The China-U.S. Relationship in Science and Technology

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I. Introduction

When Chinese and U.S. dignitaries met in Beijing on February 21 last year to commemorate the 30th anniversary of President Nixon's ice-breaking trip to China, the scientific communities of the two countries celebrated their 30 years of cooperation in science and technology. Launched in the early 1970s, the U.S.-China scientific and technological cooperation has grown into not only one of the most productive such relationships in the world but also one of the underpinnings of the bilateral relations.

Cooperation on science and technology issues has been at the forefront of China-U.S. relations since diplomatic relations between the two countries were normalized in 1979. In fact, the Agreement on Cooperation in Science and Technology was one of the first between the two countries, signed during Deng Xiaoping’s historic visit to the United States in January 1979. Beginning with only a handful of protocols, the bilateral S & T relationship has blossomed over the last 30 years, expanding to include more than 30 protocols under this umbrella agreement covering everything from earthquake science to fisheries, agriculture, forestry, energy, nuclear safety, space technology, high energy physics, the environment, nature conservation, water resources management, public health, transportation and telecommunications. These interactions involve government agencies, research institutes, universities, professional associations, and private corporations.

In the early 1970s, when the two countries began to resume the scientific and academic ties that had been interrupted more than two decades earlier, there was a clear recognition that the phenomenal economic, social, and foreign policy experiments occurring in China would affect the United States in many ways. This sense of the importance of the historical juncture in China provided much of the impetus to the rapid growth in scientific and academic exchanges. Today, cooperative scientific and technological activities between the two nations far exceed anything that was foreseen in the 1970s and constitute the largest of such relationships maintained by both countries. Multiple official, bilateral agreements link the two countries, and a complex web of public and private arrangements offers extensive opportunities for cooperation.[1]

Documenting the major cooperative activities between the two countries for three decades, the article identifies the different phases of development in the relationship, the key parties on both sides, the successes achieved and problems encountered, and lessons learned for how China and the U.S. can strengthen their S&T relationship, and challenges and opportunities that lie ahead as the relationship enters the fourth decade.

II. A History of the S & T Relationship

When people talk about the China-U.S. relations, they tend to focus their attention on the political, security, economic, and cultural relations, and often neglect the extensive and highly productive cooperation in science and technology. But, the S&T relationship has not only remained resilient to political strains and trade disputes, it has been a constant source of success in the bilateral relationship.

The evolution of the China-U.S. S&T relationship has undergone three distinct phases, corresponding to the political relationship between the two countries. And we are now in phase four. Non-governmental, sporadic visits characterized the first phase (1971-1978). During the second phase (1979-1989) rapid growth occurred following the signing of the umbrella S&T agreement. Cooperation was curtailed following the June 1989 Tiananmen events and later resumed its expansionist trend during the third phase (1990-2000). Since George W. Bush took office in 2001, we have been in a new phase, where the nature and future of the relationship is yet to be defined. [2]

Phase One: 1971-1978

Phase One of scientific and technical exchanges was initiated in months preceding and following Nixon's visit to China. In May 1971, shortly after the American Ping Pong team's visit, Arthur Galston, a plant physiologist from Yale, and Ethan Signer, a microbiologist from MIT, became the first two American scientists to visit China since 1949. Hearing of the Ping Pong team's story while they were in North Vietnam, they requested a stopover in China on their way home, and were granted an invitation. They had exploratory discussions with their Chinese counterparts and were received in Beijing by Premier Zhou Enlai. [3] In late summer 1971, US physicist and Nobel Laureate Chen-ning Yang of SUNY Stony Brook visited China, where he had extensive discussions with Chinese scientists in Beijing and Shanghai, and was received by both Zhou Enlai and Mao Zedong.

President Nixon's trip to China in February 1972 and the signing of the Shanghai Communiqué marked a turning point in Cold War-era Sino-U.S. relations, as leaders of the two nations took bold advantage of their common adversarial relationship with the Soviet Union and terminated the Sino-American enmity which had so hurt the two nations in the previous two decades. The Shanghai Communiqué endorsed both governments' commitment to the objective of normalizing relations and provided a framework for realizing this goal. First among the three steps agreed upon was the facilitation of non-governmental contacts and exchanges in the fields of science and technology, culture, sports, and journalism. So began the period of unofficial exchanges, where, in the absence of formal diplomatic relations, scientists also served as "diplomats" and shapers of professional elite opinion about China. By the time of Nixon's trip, about ten US scientists, engineers, and physicians had visited China. By the end of 1972, some 100 American scientists and scholars had traveled to China, bringing home their observations on Chinese science and society.[4]

In the fall of 1972, the first group of Chinese scientists arrived in the United States on a study tour, intended to identify areas for further exchange. Before they embarked on the trip, Zhou Enlai met with them for three hours at the Great Hall of the People, giving instruction on the purpose of the mission and discussing specific arrangements.[5]

The special role of American scientists and scholars of Chinese descent in building early relationships was already evident at this stage. While most scientists, certainly physicists, are familiar with the names of C. N. Yang, T. D. Lee, few are probably aware of their role in the reopening of the China-U.S. scientific relations. An oft cited example was the program called the China-U.S. Physics Examination and Application(CUSPEA) initiated by U.S. physicist and Nobel laureate T. D. Lee of Columbia University. Under this program, more than 900 of China’s best and brightest young physicists were placed in the premier U.S. physics programs over a period of ten years. Similarly, the presence in China of a substantial number of Chinese scientists and engineers who had been educated in the U.S. prior to 1949 represented an important resource for building mutual understanding and trust during the initial phase.

However, a major milestone in cementing the early relationship was the Frank Press visit. In July 1978, President Carter's Science Advisor Frank Press led a high-level mission to China that included the heads of numerous U.S. government technical agencies. The visit was to determine what was of interest to China for cooperation with the US. They met in Beijing with Vice Premiers Deng Xiaoping and Fang Yi as well as other high-ranking Chinese officials. It was this meeting that laid the basis for the subsequent cooperative agreements, including the Understanding on Agricultural Exchange, the Understanding on Cooperation in Space Technology, and the Agreement on the Exchange of Students and

Scholars, all of which were signed before the end of 1978.[6]

The biggest surprise for the Frank Press delegation, however, was China’s willingness to send hundreds of students and scholars to the United States rather than the twenty or thirty that the American side had expected. This was nothing short of a major breakthrough for the American side. The proposal was discussed further in Washington in October that year by the first Chinese governmental S&T delegation, headed by Zhou Peiyuan, President of China Association for Science and Technology(CAST), and an American team, headed by NSF director Richard Atkinson. On October 23, 1978, agreement was reached on a general framework for exchanges that would include students, scientists, and visiting scholars. China would send 500-700 persons to the US in 1978-1979, and the US would support sixty students and scholars to go to China during the same period, with the understanding that other American students would go to China under separate arrangements. And so it was on December 26, five days before the US and China formally established diplomatic relations on 1 January 1979, that 52 Chinese students boarded a plane, destined for university campuses all over America.

Chart 1: Number of Chinese Students Studying in the U.S.

Year	Number of Students
1978	52
2001	78,000
Total from 1978-2001	189,000

Source: Ministry of Education of China

At the time when the arrangement was made for Chinese students to study in the U.S., the motives for the both sides was simple. To the Americans, the opportunity to train bright young Chinese scientists and engineers appeared to be the most effective and natural way to expand their influence and lay the basis for long-term cooperation; to the Chinese it was an opportunity to learn from the best in the world and narrow the gap between their scientific and technological level and that of Western countries. However, events that unfolded following this decision proved this arrangement to be one of the most significant historic changes that occurred in the late 1970s, for this opening of the doors to the outside world not only changed the fate and destiny of hundreds of thousands of young Chinese but also enormously impacted China’s modernization process.[7]

In October 1978, U.S. Secretary of Energy, James R. Schlesinger traveled to China. Schlesinger took with him a 16-person team including representatives from the Department of Energy(DOE), the Department of the Interior(DOI), the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Bonneville Power Authority, and the Tennessee Valley Authority (TVA). The two sides reached agreements on a broad agenda of possible cooperation, 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.

