetically modified anti-pest cotton accounted for 50 percent of the total national allocation for cotton. Several new wheat varieties cultivated through cell engineering technology cover an area of 11 million mu. China boasts that its general S&T level in this area is equal to that of developed countries, with only a few technologies lagging behind the developed countries by about five years.

Nano-material and nanotechnology

[46] Testimony of Greg Lucier. China as an Emerging Regional and Technology Power: Implications for U.S. Economic and Security Interests. U.S.-China Economic and Security Review Commission. February 12, 2004.
[47] Testimony of Greg Lucier. China as an Emerging Regional and Technology Power: Implications for U.S. Economic and Security Interests. U.S.-China Economic and Security Review Commission. February 12, 2004.

China currently has 300 research organizations engaged in the basic research and application of nano-materials and has set up over 100 nano-material production lines. China is also starting to become a global player in nanotechnology, which Chinese leaders view as one of the nation's most important scientific fields for future research and development. While still a nascent industry, China is investing heavily in nanotechnology, with the central government budgeting approximately $240 million and local governments contributing approximately $240-360 million from 2001-2005[48]. China already ranks third in the number of nanotechnology patent application cases behind the United States and Japan. Its 2,400 patents represent 12% of the world's total[49]. China is also seeking to develop a national nanotech infrastructure and has established the China Nanotechnology Center facility in Beijing, a center dedicated to nanotechnology research and development. China' s current research in nanometric materials and their applications, tunnel microscope analysis and monatomic control, has approached internationally advanced levels, but domestic studies in nanometric electronics and nanometric biomedicine still lag behind developed countries[50].

XI. An analysis of the involvement of Chinese specialists in nuclear weapons, intelligence, and the military in the activities of the Joint Commission.

This issue is addressed in the classified annex.

XII. How US-China S&T activities have enhanced the PRC's military and industrial bases

China seeks transfers of technology from multiple sources

Since the inception of its modernization program in 1978 under Deng Xiaoping, China has developed effective methods and means to acquire scientific information and technologies from the U.S. and other industrial countries to build its industries and science establishment. China maintains a worldwide network of formal S&T cooperative agreements, military and industrial agreements with nearly every advanced industrial nation other than the U.S. This has given China access to a wide range of technologies that these partners have been eager to transfer or sell. China has long-standing cooperative ties in both the civilian industrial and military domains with countries such as Germany, France, the UK, Russia, Israel, Brazil, Japan, Korea, Australia and others. Using a variety of cooperative mechanisms, China has been able to acquire significant technologies through these worldwide links. The Chinese have employed a variety of methods to accomplish this objective, including attracting foreign investment, particularly in R&D areas; sending large numbers of students abroad to study scientific and technological disciplines; industrial partnerships, joint ventures and offset deals; placing significant numbers of Chinese scientists, technicians and engineers in key private sector firms abroad; scientific and military cooperation with countries where advanced technologies are developed; and covert means. Scores of thousands of Chinese nationals work throughout the U.S. research

[48] Business Wire. Veeco and Chinese Academy of Sciences Open Nanotechnology Center in Beijing, China September 3, 2002.
[49] Beijing Xinhua News Service. China's Nanotechnology Patent Applications Rank Third in World. October 3, 2003.
[50] Ibid.

establishment, both in academia and industry, providing a ready conduit for knowledge of cutting-edge developments to be passed to China. Those who have studied in the U.S. and then returned to China typically maintain links to U.S. scientists and institutions, providing another clear channel for knowledge flow. China reaps a technology bonanza from investment policies, which require technology transfer from commercial firms as the price of entry to the world's largest potential market. When measured against these other powerful tools available to China for acquiring scientific knowledge and technology, the role of the 1979 U.S.- China S&T Agreement must be seen as of such lesser importance as to be nearly invisible.

Another valuable source is information mined from open S&T journals and websites. In 1991, the China Defense Science and Technology Information Center –then the information arm for The Commission on Science, Technology and Industry for National Defense—published an S&T collection manual titled, "Sources and Techniques of Obtaining National Defense Science and Technology Intelligence". The manual suggested that 80% of China's defense S&T needs are met through open and gray source (purchase/subscription) materials."[51]

The Stockholm International Peace Research Institute (SIPRI) notes that, since 2000, the PRC has been the world's largest importer of weapons. SIPRI's calculations of PRC arms imports from 1993-2002 show that total arms imports exceeded $11.8 billion as summarized in the table below.