As preparations for the normalization of diplomatic relations proceeded, these three high-level missions, two U.S. and one Chinese, broke new diplomatic ground and laid the foundations for the expansive intergovernmental programs which came into being following normalization. The Understanding on the Exchange of Students and Scholars was signed in October during the Zhou Peiyuan visit, the Understanding on Agricultural Exchange was signed in November, and the Understanding on Cooperation in Space Technology was signed in December. In addition, the details for cooperation in high energy physics, which was formalized in a signed implementing accord in January, 1979 were worked out during the Schlesinger trip.[8]

Phase Two: 1979-1989

Phase two of the China-U.S. S&T relationship began with the normalization of diplomatic relations between the two countries on January 1, 1979. History will remember January 28, 1979 when Deng Xiaoping, the chief architect of China's reform and opening, started his 8 day visit to the US immediately after diplomatic recognition. On January 31, 1979 Mr. Deng and President Jimmy Carter signed a document known as the Agreement between the Governments of the People's Republic of China and the Government of the United States of America on Cooperation in Science and Technology, first formal cooperative agreement between the two governments which constructed an institutional framework for promoting bilateral science and technology exchanges. And the three existing agreements were also incorporated into the umbrella agreement through an exchange of letters. It was agreed that a China-U.S. Joint Commission on S&T Cooperation would be created and co-chaired by the U.S. President's Science Adviser and the Chairman of the Chinese State Science and Technology Commission(SSTC). The joint commission would meet annually to survey the burgeoning official scientific exchanges. Deng clearly saw science and technology as an important force in China-US relations. During his visit to the US, Deng, who later put forward his famous observation that science and technology is the first productive force, made several stops to scientific institutions and technology corporations.

With the signing of the umbrella S&T agreement, almost every U.S. technical agency began to develop constructive relations with its Chinese counterpart, both as a matter of national policy and popular inclination. By the end of 1980, 14 protocols had been signed involving S&T cooperation. These agreements launched a new era of official bilateral S&T relations and catalyzed more non-governmental efforts between the two S&T communities. Many of the protocols stemmed from discussions and observations that took place during the thirty-seven visits of Chinese scientific delegations to the United States and thirty American scholarly delegations to China that the CSCPRC sponsored between 1972 and the end of

1978.[9]

By the early 1980s, the China-U.S. S&T relationship had become the largest and most ambitious of all bilateral S&T relations maintained by both the U.S. and China. While rapidly improving political relations in the late 1970s were driven primarily by a common desire to contain the Soviet Union, scientific and technological cooperation had meaningful scientific value to the participating agencies on both sides. Following the establishment of diplomatic relations, particularly with the U.S-Soviet rivalry hardening and in the wake of the Soviet invasion of Afghanistan, China and the U.S. energetically created the framework for scientific relationship and each nation now appeared to be genuinely taking into account the interests of the other.

In his July 11, 1983 Message to the Congress, President Ronald Reagan writes: "It is in our fundamental interest to advance our relations with China. Science and technology are an essential part of that relationship and I have taken steps recently to ensure that China has improved access to the U.S. technology it needs for its economic modernization goals. We will continue to assist China through mutually beneficial cooperative efforts in science and technology." Again, in his April 11, 1986 Message to the Congress Transmitting the Annual Report on International S&T Activities, Reagan says: "Our maturing science and technology cooperation with China, a cornerstone in our expanding relationship, is now in its eighth year and is our largest government-to-government program. Not a part of our foreign assistance program, science and technology cooperation is based upon mutual benefit as are our other international exchanges. The Chinese have also added additional activities more attuned to their own interests on a reimbursable basis. We credit the doors opened by our successful science and technology program with contributing positively to the recent reforms made by the Chinese."

Through much of the 1980s, the bilateral S&T relationship was driven primarily by foreign policy considerations on the U.S. side and critical need at the initial stage of its reform and opening process to obtain foreign technology to support its modernization drive on the Chinese side. Yet, at the same time, there was also much emphasis placed on the balance and mutuality of benefits. As China's S&T capability grew, S&T cooperation became more of a two-way street, producing tangible benefits for both sides. For example, U.S. Forest Service scientists, through their collaboration with Chinese counterparts in the early and mid 1980s, gained valuable information to help them control forest pests in the United States. The U.S. Geological Survey and the China State Seismological Bureau during this same period established a China Digital Seismographic Network that helped improve the ability of both sides to predict the location, time and size of damaging earthquakes. Sharing of meteorological, remote sensing and other data improves the ability of scientists from both sides to understand and predict changes in the Earth's climate and ecosystems.

Of course, the relationship has not always been easy. Beginning in early 1989, cooperative activities were somewhat affected by the pending resolution of intellectual property rights (IPR) issues between the two countries as the United States began to take a tougher stance toward IPR protection worldwide and insist on the inclusion of much stronger IPR provisions in the umbrella S&T agreement with China. Consequently, the extension of the umbrella agreement and a number of cooperative protocols that came up for renewal was delayed.

This second phase of the relationship came to a grinding halt following the 1989 Tiananmen events which severely damaged the political foundations of normal relations between China and the U.S. Despite the willingness of Deng Xiaoping and George H. Bush to preserve the relationship, the Tiananmen events caused a public rift in the United States and created pressures in the U.S. Congress to halt all scientific and technological cooperation with China.

Phase Three: 1990-2000

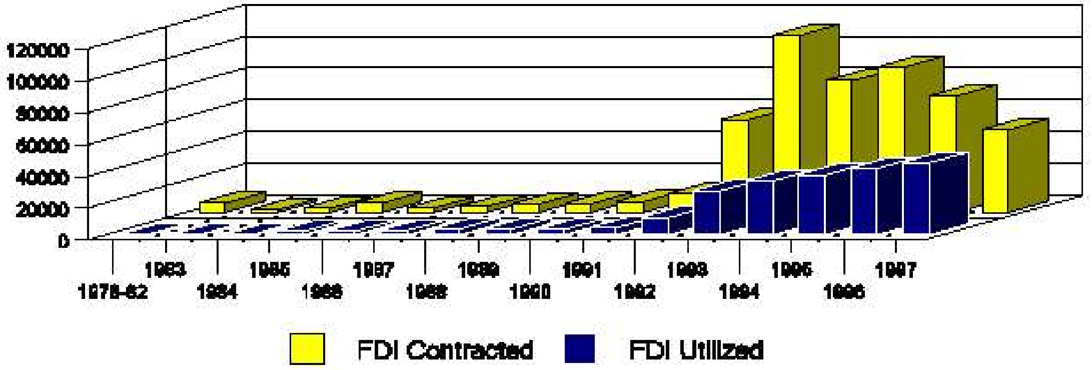
Phase three of the S&T relationship began with he US governmental sanctions announced by the Bush administration in June 1989, which included the suspension of high level contacts between officials of the two sides. One consequence of this was that normal meetings of the Joint S&T Commission were not held and the umbrella agreement was allowed to lapse. In the wake of the 1989 Tiananmen events and the ensuing sanctions imposed by the U.S. and its Western allies, China's progress on important fronts seemed to be in jeopardy. Many observers worried that China’s nascent economic reform, reliance on its scientific and technical community, and movement toward greater intellectual openness and international cooperation had come to a halt. The 1990s, however, saw dramatic Chinese progress in science, technology, education, and economic reform. Some positive political developments occurred as well.[10]

While the sanctions brought the bilateral S&T relationship to an all-time low, regular cooperative activities never stopped, and the number of Chinese S&T missions that came to the United States in 1989 still amounted to over 1,100. In the last quarter of 1989, visits by middle-ranking officials resumed and the atmosphere for continuing S&T cooperation began to improve. Toward the end of that year, the Bush administration resumed the licensing for Chinese commercial satellite launches. Interestingly, during this difficult period, science and technology not only held a steady course, but also led the way out of the low ebb for the entire bilateral relationship. For example, in 1990, 11 high-level Chinese delegations visited the United States, all of which were scientific missions.[11]

On 30 April 1991, with the conclusion of the bilateral IPR negotiations, the U.S. and China extended the umbrella S&T Agreement for another five years and added a new Annex One with strengthened provisions on IPR protection, which superseded all previous IPR references in individual protocols. This extension permitted the two sides to continue cooperative activities and plan and negotiate new tasks under the existing protocols.

Science and technology relations came back to normal in the early 1990s as U.S. sanctions dissipated. During this third phase, the role of commercial R & D carried out by private U.S. corporations began to increase notably. This happened at a time when China shifted its attention to the U.S. for inspiration for its reform program and economic growth after the collapse of the Soviet Union and the end of the Gulf War in 1991. Prior to that, China had subscribed to a Japanese model. The two earth-shattering events, however, convinced China to dismiss that model as inadequate and begin looking to the United States. China realized that it needed to improve rapidly in science and technology, with a focus on information technology, as the Gulf War signaled the arrival of a new world order dominated by the United States as the sole superpower. The shift toward a U.S. model became even more evident after the call for accelerated economic reforms by Deng Xiaoping during his famous southern trip in 1992. The U.S. responded to this shift in attitude with growing foreign direct investment, attendant technology transfers, and an increasing commercial interest in exploiting Chinese intellectual assets, all of which served to enhance the S&T relationship.[12] Private sector technological interactions with China during this period took many forms, including manufacturing operations, technology "offsets", and product development-related R & D. An extraordinary array of U.S. commercial R&D centers, labs, and programs began to take root in China, marking a new era in the S&T relationship.

Chart 2 Foreign Direct Investment in China (U.S.$Million)



Sources: Adapted from figures provided by The China Business Review; and "China: Capital Flows and Foreign Debt," EIU Country Profile 1996-97 (London: The Economist Intelligence Unit Ltd., 1996), p. 53. FDI figures include joint ventures, cooperative development projects and investments related to wholly foreign-owned enterprises.

Furthermore, during the 1990s, the bilateral S&T cooperation was elevated to a higher level also in response to growing concerns about emerging threats to the global environment, global health, and the sustainability of global economic growth. Accordingly, the increasing component of cooperative energy and environment activities in the bilateral S&T

relationship became visible. This link between energy and the environment was institutionalized as Vice President Al Gore and Premier Li Peng co-chaired the first U.S.-China Environment and Development Forum in Beijing in March 1997. The Forum met in plenary session and then broke into four working groups: Science for Sustainable Development, Energy Policy, Environmental Policy, and Commercial Cooperation.

In October 1997, during the China-U.S. summit in Washington, President Jiang Zemin and President Bill Clinton agreed to launch an Energy and Environment Cooperation Initiative to help China use clean energy sources to reduce air pollution. The two sides signed two agreements. The first, an Agreement of Intent on Cooperation Concerning Peaceful Uses of Nuclear Technology, paved the way for exchange of information and personnel, training, and participation in research and development in the field of nuclear and nuclear nonproliferation technologies. The second, a joint Energy and Environment Cooperation Initiative, targeted urban air quality, rural electrification and energy sources, and clean energy sources and energy efficiency, involving various governmental agencies in both countries and specifically calling for participation of the business and other sectors.

In April 1999, Vice President Al Gore and Premier Zhu Rongji co-chaired the second U.S. China Environment and Development Forum in Washington to provide a high-level framework for addressing the interrelated issues of environment, energy, science and commerce. A third such meeting was convened in January 2000 in Hawaii at the ministerial level. The U.S.-China Environment and Development Forum institutionalized the integration of both countries' efforts for energy, science and technology, and trade and the environment in bilateral cooperation, overarching activities under all three China-U.S. joint commissions for S&T, Economic Cooperation, and Trade. This was clearly part of a greater U.S. administration effort to constructively engage China in issues where both countries had common interests and presaged the direct engagement of the U.S. president and vice president and their Chinese counterparts.[13]

Phase three of the S&T cooperation came to a close with the NATO bombing of the Chinese embassy in Belgrade, the release of the Cox Report, and the high-profile dismissal of Wen Ho Lee. These events caused considerable damage to the Sino-U.S. relations, threatening to sidetrack the S&T cooperation that had taken nearly thirty years to build. But it is the fallout from these events and the reactions it is triggering now and in the future that should be of greater concern to both countries.

Phase Four: 2001-present

Phase four of the S&T relationship began with another difficult period of Sino-U.S. relations as the nature and the future of the relationship once again became questionable. On the political level, the limited consensus of the two governments on building a constructive strategic partnership was broken by the new Bush Administration. The EP-3 incident led to a sharp downturn in the overall bilateral relations. But then the events of September 11 brought the two countries back together to fight terrorism. During George W. Bush's visits to China in October 2001 and February 2002, and Jiang Zemin's visit to the United States last October, the two sides defined the goal of the bilateral relationship as the development of a constructive and cooperative partnership. Despite the ups and downs in the political relationship, science and technology cooperation has continued its expansionist trend as evidenced by the significant progress already made during this new phase.(For a complete list of protocols and memoranda of understanding, see Appendix A)

China-U.S. Climate Change Working Group

In February 2002, Jiang Zemin and George W. Bush agreed in Beijing to establish a China-U.S. Working Group on Climate Change to promote bilateral research cooperation on climate change focusing on key areas of policy and science. Later that year, the U.S. Department of Energy and Beijing Municipality launched a series of joint development and demonstration projects aimed at displaying the potential of environmental and clean energy technologies at the Beijing Summer Olympics in 2008. Under the agreement by the leaders of the two countries, the China-U.S. Working Group on Climate Change met in Beijing on January 14-16, 2003 and agreed to cooperate on a broad range of climate change science and technology activities. They identified 10 areas for cooperative research and analysis: non-CO2 gases, economic and environmental modeling, integrated assessment of potential consequences of climate change, adaptation strategies, hydrogen and fuel cell technology, carbon capture and sequestration, observation and measurement, institutional partnerships, energy and environment project follow-up to the World Summit on Sustainable Development (WSSD), and existing clean energy protocols and annexes.

The 10th PRC-U.S. Joint S&T Commission Meeting

The 10th meeting of the PRC-U.S Joint S&T Commission was held in Beijing on April 25-26, 2002. Xu Guanhua, Minister of Science and Technology of China, and John Marburger, Science and Technology Assistant to the President of the U.S., co-chaired the meeting. Participants included high-ranking officials with strong scientific credentials from the Chinese and U.S. governments. Discussions focused on the following topics: (1) Energy and Physical Sciences; (2) Ecosystem and Environmental Sciences; (3) Life and Health Sciences; (4) Agricultural and Food Sciences; and (5) Science Education and Public Outreach; and (6) Cooperation Mechanisms and Methods. Both sides expressed satisfaction with ongoing cooperation in areas such as fossil energy, energy efficiency and renewable energy, high energy physics and other basic scientific research and hoped to strengthen cooperation in those areas. It was agreed that, as the world's two largest energy consumers, both relying on imported petroleum, China and the United States shared a strong interest in developing cleaner energy sources to meet their development needs while protecting the environment and the global climate. There was strong interest expressed on both sides in cooperating on nanotechnology, nuclear fusion, plasma physics, genomics, catalysis, quantum computation and controls, photonics, and treatment of nuclear waste. A policy discussion on creating the infrastructure for a hydrogen energy economy was also proposed.

The two sides agreed that the following should be priority areas for future S&T cooperation: (1) Agricultural Science and Technology; (2) Clean Energy; (3) Nanotechnology; (4) Global Change; (5) Genomics; (6) Science Education; and (7) Information Technology. [14]

New Public Health Cooperation

In May 2002, China and the U.S. signed a new Memorandum of Understanding on Cooperation on HIV/AIDS prevention and research. Under this MOU. the National Institutes of Health(NIH) funds an array of AIDS-related research in China, including the $14.8 million China Integrated Program for Research on AIDS. The U.S. Centers for Disease Control and Prevention(CDC) has opened a Global AIDS Program office in Beijing to help with HIV/AIDS epidemiology and prevention. In addition, the U.S. Agency for International Development(USAID) is funding HIV/AIDS prevention efforts in parts of southern China.

Most recently, in light of the outbreak of Severe Acute Respiratory Syndrome (SARS), the two countries discussed new programs to strengthen cooperation on field epidemiology and emerging infections. Last May, HHS Secretary Tommy Thompson reached an agreement with Chinese Vice Premier and Health Minister Wu Yi to increase collaboration toward improved detection and management of infectious diseases. The agreement resulted from President Bush's pledge to Chinese President Hu Jintao during their recent phone conversation to provide resources necessary to help stem the SARS epidemic in China. Vice Premier Wu and Secretary Thompson agreed to proceed with planning for expanded collaborative efforts in epidemiological training and development of greater laboratory capacity in China. The new efforts, which would expand the number of HHS personnel working in China, were spurred by the recent SARS epidemic, but would be important for all other infectious diseases, especially newly emerging infectious diseases.

The world’s recent experience with the SARS epidemic highlighted the challenge that infectious diseases pose to contemporary society on a global scale. A strong global network is therefore needed to quickly identify and manage disease outbreaks, and this network will depend on the strength of each nation's epidemiological capacity, as well as on cooperation between nations. China and the U.S. are currently developing a plan for increased technical assistance, including training, lab capacity and improved health information technology.[15] In addition, China and the United States are having discussions on creating a bilateral health forum to look at economic aspects of the challenges posed by SARS and other emerging infectious diseases, such as the rebuilding of China’s rural health care system, creation of standardized drug and medical equipment procurement system, and involvement of private corporations on both sides.

III. Major Accomplishments

As we enter phase four of the S&T relationship, it is perhaps fitting to review what has been accomplished. During the past 30 years, the China-U.S. scientific and technological cooperation has blossomed beyond expectations. The features of the cooperation are wide-ranging and large-scaled with fruitful and mutually beneficial outcomes, which has promoted scientific, economic and social progress, and improved the living standards in both nations. Science and technology cooperation, like trade and economic relations, has become an important component of the China-US relations and has made contributions to stabilizing and enhancing the development of the overall relations.