Figure 2: People's Republic of China Arms Imports, 1993-2002*

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Totals	%
Russia	772	79	376	945	430	111	1334	1642	2948	2185	10822	91
Ukraine	55	22		73	73	73	73	78	73	113	633	5
Israel	18	18	18	18	18	18	18	18	18		162	1
France	5	19	14	21	15	7	18	7	7	9	122	1
Italy		5	11	5	3		11		3		38	.003
USA	1						31				32	.003
UK						16	10				26	.002
Year Totals	851	143	419	1062	539	225	1495	1745	3049	2307	11835	

* $ millions; Source: Stockholm International Peace Research Institute, February 26, 2003

Since the fall of the Soviet Union, Russia has become China's main source for advanced military hardware, military technology, military-technical training and advice.[52] The over $2 billion

[51] Department of Defense. Annual Report on the Military Power of the People's Republic of China, 2003.

Chinese arms purchases, annually, from Russia is expected to continue. China has purchased several advanced Sukhoi air fighters, Sovremmeny class missile destroyers, and KILO submarines and assorted advanced munitions, missiles and surveillance technologies from Russia[53]. Although the U.S. has implemented export controls on potentially sensitive dual-use items, many commercial technologies are available from other Western industrial nations that do not support an embargo on advanced technology exports[54]. Many Western nations supported an embargo to sell military technology and dual use items to China in response to the 1989 Tiananmen Massacre. But since then, many European countries have relaxed their interpretations of the 1989 sanctions and have increasingly allowed dual-use technologies to be sold to the PRC. In the last few years, restrictions have loosened even further, especially concerning the sale of space technology to the PRC[55].

The PRC's sustained, heavy reliance on foreign military technology underscores the indigenous defense industry's struggle to absorb foreign technologies and production methods in order to produce the high-technology weapons that the PRC desires. China's strategy to acquire, reverse-engineer and produce technologies has met with mixed success due to structural problems within China's defense industry, including a bloated work force, lack of capital and poor plant infrastructure. Reports that China has had to return advanced jet fighter engines and ship propulsion systems to the original foreign suppliers for maintenance and repair support the notion that China generally lacks the maintenance and logistical capabilities to fully take advantage of its advanced weapons purchases[56]. But the extent to which ongoing structural reforms within the defense sector and the influence of China's booming commercial information technology companies will aid the Chinese military in its ability to better use foreign expertise in the future has yet to be determined.

The Cox Report contains an exhaustive discussion of this issue in Chapter 1, which also lists nine different "PRC approaches to acquire military technology" (pg.20). It is significant that the Cox Report does not cite science and technology cooperation, whether under the 1979 Agreement or other instruments, as one of the technology-acquisition methods used by the PRC.

XIII. The impact of projected activities, including transfers of technology, on China's economic and military capabilities

China's dramatic economic transformation over the past two decades has been the result of macroeconomic decisions by the PRC that allowed market forces and capital to operate in China, and stimulated massive foreign and domestic capital investment. Advances in China's science and technology capacity have also played a critical role in driving China's economic growth. The Chinese Academy of Science reports that in 2003, Chinese high technology enterprises

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[52] Fisher, Richard. The Impact of Foreign Weapons and Technology on the Modernization of China's People's Liberation Army. January 2004.
[53] Frankenstein, John. Globalization of Defense Industries: China. Senior Fellows Publication. February 2003.
[54] James Lewis. Testimony before the U.S. China Economic and Security Review Commission, January 17, 2002
[55] Richard Fisher. The Impact of Foreign Weapons and Technology on the Modernization of China's People's Liberation Army. January 2004.
[56] John Frankenstein. Globalization of Defense Industries: China. Senior Fellows Publication. February 2003.

produced goods valued at $335 billion, increasing 30 percent annually[57]. In 2004, China exported $180 billion worth of ICT goods, including mobile phones, laptops and digital cameras, up 123 billion in 2003[58]. Although high-tech industry has been at the leading edge of China's economic growth, the driving force behind China's scientific and technological advances has not been technology transfer from U.S.-China bilateral S&T activities, but rather:

- Market-based reforms of China's science and technology infrastructure
- The large supply of domestic S&T research talent
- Foreign capital investment from multinational companies
- Technology transfer from foreign companies
- Chinese government investment in strategic high-tech technology
- Production of home-grown innovation arising from the growing sophistication of China's science community

The same internal reforms of the S&T infrastructure that have helped bolster China's economic transformation have also contributed to China's military modernization, particularly from advances in China's IT industry. China's IT industry first started with the Chinese military, which commercially exploited internal telecommunications networks and bandwidth spectrum to provide IT services to civilian customers. In 1989, the State began to promote the "civilianization of military technologies" in order to spur greater indigenous IT capacity and innovation of new commercial technologies. The PRC coordinated resources in IT companies, state research facilities and the military in order to leverage product-oriented research and commercialization.