Success Stories

China-US science and technology cooperation has been highly fruitful in generating a great number of internationally top-ranked achievements with significant scientific, economic, and social values. Success stories of the cooperative programs under the China-US umbrella S&T agreement are many, but a short list of these accomplishments includes the Landsat Remote Sensing Ground Station, Beijing Electron-Positron Collider, China Digital Seismic Network, the model for nuclear safety management and regulation, joint discovery of a hitherto unknown spiral-shaped galaxy, Dalian Industrial Management Training Center, air-sea interaction studies on the West Pacific, biological control of forest pests, and a number of large-scale public health-related epidemiological studies carried out in northern China. These achievements have enhanced scientific knowledge, economic productivity, and promoted sustainable social development in both nations. For example, the cooperation in the area of seismology and meteorology has improved the ability in predicting and addressing natural disasters, and the progress in the area of medical cooperation has contributed to cancer treatment and AIDS prevention and control in both China and the US.

The consistent governmental involvement between Beijing and Washington has stimulated and guided an extremely wide range of fast-growing nongovernmental science and technology collaborations and exchanges. Cooperative science and technology relationships of various forms have been established at the provincial, university, institute, and enterprise levels. For instance, out of the 54 international R&D organizations established at Tsinghua University, one of the most prestigious institutions in China by the end of 2002, 24 were jointly sponsored by the US side, whose R&D funding totaled at 1.4 billion RMB and accounted for 85% of the total R&D funding of the 54 organizations. These figures speak for themselves. The bilateral S&T cooperation during this period have also led to cooperation on other significant common interests. There were a few projects that started out as cooperative scientific and technical activities and later evolved into joint economic and commercial ventures such as the AMC-Beijing Jeep Plant, the Shanghai MD80 Aircraft Assembly Line, and the Pingshuo Open-cut Coal Field in Shanxi province.

Through collaboration, scientists of the two countries share numerous basic scientific data and research achievements. This process enables them to avoid repetitive labor, to stimulate innovative ideas, and to complement each other's strength in addressing these common challenges for the common good. One of the most recent examples is China-US SARS research cooperation. The joint efforts against SARS by the research communities of the two countries helped the Chinese scientists become familiar with the latest American methods of virology and immunology research and apply the expertise gained to the prevention and control of SARS in China on the one hand. On the other hand, this cooperation provided American scientists first-hand knowledge, data and experiences in SARS epidemiology and it was helpful for the US in formulating necessary measures to contain this disease from spreading.

A New Generation of Talent

The flow of hundreds of thousands of Chinese students and scholars to the United States during the past 30 years has benefited both countries. The United States has gained a critical influx of talent and, to the extent that these people return home, China has received an injection of scientists and engineers who are not only trained at the frontiers of knowledge but familiar with the world's most productive system of research and innovation. Take the Chinese Academy of Sciences for example: in the past 30 years, about 10,000 scientists or researchers have gone to the United States for study or research. Most of the leading researchers and top management personnel of the academy and its 123 affiliated institutes have had experience in studying or working in the U.S., including such names as Bai Chunli, Hong Guofan, and Ma Zhiming. Both countries have a stake in the continuation of this process.

Those who have not returned are also able to contribute to China's scientific enterprise part time or intermittently as transnational researchers. Such arrangements benefit all parties: these individuals contribute to China's development while continuing to enjoy the advantages of remaining within the U.S. system; China has access to researchers whose value is higher because they are still connected to the U.S. S&T enterprise; and the United States retains U.S.-trained Chinese talent, at least for part of the time.[16] The two nations are now closely linked together by an extensive web of scientific and commercial ties that bind the two peoples together through countless daily human exchanges.

Moreover, China is learning to harness Chinese intellect outside its borders and turn it into a competitive advantage. This has already contributed to remarkable progress in S&T fields such as superconductivity, nanotechnology, opto-electronics, and sequencing of the rice genome. While no one has attempted to measure the overseas brain trust that China can tap into, it is clearly sizable. Chinese scholars educated abroad over the last decade reportedly make up more than half of the top scientific researchers now working on key national research projects and receiving priority in conducting research in China. As China's economic reforms continue and older researchers retire, there will be more opportunities for China's younger, U.S.-trained scientists and engineers. As a result, high-tech firms in the United States and the government of China are finding themselves competing in some cases today for the services of these same talented individuals.

Commercial R&D Cooperation

Commercial research and development in high-tech industries has become an increasingly global undertaking. These activities have spread from the industrialized economies to parts of the developing world, including China which has attracted hundreds of foreign–funded, commercial R&D projects from around the globe. In particular, it is the world's leading high-tech and Fortune 500 companies that Chinese officials and enterprise managers are most interested in attracting, and have had a remarkable success. For China, in addition to the obvious inflow of capital, the benefit is to learn from the best in the world in order to accelerate its modernization drive. In the computer and telecom sector, foreign investors have established over 200 R&D centers, programs, or labs in China between 1990 and 2002. Chinese press reports estimate the total number of foreign R&D centers in China to be around 400, most of which are U.S.

This wave of globalization of commercial R&D that began in the mid-1980s has coincided with China's own efforts since 1985 to reform and restructure the nation's R&D management system. Through such commercial R&D ventures over the last two decades, China has benefited considerably and is, by all accounts, beginning to emerge as a serious high-tech competitor in its own market and in a few key sectors globally, including computer hardware, software, and telecom equipment.

From a strategic perspective, foreign-funded R & D plays an increasingly critical role in China's long-term S & T development goals. A main objective of China's scientific and technological modernization and long-term technological development programs is to acquire from foreign investors the modern innovative concepts and technology development skills needed to bridge the wide gap that exists in the US and elsewhere between the realization of new advances in basic research and the market forces that can help to bring these ideas to commercial fruition. Foreign-funded R&D centers in China, which focus mainly on the key areas of applied research and technology development, are helping to fill this critical gap. Foreign commercial R&D has also contributed to China's efforts in the construction of a national innovation system. Furthermore, access to U.S. commercial technologies has helped improve the international competitiveness of a variety of Chinese companies and has enabled China to become a commercial player in new areas of high technology.

New Approach to S&T Development

While the contribution this S&T relationship has made to China's overall industrial, economic, or other successes is difficult to measure, there is no doubt that the continuous scientific and technical exchanges that this relationship makes possible have had an enormous impact on China's approach to science and technology development. Many of the reforms Beijing has introduced over the last three decades reflect strategies, priorities, practices, and lessons learned from the U.S. For example, a key ingredient in nearly all cooperative protocols under the umbrella agreement was personnel exchange as a vehicle for scientific training and technical know-how. The Chinese interest in personal exchanges as an instrument for technology transfer came as a result of lessons learned from earlier decades when the country preferred wholesale transfers of complete plants, turnkey projects, and heavy industrial equipment instead of the fundamental know-how underlying these capabilities and technologies.

In late 1970s and early 1980s, China's approach to science and technology development was characterized by strengthened central government planning and funding of S&T programs at government laboratories and large state-owned enterprises, which proved to be largely ineffective and unsustainable. Since 1985, the central government has approached science and technology development with guidance and market-oriented incentive measures in order to spur competition among government laboratories and state-owned enterprises for limited government funding in selected areas. This drastic change may have been one of the critical factors in China's ability to maintain an impressive annual GDP growth over the last two decades.

Similarly, the creation of the National Natural Science Foundation of China(NSFC), the introduction of the peer review process, the establishment of numerous National Engineering Research Centers, and the construction of a national innovation system are clearly the outcomes of S&T exchanges with the United States.

IV. Problem Areas

Although China-US science and technology cooperation has developed successfully and smoothly in general, there are several issues that negatively affect this relationship. At times, these non-scientific factors impede normal implementation of cooperative S & T activities.

Political Constraints

In the history of Sino-U.S. relations, the one constant has been that political considerations have limited and shaped actions in the scientific and technological realm. This is almost as true in 2003 as it was when President Nixon made his historic visit to China in 1972. Since the early 1990s, China-U.S. relations have followed an uneven course, with modest improvements overshadowed by various recurring difficulties and setbacks. As a result, the S&T cooperation has traversed a more or less similar rocky path, but managed to grow substantially.

While politics remains preeminent, the S&T relationship has certainly shown some immunity from the turbulences in the bilateral political relations. In fact, it is sometimes likened to life savers in troubled waters. Perhaps the most important accomplishment over the past 30 years is that the S&T relationship is now so broad and deep that it can withstand trying times and often leads the way out of political difficulties, as clearly evidenced by its performance in the period following the 1989 Tiananmen incident. Further, although of secondary importance compared with other issues of “high politics”, S&T cooperation has come to figure prominently in China’s foreign relations and diplomatic repertoire. Visits by Chinese leaders to the United States or vice versa are often marked by the signing of a scientific agreement. Nevertheless, healthy US-China scientific ties will require ongoing attention of the top leaders of both countries to the political as well as the technical challenges for a long time to come.

Brian Drain

The excellence of the U.S. university system is a major reason for the predominantly one-way flow of S&T talent. The quality, openness, and flexibility of the U.S. higher education system, historic academic ties between the two countries reaching back to the 1930s, and the important human bridges created by a relatively large proportion of ethnic Chinese scientists and engineers have made U.S. universities most attractive to Chinese students. China has very strong representation in the United States, with the largest number of students overall (about 60,000 in 2000-2001). Over 80 percent of the Chinese students were pursuing graduate studies and about two-thirds were in the natural sciences and engineering. American universities awarded about half as many engineering doctorates to Chinese students as did Chinese universities in 1992. Most Chinese scientists and engineers receiving U.S. doctorates plan to stay in the United States.[17]

Over the years, Chinese students and visiting scholars have become a vital human resource in U.S. research laboratories, reducing their numbers could inflict as much harm on the United States as on China. Since the late leader Deng Xiaoping announced the “open-door” policy in 1979, more than 580,000 Chinese students have traveled abroad. Only about less than one third of them have returned home.

But the downturn in the U.S. high-tech industry, along with a rapidly expanding market in China, has renewed hopes that China's "stored brainpower overseas" may be ready to return. After three decades of watching hundreds of thousands of best and brightest engineering and science students immigrate to the United States, the Chinese government has launched an aggressive push over the recent years to win back some of the country's brainpower. Through its recruiting drive and other incentive packages, the government is hoping that more will return home, ending the historic outflow of top graduates. They include green card holders, individuals who possess H1B visas for skilled high-tech workers, and naturalized American citizens-- including many who benefited from the blanket asylum granted to students after the 1989 Tiananmen events. Stanching the outflow of scientific and technical talent and encouraging Chinese students and scholars abroad to return has now become an important aspect of Chinese national policy.

While there is this continuing international "brain drain" to the United States and other industrialized economies, simultaneously, Chinese officials fear a growing "internal brain drain" of top scientists and researchers moving from lower-paid state-run research institutes to the typically higher-salaried MNC research centers established in China without even leaving the country. Although both trends provide clear long-term benefit to China in terms of high-tech training, skills, and know-how, Chinese officials are wary of allowing too many of China's best and brightest to work for foreign commercial interests.

Technology Transfer/Export Controls

The US technology export policy toward China has been a constant source of tension and friction for the bilateral S&T cooperation and indeed for the overall bilateral relations over the last three decades. But despite ups and downs, the general trend, arguably, has been toward greater relaxation. (For an annotated timeline, see Appendix B)

Technology embargo on China was lifted in April 1971, ten months before Nixon's trip to China in February 1972. In May 1975, the U.S. moved China up on the ladder of technology export control, from Group S to a particular Group P, which meant that China could buy, from the United States, more and better technologies than what the Soviet Union could at the time. Subsequently, under U.S. administrations of Carter, Reagan and till the first 180 days of the first Bush administration, the general trend was to significantly liberalize the control over technology exports to China. However, the US technology export policy toward China underwent a terrific twist after June 4th incident in 1989, when Bush signed an executive order, which virtually stopped all dual-use technology exports to China. And the effort to liberalize control on technology exports to China was suspended. Moreover, the US Congress passed an act that prohibited the launching of American satellites by Chinese launch vehicles.

In 1993, the US technology export policy towards China took a turn for the better. It occurred at a time when U.S. businesses, especially the information industry, had intensified their lobbying efforts to revamp the existing U.S export control laws and regulations. As a result, the US government published its first “national export strategy” which included two positive moves: (1) It reformed the export license system by increasing the upper limit of computers that could be exported without a license from 12.5 M Flops to 500 M Flops; and (2) It dismantled the Coordinating Committee for Multilateral Export Controls(CoCom) a Paris-based multilateral control regime led by the U.S. that had existed throughout the Cold War era, and replaced it with a more flexible mechanism, the so-called Wassenaar Arrangement.

Commercial satellite launching was an issue throughout this period. Although the 1989 congressional act had prohibited the launching of US –made satellites with Chinese rockets, it did grant the President the privilege to waive certain launching contracts from this ban. From 1989 to 1993, Bush gave green lights to 9 satellite-launching contracts, and Clinton issued waivers for 11 contracts during the first 5 years of his term.

In February 1996, a tragic event occurred. A Chinese carrier rocket exploded when launching a U.S.-made satellite. To help investigate the explosion, American experts provided some information to their Chinese colleagues. This should have been taken as a normal cooperative activity, but it happened during another tough period of US-China political relationship. In 1998, American media alleged that those American experts had leaked classified information to the Chinese, and China used that information to improve its missile technology. The U.S. Congress responded by constituting a committee, headed by Congressman Christopher Cox, to investigate the allegations. The committee submitted its final report to the congress in December 1998, in which they put forward 38 measures to tighten the restriction on technology export to China. While containing little evidence to support the allegations, the “Cox Report” has added a complicating factor to the US-China technology relationship by poisoning the atmosphere for cooperation.

In 1999, the sale of a $124 million Loral ChinaSat-8 was in jeopardy due to new State Department regulations. China cancelled its order because the review process took too long, the US satellite maker had to return $124 million to China, pay $12 million in fines, and spend another $38 million to refurbish the satellite for sale to another buyer. Tighter export controls on satellite exports are crippling the U.S. satellite industry and eroding U.S. superiority in this critical sector when global competition is intensifying. Rigorous U.S. controls have put American companies at an unfair disadvantage against their European and Japanese competitors, and the U.S share in the global satellite market has sharply shrunk from 75% to 45% over the recent years.[18]

Yet, U.S. efforts to adapt export controls to the new realities of the world today have often been hampered by bureaucratic inertia and partisan debate over how best to reform the export control system. In the aftermath of the Cox Report, technology transfer has been much clouded by rhetoric and imprecision. As James Lewis has argued, in his testimony before the U. S.-China Security Review Commission on January 17, 2002, that transfers of U.S. technology to China can damage national security has become a staple of the larger debate over China policy. While charges that China improves its military capabilities with U.S. commercial technology are widely accepted, they are wrong. A close examination suggests that U.S. commercial technology is irrelevant to China's military modernization and that efforts to restrict high technology trade are more likely to damage than to improve U.S national security.[19]

Contrary to claims that China acquires U.S. commercial technology and turns it to military use, the Chinese follow the more sensible course of acquiring modern military technology from non-U.S. sources. U.S. commercial technology is important to China's continued economic growth, but these technologies are all available from other Western industrial nations that do not share U.S. concerns with China. Other countries with advanced military and industrial technologies are willing to sell to China.

Ironically, the China technology transfer debate in the U.S. focuses on general purpose industrial goods, not weapons or military technology. It has blurred differences between military and civil technologies in a way that is unhelpful for analysis. Additionally, efforts to restrict access to these industrial goods make little sense in light of growing global economic integration. A large portion of the U.S. and multilateral controls were designed to constrain Soviet weapons programs in the 1980s and make little sense in a different strategic context. Restrictions on semiconductor manufacturing have survived almost intact from Cold War export controls aimed at the Soviet bloc, despite radical changes in the international security and economic environment.[20]

During the Cold War, export controls served as an essential tool in US efforts to curb the flow of sensitive technologies to real or potential enemies. Sharing such technologies, even with its NATO allies, was carefully scrutinized. Today, a growing number of voices in U.S. government, the private sector, and non-governmental expert community are proposing far-reaching reforms to establish export control procedures and regulations that are more adaptable to an ever-changing civilian/military technology environment and to new strategic realities. The CoCom regime has been replaced by the Wassenaar Arrangement based on national discretion which virtually renders unilateral controls useless. Therefore, it is critical for the U.S. government to assess continually the effectiveness of its export controls in the context of both foreign availability of technology products and Chinese indigenous capabilities.

Protection of Intellectual Property Rights

As mentioned earlier, in April 1991, the umbrella S&T Agreement was extended for another five years with strengthened provisions on the protection of intellectual property rights(IPR) which superseded all previous IPR references in individual protocols. While never a serious problem in cooperative activities under the umbrella S&T Agreement, IPR protection has been an important issue on the U.S.-China bilateral agenda for more than a decade. Bilateral discussions have covered the full gamut of IPR issues.