The integration of the state research infrastructure, commercial companies and the Chinese military has combined the resources of the state and the commercial sector to advance Chinese IT technologies. Many commercial IT companies sprang from or are significantly engaged in joint research with state research institutes, and both often maintain longstanding ties with the Chinese military. The military, in turn, provides capital and R&D support to Chinese state research institutes and commercial enterprises and serves as the primary customer to the IT off-the-shelf technologies that they produce. Common consumer electronic and telecommunications products and their components are now used extensively in military hardware, thus making the technology much easier and cheaper to obtain. The combination of China's surging commercial IT sector and the growing use of off-the-shelf technology for military communications have doubtless lowered China's military support costs. Domestically produced IT technologies are now critical to the Chinese military in increasing its command, control, communications, computers and intelligence capabilities so that it can be less reliant on the importation of foreign technologies. Increased IT capacity has helped the Chinese military accelerate their digitization process and the rapid transmission and processing of military information. The development of strategic communications networks has facilitated communication between command headquarters and operational units and between inland areas and border and coastal areas59.

In consultation with relevant agencies, State's analysis has found no area in which China's acquisition of militarily-useful technologies or information can be attributed with any degree of

[57] Beijing Embassy. China's S&T Reforms: From Communism to Capitalism. March 22, 2004.
[58] Nancy Gohring. China surpassed the U.S. to become the world's No. 1 exporter of IT goods in 2004, according to a report by the OECD. IDG News, December 12, 2005.
[59] Evan Medeiros. The Digital Triangle: A New Defense-Industrial Paradigm?

certainty to cooperative S&T activities under the Agreement. In light of the great number of other sources and avenues open to China for acquiring technologies and scientific information, it is State's belief that, if indeed any technologies of military utility were transferred to China in the context of S&T cooperation under the Agreement – and to date we have seen nothing to suggest that this was in fact the case – the impact on enhancement of China's military capabilities would have been minimal and of little significance in the larger context of PRC efforts to strengthen its military.

The projections of planned U.S.-China cooperation received from the agencies suggest a level of future S&T cooperative activity likely to be similar in volume and content to that conducted over the past two years. Unless it can be shown that the U.S. is the unique provenance for a particular technology acquired by China, there is a strong possibility that the technology may have been gained from a non-U.S. source.

The Intelligence Community's observations on this issue are addressed in the classified annex.

XIV. Recommendations for improving the monitoring of the Commission activities by the Secretaries of Defense and State

Based on State's assessment, it is not apparent that cooperative activities carried out under the Agreement between the U.S. technical agencies and their Chinese counterparts have served to significantly enhance China's military capabilities or industrial base, or that joint S&T activities under the Agreement pose a threat to U.S. national interests. While it is beyond dispute that in recent years China has acquired technologies which have enhanced its capabilities in both the military and industrial domains, it is not clear that any of these technologies were acquired through, or as a result of, S&T cooperation conducted under the Agreement. Many other potential sources exist for China to gather information on militarily-enabling technologies, and in the overall context of China's S&T cooperation with advanced industrial nations around the globe, activities conducted under the S&T Agreement do not seem likely to have made a major contribution to the enhancement of China's military and industrial capabilities. Given China's increased attention to the development of national plans focusing on S&T, and an impending issue with its lack of enforcement of intellectual property, State recommends the following:

1. **Continued engagement on S&T cooperation**. State recommends that the USG continue to engage China on S&T cooperation through open dialogue and collaboration as S&T cooperation is vital to the U.S. economy. An S&T relationship with China will ensure future contributions to U.S. academic research and industrial development and a sharing of knowledge, experience, perspective, and data.
2. **Continued engagement on long-term macro-level Intellectual Property issues:** China is in the process of refining its intellectual property policies to foster homegrown innovation and national scientific development. Now is the time to engage with officials responsible for drafting the National IPR Strategy. The implementation of new policy reforms in China focuses more attention on developing domestic science and technology as a means to spur economic growth. At the same time, broad tax and foreign investment incentives that are created to attract FDI are designed to encourage foreign enterprises to transfer technologies in exchange for the benefit of market access. State recommends that the U.S. Government engage China on these long-term, macro-level IP developments to ensure that U.S. IP holders

benefit from future cooperation with China on S&T, and that their technologies are protected. The U.S. Mission in China works closely with USTR, Commerce, USPTO, the Department of Justice, the Library of Congress and law enforcement agencies on IPR protection and enforcement issues, and China Mission staffing levels dedicated to IPR issues will be increased.

3. **Agency self-evaluations**: For agencies where this may be appropriate, State recommends that the agency take added internal precautions and develop a concept unique to their respective activities with China in compliance with Export Administration Regulations (EAR). An example of such may be annual reviews of foreign personnel, regular inventory of equipment, and monitoring of access areas in and out of controlled facilities.

The biennial report mandated by Congress will continue to serve as a periodic monitoring mechanism of all U.S.-China S&T cooperative activities. An interagency working group will also help to provide oversight and coordination for the science and technology cooperative activities between the U.S. and China. Furthermore, this interagency working group will help initiate a more active dialogue among the technical agencies and the defense and intelligence communities in addressing national security concerns stemming from activities under the Agreement. This committee is designed to be flexible and able to evolve, so State believes that it should be allowed to serve its purpose.

XV. Conclusion

Against the overall context of market-driven economic growth in China, the role of government-to-government cooperation appears to have had, at best, a minor and ancillary role in contributing to the buildup of China's economic, industrial and military capabilities. It is clear that China's remarkable economic development occurred largely independent of the 1979 U.S.-China S&T Agreement. Certain economic benefits undoubtedly accrued to China from S&T cooperation with the U.S. under the Agreement, but against the backdrop of the colossal economic transformation taking place on its own momentum, the restructuring of China's S&T system and high levels of PRC investment in applied research and commercialization, economic contributions derived from the Agreement could only have played a small supporting role. Given that China obtains most of its technologies through private sector technology transfers and R&D centers and it also has similar agreements for S&T cooperation with many advanced industrial nations (many EU member states, Canada, Japan, Brazil, Australia, Korea, etc.), the U.S. is only one of many international players drawn upon to bolster the growth of the Chinese economy. While formal, government-to-government S&T cooperation with China most likely played some contributory role in setting the stage for rapid economic growth, it is difficult to quantify the role that activities under the 1979 Agreement has had on economic growth. The 1979 Agreement is only one minor part of a much larger overall effort by China.

The impact of transfers of dual-use technologies on China's military potential is real but difficult to quantify and even more difficult to control in the absence of an international agreement to limit such transfers. China's S&T enterprise still has its weaknesses that may continue to have an impact on its military modernization. China still suffers from a lack of venture capital, a heavy reliance on foreign designs, technologies and know-how, ineffective management, lack of intellectual property enforcement and a relatively small (but growing) percentage of research and development expenditures relative to total income (1% of GDP in China compared to 2.7% in the

U.S. with a much bigger economy)[60]. But the growing S&T sophistication of its high-tech industries has been the pillar of China's economic growth and is likely to continue to be in the future.

Examination of the S&T relationship between the U.S. and China under the 1979 S&T Agreement shows that cooperation has been of significant value to both countries. The cooperation undertaken by USG agencies under this agreement is, as intended, in the benign civilian domain. Although it is impossible to rule out unintended benefits to the military sphere, such side effects are almost impossible to document or substantiate. Almost any modern technology can be considered dual use. Any benefits to China's military would have been small compared to the overall benefits of cooperation. As a vehicle for acquiring technology useful in the military or industrial area, the Agreement is of minuscule importance in the overall perspective of China's abilities and means to gather scientific and technological information. The U.S.-China S&T Agreement is useful, mutually beneficial, promotes stability in the bilateral relationship and should be maintained. S&T cooperation under the Agreement brings significant benefits to both countries and should be continued.

[60] Testimony of Peter Cowhey. China as an Emerging Regional and Technology Power: Implications for U.S. Economic and Security Interests. U.S.-China Economic and Security Review Commission. February 12, 2004.