In January 1992, as a result of an investigation under the Special 301 provisions, the two sides agreed on improved protection for U.S. inventions and copyrighted works, including computer software, motion pictures and sound recordings, trademarks, and trade secrets. Although China improved its intellectual property laws after 1992, enforcement of these laws appeared to be inadequate. In February 1995, the U.S. and China concluded an IPR Enforcement Agreement which resulted in fundamental changes in China in the area of IPR protection enforcement and established the parameters of an enforcement system. Since then, China's actions have animated this system through vigorous, concrete anti-pirating efforts.

As a result of these actions, China has a functional system which protects IPR more effectively than before. As World Intellectual Property Organization Deputy Director General Castelo noted recently, "Within less than 20 years, China has developed from scratch a modern, well-functioning intellectual property system which is in harmony with the international intellectual property laws and practices.” Recently, China's State Council issued a directive to all government ministries mandating that only legitimate software be used in government and quasi-government agencies. Many Chinese industries and their governing ministries have heeded the calls within and outside of China to improve IPR protection. Enforcement efforts have produced remarkable results including increased raids against pirate CD factories, fining and imprisoning IPR violators and a campaign to disseminate IPR rules and information to government officials, enterprise managers, and the general public to increase awareness of IPR issues.

Strong statements by the State Council have demonstrated that the government understands the widespread economic losses of Chinese and foreign firms alike due to IPR violations. Moreover, the State Council clearly understands that the lack of IPR protection is a severe constraint on the development of a national innovation system in China. The high priority attached to the IPR protection by the Chinese government has been translated into continuing progress in promulgating legislation, administrative regulations, and enforcement guidelines in accordance to the WTO rules.

But compared with the legal systems established over hundreds of years in the west, China’s legal system still has some flaws. Notwithstanding the remarkable progress, enforcement remains weak and ineffective in parts of China as the law enforcement units are faced with a number of problems, such as low compensation vs. the burden of proof, shortage of well-trained judges, insufficient resources of police, prosecutors, and competent administrative authorities, difficulties in transferring cases from civil to criminal proceedings, lack of cooperation and coordination within the law enforcement community, and strong local protectionism. Thus the problem now facing China is to translate the improved legal framework into a significantly changed environment at the local level. This can only be done by improving the criminal justice system and by improving the professional capabilities of the police, prosecutors, courts, and administrative agencies, and strengthening cooperation in the entire law enforcement community. And such efforts take time.

Nuclear Energy Agreement

In 1985, China and the United States signed the Agreement for Cooperation in the Peaceful Uses of Nuclear Energy. In approving the agreement, the U.S. Congress required that prior to implementation, the President would have to make certain certifications and a report to the Congress on China's nonproliferation policies and practices. In 1990, legislation was passed requiring additional Presidential certifications related to non-proliferation and human rights. These sanctions also precluded the U.S. Department of Energy from authorizing the export of nuclear technology and services to China, any Nuclear Regulatory Commission-licensed exports to China, and any Department of Commerce-licensed dual-use exports to nuclear end users or end uses in China.

Over the past 10 years or so, the United States has been working with China to address the concerns outlined in the Congressionally-mandated certifications. Issues at the top of the U.S.-agenda included China's need to terminate assistance to unsafeguarded nuclear facilities, curtail cooperation with Iran's nuclear program, establish an effective nuclear export control regime (including dual-use items) and join multilateral nonproliferation and export control efforts. These negotiations bore fruit when on 29 October 1997, at the U.S.-China summit in Washington, Clinton announced that he would certify that China has met the requirements for implementation of the agreement. Clinton's announcement was made in response to: (1) China’s 11 May 1996 pledge not to provide assistance to unsafeguarded nuclear facilities; (2) its September 1997 promulgation of new nuclear export control regulations; (3) its October 1997 joining of the Zangger Committee(ZAC); (4) its October 1997 announcement that it will formulate nuclear-related dual-use export control regulations by mid-1998; and (5) its October 1997 confidential written assurance to Washington that it would halt all new nuclear cooperation with Iran.

On 5 November 1997, the U.S. House of Representatives voted, by 394-29, to extend from

30 days to 120 days the period for review of President Clinton's certification for the agreement. With such an extension, Congress would have until March 1998 to review the certification. On 12 January 1998, Clinton signed the formal certifications and reports required by U.S. law to implement the agreement, and submitted them to the U.S. Congress. On 19 March 1998 after the Congress failed to take action, the agreement went into effect.

Currently, the United States has halted all nuclear-related exports to China. A 4 April 2000 memo from the U.S. Nuclear Regulatory Commission (NRC) revealed that 16 requests for export licenses, known as Part 810s, made in 1998 from U.S. companies to sell civilian nuclear power reactor technology had still not been approved. The memo stated, "To date, China has not provided any assurances for any of the Part 810 cases. China would prefer to provide such assurances on a case-by-case basis, but the U.S. is requiring generic assurances, or the "catch all" approach. China opposes U.S. demands because they were not included in the original 1985 agreement. [21]

Space Cooperation

Although the protocol on space technology cooperation was one of the first agreements signed between the two countries, the current China-U.S. cooperation in this area consists of very limited, low-level, project-specific cooperation, involving geodynamics/plate tectonics research and joint participation in certain multilateral coordination groups, such as the Committee on Earth Observation Satellites(EOS). Due to strong U.S. Congressional opposition, there is no joint satellite, launch vehicle or human space flight related cooperation under discussion or contemplated at this time. NASA is, however, cooperating through the U.S. Department of Energy (DOE) with Chinese Government sponsored researchers as a part of the Alpha-Magnetic Spectrometer (AMS) program. AMS is a DOE-sponsored high-energy particle physics experiment designed to study the origin of the universe from the International Space Station (ISS).

Over the last 4 years, at the request of the U.S. Department of State, NASA has informed all interested Chinese entities that a prerequisite for any potential new cooperation with NASA, would be China's adherence to the Missile Technology Control Regime (MTCR) guidelines and adoption of export control policies consistent with the MTCR..

With China's recent successful launch of a precursor human space flight mission and expressed interest in placing a human into space in the 2003 or 2004 time frame, NASA and the U.S. State Department are reported to be seeking new ties with China. According to Aviation Week and Space Technology, two days after the Shenzhou 4 launch, NASA administrator Sean O'Keefe told a forum in Washington that he and Deputy Secretary of State Richard Armitage are spending "a lot of time" exploring whether and how to bring China into closer cooperation with the U.S. in space.

China has previously sought to join the U.S.-led International Space Station (ISS) as a partner. For a number of years, the Europeans have been trying to sell China manned space technologies and they are pushing to get China into the ISS. The new PRC-U.S. space cooperation could also play into the possible loosening of U.S. aerospace export restrictions that have prevented the commercial Chinese launch of U.S.-built communications satellites and foreign satellites containing U.S. parts.

However, possible new links to China via the ISS brought a swift reaction on Capitol Hill. The Congress demanded and received an official explanation for the statements from NASA. Congressional sources noted that the proposal being floated by NASA administrator O'Keefe and State Department Deputy Armitage are not, and have never been, an official policy. NASA officials will neither bring up nor support any Chinese participation in the International Space Station.[22] Further, in light of recent U.S. State Department charges against two U.S. aerospace firms, Hughes and Boeing, that they illegally shared sensitive technology with China, it's clear that major political hurdles remain in fostering a U.S.-Chinese space program.

Lack of Funding

Inadequate funding levels have affected the implementation of cooperative projects over the last 30 years. In addition to the absence of USAID assistance, the U.S. side has never had any funding earmarked for its S&T cooperation with China. As a result, each participating U. S technical agency has had to fund cooperative activities out of its regular domestic budget on the basis of scientific value of participation for the agency involved. While this approach has a number of merits, it means that there may be areas where the domestic agency has no interest in programs with its Chinese counterpart even though there may be significant foreign policy or commercial benefits for the United States and a high degree of Chinese interest.

On the Chinese side, however, the absence of special funding earmarked for its cooperation with the U.S. has not caused significant difficulties in supporting cooperative activities as the participating agencies have always been able to come up with the funding needed.

But some U.S. technical agencies have fared much better than others depending on the nature of their mandate. For example, since the 1980s, the National Science Foundation (NSF) has funded more than 500 projects in the area of basic science, backing everything from geology to physics. Last year, the National Institutes of Health supported more than 80 projects in China, continuing a 10-year trend. China is one of three countries where NIH funds a center for tropical medical research -- the Shanghai Institute of Parasitic Diseases.

Inadequate funding on the U.S. side has been brought up as a serious detriment to cooperation at a number of Executive Secretaries ' Meetings(ESM) over the recent years. The U.S. side has been urged to take seriously the Sino-U.S. relationship when it comes to science and technology, a collaboration that suffers from a tremendous lack of funding. As Denis Simon has pointed out, the U.S. must invest in and participate in China's technological push and promote commercial exchanges with China, particularly those that offer major inroads into the country's knowledge base and emerging research and development networks.[23]

Visa Restrictions

Recently, problems with obtaining U.S. visas have become a serious obstacle to U.S.-China cooperation. Starting in August 2002, almost every visa applicant from a non-waiver country — including China, India, and six other top suppliers of international students to the U.S. — must be interviewed by a US consular official. The long waiting period this has caused could be stretched further by an inadequate security information system. On 23 August 2002, organizers of the World Space Congress protested about the treatment of dozens of Chinese scientists and engineers. All but two of the seventy Chinese delegates were denied visas for the congress, which was held in Houston. The delegates and conference organizers only learned of the decision at the last minute, leading to the sudden withdrawal of most of the Chinese papers.

A high percentage of Chinese scholars and scientists in areas such as biotechnology, information technology, and engineering are facing an unrealistically lengthy and unpredictable U.S. visa application procedure. For example, last year more than 100 scientists and project managers from the Chinese Academy of Sciences including one of its vice presidents experienced visa refusals or delays. In addition, the implementation of the China-US Science Park at the University of Maryland, a cooperative project both sides take great interests in, has been seriously delayed for a significant time period because of the visa problem.

Since the 11 September 2001 terrorist attacks, visitors to the United States have faced tighter entry controls. Restrictions tightened further in August last year, when the U.S. Department of State broadened its guidelines covering visiting researchers from "sensitive countries" to encompass those from all destinations. The clampdown is affecting numerous scientific programs, for which foreign scientists are a vital source of new ideas and perspectives. Also affected are public-health programs, particularly those aimed at tackling infectious diseases such as HIV/AIDS. Two surveys conducted by the Association of American Universities and the American Physical Society (APS) indicate that student enrolments for 2002-2003 were clearly affected. For example, the number of visiting researchers on 'J visas', for exchange visitors, dropped by 11 per cent.[24]

To further compound the problem, the White House has reorganized the Immigration and

Naturalization Service(INS) to create three new agencies: the Bureau of Citizenship and Immigration Services (BCIS), the Bureau of Customs and Border Protection (BCBP), and the Bureau of Immigration and Customs Enforcement (BICE), all housed within the Department of Homeland Security. The changes have done nothing to streamline the acquisition of visas, and the process continues to be plagued with delays. Intensified security measures have made issuance of visas overseas an even more difficult exercise.

The leaders of the US National Academies have warned that security reviews for foreign researchers are causing delays that threaten the health of US science. In a statement released on 13 December 2002, they called on the US government to fast-track foreign scientists seeking to enter the country, and said that the scientific and technical community should be involved in determining areas of particular security concern. To prevent future disruptions, they also ask the Department of State to reinstate a "precleared" status for foreign scientists who travel frequently to the United States, to create a special visa for researchers with solid credentials and an invitation from US scientists.

V. Conclusion

As China and the United States enter their fourth decade of cooperation in science and technology, policy makers and scientific communities on both sides face new challenges and unprecedented opportunities. The growing power of both the United States and China has raised the stakes of cooperation and imposes new complexities in managing the S&T relationship. With the disintegration of the Soviet Union, the United States has emerged as the sole super power in the world and enjoys unprecedented freedom to pursue its global objectives, which will not always coincide with China’s interests. China appears destined to become one of the 21st century's most powerful and influential countries. In the midst of the U.S. and European economic slowdown, you cannot attend a business gathering without hearing about the importance of the China market. In the years ahead, the prosperity and security of East Asia and indeed of the world at large will be affected significantly by how China defines and pursues its national interests. These developments, coupled with a different political system and a sharply contrasting worldview, makes some on the American side wary of working together with China, lest that of it can strengthen a potential strategic competitor and political adversary.

The rapidly growing trade deficit, massive investment flows, recurring political tensions, technology transfers, disputes over human rights, WTO compliance, proliferation of WMD-related technologies, military modernization, Taiwan, and others — have all been thorny issues in the bilateral relations. After a rocky start with the new Bush Administration and the EP-3 incident, the United States and China are now tentatively building a constructive cooperative partnership in a wide range of areas, including international politics, trade, education, science and technology, and the environment, etc. Now the two countries are working closely to handle the North Korea and non-proliferation issues. As Joseph Nye has noted, “September 11 not only realigned the great powers, it also proved to the United States, as well as other powers, that there was a new agenda in which nobody could go it alone. And that means that the United States and China have very strong cooperative interests.” While not minimizing the significant differences that remain between the two countries in important areas, the recent meetings between the Chinese and American leaders may result in a U.S.-China relationship that carries great potential to be more cooperative and productive than in the past.

With respect to the S&T relationship, it is no longer simply a foreign policy instrument used to overcome decades of isolation and hostility and thus lay the foundations for the overall bilateral relations between the two nations. As Pete Suttmeier has argued in his paper, much has changed on both sides since the late 1970s with regard to domestic politics, perceptions of international security issues, economic development matters, and research and development needs and capabilities. In addition, science and technology have become far more important in influencing the political, economic, and other issues of “high politics” as well as traditional diplomacy. This has resulted in an increasing high-level attention given to S&T cooperation, as demonstrated by a growing list of S&T issues on the agenda for summit meetings between leaders of the two countries as we enter phase four of the S&T relationship. At the same time, however, these strong, positive trends do not exist in a vacuum, major issues that can cloud the future of the S&T relationship are not hard to identify. With increased political importance, S&T issues run the risk of becoming more politicized and causing more conflicts, as disputes over such issues as technology transfer, intellectual property rights, and nuclear energy cooperation illustrate.

In strengthening the China-U.S. S&T relationship, it is important to realize that more is at stake than scientific knowledge and technical know-how. Cooperation can have a broad impact on our mutual understanding. Cooperation in science and technology increases our knowledge of each other's systems; conversely, a better appreciation of our respective values can help us identify and remove obstacles to productive cooperation during this new phase. To expand and elevate the bilateral S&T cooperation, China and the United States may find it useful to explore such areas as approaches to human subjects and genetic research, the social and ethical implications of new technologies, science education, and the treatment of intellectual property rights.

Cooperation may include subjects such as research financing, access to and dissemination of S&T information, and the interaction of the scientific communities with policymakers which can lead to broader questions of political processes and cultural norms. An example of what might be done on a broader scale is sustained policy dialogues. Since 1999, NSF and its Chinese equivalent have sponsored discussions between Chinese and U.S. scientists and policymakers as a complement to the agencies' support of research collaborations. The time is also right to encourage joint in-depth comparative policy studies with China's emerging community of policy researchers. [25]

China today is a much-changed and changing place. Its S&T capabilities have reached the threshold where the payoffs of cooperation can benefit not only China and the United States but also the rest of the world. The U.S. needs a China that is vibrant, entrepreneurial and able to deliver positively to the global research promises on the technological horizon. Despite the existence of a broad-based overarching science and technology cooperation agreement between the two countries, S&T cooperation extends far beyond what is covered by the official umbrella agreement. The fact is that the more than 30 years of bilateral S&T relations between the two science and technology communities have been just the icing on the cake. We must now recognize that China's ever-increasing knowledge resources are the actual cake. Forging positive alliances with China can only put the U.S.- indeed the world- in a more prosperous position. [26]

While cooperation is most easily initiated and administered bilaterally, bilateral S&T relations are also more prone to misunderstanding and political volatility. The two sides must not cooperate alone and need to invite, wherever possible, others players into the game and fashion multilateral solutions to global problems. It is therefore necessary to complement bilateral cooperative arrangements with multilateral partnerships, as demonstrated by the recent U.S.-led multilateral Carbon Sequestration Leadership Forum and Earth Observation Initiative, of which China has been a strong supporter. For the U.S. side, the objective of encouraging Chinese political and economic change through S&T cooperation is more likely to be met by helping China in its quest for integration into the fold of global economic system and the global S&T enterprise.[27] Sanction-oriented approaches will not work.

In short, phase four of China-U.S. cooperation in science and technology begins with new challenges and opportunities. The future of the China-U.S relationship in science and technology depends upon domestic policy developments on both sides. Despite complexities and pitfalls on the road to successful cooperation, many trends in China and the United States provide grounds for optimism about future development of the bilateral S&T relations. Building on the significant assets the two sides have created over the past 30 years, we have an opportunity to fashion a new and innovative approach to the China-U.S. S&T relationship--one appropriate to a new era and one built on long-term mutual interests.

Appendix A:

List of Protocols and Memoranda of Understanding under the 1979 China-U.S. S&T Agreement

1. Understanding on Exchange of Students and Scholars
2. Understanding on Agricultural Exchange
3. Understanding on Cooperation in the Field of Space Technology
4. Implementing Accord on Cooperation in the Field of High Energy Physics
5. Protocol on Cooperation in the Field of Metrology and Standards Science and Technology
6. Protocol on Cooperation in the Field of Atmospheric Science and Technology
7. Protocol on Cooperation in the Field of Marine and Fisheries Science and Technology
8. Protocol on Cooperation in the Fields of Management of Science and Technology and Scientific and Technical Information
9. Protocol on Cooperation in the Field of Public Health Science and Technology
10. Protocol for Scientific and Technical Cooperation in the Field of Earth Sciences
11. Protocol for Scientific and technical Cooperation in Earthquake Studies
12. Protocol for Scientific and Technical Cooperation in the Field of Environmental Protection
13. Protocol on Cooperation in the Field of Basic Sciences
14. Protocol on Cooperation in the Field of Nuclear Safety Matters
15. Protocol for Scientific and Technical Cooperation in the Study of Surface-Water Hydrology
16. Protocol on Cooperation in the Field of Housing Construction and Urban Development
17. Protocol on Cooperation in Science and Technology of Transportation
18. Protocol on Cooperation in the Field of Nuclear Physics and Controlled Magnetic Fusion
19. Protocol on Cooperation in the Field of Aeronautics Science and Technology
20. Protocol on Cooperation in the Field of Industrial Management
21. Protocol on Cooperation in the Field of Statistics
22. Protocol for Scientific and Technical Cooperation in Surveying and Mapping Studies
23. Protocol on Cooperation in the Field of Fossil Energy Science and Technology Development and Utilization
24. Protocol for Scientific and Technical Cooperation in the Field of Water Resources Management
25. Protocol on Cooperation in the Field of Telecommunications Science and Technology
26. Protocol for Scientific and Technical Cooperation in the Conservation of Nature
27. Protocol on Cooperation in the Field of Railroad Science and Technology
28. Protocol on Cooperation in the Field of Non-ferrous Metals Science and Technology

29. Protocol on Cooperation in the Field of Land Management
30. Protocol on Cooperation in the Field of Mine Safety
31. Protocol on Cooperation in the Field of Energy Efficiency and Renewable Energy Technology Development and Utilization
32. Protocol on Cooperation in the Field of Agricultural Science and Technology
33. Protocol on Cooperation in the Field of Water Management in Agriculture
34. Memorandum of Understanding on Mineral Resources Management

35. Protocol on Cooperation in Civil Industrial Technology and Scientific and Technical Information
36. Memorandum of Understanding on AIDs Cooperation
37. Memorandum of Understanding on Cooperation in the Field of Basic Biomedical Science

Source: Ministry of Science and Technology of China

Appendix B:

U.S.-China Technology Transfer: Annotated Timeline 1980-1998

1980

March - US State Department issues Munitions Control Letter 81 allowing China to buy helicopters, engine testing equipment, some integrated circuitry and transport aircraft.

April - Commerce Department changes China's Technology Transfer Category from 'Y' to 'P' allowing U.S. firms to sell high technology to China at twice the rate of that sold to USSR and its satellites, and to transfer selected "dual use" technology to China.

June - Chinese Defense Minister Geng Biao visits the U.S. and submits a wish list of defense items which China wants, including weapons such as the Hawk ground-to-air missile.

September - U.S. Undersecretary of Defense for Research and Engineering William Perry visits China, announces U.S. approval of over 400 Commodities Control List (CCL) export licenses.

1981

June - Secretary of State Alexander Haig visits China, announces the Defense Department is willing to sell China potentially 'lethal' weapons on a case-by-case basis.

1983

May - Secretary of Commerce Malcolm Baldridge moves China from category 'P' to 'V' ("friendly state") category for purposes of reviewing technology transfer licenses controlled under the auspices of Commerce Department's CCL.

September - Baldridge announces further regulation revisions concerning technology transfer to China through implementation of broad 'zones' or categories.

Secretary of Defense Casper Weinberger visits China and proposes linking Sino-American military exchanges and technology transfer to detailed strategic roles and missions to be shared by Washington and Beijing, but China declines.

1984

June - China becomes eligible for U.S. government-to-government sales under the Foreign Military Sales (FMS) program under Section 3(a)(1) of the Arms Export Control Act that such sales will strengthen US national security, thereby allowing for more active government-to-government cooperation in US defense exports to China.

1985

December - Thirty technology equipment/product categories are officially designated for liberalized treatment of export licensing to China.

1986

October - U.S. Defense Secretary Caspar Weinberger visits China for talks on further liberalization of US technology transfer policies.

1987

April to September - A further easing of high technology sales to China through expansion of 'green zone' range by 32 products and raising the limits on computer processing speed from 155 megabytes per second to 285 megabytes per second.

August - U.S. and China announce the 'Peace Pearl' program, whereby Grumman Aerospace as prime contractor would provide China with 55 fire control and avionics upgrades for Chinese J-8 fighters at an approximate cost of $550 million.

1989

June - In response to the Tiananmen events, the U.S. Government freezes arms transfers to China and halts high-level military-to-military meetings.

December - Bush Administration approves the export of three communications satellites to be launched into space on Chinese launch vehicles. U.S. also removes restrictions on U.S. Export-Import Bank financing to U.S. firms doing business with China.

1991

May - U.S. Government refuses to grant approval of export license for U.S. components to equip a Chinese domestic communications satellite and bars U.S. companies from participating in Chinese satellite launches. It also restricts the transfer of computer and missile technology to China. In addition, U.S. companies are barred from selling technology and equipment to the China Precision Machinery Import Export Corporation (CPMIEC) and Great Wall Industry Corporation.

1992

February - Having received written assurances that China would adhere to the guidelines of the Missile Technology Control Regime, the U.S. Government lifts high-technology sanctions imposed against China in May 1991 for missile exports to Pakistan.

The U.S. Commerce Department approves the export of the Allied Signal Garrett TFE731-2A-2A turbofan engine to China.

1993

January - President Bush allows the export of Cray supercomputer to China, pending necessary processing.

August - Citing evidence that 'items related to the M-11 missiles have been transferred by China to Pakistan', the Clinton Administration bans U.S. companies for 2 years from exporting items related to rockets and satellites to China or Pakistan, including a ban on dealing with 10 Chinese aerospace companies.

November - Clinton Administration agrees to allow the sale of generators and other components for China's nuclear power plants and announces the final go-ahead for sale of Cray supercomputer to China.

1994

January - Clinton Administration announces that commercial satellites under Department of Commerce auspices are not subject to August 1993 restrictions and that export licenses for them could be approved.

May - In renewing MFN status for China, Clinton Administration maintains sanctions imposed in June 1989, including suspension of weapon deliveries, denial of licenses for dual-use technology and suspension of consideration of licenses for U.S. Munitions List items.

October - The U.S. lifts August 1993 high-technology trade sanctions imposed on China for missile exports to Pakistan. In return, China pledges not to export 'ground-to-ground missiles featuring the primary parameters of the Missile Technology Control Regime.

1995

Following private visit of Taiwan's Lee Teng-hui to the United States, China cancels in protest planned discussions on missile proliferation to take place between U.S. and Chinese officials.

1996

February - Clinton administration lifts sanctions imposed in 1989 to allow for transfer of four communications satellites from U.S. to China.

On Feb. 15, a Chinese "Long March" rocket carrying a satellite for the U.S. companies Loral and Hughes Aircraft explodes on liftoff. The two companies launched an investigation of the mishap and shared the conclusions with Chinese officials.

March - The Clinton administration transfers responsibility for approving Chinese satellite launch licenses from the State Department to the Commerce Department.

1997

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May – U.S. Justice Department begins investigating Loral for allegedly compromising U.S. national security by sharing with China the results of an investigation into the explosion of a Long March rocket bearing one of Loral's satellites. Loral applies for a waiver asking permission to launch another satellite on a Chinese rocket. The U.S. imposed sanctions on Chinese entities and persons for chemical weapons-related sales to Iran. China calls the sanctions "entirely unreasonable."

September - During a meeting in New York, Chinese Foreign Minister told Secretary of State Madeleine Albright that China would halt its future sales of conventional cruise missiles to Iran.

October - During the U.S.-China summit, the Clinton administration agrees to certify the 1985 peaceful nuclear cooperation agreement between the two countries. The move allows U.S. companies to apply for licenses to sell equipment to Chinese nuclear power plants.

On 31 October, China's State Council and Central Military Commission jointly promulgated China's Military Product Export Control Regulations; the regulations will go into effect on 1 January 1998.

1998

The Clinton administration approves another Loral satellite launch waiver.

Source: Adapted from the timeline from Bates Gill, Center for Nonproliferation Studies, Monterey Institute for International Studies.

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